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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Research paper

The impact of COVID-19 on the psychological distress of youths in Japan: A latent growth curve analysis

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ABSTRACT

Background: This study expands on previous studies that have investigated the impact of the novel coronavirus disease (COVID-19) on mental health in two ways. We first model the change in mental health, then examine the various factors that predict changes in psychological distress.
Method: Longitudinal surveys were conducted once each in 2015, 2017, and 2019 on mothers and their children born between April 2000 and March 2001 ($n = 1854$), and three times in 2020 (February, July, and December) on the children in Japan. A latent growth curve model with four time points from December 2019 to December 2020 was used to depict the changes in the psychological distress of youths and to examine the factor associated with the level and change in psychological distress.
Results: The psychological distress of youths increased from December 2019 to July 2020, especially among female youths, then decreased in December 2020. Initial health status and psychological traits were related to the initial level of psychological distress, but not the change. Gender was not related to the initial level of psychological distress but an increase in distress.
Conclusion: Although the effect size was small, gender was related to changes in distress during the COVID-19 pandemic. Other factors, such as health-related characteristics and personality traits, were associated with the level of distress before the pandemic but could not explain the changes in distress during the pandemic.

1. Introduction

The novel coronavirus disease is not only identified as a direct threat to human health and life, but also to economies and lifestyles, thus influencing the mental health of people (Pfefferbaum and North, 2020). Various studies have reported on the impact of the COVID-19 pandemic on the mental health of patients (Zhang et al., 2020), health care workers (Lai et al., 2020; Rossi et al., 2020; Salazar de Pablo et al., 2020), and the general population (Ren et al., 2020; Xiong et al., 2020) or specific groups, such as young adults (Liu et al., 2020), college students (Li et al., 2020), children (Li et al., 2021), people exposed to COVID-19 patients in a closed setting (Tanoue et al., 2020), and women during pregnancy and perinatal period (Hessami et al., 2020). A systematic review by Xiong et al. (2020) showed that the mental health of people in China, Spain, Italy, Iran, the United States, Turkey, Nepal, and Denmark has worsened from before the pandemic. They also reported that being female, of a young age or being a college student, and having lower levels of education were the risk factors for depression during the COVID-19 pandemic.

Longitudinal surveys that have continuously collected mental health information are valuable for examining the impact of COVID-19. Many studies have utilized them to focus on mental health changes over an extended period of time, rather than the level of mental health, and who were more likely to experience declining mental health during the COVID-19 pandemic (Daly and Robinson, 2021; Fancourt et al., 2021; O'Connor et al., 2020; Pierce et al., 2020; Robinson and Daly, 2021; Kwong et al., 2021). For example, using data from eight waves of the Understanding American Study, Daly and Robinson (2021) found that psychological distress significantly increased from March 10–18 to April 1–14 in 2020, but returned to the mid-March level in June 2020 in the United States. They also found that the pattern of changes in distress differed little in socio-demographic characteristics and pre-existing mental health conditions, suggesting a homogenous pattern of change among different sociodemographic groups and those with different

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levels of baseline distress. Robinson and Daly (2021) also observed that these changes in distress were partially explained by perceived financial risks, lifestyle changes, and personal health concerns. Robinson et al. (2022) conducted a systematic review and meta-analysis of 65 longitudinal studies. They found a significant, but statistically small increase in mental health symptoms, especially during the early stage of the pandemic (March–April 2020), then a decline in distress to pre-pandemic levels by mid-2020 (May–July).

This study expands on the previous studies using longitudinal data in two ways—modeling the changes in mental health and examining the various factors that predict these changes. First, although the growth curve model can reveal the different factors associated with levels and changes in mental health, it has not been widely used to examine the process of mental health changes during COVID-19 (Parola et al., 2020; Zacher and Rudolph, 2021). Second, some studies indicated that the impact of the pandemic on mental health changes was homogeneous across all populations (e.g., Daly and Robinson, 2021; Robinson et al., 2022), but this will need to be explored with more variables that many cross-sectional studies have shown to be associated with mental health.

We apply the latent growth curve model to longitudinal data of Japanese youths from December 2019 to December 2020. We investigate the changes in their psychological distress, as measured by the Kessler psychological distress scale (K6) (Kessler et al., 2003). We also examined the relationship of both the level of and change in psychological distress with several characteristics.

2. Methods

2.1. Data

We used data from a panel survey of junior high school students and their mothers, the outline of which is shown in Table 1. An access panel constructed by a survey company was used to select the respondents across Japan. For the first wave of the survey conducted in October 2015, the questionnaires were mailed to students in the 3rd year of junior high school (9th grade), born between April 2000 and March 2001, and their mothers. Of the 4117 households the survey was sent to, 1854 (45.0%) submitted valid responses. The second wave was conducted in December 2017. Valid responses were obtained from 1499 children and 1588 mothers (80.9% and 85.7%, respectively).

The third wave (December 2019) and later waves of the survey were carried out online. Respondents were asked to provide online-based informed consent to participate. They were informed that they could skip questions they did not want to answer. In the third wave, a letter requesting responses was sent to the 1854 households. From the third wave, the survey began to obtain information about children's health status and behaviors. The number of mothers who responded to the survey was 1279 (69.0% of 1854 households), while the number of child respondents was 941 (50.8%).

The online experimental survey of the children was carried out in February 2020 (Lavrakas et al., 2020).[1] Because it coincided with the period when the effects of COVID-19 were becoming more serious, questions about health were also asked in addition to the experimental items. Owing to budget constraints, the survey asked 1100 children to participate in the survey, of whom 909 responded (49.2%).

In April 2020, the spread of COVID-19 became more serious, and a state of emergency was declared in Japan. An additional online survey was therefore administered to the child respondents (1138 children) from July 2020 to clarify the impact of COVID-19 on the lives and attitudes of young people. Of these children, 877 responded (47.3%). From December 2020 to February 2021, the fourth wave of the survey asked the 1810 children almost the same questions as the third wave and obtained 1188 (64.1%) responses.

In this study, we focus on the changes in psychological distress of youths during four time points: December 2019 (T1: time point 1) when the impact of COVID-19 was still small, and in February (T2: time point 2), July (T3: time point 3), and December 2020 (T4: time point 4), when the impact had gradually increased.

2.2. Variables

The outcome variable is the psychological distress of youths, and the predictor variables are demographic and socioeconomic background, social network, health background, academic ability, and personality traits (See Appendix for details). Previous studies suggested that all predictors used in the analysis are related to the initial status of psychological distress, but less is known about the relationship of these predictors with changes in distress.

2.2.1. Psychological distress

The outcome variable is psychological distress, as measured by the Kessler psychological distress scale (K6), a composite score of six items (Kessler et al., 2003). The K6 score ranges from 0 to 24 points, where higher values indicate higher psychological distress. This study used the Japanese version of the K6 developed by Furukawa et al. (2008). Although this study used K6 as a continuous variable indicating the level of psychological distress, it also used the cut-off point (K6 $\geq$ 13) for severe psychological distress (SPD) or serious mental illness as previous studies (Furukawa et al., 2008; Kessler et al., 2003; Kikuchi et al., 2020). The SPD is only presented in the descriptive analyses.

2.2.2. Demographic and socioeconomic background

Socioeconomic background is associated with the mental health problems of children and adolescents (Reiss, 2013; Miech et al., 1999). Several types of variables were used including gender, parental education (measured by the average of years of schooling of the father and mother), father's socioeconomic index (SEI), logged household income,[2] logged savings, property, and neighborhood. The mothers provided information about their socioeconomic background in 2015, 2017, and 2019. The 10-point scale of subjective social status reported by the children was included because it has been found to be a strong predictor of psychological distress in Japan (Sakurai et al., 2010). We also use variables to represent whether they were attending school (technical college, junior college, or university) and whether they were working in December 2019 or February 2020. Xiong et al. (2020) reported that being a student was a significant risk factor for more depressive symptoms.

2.2.3. Social network

Social networks and social ties may positively and negatively affect psychological distress depending on the current situation (Fiore et al., 1983; Kawachi and Berkman, 2001; Perry and Pescosolido, 2015). Cohabitation status (1 = live alone, 0 = not), having a partner (1 = yes, 0 = no), dating anyone (1 = yes, 0 = no), and the number of individuals in their discussion network were used. The discussion network is an interpersonal network in which an individual discusses important matters (Marsden, 1987).

2.2.4. Health background

Health background included the self-rated health of the youth (0 = poor, 4 = excellent) in 2019, self-rated health of the youth during the past three years (reported by mother in 2019; 0 = poor, 4 = excellent), body mass index (BMI) in February 2020 (continuous), and mother's psychological distress (reported by mother in 2019; K6 ranging from 0 to 24).

[1] In addition to asking the usual questions, the survey conducted list (known as the item count technique) and conjoint experiments (Lavrakas et al., 2020).

[2] The unit is million yen (about 9100 US dollars as of June 2021).

Table 1
Outline of the survey.

Survey	1st wave		2nd wave		3rd wave	Experi-mentalsurvey	COVID-19survey	4th wave
Period	2015.10	2016	2017.12	2018	2019.12 (T1)	2020.2 (T2)	2020.7 (T3)	2020.12 (T4)
Mode	Mail		Mail		Online	Online	Online	Online
(Approximate) Grade	3rd year of junior high school (9th grade)	1st year of high school (10th grade)	2nd year of high school (11th grade)	3rd year of high school (12th grade)	1st year of university		2nd year of university	
Child(Response Rate)	1854		1499 (80.8%)		941 (50.8%)	909 (49.2%)	877 (47.3%)	1188 (64.1%)
Mother(Response Rate)	1854		1588 (85.7%)		1279 (69.0%)			

Note: Child respondents were born between April 2000 and March 2001. The response rates were based on the sample size of the 1st wave (1854). The response rate for the 1st wave was 45.0% (=1854/4117 * 100). See the main text for details.

2.2.5. Academic performance

Previous studies have reported that academic and cognitive performance are related to mental health (Hatch et al., 2007; Hung et al., 2016). Because the survey did not conduct any tests to measure academic performance or cognitive ability, self-reported grades from the 3rd year of junior high school in 2015 were used (Yamamoto and Brinton, 2010).

2.2.6. Personality traits and school connectedness

The personality trait of high anxiety, known as neuroticism, has been pointed out as a risk factor for depression and anxiety disorders (Kendler et al., 2004; Sandi and Richter-Levin, 2009; Sep et al., 2019; Weger and Sandi, 2018). We measured the anxious personality trait based on three items: (1) I feel anxious and get upset easily; (2) I sometimes feel shy and tend to be quiet; and (3) When I feel down, I have a hard time improving my mood (Cronbach's $\alpha = 0.566$). Because psychological orientation is related to psychological distress (Benassi et al., 1988; Sowislo and Orth, 2013; Ross and Broh, 2000), we also used self-esteem, measured using three items: (1) I am able to do things as well as most people; (2) On the whole, I am satisfied with myself; and (3) I certainly feel useless at times (three items, $\alpha = 0.629$).

School connectedness is associated with the health of young people (McNeely et al., 2002). Since not all the respondents attended school in 2019, we used the degree to which they liked their school, measured in 2017 using three items: (1) On the whole, I enjoy school life; (2) I enjoy my life more outside of school than when I am in school; and (3) I do not want to go to school ($\alpha = 0.772$) (Libbey, 2004).

2.3. Statistical model

2.3.1. The latent growth curve model

This study applied the latent growth curve model (Curran et al., 2010; McArdle and Epstein, 1987; Stoel et al., 2004). The latent growth curve model for the K6 score y_{it} of youth i at time point t (t=T1, T2, T3, T4) can be written as follows:

$$y_{it} = \eta_{0i} + \eta_{1i}x_{it} + \epsilon_{it},$$

$$\eta_{0i} = \alpha_0 + \sum_k \gamma_{0k} w_k + \zeta_{0i},$$

$$\eta_{1i} = \alpha_1 + \sum_k \gamma_{1k} w_k + \zeta_{1i},$$

where x_{it} is the time score for time t. Based on the intervals of the surveys, we assigned non-equidistant time scores for four time points as 0 (0 days, initial status) for T1, 0.289 (56 days) for T2, 1 (194 days) for T3, and 1.866 (362 days) for T4 (the score for T1 was set to 0 and that for T3 to 1). Thus, the outcome was modeled as a linear function of time (Biesanz et al., 2004). η_{0i} represents the intercept or initial status of psychological distress (K6 at T1), and η_{1i} represents the slope or growth rate of psychological distress from T1 to T4. ϵ_{it} is the time-specific residual term. In the second and third equations, α_0 and α_1 are the intercepts for the intercept (η_{0i}) and slope (η_{1i}), respectively. The variances of the intercept and slope factors are ψ_0 and ψ_1, respectively. The w_k is the kth time-invariant or baseline predictors that predict the level (η_{0i}) and the change (η_{1i}) in outcome y_{it}. The terms ζ_{0i} and ζ_{1i} represent the residuals for the intercept and slope, respectively. They are allowed to covary (the covariance is ψ_{01}), and shows the relationship between individual status and growth rate that was not explained by the predictors. The latent growth model can add the term $\eta_{2i}x_t^2$ in the first equation, and add the fourth equation: $\eta_{2i} = \alpha_2 + \sum_k \gamma_{2k} w_k + \zeta_{2i}$.

The latent growth curve model can also include time-varying predictors. Because the surveys have collected limited information on time-varying variables, especially in T2 and T3, this study mainly focused on the time-invariant predictors. The time-varying predictors at only a single time point (basically measured at T1 or before) or averaged over multiple time points (e.g., 2015, 2017, and 2019) were included in the models.[3] All predictors, except for gender were centered on the mean in the latent growth curve models to facilitate the interpretation of the estimated mean of the intercept and slope. All statistical analyses were conducted using R version 4.1.0, and the latent growth curve models were fitted using the *lavaan* package (Rosseel, 2012).

2.3.2. Multiple imputation

The following analyses were conducted using an imputed longitudinal data-set of 1854 youths who participated in the 2015 survey. Longitudinal surveys have the advantage of being able to capture observable changes, but its disadvantage are the missing values owing to sample attrition and non-responses. We conducted the logistic regression analysis using demographic, socioeconomic backgrounds, and other characteristics collected in 2015 (Table A1 in Appendix). The results indicate that female youths were more likely to respond to the surveys in all four points (T1-T4). Logged household savings (T1), the number of goods at home (T1 and T3), neighborhood advantage (T2), academic performance in the 9th grade (T1 and T3), and anxious personality trait (T3) were also associated with the response rates. Because the listwise deletion of missing data may produce bias (Van Buuren, 2018), this survey used multiple imputation for missing data via the *Amelia II* package in R (Honaker et al., 2011). Regardless of the proportion of missing data, a correctly specified multiple imputation can reduce bias and improve efficiency (Madley-Dowd et al., 2019).

To improve the prediction of missing values, we incorporated auxiliary variables into the imputation model in addition to the variables used in the latent growth curve model. We did not delete imputed outcomes (K6) before the analysis (Sullivan et al., 2015). >30 auxiliary variables assumed to be correlated with missingness and incomplete

[3] Only BMI was measured at T2 in February 2020.

variables were used in the imputation (Sullivan et al., 2015) (See Appendix for details). The number of imputations was $M = 80$.

3. Results

3.1. Basic statistics

Table A2 in Appendix summarizes the means of the variables before (Mean [Obs.]) and after imputation (Mean [MI]), and the listwise deleted mean (Mean [LD]). The means of K6 for each time point by predictor variables and the correlation matrix are shown in Tables A3 and A4 in Appendix, respectively.

The mean (MI) of K6 increased from 5.04 to 6.09 between T1 (December 2019) and T3 (July 2020), then decreased to 5.08 in T4 (December 2020). The same is true for SPD (K6 $\geq$ 13); the proportion of SPD increased from T1 to T3 (7.7% to 12%), then decreased at T4 (8.7%).

The descriptive analysis was also conducted separately for male and female youths. The mean scores of K6 at T1 were 5.00 and 5.07 (the proportion of SPD: 7.1% and 8.3%) for male and female youths, respectively. There were no differences in K6 between male and female youths at T1 (0.06, $p = .85$). They were 5.61 and 5.85 (SPD: 8.9% and 9.8%) at T2, 5.41 and 6.75 (SPD: 9.1% and 14.7%) at T3, and 4.59 and 5.56 (SPD: 7.3% and 10.1%) at T4, respectively. Fig. 1 shows the change in the mean value of K6 with the 95% confidence intervals by gender. K6 increased for both male and female youths at T2, but increased further only in female youths at T3, with little change in male youths. The effect size (Cohen's *d*) for the change in K6 from T1 to T3 was 0.08 (95% CI: −0.02, 0.17) for men and 0.31 (CI: 0.22, 0.40) for women, and the odds ratio for the changes in SPD from T1 to T3 was 1.32 (CI: 0.85, 2.05) for men and 1.90 (CI: 1.34, 2.71) for women, indicating that the effect size was small (Chen et al., 2010).

K6 decreased in both male and female youths at T4, but the K6 of female youths at T4 was higher than that at T1 (0.50, $p = .032$) and than that of male youths at T4 (0.97, $p < .001$).

3.2. Latent growth curve model

To choose the baseline model, we fitted the simple latent growth curve models with gender as the predictor of the data from T1 to T4 (Models 1 to 3) before estimating the models with many predictors. We considered three models: the intercept-only model (Model 1), linear growth model (Model 2), and quadratic growth model (Model 3). Table 2 shows the goodness of fit of the models (Wu et al., 2009). The Chi-square goodness of fit test showed that only Model 3 fit the data well ($p > .05$). Moreover, the *AIC* (Akaike information criterion), *BIC* (Bayesian information criterion), *RMSEA* (root mean square error of approximation), and *SRMR* (standardized root mean squared residual) were smaller, and the *CFI* (comparative fit index) was larger for Model 3 than for Models 1 and 2. This indicates that the quadratic model (Model 3) fit better than the intercept-only model (Model 1) and linear growth model (Model 2). The estimated parameters for each model are shown in Table 3. Fig. 1 shows that the quadratic curve model (Model 3) indicates that psychological distress increases and decreases from T1 to T4.

The quadratic curve model, which was chosen as the best fit model, can be considered a baseline model. However, as we were interested in which youths reported increased psychological distress due to the COVID-19 pandemic, we restricted the time point from T1 to T3, then fitted the growth linear model (Models 4 to 5). The slope parameter of a growth linear model can be interpreted in a more straightforward way than that of a non-linear growth model. However, this analysis can only capture the rising part of the distress from T1 to T3. Therefore, the factors affecting the subsequent decrease in distress were also examined using a linear regression model that predicts the difference (decline) in distress between T3 and T4.

3.3. Latent growth linear model to predict changes from T1 to T3

The bottom two rows of Table 2 show the goodness of fit of the models for three time points. There is no quadratic model here. Table 2 indicates that the linear growth model (Model 5) fits better than the intercept-only model (Model 4), indicating that K6 was not constant from T1 to T3, but changed linearly. Table 3 presents the estimates from Models 1 to 5. The results of Model 5 show that the coefficient of gender on the intercept was −0.01 ($SE = 0.36$) and not statistically significant ($p > .05$), indicating no gender difference in the level of psychological distress at T1. The coefficient of gender on the slope was 1.26 ($SE = 0.40$) and statistically significant ($p < .05$). The fitted line from Model 5 was presented in Fig. 1. This result demonstrates that gender is a significant predictor for the slope (change), but not for the intercept (level or initial status), as shown in Fig. 1.

Based on the latent growth linear model with gender as a predictor (Model 5), we considered several models with different sets of predictors. Model 6 added variables about socioeconomic background (objective social status) and subjective social status as predictors. Model 7 included academic performance, education, and employment status. To observe the effect of social networks, Model 8 added variables about cohabitation, social networks, and partnership. Model 9 included

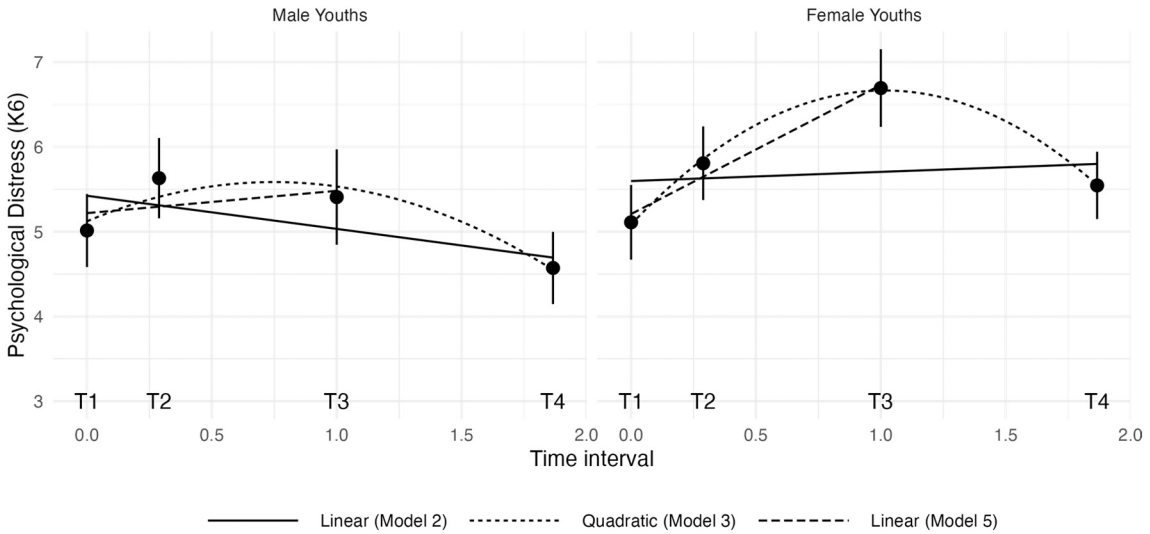

Fig. 1. Changes in the mean values of K6 by gender and the fitted lines and curves for Models 2, 3, and 5; T1 = 2019.12, T2 = 2020.2, T3 = 2020.7, T4 = 2020.12.

Table 2
The goodness of fit of the models.

Time points	Model	χ^2	df	p	AIC	BIC	CFI	RMSEA	SRMR
T1 to T4	Intercept only (Model 1)	84.7	11	0.000	43,144	43,183	0.918	0.060	0.054
T1 to T4	Linear (Model 2)	55.4	7	0.000	43,076	43,137	0.946	0.061	0.042
T1 to T4	Quadratic (Model 3)	2.9	2	0.232	42,949	43,037	0.999	0.016	0.009
T1 to T3	Intercept only (Model 4)	46.8	6	0.000	32,799	32,832	0.922	0.061	0.052
T1 to T3	Linear (Model 5)	7.2	2	0.028	32,705	32,760	0.990	0.037	0.016

Note: $n = 1854$. AIC: Akaike information criterion; BIC: Bayesian information criterion; CFI: comparative fit index, RMSEA: root mean square error of approximation; SRMR: standardized root mean squared residual. T1 = 2019.12; T2 = 2020.2; T3 = 2020.7; T4 = 2020.12.

health-related variables, including mother's mental health. Finally, Model 10 included personality traits and school connectedness measured before the COVID-19 outbreak. The results from Models 6 to 7 are shown in Table 4 and those from Models 8 to 10 are shown in Table 5.

First, we examined the factors associated with the intercept. The results of Model 6 show that subjective social status was negatively associated with psychological distress (−1.00, SE = 0.17, $p < .05$). The results of Model 7 show that youths who worked had less psychological distress. The results of Model 8 indicate that those who had more networks tended to be less psychologically distressed at T1. The result of Model 9 shows that the self-reported health of the respondents and their mothers, and the mother's psychological distress were related to the respondents' psychological distress at T1. Finally, the result of Model 10 indicates that all personality traits used in the analysis had a significant relationship with the level of psychological distress at T1; anxious personality was positively associated with psychological distress, while self-esteem and school connectedness were negatively associated with it. After controlling for these characteristics, the association of subjective social status, employment, and the size of discussion network with psychological distress disappeared.

Second, we examined the factors associated with the slope, that is, the changes in psychological distress. Model 6 indicates that socioeconomic background (objective social status) and subjective social status were not related to changes in distress. Model 7 indicates that those who were in school in 2019 have increased levels of psychological distress. The results from Models 8 to 10 suggest that social networks, health-related variables, personality trait, or school connectedness were not associated with changes in distress from T1 to T3.

3.4. Linear regression model to predict changes from T3 to T4

We conducted a linear regression analysis to investigate the factors related to the decrease in distress between T3 and T4, following Daly and Robinson (2021). The outcome was the difference in K6 scores between T3 and T4 (T3 – T4) and the predictors were the same as those for the growth linear model. As before, we started with a model that only included only gender as a predictor, and gradually added more variables. The result is shown in Table A5 in Appendix. From Models 1 to 5, we did not find any significant factors to predict the changes in distress between T3 and T4. In Model 6, we found that only the GPA in the 3rd year of junior high school was significant in explaining the change; the higher the GPA, the more distress was reduced. Our results suggest that academic achievement has a positive effect on recovery from increased psychological distress (c.f. Weeks et al., 2014).

4. Discussion

This study used data from longitudinal surveys of youths in Japan that have been administered since 2015. We investigated the factors related to their levels and changes in psychological distress from December 2019 to December 2020 (four time points). The latent growth curve model was applied to examine the trajectory changes of psychological distress of the youth. The results indicate that psychological distress among female youths rose sharply between December 2019 (T1) and July 2020 (T3), and declined in December 2020 (T4). Although the size of the change was small, the rise and decline in psychological distress are consistent with the results of previous studies (Daly et al., 2020; Robinson and Daly, 2021; Robinson et al., 2022). However, the timing of the peak of psychological distress may vary depending on the social context. In the United States, distress increased from April to June before decreasing (Robinson and Daly, 2021). In the United Kingdom, the percentage of mental health problems decreased between April and June (Daly et al., 2020). In Japan, our result indicates that distress increased until July before decreasing, especially among female youths.

The latent growth linear model with various factors was also used to predict the level of and change in psychological distress from December 2019 to July 2020. The result demonstrated that the factors associated with psychological distress before COVID-19 were not the same as those associated with changes in psychological distress during the pandemic. As previous studies suggested, subjective social status, employment, size of discussion networks, health-related variables, personality traits, and school connectedness were related to psychological distress at the baseline (T1). However, only gender and school attendance were the only factors associated with changes in psychological distress from T1 to T3. This result indicates that an increase in psychological distress caused by the COVID-19 pandemic occurred in a wider range of people. We did not find any factors associated with both the level of and change in psychological distress. While previous studies have shown that increased psychological distress occurred in many subpopulations (Daly and Robinson, 2021), this study found that this pattern was confirmed even when more distress-related predictors were used.

Although the effect size was small, the increase in psychological distress among female youths is a significant finding, which is in line with the results of previous studies conducted in various countries (Daly et al., 2020; Niedzwiedz et al., 2020; Xiong et al., 2020; Yarrington et al., 2021). The psychological distress we used here was a self-reported measure, and the results of this study may simply reflect the fact that the way distress is expressed in a serious situation, such as a pandemic, can vary by gender. However, our result is also consistent with the excess suicide rate among female youths in July, August, and September in Japan (Nomura et al., 2021; Tanaka and Okamoto, 2021; Ueda et al., 2021). Tanaka and Okamoto (2021) reported that the increase in the suicide rates among women was about five times greater than that among men during the second wave of the COVID-19 pandemic, which corresponds to T3 in this study. Therefore, we can assume that female youths in Japan actually experienced increased distress. However, even after controlling for various factors, including personality traits and health status, the coefficient of gender on the slope remained almost the same and was not explained by other variables. We added the interaction terms of predictors and gender to Model 10 and conducted the analysis, but none of the coefficients for the interaction terms were statistically significant for the intercept nor the slope (the results were not shown here). This means that the mechanism to explain why psychological distress increased among female youths is still unknown. This result also implies that there are limitations to attributing the deterioration of individuals' mental health during the COVID-19 pandemic to their personality traits and health status.

Table 3
The estimated parameters from the latent growth curve models (Models 1 to 5).

Predictor	Model 1	Model 2		Model 3			Model 4	Model 5	
	I	I	S	I	S	Q	I	I	S
Gender (Female = 1, Male = 0)	0.59 (0.31)	0.17 (0.34)	0.50 (0.19)**	−0.04 (0.36)	1.88 (0.75)*	−0.71 (0.37)	0.42 (0.32)	−0.01 (0.36)	1.26 (0.40)**
Mean	5.16 (0.22)***	5.42 (0.24)***	−0.39 (0.13)**	5.12 (0.26)***	1.24 (0.54)*	−0.83 (0.26)**	5.37 (0.23)***	5.22 (0.25)***	0.26 (0.28)
Variance	14.98 (0.93)***	15.48 (1.16)***	2.32 (0.56)***	16.74 (1.53)***	27.12 (9.86)**	5.47 (2.32)*	15.13 (1.02)***	16.18 (1.33)***	11.82 (4.09)**
Covariance (I and S)		−0.96 (0.52)		−5.07 (2.96)				−2.74 (1.35)*	
Covariance (I and Q)				1.77 (1.32)					
Covariance (S and Q)				−11.69 (4.43)**					
R-squared	0.01	0.00	0.03	0.00	0.03	0.02	0.00	0.00	0.03

Note: $n = 1854$. I = Intercept, S = Slope, Q = Quadratic. Standard errors are in parentheses.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

The average level of psychological distress among female youths seems to have recovered at T4 (December 2020); however, it was still higher than that of male youths. Research to better understand the impact of COVID-19 on female youths and policies to improve their mental health is needed. It will also be necessary to understand differences in trends and analyze their causes from a longitudinal study across a longer time period. This study mainly used the time-invariant characteristics as the predictor, but time-varying characteristics, such as the economic situations of the respondents (child) and their parents, should be considered as factors influencing the changes in distress in the future analysis.

Those who were attending school before and after the outbreak had increased psychological distress from December 2019 to July 2020. School closures, online classes, heavier course load, decreased interaction with school friends, restrictions on extracurricular activities, and the cessation of part-time jobs might have caused more changes in the school lives and lifestyles of students, compared to non-student youths, which in turn might have increased psychological distress. More detailed surveys and analyses are needed to clarify the factors contributing to the deterioration of students' mental health (Cao et al., 2020; Li et al., 2020; Son et al., 2020).

There are several limitations to this study. The surveys were not based on random sampling, and the proportion of missing data was very high, which might have biased the results. Moreover, our sample is limited to a specific cohort born in 2000 and 2001, and the results cannot be generalized to other age groups. Since many variables, such as distress and personality traits, are self-rated measures, the observed effects may be biased. Our approach, based on several predictive models, is rather exploratory, and the observed statistically significant results may have occurred by chance. After correcting for p-values using Holm's method for multiple comparisons, the coefficients for "in school" in Model 10 in Table 5 and for "GPA in the 9th grade" in Model 6 in Table A5 were not found to be statistically significant. The coefficients of the variables that were not highly significant ($0.005 < p < .05$) will need to be carefully examined using other data or methods (Benjamin et al., 2018).

Another limitation of this study is that it does not examine the level of mental health and the impact of the mental health changes of other family members. In our study, the impact of changes in the mental health of mothers and other family members during COVID-19 was not examined. It may also be necessary to consider higher-order interactions using more flexible models (e.g., machine learning models) to examine the characteristics of people or subgroups with particularly increased levels of distress.

In conclusion, the effect of COVID-19 on changes in psychological distress was essentially homogeneous among individuals of different socioeconomic backgrounds and psychological characteristics, although there were heterogeneous effects of gender. Factors associated with levels of distress before COVID-19 and changes in distress during the pandemic were different, which underscores the importance of data from longitudinal surveys. In this study, other factors, such as health-related characteristics and personality traits, could not explain the changes, and the explanatory power of the model for the change was weak. Therefore, it is necessary to explore the possibility of more diverse factors. Theories and measurements of factors that might explain the changes in distress during crisis situations will be needed.

CRediT authorship contributor statement

Sho Fujihara and Takahiro Tabuchi designed research and collected the data; Sho Fujihara analyzed the data and drafted the manuscript; Tabuchi Takahiro revised the manuscript. Sho Fujihara had primary responsibility for final content. All authors read and approved the final manuscript.

Table 4
The estimated parameters from the latent growth linear models (Models 6 and 7).

Predictor	Model 6		Model 7	
	I	S	I	S
Gender (Female = 1, Male = 0)	−0.06 (0.33)	1.32 (0.38)***	0.02 (0.33)	1.23 (0.38)**
Father's SEI / 10	0.11 (0.21)	0.29 (0.24)	0.14 (0.21)	0.30 (0.24)
Parental education (years)	0.39 (0.21)	−0.13 (0.24)	0.41 (0.22)	−0.14 (0.25)
Logged household income	0.07 (0.21)	−0.20 (0.24)	0.07 (0.21)	−0.21 (0.24)
Logged household savings	−0.07 (0.20)	0.13 (0.23)	−0.01 (0.20)	0.09 (0.23)
# of goods at home	−0.15 (0.18)	−0.07 (0.21)	−0.13 (0.18)	−0.11 (0.21)
Neighborhood advantage	0.13 (0.18)	−0.01 (0.20)	0.13 (0.18)	−0.04 (0.20)
Grandparents' higher education	0.10 (0.18)	0.04 (0.20)	0.09 (0.17)	0.05 (0.20)
Prefectures with large cities	0.12 (0.17)	0.10 (0.19)	0.14 (0.17)	0.08 (0.19)
Subjective social status	−1.00 (0.17)***	0.29 (0.19)	−0.98 (0.17)***	0.27 (0.19)
GPA in the 9th grade			−0.29 (0.18)	−0.04 (0.20)
In school (Yes = 1, No = 0)			−0.14 (0.17)	0.41 (0.20)*
Working (Yes = 1, No = 0)			−0.48 (0.17)**	0.36 (0.19)
Cohabiting (Yes = 1, No = 0)				
# of discussion networks				
Dating anyone (Yes = 1, No = 0)				
BMI				
Self-rated health				
Self-rated health in past 3 years				
Mother's K6 (December 2019)				
Anxious personality				
Self-esteem				
School connectedness				
Mean	5.23 (0.24)***	0.28 (0.27)	5.19 (0.23)***	0.32 (0.27)
Variance	14.94 (1.21)***	11.12 (3.81)**	14.59 (1.18)***	11.09 (3.77)**
Covariance (I and S)	−2.47 (1.25)*		−2.27 (1.22)	
R-squared	0.07	0.05	0.09	0.08

Note: $n = 1854$. I = Intercept, S = Slope. Standard errors are in parentheses.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 5
The estimated parameters from the latent growth linear models (Models 8 to 10).

Predictor	Model 8		Model 9		Model 10	
	I	S	I	S	I	S
Gender (Female = 1, Male = 0)	0.04 (0.33)	1.25 (0.37)***	−0.06 (0.31)	1.28 (0.38)***	−0.09 (0.27)	1.28 (0.38)***
Father's SEI / 10	0.17 (0.20)	0.29 (0.23)	0.17 (0.19)	0.29 (0.24)	0.08 (0.17)	0.31 (0.24)
Parental education (years)	0.38 (0.21)	−0.13 (0.24)	0.27 (0.20)	−0.12 (0.25)	0.22 (0.18)	−0.11 (0.25)
Logged household income	0.07 (0.20)	−0.22 (0.24)	0.24 (0.20)	−0.25 (0.24)	0.22 (0.17)	−0.24 (0.24)
Logged household savings	−0.06 (0.20)	0.10 (0.23)	0.04 (0.19)	0.09 (0.23)	−0.06 (0.17)	0.12 (0.23)
# of goods at home	−0.08 (0.18)	−0.11 (0.21)	−0.11 (0.17)	−0.11 (0.21)	−0.03 (0.15)	−0.13 (0.21)
Neighborhood advantage	0.10 (0.18)	0.00 (0.20)	0.07 (0.17)	0.01 (0.20)	0.15 (0.15)	−0.01 (0.21)
Grandparents' higher education	0.13 (0.17)	0.04 (0.20)	0.14 (0.16)	0.04 (0.20)	0.13 (0.14)	0.04 (0.20)
Prefectures with large cities	0.15 (0.17)	0.08 (0.19)	0.13 (0.16)	0.08 (0.19)	0.21 (0.14)	0.06 (0.19)
Subjective social status	−0.93 (0.17)***	0.25 (0.19)	−0.76 (0.16)***	0.22 (0.19)	−0.12 (0.15)	0.07 (0.21)
GPA in the 9th grade	−0.27 (0.18)	−0.07 (0.20)	−0.10 (0.17)	−0.10 (0.21)	0.14 (0.15)	−0.15 (0.21)
In school (Yes = 1, No = 0)	−0.09 (0.17)	0.39 (0.20)*	−0.04 (0.16)	0.39 (0.20)	−0.10 (0.14)	0.40 (0.20)*
Working (Yes = 1, No = 0)	−0.45 (0.16)**	0.35 (0.19)	−0.38 (0.16)*	0.34 (0.19)	−0.24 (0.14)	0.30 (0.19)
Cohabiting (Yes = 1, No = 0)	−0.05 (0.17)	0.21 (0.19)	−0.05 (0.16)	0.21 (0.19)	−0.13 (0.14)	0.23 (0.19)
# of discussion networks	−0.64 (0.16)***	0.19 (0.19)	−0.50 (0.16)**	0.17 (0.19)	−0.24 (0.14)	0.10 (0.19)
Dating anyone (Yes = 1, No = 0)	0.03 (0.16)	0.06 (0.19)	−0.02 (0.16)	0.07 (0.19)	0.11 (0.14)	0.04 (0.19)
BMI			0.07 (0.16)	0.09 (0.19)	0.12 (0.14)	0.08 (0.19)
Self-rated health			−1.06 (0.16)***	0.20 (0.20)	−0.63 (0.15)***	0.09 (0.20)
Self-rated health in past 3 years			−0.53 (0.16)**	0.04 (0.20)	−0.42 (0.14)**	0.01 (0.20)
Mother's K6 (December 2019)			0.62 (0.16)***	−0.14 (0.19)	0.48 (0.14)***	−0.10 (0.20)
Anxious personality					1.04 (0.15)***	−0.34 (0.21)
Self-esteem					−1.55 (0.16)***	0.34 (0.22)
School connectedness					−0.57 (0.15)***	0.16 (0.20)
Mean	5.18 (0.23)***	0.31 (0.27)	5.24 (0.22)***	0.30 (0.27)	5.24 (0.19)***	0.30 (0.27)
Variance	14.12 (1.16)***	10.79 (3.73)**	11.67 (1.05)***	8.79 (3.66)*	7.51 (0.86)***	11.23 (3.46)**
Covariance (I and S)	−2.06 (1.20)		−1.17 (1.16)		−0.73 (1.02)	
R-squared	0.12	0.09	0.25	0.11	0.53	0.11

Note: $n = 1854$. I = Intercept, S = Slope. Standard errors are in parentheses.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

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Declaration of competing interest

The authors declare that they have no conflict of interest.

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Appendix A. Supplementary data

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