NEW RESEARCH

Sex Differences in Adolescent Depression Trajectory Before and Into the Second Year of COVID-19 Pandemic

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Objective: Evidence on the impact of the COVID-19 pandemic on adolescent mental health is mixed and does not disentangle natural age-related changes. We compared depressive symptoms among 16-year-olds surveyed, at a fourth wave, before or during the pandemic, while accounting for expected trajectories of within-person change based on 3 prior waves.

Method: In this longitudinal cohort of 3,171 adolescents in Tokyo, Japan, adolescents were grouped based on their age 16 survey timing: pre-pandemic (February 2019 to February 2020) and during-pandemic (March 2020 to September 2021). Depressive symptoms were self-reported using the Short Mood and Feelings Questionnaire. Mixed-effect models were fitted to assess group differences while controlling for previous trends. Variations by sex, household income, and pandemic phase (early, late first-year, and second-year) were examined.

Results: Of 2,034 eligible adolescents, 960 (455 girls) were assessed before and 1,074 (515 girls) during the pandemic. Overall, depressive symptoms increased by 0.80 points (95% CI 0.28-1.31, 0.15 SD of the population average). This increase varied by sex and pandemic phase. For boys the increase emerged in the late first-year phase and enlarged in the second-year phase (mean difference from pre-pandemic: 1.69, 0.14-3.24), whereas for girls it decreased in the early school-closure phase (mean difference: –1.98, –3.54 to –0.41) and returned to the pre-pandemic level thereafter, with no additional increases during the pandemic.

Conclusion: Into the second year of the COVID-19 pandemic, depressive symptoms of 16-year-olds worsened above the expected age-related change only in boys. Continuous monitoring and preventive approaches for adolescents at the population level are warranted.

Diversity & Inclusion Statement: We worked to ensure that the study questionnaires were prepared in an inclusive way. We worked to ensure sex and gender balance in the recruitment of human participants. One or more of the authors of this paper self-identifies as a member of one or more historically underrepresented racial and/or ethnic groups in science. We actively worked to promote sex and gender balance in our author group. The author list of this paper includes contributors from the location and/or community where the research was conducted who participated in the data collection, design, analysis, and/or interpretation of the work.

Key words: COVID-19 pandemic; adolescent mental health; depressive symptoms; gender differences; longitudinal cohort

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Emerging studies have reported that adolescent mental health has worsened during the COVID-19 pandemic.[1-5] In addition to the psychological distress owing to COVID-19 infection, public health measures implemented to prevent the spread of the virus, such as school closures, stay-at-home requirements, and restrictions on social contact and recreational activities, may have negatively affected adolescent mental health.[6] A recent meta-analytic study reported that the prevalence of clinically elevated depressive symptoms doubled during the pandemic, affecting approximately one-fourth of youth globally.[5] Furthermore, the mental health of some groups, such as girls and adolescents living in less affluent households, was disproportionally affected by the pandemic, leading to widening disparity.[1,2,5,7]

A precise understanding of the impact of the pandemic on adolescent mental health, particularly depression, is crucial for designing strategies to mitigate the negative impact of the pandemic. However, much of the evidence is from cross-sectional studies or is based on convenient samples,[2,5] making it difficult to adequately assess the changes associated with the pandemic. Findings from

longitudinal or repeated cross-sectional studies with representative data collected before and during the pandemic are mixed; some studies have reported worsening mental health of adolescents,[1,8-11] while others have reported no change.[7,12-14] Importantly, population average for depressive symptoms increases during adolescence, with varying ages of peak velocity based on gender.[15,16] Therefore, the observed increase in depressive symptoms during the pandemic in studies following the same participants over time could be confounded by expected age- and gender-related changes during adolescence.[8] Furthermore, population-based repeated cross-sectional studies comparing pre- and during- pandemic data can be used to examine the overall population trends.[10,11] However, to fully understand the impact of the pandemic on adolescent depressive symptoms, a longitudinal study examining within-person changes associated with the pandemic while considering individual differences in this change and the age- and gender-related changes during adolescence is required.[17,18] To our knowledge, no studies have taken this approach. In addition, many studies have been conducted during the initial months of the pandemic (ie, up to the summer of 2020), when adolescents were experiencing strict stringency measures, including school closures.[1,7,8,12] However, the impact of the pandemic on adolescent mental health may change with time, as schools re-open or social distancing regulations change. Studies from the United States[9] and the Netherlands[19] found a small increasing trend in depressive symptoms during the first year of the pandemic. However, the trajectory of these trends into the second year of the pandemic remains largely unknown.

Our use of data from the Tokyo Teen Cohort study (TTC), an ongoing population-based cohort in Tokyo, Japan, allowed us to address these gaps in the evidence. The TTC collected data on adolescent depressive symptoms in 3 consecutive waves before the pandemic, when the participants were aged 10, 12, and 14 years. The age 16 survey was administered before and during the pandemic between February 2019 and September 2021. Furthermore, the data collection for the TTC continued almost uninterrupted throughout the pandemic; some participants were interviewed during the initial months of the pandemic when the first state of emergency was announced and school closure was implemented, whereas others were interviewed in the subsequent school re-opening phase, followed by the re-introduction of the state of emergency phase when Japan experienced a surge in the number of COVID-19 infections. This allowed us to examine the potential impact of the pandemic on adolescents' depressive symptoms, both overall and by phase of the pandemic, including the school closure phase. To the best of our knowledge, the TTC dataset is the only adolescent cohort study that has assessed mental health outcomes and continued through the onset of COVID-19, providing a rare opportunity to understand the nuanced association between phases of the pandemic and depression severity over time.

Reflecting the unique feature of the timing of data collection of the age 16 survey in the TTC, we aimed to examine whether depressive symptoms of 16-year-olds surveyed during the pandemic (ie, 18 months into the pandemic) exceeded that for 16-year-olds surveyed before the pandemic, while controlling for previous within-person changes. We also aimed to investigate whether the impact differed by phase of the pandemic and by sex. Considering that the pandemic disproportionally affected the economic status of people living in less-affluent households,[20] which could have led to increased psychological distress among adolescents from such households,[7] we additionally examined whether the impact differed by household income. Based on previous reports, we hypothesized that adolescent depressive symptoms would increase beyond the expected age-related change during the pandemic, and that this additional increase would be greater among girls and those from less affluent households.

METHOD

Study Design and Participants

The TTC is an ongoing population-based cohort study following the health and development of 3,171 adolescents born in 3 municipalities in the metropolitan area of Tokyo, Japan, between 2002 and 2004. The study participants were recruited from an existing cross-sectional study (N = 4,478, response rate 44%), which randomly recruited eligible adolescents based on resident register data and via an invitation letter and home visits by trained interviewers.[21] Of the 4,478 adolescents in the original study, we oversampled adolescents in lower-income households and invited 3,171 adolescents for the second TTC survey. Details of the study recruitment are described elsewhere.[21] Data were collected when the participants were aged 10, 12, 14, and 16 years. Of the 3,171 adolescents who participated in the age 10 survey (conducted between October 2012 and January 2015), 3,007 participated in the age 12 survey (conducted between August 2014 and January 2017, response rate 95%); 2,667 in the age 14 survey (between March 2017 and March 2019, response rate 84%), and 2,614 in the age 16 survey (between February 2019 and September 2021, response rate 82%). We restricted our study sample to individuals with valid responses for depressive symptoms in the age 16 survey and

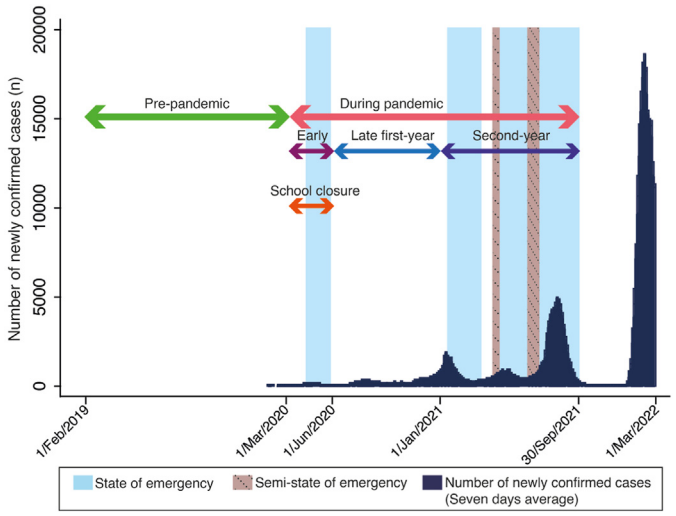
depressive symptoms in at least 1 of the 3 previous surveys, excluding 575 participants. In addition, we excluded participants without data on household income in all surveys (n = 5; Figure S1, available online). All procedures involving human participants were approved by the Institutional Review Board of the Tokyo Metropolitan Institute of Medical Science (approval number: 12-35), SOKENDAI (Graduate University for Advanced Studies, 2012002) and the University of Tokyo (10057). Written informed consent was obtained from all parents of the participating adolescents, and informed assent was obtained from all adolescents.

Procedures

The age 16 survey was conducted before and during the COVID-19 pandemic from February 2019 to September 2021. In Japan, school closures to prevent the spread of COVID-19 began on March 2, 2020, followed by the first nationwide state of emergency declaration on April 7. During the state of emergency period, residents were requested to avoid non-essential outings and to maintain social distancing. School closure lasted until May 31, 2020, for most schools in Tokyo Prefecture, and no further school closures were implemented thereafter. However, in Tokyo, the second state of emergency declaration was announced on January 8, 2021, in response to the increase in the number of COVID-19 patients, which was repeated intermittently until the fourth declaration ended on September 30, 2021. Under the state of emergency declaration, schools were requested to limit extracurricular activities, mainly physical activities with dense gatherings, to a minimum. Other pandemic prevention measures in Tokyo included shorter business hours and restrictions on public gatherings, which remained relatively stable throughout the declaration.

For this study, we grouped the participants into 2 groups according to the timing of the age 16 survey; the pre-pandemic group comprised participants who took the survey between February 2019 and February 2020, and the during-pandemic group included those who took the survey after March 2020 up to September 2021. In addition, to examine the possible different associations between the pandemic and adolescents' mental health by phase of the pandemic, we further divided the during-pandemic group into 3 groups. The early group included data collected from March to May 2020, which corresponds to the school closure period in Tokyo. The late first-year group included data collected from June to December 2020, when schools re-opened and social distancing measures were eased. The second-year group included data collected from January to September 2021, when the second to the fourth state of emergency were repeatedly declared, and stricter school restrictions were implemented (summarized in Figure 1).

FIGURE 1 Study Period and the COVID-19 Context in Tokyo, Japan



Note: *The COVID-19 context in Tokyo[a] (number of newly confirmed cases averaged for 7 days,[b] state of emergency and semi-state of emergency declaration period, and school closure period) and the study phases are shown.*
[a]The population of Tokyo as of 2020 is estimated to be 14 million.
[b]Data obtained from https://data.stopcovid19.metro.tokyo.lg.jp/130001_tokyo_covid19_patients_per_report_date.csv

Measurements

Depressive symptoms were measured at ages 10, 12, 14, and 16 using the Japanese version of the Short Mood and Feelings Questionnaire (SMFQ).[22] The SMFQ is a well-validated 13-item self-reported questionnaire designed to measure depressive symptoms during the last 2 weeks in children and adolescents aged 8 to 17 years.[16,22] Items are rated on a 3-point Likert scale, and a total score is derived for each wave (range 0-26; higher scores indicate more depressive symptoms). Guided by previous studies on the SMFQ,[23] scores for participants with 1 missing item (missing in 0.98%-1.83% of the total sample across waves) were imputed using person-mean scores. The Cronbach alpha for this study ranged from 0.86 to 0.92 across waves.

Sex (male vs female) was identified based on parental report. A time-varying indicator of low annual household income (defined based on the parental report as annual household income below 4,000,000 yen in the previous year or not at each wave, which is just below the Japanese

national median household income) was used to consider the changes in poverty status across waves.

Statistical Analysis

We first conducted descriptive statistics of the study sample and assessed potential biases by comparing the participants included in the analysis with those excluded because of missing data. We then examined the potential impact of the COVID-19 pandemic on depressive symptoms by analyzing differences in depressive symptoms at the age 16 survey between the pre- and during-pandemic groups, while controlling for previous within-person changes using mixed-effect models. The time variable included in the model was calculated as the difference in months between March 2020 (ie, the onset of the COVID-19 epidemic in Japan) and each survey data collection, which was converted to years to aid interpretation. We included linear and quadratic slopes to account for the curved shape of average depressive score trajectories during adolescence.[15] All models were adjusted for chronological age at the age 16 survey, which was grand-mean centered to age 16 to account for the age differences at the time of the age 16 survey data collection. In model 0, intercept, linear, and quadratic slope factors were included. Model 1 included the COVID-19 pandemic indicator (defined as an interaction term between the indicator of pre- or during-pandemic groups and a dummy variable for the age 16 survey) to examine differences in average depressive scores between the pre- and during-pandemic groups. In model 2, to test whether the differences in depressive scores varied by sociodemographic groups, we included an interaction term between the COVID-19 pandemic indicator and sociodemographic factors (ie, sex and low household income). All interaction terms were mutually adjusted. As previous studies showed that average trajectories of depressive scores in adolescence differ by sex, an interaction term between linear and quadratic slopes and sex was also included in model 2. To aid the interpretation of the interaction effects, we conducted a post-estimation analysis to obtain predicted means for each sociodemographic factor by pandemic status using the Stata command "contrast," and we produced graphs of the predicted values for the significant interaction effects found in model 2. As an additional analysis, to investigate whether group differences in depressive symptoms varied by phase of the COVID-19 pandemic, we repeated the analysis using a 4-level indicator of the pandemic phases (pre-pandemic, early, late first-year, and second-year, defined earlier).

Although the proportion of missing data for covariates was not large (maximum 8.4% for household income), we obtained and applied inverse probability weights in our analysis to account for non-responses (Supplement 1, available online). As a sensitivity analysis, we repeated our main analysis using unimputed depressive scores and without weights. All analyses were conducted using STATA version 17SE (StataCorp LLC).

RESULTS

Of the 2,034 participants included in this study (n = 970, 47.3% were girls), 960 (47.1%) were grouped into the pre-pandemic group, and 1074 (52.9%) were grouped into the during-pandemic group. Compared to the pre-pandemic group, participants in the during-pandemic group were slightly older at the time of age 16 survey data collection (mean age 16.6 vs 17.0 years). However, the 2 groups did not differ in the proportion of sex or low household income across waves. For both groups, mean depressive symptoms were highest at age 10 years, showed a declining trend toward age 14, and increased again at age 16 (Table 1; characteristics by pandemic phases are presented in Table S3, available online). Sample bias analysis revealed that adolescents with low household incomes in previous waves and those with higher depressive symptoms at age 10 were more likely to be excluded (Tables S1 and S2, available online).

Our mixed-effect models revealed that the during-pandemic group showed 0.796 points (95% CI, 0.283-1.309) greater increase in depressive symptoms compared to the pre-pandemic group (corresponding to 0.15 SD of the age 16 average in the TTC population, model 1, Table 2; full estimates Table S4, available online). Our interaction model revealed significant sex differences for the impact of the pandemic on depressive symptoms, as indicated by the interaction term for sex and the pandemic (b = –1.228, 95% CI = –2.274 to –0.181, model 2). Post-estimation prediction showed that for boys, the increase in depressive scores was 0.968 points (95% CI = 0.151-1.785) higher for the during-pandemic group than for the pre-pandemic group. However, for girls, the difference between groups was small and non-significant (–0.260, 95% CI = –1.248 to 0.729). This sex difference is further illustrated in Figure 2. No evidence for a difference in depressive symptoms associated with the pandemic by household income was identified.

Our additional analysis by phase of the pandemic revealed the temporal pattern of group differences in depressive symptoms during the pandemic (Table 3; full estimates, Table S5, available online). Taking the pre-pandemic group as a reference, there was no significant difference during the early phase (b = –0.575, 95%

TABLE 1 Characteristics of the Study Sample by Timing of the Age 16 Survey

	Total sample (N = 2,034)				
	Pre-pandemic group[a] (n = 960, 47.1%)		During-pandemic group[b] (n = 1,074, 52.9%)		
	n	%, Mean (SD)	n	%, Mean (SD)	*p*
Mean age at age 16 wave (SD)	960	16.6 (0.3)	1,074	17.0 (0.4)	<.0001
Sex					
Male	505	53.2	559	53.2	.98
Female	455	46.8	515	46.8	
Low household income at age 10[c]					
No	845	89.7	938	88.5	.44
Yes	83	10.3	106	11.5	
Low household income at age 12[c]					
No	841	91.0	902	90.1	.52
Yes	72	9.0	87	9.9	
Low household income at age 14[c]					
No	849	92.2	888	91.8	.79
Yes	61	7.8	69	8.2	
Low household income at age 16[c]					
No	867	91.6	883	89.7	.18
Yes	72	8.4	90	10.3	
Depressive symptoms, mean (SD)[d]					
Age 10	913	4.9 (4.7)	1,041	4.7 (4.5)	.41
Age 12	879	4.0 (4.5)	912	3.8 (4.5)	.46
Age 14	866	3.2 (4.6)	881	3.1 (4.7)	.73
Age 16	960	3.3 (5.0)	1,074	4.3 (5.5)	<.0001
Proportion with clinically significant depression[e]					
Age 10	89	10.3	77	8.4	.17
Age 12	58	7.0	62	7.3	.81
Age 14	54	6.6	61	7.2	.62
Age 16	83	8.8	122	11.6	.04

Note: Unweighted counts and weighted percentages are shown. Number (n) for household income varies because of missing values. The p *values for group differences are shown.*

[a]*Data collection conducted between February 2019 and February 2020.*

[b]*Data collection conducted between March 2020 and September 2021.*

[c]*Low household income defined as annual household income below 4,000,000 yen (approximately USD 30,000).*

[d]*Measured based on self-reports of the Short Mood and Feelings Questionnaire.*

[e]*Defined as scoring above 12 on the Short Mood and Feelings Questionnaire.*

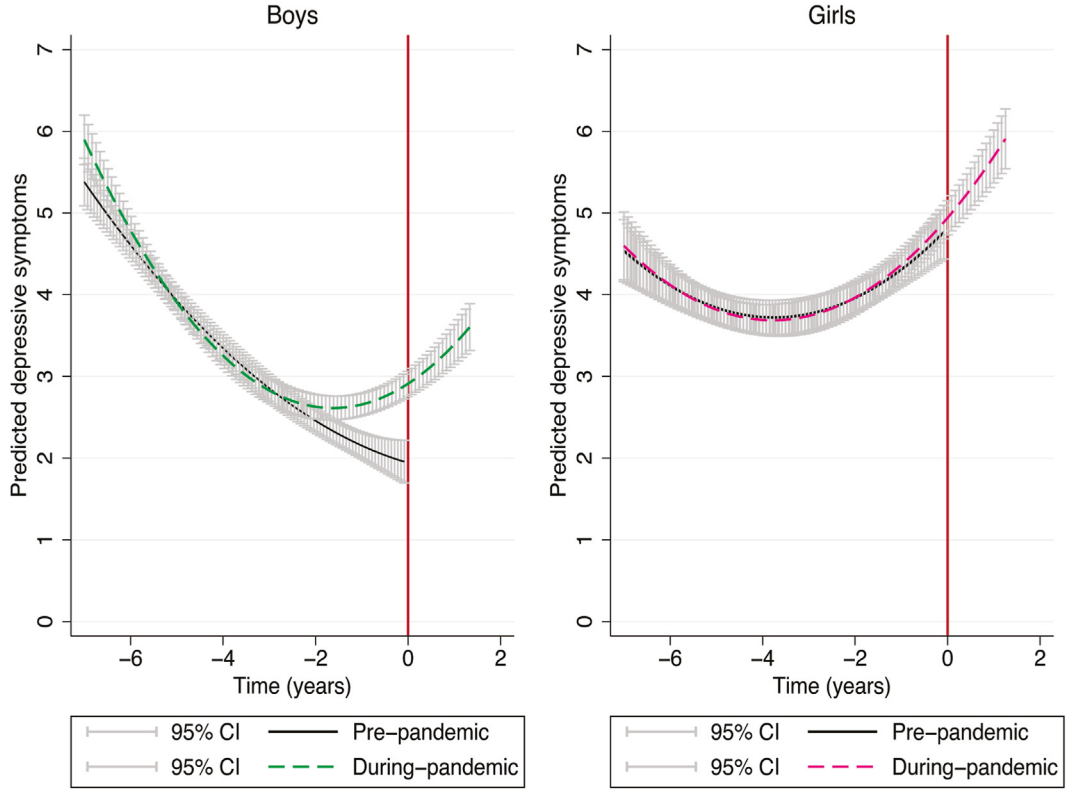
CI = –1.293 to 0.144, model 1). However, a significant increase emerged from the late first-year phase, which further increased in the second-year phase (b = 1.188, 95% CI = 0.620-1.757; b = 1.370, 95% CI = 0.568-2.171, respectively, model 1). The interaction-included model showed a significant difference in this temporal pattern according to sex (model 2; Figure S2, available online). For boys, the temporal pattern followed the overall pattern, showing a significant increase in the late first-year phase (mean difference = 1.090, 95% CI = 0.147-2.033) and the second-year phase (1.690, 95% CI = 0.136-3.244). In contrast, for girls, mean depressive symptoms showed a significant decrease during the early phase compared to the pre-pandemic (–1.976, 95%

TABLE 2 Estimates of Within-Person Change in Depressive Symptoms Associated With the COVID-19 Pandemic (N = 2,034)

	Model 0: time included	Model 1: pandemic indicator included[a]	Model 2a: sex interaction included	Model 2: sex and income interaction mutually included[b]
Fixed effects	**b [95% CI]**	**b [95% CI]**	**b [95% CI]**	**b [95% CI]**
Intercept	3.687 [3.256, 4.117]	3.324 [2.840, 3.807]	1.970 [1.446, 2.493]	1.908 [1.378, 2.439]
Slope	0.404 [0.291, 0.517]	0.181 [−0.005, 0.366]	−0.179 [−0.413, 0.055]	−0.186 [−0.427, 0.055]
Quadratic slope	0.088 [0.072, 0.104]	0.063 [0.040, 0.086]	0.047 [0.018, 0.077]	0.046 [0.015, 0.077]
Age at age 16 survey	0.059 [−0.405, 0.522]	0.003 [−0.464, 0.471]	−0.004 [−0.467, 0.459]	−0.082 [−0.545, 0.382]
Pandemic (Ref = pre-pandemic)		0.796 [0.283, 1.309]	1.350 [0.741, 1.959]	1.428 [0.805, 2.051]
Sex (Ref = male)			2.924 [2.234, 3.613]	2.939 [2.238, 3.639]
Sex*slope			0.779 [0.410, 1.149]	0.788 [0.410, 1.167]
Sex*quadratic slope			0.034 [−0.012, 0.080]	0.036 [−0.011, 0.083]
Sex*pandemic			−1.226 [−2.252, −0.199]	−1.228 [−2.274, −0.181]
Low income				1.132 [0.606, 1.658]
Low income*pandemic				−0.920 [−2.119, 0.280]
BIC	68256.14	68249.74	68059.21	65955.08

Note: *The results show a 1-year increase in time (centered in March 2020). BIC = Bayesian information criterion.*
[a]*A pandemic indicator is defined as an interaction term between the indicator of pre- or during-pandemic groups and a dummy variable for the age 16 survey.*
[b]*The interaction between the pandemic indicator, sex, and low household income was included.*

FIGURE 2 Predicted Trajectories of Depressive Symptoms Before or During the Pandemic by Sex



Note: *Predicted trajectories derived from sex and income interaction included model (model 2). Time is centered to March 2020 (ie, the onset of the COVID-19 epidemic in Japan, red vertical line in the figure).*

TABLE 3 Estimates of Within-Person Change in Depressive Symptoms Associated With the COVID-19 Pandemic by Phase of the Pandemic (N = 2,034)

	Model 1: pandemic-phase indicator included[a]	Model 2a: sex interaction included	Model 2: sex and income interaction mutually included[b]
Fixed effects	**b [95% CI]**	**b [95% CI]**	**b [95% CI]**
Intercept	3.255 [2.771, 3.740]	1.901 [1.377, 2.425]	1.849 [1.317, 2.380]
Slope	0.119 [−0.070, 0.308]	−0.238 [−0.475, −0.000]	−0.234 [−0.477, 0.009]
Quadratic slope	0.055 [0.031, 0.078]	0.040 [0.010, 0.070]	0.040 [0.009, 0.071]
Age at age 16 survey	−0.023 [−0.493, 0.446]	−0.026 [−0.492, 0.440]	−0.092 [−0.556, 0.372]
Pre-pandemic	Ref	Ref	Ref
Early	−0.575 [−1.293, 0.144]	0.471 [−0.433, 1.376]	0.577 [−0.325, 1.480]
Late first-year	1.188 [0.620, 1.757]	1.534 [0.874, 2.193]	1.601 [0.925, 2.278]
Second-year	1.370 [0.568, 2.171]	2.226 [1.171, 3.281]	2.354 [1.175, 3.532]
Sex (Ref = boy)		2.924 [2.226, 3.622]	2.909 [2.203, 3.616]
Sex*slope		0.778 [0.401, 1.155]	0.769 [0.385, 1.152]
Sex*quadratic slope		0.034 [−0.013, 0.081]	0.034 [−0.014, 0.081]
Sex*pre-pandemic		Ref	Ref
Sex*early		−2.269 [−3.722, −0.817]	−2.311 [−3.799, −0.824]
Sex*late first-year		−0.721 [−1.864, 0.422]	−0.788 [−1.946, 0.370]
Sex*second-year		−2.015 [−3.598, −0.433]	−1.724 [−3.485, 0.037]
Low income			1.133 [0.606, 1.659]
Low income*pre-pandemic			Ref
Low income*early			−0.483 [−3.098, 2.131]
Low income*late first-year			−1.022 [−2.531, 0.487]
Low income*second-year			−1.328 [−4.063, 1.406]
BIC	68235.86	68054.69	65973.90

Note: *The results show a 1-year increase in time (centered in March 2020). The phase of the pandemic was defined based on the timing of data collection for the age 16 survey (pre-pandemic: between February 2019 and February 2020; early: between March and May 2020; late first-year: between June and December 2020; and second-year: between January and September 2021). BIC = Bayesian information criterion.*

[a]*A pandemic-phase indicator was defined as an interaction term between the indicator of the phase of the pandemic and a dummy variable for the age 16 survey.*

[b]*The interaction between the pandemic-phase indicator, sex, and low household income was included.*

CI = –3.545 to –0.406) and returned to the pre-pandemic level thereafter (0.302, 95% CI –0.825 to 1.429 for late first-year phase; –0.034, 95% CI = –1.883 to 1.814 for second-year phase). Our sensitivity analysis, using unimputed depressive symptoms and without non-response weights, revealed similar results (Table S6, available online).

DISCUSSION

Using data from a prospective population-based cohort of adolescents in Tokyo, this study estimated the potential impact of the pandemic by comparing adolescent depressive symptoms before or during the pandemic while controlling for previous within-person changes. Our mixed-effect models revealed that depressive symptoms increased during the pandemic beyond the expected age-related changes. Although girls showed higher average depressive symptoms than boys, additional increases in depressive symptoms during the pandemic were observed only for boys. Further analyses by phase of the pandemic revealed that compared to the pre-pandemic group, marked increases emerged in the late first-year phase and enlarged in the second-year phase for boys, whereas, for girls, depressive symptoms showed a significant decrease in the early phase when schools were closed and returned to the pre-pandemic level thereafter.

Overall, we found that depressive symptoms among 16-year-olds increased during the pandemic, in line with findings from previous longitudinal or repeated cross-sectional studies conducted in Europe and the Americas (mostly in North America; 1 study from Peru was included in a multi-cohort study).[1,9-11] Our study extended these previous studies by demonstrating a significant increase even after accounting for within-person differences and natural age-related changes during adolescence. In our study, the observed increase was relatively small (0.8 points on the SMFQ corresponding

with 0.15 SD of the age 16 average), which corresponds with the results of other population-representative studies.[10,11] For example, a population-based repeated cross-sectional study conducted in Iceland found a small increase in depressive symptoms in the late first year of the pandemic (N = 59,701, effect size = 0.16 for 16-year-olds),[10] and another such study conducted in Norway also found a small increase in the early second year of the pandemic (N = 227,258, effect size = 0.08).[11] This similarity in findings, despite the differing COVID-19 infection intensity or public health measures taken across countries,[24] suggests that the average impact of the pandemic on adolescents' depressive symptoms could be similar, at least across high-income countries. Given that even subclinical depressive symptoms during adolescence may have a lasting negative impact on psychosocial outcomes into adulthood,[25] such a small increase may not be negligible at the population level.

In contrast to our hypothesis, the increase in depressive symptoms associated with the pandemic was observed only among boys; the increase in girls was within the expected age-related change. This finding contrasts with previous longitudinal studies[1,7,10,11] and meta-analyses,[2,5] which showed that the pandemic disproportionally affected girls' mental health. This could be due to methodological differences, such as a cross-sectional design[2,5] or not having accounted for the normative age- and gender-related changes in depressive symptoms in previous studies.[1,7,10,11] Indeed, a recent meta-analysis of European-based studies reported that the pooled estimate for an increase in depressive symptoms was higher for older adolescent boys aged 16 to 19 years than for girls when limited to low/moderate-risk-of-bias studies.[4]

Analysis by phase of the pandemic revealed that the increase among boys was driven mainly by the increase during the late first-year and second-year phases, which may reflect the country's context regarding the pandemic and the social restrictions implemented. In Japan, school closures were limited to the first few months of the pandemic. However, school restrictions, including wearing masks, prohibition of talking during lunchtime, and physical distancing measures, were implemented for an extended period. In this regard, wearing face masks in school, in particular, reportedly impairs facial emotional recognition and affects the quality of communication or interpersonal relationships.[26] As women are generally reported to have better facial-emotional recognition,[27] the negative impact of wearing face masks may have affected boys more significantly. Furthermore, school extracurricular activities, mainly physical activities with dense gatherings, were limited to a minimum when the state of emergency was re-introduced (corresponding to the second-year phase in our study). The prolonged constraints on school physical activities could have increased distress,[28,29] particularly among boys.[30] Another explanation could be related to sex differences in coping styles and associated gender-based social norms. Some studies report that adolescent boys are more reluctant than girls to seek help for their mental health problems,[31] and this tendency may be more prevalent in masculine societies such as Japan.[32,33] In situations of prolonged reduction in interpersonal contact due to social distancing measures, Japanese boys might have experienced particular difficulty seeking support to cope with their distress.

Interestingly, compared to the pre-pandemic period, the average depressive symptoms of girls improved during the initial school closure period and returned to the pre-pandemic level in the following school re-opening period. Some studies have reported a positive aspect of school closure on adolescents' lives, including less academic pressure, less interpersonal stress such as bullying, and longer sleep time.[34] Adolescent girls, compared to boys, reportedly experience more stress due to school demands or peer relationships, which may partly explain the gender gap in depressive symptoms in adolescence.[35,36] Time away from school may have lessened school-related stress, resulting in improved depressive symptoms among girls. Exploring the underlying mechanism for the observed results, including sex differences, is vital for approaches to better support the mental health of adolescents during and beyond the pandemic.

We found no clear evidence for the difference in the effect of the pandemic on adolescent depressive symptoms by household income as of up to September 2021. This may, in part, reflect the effectiveness of government benefits and schemes provided in Japan to buffer the adverse economic impact of the pandemic, particularly among low-income households.[20] Some examples of government benefits include the COVID-19 Employment Adjustment Subsidy to maintain employment, which helped prevent a large increase in unemployment during the pandemic,[20] and cash payment to all residents, which supported the livelihood of the people.[20,37] Nevertheless, adolescents from low-income households had higher depressive symptoms, irrespective of the pandemic, highlighting the need for further approaches to support their mental health in the long term.

Our study needs to be interpreted in light of several limitations. First, although our analyses provided a clearer picture of the changes in adolescent depressive symptoms during the pandemic, this study cannot offer evidence of the causal effect of the pandemic; the observed changes

could be due to societal changes unrelated to the pandemic. Relatedly, we did not have information on whether the participants were directly infected with COVID-19. Although the sequelae of COVID-19 infection are reported to be smaller in children than in adults, such sequelae could have influenced the depressive symptoms of adolescents.[38] Second, TTC is designed to represent adolescents in Tokyo. However, our sample bias analysis revealed that adolescents with low household incomes in previous waves and those with higher depressive symptoms at age 10 years were more likely to be excluded, which could be a source of bias. Third, we identified family poverty based on parent-reported annual household income in the previous year, which may not have captured the economic hardships that emerged during the pandemic. Future studies assessing the association between changes in family economic status during the pandemic and adolescent mental health are important to better understand whether the pandemic had a disproportional impact on the disadvantaged. Fourth, our results are specific to adolescents living in Tokyo, Japan. Although our overall findings correspond with those of studies conducted in other high-income countries,[9-11] the situation may be different for adolescents in other contexts, for example, those living in low- to middle-income countries.[39] Finally, our study covered a relatively long period from the beginning of the outbreak into the second year of the pandemic, which demonstrates the temporal patterns of depressive symptoms by phase of the pandemic. Although we found that the increase in the depressive symptoms of boys was largely due to the increase during the late first-year and second-year phases, we cannot distinguish whether these phases had a specific acute effect on depressive symptoms. Furthermore, we cannot distinguish whether the pandemic had a visible impact in these phases simply because it has lasted for a longer time, resulting in the culmination of increased stress. Given that the pandemic and associated social changes have continued beyond our study period, studies extending the study period further are required to derive a more nuanced picture of the pandemic's long-term impact on adolescent mental health.

Our findings offer robust evidence for a small but significant increase in adolescents' depressive symptoms during the pandemic, highlighting the need to provide preventive approaches for this age group at the population level. Although consideration should be given to girls and those from less affluent households who showed higher depressive symptoms irrespective of the experience of the pandemic, the enlarging impact of the pandemic over time on depressive symptoms among boys requires attention. Further studies clarifying the underlying mechanism for the observed results will aid the provision of tailored approaches to mitigate the negative impact of the pandemic and to better support the mental health needs of adolescents.

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Author Contributions

Drs. Hosozawa, Ando, and Nishida conceptualized and designed the study. Drs. Ando, Yamasaki, Miyashita, Endo, and Nishida collected the data. Dr. Hosozawa conducted the analysis with Drs. Yamaguchi and Usami and Dr. Yamaguchi verified the analysis. Dr. Hosozawa wrote the original draft. All authors contributed to the interpretation of the data, review, revision, and approval of the final manuscript.

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REFERENCES

1. Barendse MEA, Flannery J, Cavanagh C, *et al*. Longitudinal change in adolescent depression and anxiety symptoms from before to during the COVID-19 pandemic. J Res Adolesc. 2023;33(1):74-91. https://doi.org/10.1111/jora.12781
2. Samji H, Wu J, Ladak A, *et al*. Review: mental health impacts of the COVID-19 pandemic on children and youth—a systematic review. Child Adolesc Ment Health. 2022;27(2):173-189. https://doi.org/10.1111/camh.12501
3. Kauhanen L, Wan Mohd Yunus WMA, Lempinen L, *et al*. A systematic review of the mental health changes of children and young people before and during the COVID-19 pandemic. Eur Child Adolesc Psychiatry. 2023;32(6):995-1013. https://doi.org/10.1007/s00787-022-02060-0
4. Ludwig-Walz H, Dannheim I, Pfadenhauer LM, Fegert JM, Bujard M. Increase of depression among children and adolescents after the onset of the COVID-19 pandemic in Europe: a systematic review and meta-analysis. Child Adolesc Psychiatry Ment Health. 2022;16(1):109. https://doi.org/10.1186/s13034-022-00546-y
5. Racine N, McArthur BA, Cooke JE, Eirich R, Zhu J, Madigan S. Global prevalence of depressive and anxiety symptoms in children and adolescents during COVID-19: a meta-analysis. JAMA Pediatr. 2021;175(11):1142-1150. https://doi.org/10.1001/jamapediatrics.2021.2482
6. Orben A, Tomova L, Blakemore SJ. The effects of social deprivation on adolescent development and mental health. Lancet Child Adolesc Health. 2020;4(8):634-640. https://doi.org/10.1016/s2352-4642(20)30186-3
7. Knowles G, Gayer-Anderson C, Turner A, *et al*. Covid-19, social restrictions, and mental distress among young people: a UK longitudinal, population-based study. J Child Psychol Psychiatry. 2022;63(11):1392-1404. https://doi.org/10.1111/jcpp.13586
8. Hafstad GS, Saetren SS, Wentzel-Larsen T, Augusti EM. Adolescents' symptoms of anxiety and depression before and during the Covid-19 outbreak—a prospective population-based study of teenagers in Norway. Lancet Reg Health Eur. 2021;5(100093):100093. https://doi.org/10.1016/j.lanepe.2021.100093
9. Sadeghi N, Fors PQ, Eisner L, *et al*. Mood and behaviors of adolescents with depression in a longitudinal study before and during the COVID-19 pandemic. J Am Acad Child Adolesc Psychiatry. 2022;61(11):1341-1350. https://doi.org/10.1016/j.jaac.2022.04.004
10. Thorisdottir IE, Asgeirsdottir BB, Kristjansson AL, *et al*. Depressive symptoms, mental wellbeing, and substance use among adolescents before and during the COVID-19 pandemic in Iceland: a longitudinal, population-based study. Lancet Psychiatry. 2021;8(8):663-672. https://doi.org/10.1016/s2215-0366(21)00156-5
11. von Soest T, Kozak M, Rodriguez-Cano R, *et al*. Adolescents' psychosocial well-being one year after the outbreak of the COVID-19 pandemic in Norway. Nat Hum Behav. 2022;6(2):217-228. https://doi.org/10.1038/s41562-021-01255-w
12. Ravens-Sieberer U, Kaman A, Erhart M, Devine J, Schlack R, Otto C. Impact of the COVID-19 pandemic on quality of life and mental health in children and adolescents in Germany. Eur Child Adolesc Psychiatry. 2022;31(6):879-889. https://doi.org/10.1007/s00787-021-01726-5
13. Burdzovic Andreas J, Brunborg GS. Self-reported mental and physical health among Norwegian adolescents before and during the COVID-19 pandemic. JAMA Netw Open. 2021;4(8):e2121934. https://doi.org/10.1001/jamanetworkopen.2021.21934
14. van der Velden PG, van Bakel HJA, Das M. Mental health problems among Dutch adolescents of the general population before and 9 months after the COVID-19 outbreak: a longitudinal cohort study. Psychiatry Res. 2022;311:114528.
15. Kwong ASF, Manley D, Timpson NJ, *et al*. Identifying critical points of trajectories of depressive symptoms from childhood to young adulthood. J Youth Adolesc. 2019;48(4):815-827. https://doi.org/10.1007/s10964-018-0976-5
16. Thapar A, Eyre O, Patel V, Brent D. Depression in young people. Lancet. 2022;400(10352):617-631. https://doi.org/10.1016/S0140-6736(22)01012-1
17. Grimm KJ, Ram N. Latent growth and dynamic structural equation models. Annu Rev Clin Psychol. 2018;14:55-89. https://doi.org/10.1146/annurev-clinpsy-050817-084840
18. Butler AE, Battista K, Leatherdale ST, Meyer SB, Elliott SJ, Majowicz SE. A comparison of repeat cross-sectional and longitudinal results from the COMPASS study: design considerations for analysing surveillance data over time. Int J Soc Res Methodol. 2022;25(5):597-609. https://doi.org/10.1080/13645579.2021.1922804
19. van der Laan SEI, Lenters VC, Finkenauer C, van Harmelen AL, van der Ent CK, Nijhof SL. Tracking mental wellbeing of Dutch adolescents during the first year of the COVID-19 lockdown: a longitudinal study. J Adolesc Health. 2022;71(4):414-422. https://doi.org/10.1016/j.jadohealth.2022.06.006
20. Kotera S, Schmittmann JM; The Japanese Labor Market During the COVID-19 Pandemic. Report No. WP/22/89. International Monetary Fund; 2022.
21. Ando S, Nishida A, Yamasaki S, *et al*. Cohort profile: the Tokyo Teen Cohort study (TTC). Int J Epidemiol. 2019;48(5):1414-1414. https://doi.org/10.1093/ije/dyz033
22. Thapar A, McGuffin P. Validity of the shortened Mood and Feelings Questionnaire in a community sample of children and adolescents: a preliminary research note. Psychiatry Res. 1998;81(2):259-268. https://doi.org/10.1016/s0165-1781(98)00073-0
23. Eyre O, Bevan Jones R, Agha SS, *et al*. Validation of the Short Mood and Feelings Questionnaire in young adulthood. J Affect Disord. 2021;294:883-888. https://doi.org/10.1016/j.jad.2021.07.090
24. Mathieu E, Ritchie H, Rodés-Guirao L, *et al*. Coronavirus pandemic (COVID-19). OurWorldInData.org. Accessed June 1, 2023. https://ourworldindata.org/covid-stringency-index
25. Allen JP, Chango J, Szwedo D, Schad M. Long-term sequelae of subclinical depressive symptoms in early adolescence. Dev Psychopathol. 2014;26(1):171-180. https://doi.org/10.1017/S095457941300093X
26. Spitzer M. Masked education? The benefits and burdens of wearing face masks in schools during the current Corona pandemic. Trends Neurosci Educ. 2020;20:100138. https://doi.org/10.1016/j.tine.2020.100138
27. Olderbak S, Wilhelm O, Hildebrandt A, Quoidbach J. Sex differences in facial emotion perception ability across the lifespan. Cogn Emot. 2019;33(3):579-588. https://doi.org/10.1080/02699931.2018.1454403
28. Korczak DJ, Madigan S, Colasanto M. Children's physical activity and depression: a meta-analysis. Pediatrics. 2017;139(4):e20162266. https://doi.org/10.1542/peds.2016-2266
29. LaForge-MacKenzie K, Tombeau Cost K, Tsujimoto KC, *et al*. Participating in extracurricular activities and school sports during the COVID-19 pandemic: associations with child and youth mental health. Front Sports Act Living. 2022;4:936041. https://doi.org/10.3389/fspor.2022.936041
30. Hayward J, Jacka FN, Skouteris H, *et al*. Lifestyle factors and adolescent depressive symptomatology: associations and effect sizes of diet, physical activity and sedentary behaviour. Aust N Z J Psychiatry. 2016;50(11):1064-1073. https://doi.org/10.1177/0004867416671596
31. Aguirre Velasco A, Cruz ISS, Billings J, Jimenez M, Rowe S. What are the barriers, facilitators and interventions targeting help-seeking behaviours for common mental health problems in adolescents? A systematic review. BMC Psychiatry. 2020;20(1). https://doi.org/10.1186/s12888-020-02659-0
32. Seidler ZE, Dawes AJ, Rice SM, Oliffe JL, Dhillon HM. The role of masculinity in men's help-seeking for depression: a systematic review. Clin Psychol Rev. 2016;49:106-118. https://doi.org/10.1016/j.cpr.2016.09.002
33. Ando S, Nishida A, Usami S, *et al*. Help-seeking intention for depression in early adolescents: associated factors and sex differences. J Affect Disord. 2018;238:359-365. https://doi.org/10.1016/j.jad.2018.05.077
34. Soneson E, Puntis S, Chapman N, Mansfield KL, Jones PB, Fazel M. Happier during lockdown: a descriptive analysis of self-reported wellbeing in 17,000 UK school students during Covid-19 lockdown. Eur Child Adolesc Psychiatry. 2023;32(6):1131-1146. https://doi.org/10.1007/s00787-021-01934-z
35. Ostberg V, Plenty S, Laftman SB, Modin B, Lindfors P. School demands and coping resources-associations with multiple measures of stress in mid-adolescent girls and boys. Int J Environ Res Public Health. 2018;15(10). https://doi.org/10.3390/ijerph15102143
36. Rudolph KD. Gender differences in emotional responses to interpersonal stress during adolescence. J Adolesc Health. 2002;30(4):3-13. https://doi.org/10.1016/s1054-139x(01)00383-4
37. [COVID-19] Official Website of the Prime Minister of Japan and His Cabinet. Emergency economic measures for response to COVID-19 to protect the lives and lifestyles of the public and move toward economic recovery. Accessed June 1, 2023. https://japan.kantei.go.jp/ongoingtopics/_00019.html
38. Roessler M, Tesch F, Batram M, *et al*. Post-COVID-19-associated morbidity in children, adolescents, and adults: a matched cohort study including more than 157,000 individuals with COVID-19 in Germany. PLoS Med. 2022;19(11):e1004122. https://doi.org/10.1371/journal.pmed.1004122
39. Banati P, Jones N, Youssef S. Intersecting vulnerabilities: the impacts of COVID-19 on the psycho-emotional lives of young people in low- and middle-income countries. Eur J Dev Res. 2020;32(5):1613-1638. https://doi.org/10.1057/s41287-020-00325-5