



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.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

COVID-19-related stressors and depression in Chinese adolescents: The effects of life history strategies and gender

Zhengqian Yang^{a,1}, Yuhan Luo^{a,b,1}, Qing Zhou^c, Fumei Chen^b, Zijing Xu^a, Li Ke^b, Yun Wang^{a,*}

^a State Key Laboratory of Cognitive Neuroscience and Learning, Beijing Normal University, Beijing, China

^b Collaborative Innovation Center of Assessment for Basic Education Quality, Beijing Normal University, Beijing, China

^c Department of Psychology, University of California Berkeley, Berkeley, CA, USA

ARTICLE INFO

Keywords:

COVID-19-related stressors
Adolescent mental health
Depression
Life history strategies
Gender difference

ABSTRACT

Purpose: The COVID-19 pandemic has changed the way people live, affecting both their physical and mental health. Adolescents are vulnerable to the stress of the pandemic, and may experience indicators of psychological distress, such as depression. This study aimed to examine the impact of COVID-19-related stressors on depression and the mediating role of life history strategies.

Methods: A two-wave longitudinal study was conducted with 1123 adolescents (51.20% girls, $M_{age} = 14.30$) recruited from three junior high schools in the Northeastern province of China. Adolescents' life history strategies, depressive symptoms, and demographic variables were assessed at Time 1 (November 2019) and Time 2 (August 2020), and adolescents' experience of COVID-19-related stressors was assessed at Time 2. None of participants was infected by COVID-19 virus.

Results: COVID-19-related stressors were positively associated with depressive symptoms at Time 2 ($\beta = 0.08$, $p < 0.01$), after controlling for gender, age, SES and depressive symptoms at Time 1. And life history strategies partially mediated the relation of pandemic stress to depression (indirect effect = 0.02, $p < 0.05$, 95% CI [0.004, 0.034]). There were no gender differences in the relations between stress on depression.

Limitations: The sample was from a district where the pandemic was not very severe, which may limit generalizability of the results.

Conclusions: This study revealed that COVID-19-related stressors may have a long-term impact on adolescents, increasing depression through speeding up their life history strategies. Interventions should focus on life history strategies, particularly cognitive style, among adolescents during and after the pandemic.

1. Introduction

The sudden outbreak and rapid spread of a new coronavirus disease (COVID-19) that began in December 2019 has put the lives of ordinary people at risk (Chen et al., 2020). In addition to its effects on physical health, the COVID-19 pandemic can also have a range of negative effects on people's mental health (Brailovskaia et al., 2021). Adolescence as a transitional and critical developmental stage, are susceptible to develop mental health problems (Zhang et al., 2014). Existing studies have found that during the COVID-19 pandemic, preventative measures and the threat of being infected have caused adolescents to experience depression, mood swings, irritability, insomnia, attention deficit hyperactivity

disorder, and anger (Brooks et al., 2020; Zhou et al., 2020).

As a common mental trauma, depression is associated with impairments in school, family and social functioning (Fergusson and Woodward, 2002). Adolescents who are depressed are not only more likely to develop psychiatric comorbidities, severe role impairment, and suicidality (Avenevoli et al., 2015), but also have negative psychosocial outcomes in the long term, including failure to complete secondary school, unemployment and a low level of social support (Clayborne et al., 2019). During the COVID-19 outbreak, adolescents in China have been physically isolated from their peers, teachers and community, and have been carrying out their school curricula online. These changes in their lives, including social isolation and school closures, are associated

* Corresponding author at: State Key Laboratory of Cognitive Neuroscience and Learning, Beijing Normal University, 19# Xijiekouwai Street, Haidian District, Beijing 100875, China.

E-mail address: wangyun@bnu.edu.cn (Y. Wang).

¹ These authors contributed equally to this work and should be considered co-first authors.

<https://doi.org/10.1016/j.jad.2022.02.060>

Received 27 July 2021; Received in revised form 19 January 2022; Accepted 20 February 2022

Available online 24 February 2022

0165-0327/© 2022 Elsevier B.V. All rights reserved.

with higher levels of stress and higher rates of depression (Loades et al., 2020; Qi et al., 2020). Research has also indicated a high prevalence of depressive symptoms during the COVID-19 pandemic; a survey of 8079 Chinese adolescents aged 12–18 years found that 43% were experiencing depression (Zhou et al., 2020).

Both theoretical and empirical studies have indicated that stress may contribute to the increase of depression in adolescents (Bernaras et al., 2019; Hankin, 2008). Specifically, compared to stress from daily life events (e.g., academic or relationship problems), the COVID-19 pandemic caused major disruptions in normal life in a very short time. This acute, large-scale and uncontrollable stressor may lead to adolescents' losing a sense of control, which in turn can increase depressive symptoms (Abramson et al., 2002; Hankin, 2008). Moreover, prevention measures (e.g., quarantine, study from home) implemented to control the Covid-19 pandemic also constitute stressors, further increasing adolescents' loneliness and risk of depression, and possibly also their anxiety (Loades et al., 2020). Empirical research demonstrated that perceived stress related to the COVID-19 pandemic was associated with more emotional distress, including depression, fear, and compulsion-anxiety during the COVID-19 pandemic (Havnen et al., 2020; Yan et al., 2021). However, there have been few longitudinal studies examining the links between COVID-19-related stressors and depression in adolescents, and the mediating mechanisms in these links.

Life History Theory provides a useful framework to understand the potential mechanism of adolescents' depression under conditions of extrinsic risk. Considering their limited energy and resources, individuals will adopt different Life History (LH) strategies to accomplish different goals throughout their lives (Griskevicius et al., 2011; Hill and Kaplan, 1999). In particular, fast LH strategies emphasize allocating resources to the present, favoring a present-oriented cognitive style and sensation seeking, as individuals gamble for large immediate rewards. Slow LH strategies, on the other hand, emphasize allocating resources to the future, and tend toward a future-oriented cognitive style and personal growth (Figueredo et al., 2004; Griskevicius et al., 2011). Both theoretical and empirical studies endorse the notion that fast LH strategies are the result of living in a stressful environment (i.e., cues for unpredictability and morbidity/mortality) (Chang et al., 2019; Ellis et al., 2012). Li and Cao (2021) compared LH strategies between groups in two cities, and found that participants from Wuhan, the initial epicenter of the pandemic in China, showed a faster LH strategy than did participants from Chongqing, which was less affected by the virus at that time. However, Li and Cao (2021) only focused on different levels of the pandemic's severity and did not measure direct stressors perceived by participants. Thus, it remains to be explored whether perceived stressors contribute to adolescent LH strategies during the COVID-19 pandemic.

Studies have consistently shown the links of environmental stressors to externalizing behaviors in adolescents from the life history perspective, and LH strategies have been identified as a mediating mechanism (Doom et al., 2016; Griskevicius et al., 2011). Adolescents who are exposed to more unpredictable environments are hypothesized to be inclined to adopt faster LH strategies, which in turn would lead to higher levels of risk-taking and more aggressive and delinquent behaviors (Griskevicius et al., 2011; Lu and Chang, 2019). Direct empirical evidence has demonstrated that early childhood intervention caused a slowing of LH strategies, and that LH strategies mediated the effect of the intervention on mental health in young adults (Dunkel et al., 2021). Thus, the effect of environmental stressors on depression may also be mediated by LH strategies.

To investigate the relationship between LH strategies and depression, we followed the cognitive vulnerability-stress models of depression, which suggest that the cognitive styles people adopt, or the inferences (e.g., LH strategies) they make about stressful life events, will significantly influence their vulnerability to depression (Abramson et al., 2002). Specifically, adolescents exposed to a greater number of COVID-19-related stressors may prefer to orient themselves in the present, due to their loss of control in the current unpredictable

environment, and may in turn exhibit more depressive symptoms. When exposed to a large number of COVID-19-related stressors, adolescents might develop fast LH strategies, which in turn may associate with a higher level of depression.

Past studies have also revealed that there are gender differences in prevalence of depression and LH strategies in adolescent. A previous study investigated gender differences in LH strategies, and found that males exhibit faster LH strategies among young adults (Salas-Rodríguez et al., 2021). Lu and Chang (2019) also found that boys were faster LH strategists, more aggressive and prone to risk-taking than girls. As for depression, some COVID-19 studies have found that girls showed higher rates of depression and more anxiety symptoms than boys (Qi et al., 2020; Zhou et al., 2020), but others have not yielded significant results (Havnen et al., 2020). However, few studies examined whether there are gender differences in depression-generating mechanisms during the COVID-19 pandemic. Thus, the current study aims to explore whether gender moderate the relationship between LH strategies and depression related to the COVID-19 pandemic.

Based on the above literature review, the current study aimed to investigate the relation of COVID-19-related stressors to adolescents' depression, and examine the mediating mechanism in the association between stressors and depression. We hypothesized that: (1) COVID-19-related stressors would be negatively linked to T2 adolescents' depression symptoms; (2) LH strategies would mediate the above association, after controlling covariates (see Fig. 1). Meanwhile, we also explored whether the estimated parameters of mediation model differed significantly by gender. This study would help to clarify the relationship between COVID-19-related stressors and depression from the perspective of LH theory, and also provided possible practical direction for depression interventions during pandemic.

2. Method

2.1. Procedures and participants

Data were derived from the "Life History Strategies and Adolescents' Adaptation Project" (LHSAP), which examined the mental health of 1382 adolescents who were recruited free of charge from three public junior high schools in Heilongjiang, the Northeastern province of China, bordering with Russia. The Time 1 (T1) survey was completed in November 2019, using paper-based questionnaire responses. The informed consent forms (with names) and the questionnaires (with ID code) were collected separately to ensure anonymity. The Time 2 (T2) survey was administered between August 6th and August 14th, 2020. During this period, the first wave of the COVID-19 pandemic that had started in February was nearly at an end in China. But the three schools had been closed since another outbreak in Heilongjiang in April. With the help of class teachers and parents, we invited adolescent participants to complete an online survey at T2. Time 2 surveys included additional questions about the COVID-19 pandemic. Informed consent was obtained from all participants and their parents. And participants were invited to complete the questionnaires and informed consent separately to ensure the anonymity. The project was approved by the Institutional Review Board of the Faculty of Psychology, *** (blinded for anonymity).

For the present study, 1125 adolescents who had completed both T1 and T2 surveys were selected. Participants ranged from 11.92 to 17.75 years at T1 ($M_{age} = 14.30$, $SD = 0.73$), among whom 576 (51.20%) were

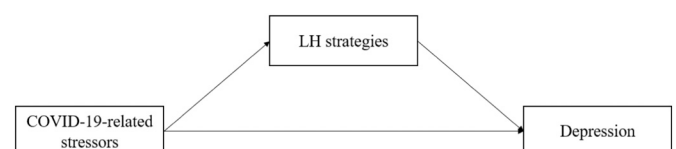


Fig. 1. The proposed mediation model.

girls, 613 (54.50%) were 8th graders and 512 (45.50%) were 9th graders at T1. And 9th graders at T1 had graduated at T2. We compared the students who participated at both time points with those who participated at only one time point on gender, age, parental education, depression, and LH strategies, and no statistically significant differences were found. Further sample demographic information is reported in Table 1.

2.2. Measures

2.2.1. Depression

The 20-item Chinese version of the Center for Ambulatory Survey Depression Scale (CES-D) (William Li et al., 2010) was used to measure depressive symptoms in adolescents (e.g., “I felt like crying this week”). Participants were required to report how they had been feeling in the past week on a 3-point scale (from 0 = *Less than 1 day* to 3 = *5–7 days*). Higher mean scores indicate higher levels of depressive symptoms. In the current study, the same questions were asked at both Time 1 and Time 2, with Cronbach's alphas of 0.92 and 0.94, respectively, indicating a high degree of internal consistency.

2.2.2. LH strategies

Adolescents' LH strategies were measured using the Mini-K scale from the Arizona LH Battery (ALHB). The Mini-K scale has been substituted for the entire ALHB scale by many researchers (Olderbak et al., 2014) and has shown good reliability and validity in Chinese adolescents (Lu and Chang, 2019). The Mini-K scale has 20 items (e.g., “I often make plans in advance”; “I can usually predict how things will turn out”) and is scored on a 6-point scale (from 1 = *not at all* to 6 = *fully*), with higher scores indicating an individual's preference for slow LH strategies. In this study, the same items appeared at both Time 1 and Time 2, with Cronbach's alphas of 0.86 and 0.95, respectively, indicating a high level of internal consistency.

2.2.3. COVID-19-related stressors

The 22 items of the SARS-related stress checklist (Main et al., 2011) were used to measure adolescents' exposure to COVID-19-related stressors. The SARS-related statements in the checklist were revised to refer to the COVID-19 pandemic, and participants were asked whether they, their relatives, and friends had been isolated, suspected, or confirmed as COVID-19 cases. Example items included, “A member of your family was infected with COVID-19 and is receiving treatment,” and “You have symptoms similar to COVID-19, such as fever, cough, diarrhea, weakness, etc.” (0 = No, 1 = Yes). Higher average scores indicate adolescents' exposure to more COVID-19-related stressors. In this study, 15.3% participants ($N = 172$) had experienced at least one of the COVID-19-related stressors listed. None of the participants was confirmed to be infected with COVID-19 at T2.

Table 1
Demographic characteristics of the sample ($N = 1125$).

		<i>M (SD)</i>	<i>N (%)</i>
Gender	Female	–	549 (51.2)
	Male	–	576 (48.8)
Age	–	14.3(0.7)	–
Grade	Grade 8	–	613 (54.5)
	Grade 9	–	512 (45.5)
Registered residence	Rural	–	434 (42.3)
	Urban	–	593 (57.7)
Mother's age	–	39.8(4.7)	–
Father's age	–	41.3(4.7)	–
Mother's education	Middle school or less	–	646 (59.4)
	High school	–	188 (17.3)
	College graduate or higher	–	253 (23.3)
Father's education	Middle school or less	–	602 (55.6)
	High school	–	257 (20.7)
	College graduate or higher	–	257 (23.7)

2.2.4. Covariates

Demographic covariates include gender (male/female), age (in years, continuous) and Socioeconomic Status (SES). Adolescents' age was derived by subtracting their birth date (day, month, and year) from the date of the survey (day, month, and year). SES was measured using the four-item Family Affluence Scale II (Liu et al., 2012) to assess family wealth with questions such as, “Does your family own a car, van or truck?” (No = 0; Yes, one = 1; Yes, two or more = 2).

2.3. Data analysis

First, descriptive and correlative analyses were conducted using SPSS 22 to show the preliminary information of all the variables. Second, hierarchical multiple regression models were conducted using SPSS 22 to examine the relation between COVID-19-related stressors, LH strategies and depression separately and directly. For all four regressions, the order of entry of the predictors was: step 1 — gender, age and SES; step 2 — T1 depression; step 3 — COVID-19-related stressors; step 4 — LH strategies.

Third, we estimated a mediation model in Mplus version 8 (Muthén and Muthén, 2017), using path analysis to test the associations between COVID-19-related stressors, LH strategies (T2), and depression (T2) after control for LH strategies (T1), and depression (T2). Covariates also including age, gender, and SES were controlled by allowing them to predict all dependent variables. Indirect effects were assessed using bias-corrected bootstrapping ($n = 5000$) (MacKinnon et al., 2004). For the evaluation of the overall model fit, four different model fit indices were used: the chi-square statistic (χ^2), the Tucker–Lewis index (TLI), the comparative fit index (CFI), and the root-mean-square error of approximation (RMSEA): $\chi^2/df < 3$, TLI and CFI > 0.90 , and RMSEA < 0.05 , which indicated a very good model fit (Hu and Bentler, 1999).

Furthermore, as Edwards and Lambert (2007) suggested, we utilized a multiple group analysis (MGA) approach to test the gender differences for the indirect and direct paths in the mediation model. The differences in the Chi square statistic were used to compare nested models with an iterative, step-wise approach (Bowen and Guo, 2012). First, a freely estimated model was run to set the baseline model. Second, we proceeded to constrain the direct and indirect paths of the freely estimated model in an enter fashion to see if any improvements in model fit could be generated, using the Chi square difference test in Mplus. If this partially constrained model resulted in a statistically significant worsening of model fit, those variables should not be constrained to be equal across gender (Bowen and Guo, 2012).

3. Results

3.1. Descriptive statistics and correlations among variables

Descriptive statistics and correlations for all variables are shown in Table 2. The results indicate that COVID-19-related stressors were negatively correlated with slow LH strategies (T2) and positively correlated with depression (T2). At each time point, slow LH strategies were negatively correlated with depression.

3.2. The relation between COVID-19-related stressors and depression

In the hierarchical regressions for depression at T2 (as shown in Table 3), demographic covariates (Step 1) were generally nonsignificant predictors of variance. The exception was that adolescents who had lower SES reported more depressive symptoms at T2. The addition of depression (T1) (Step 2) accounted for a significant increase in variance explained ($\Delta R^2 = 0.13$, $p < 0.001$) and was the strongest indicator of adolescents' depression at Time 2. COVID-19-related stressors at Step 3 positively predicted depression at Time 2 ($\beta = 0.08$, $p < 0.01$), which accounted for a significant increase in variance ($\Delta R^2 = 0.01$, $p < 0.01$). There was additional variance explained ($\Delta R^2 = 0.06$, $p < 0.001$) when

Table 2
Basic descriptive statistics and correlation matrix for all dimensions ($N = 1125$).

	1	2	3	4	5	6	7	8
1. Gender								
2. Age	-0.09**							
3. SES	0.04	-0.09**						
4. COVID-19-related stressors (T2)	0.00	0.00	0.00					
5. LH strategies (T1)	0.11**	-0.02	0.10***	-0.04				
6. LH strategies (T2)	0.11**	-0.04	0.09**	-0.11***	0.22***			
7. Depression (T1)	0.06	0.08**	-0.05	0.05	-0.30***	-0.12***		
8. Depression (T2)	0.02	0.05	-0.11***	0.09**	-0.14***	-0.29***	0.38***	
<i>M</i>	-	14.30	-0.01	0.02	4.27	4.17	0.94	0.75
<i>SD</i>	-	0.73	1.01	0.06	0.69	0.90	0.63	0.64

** $p < 0.01$.
*** $p < 0.001$.

Table 3
Results of the hierarchical multiple regression models predicting depression (T2) ($N = 922$).

Variables	<i>b</i>	<i>SE</i>	β	ΔR^2
Step 1				0.01**
Gender	0.06	0.07	0.03	
Age	0.03	0.03	0.03	
SES	-0.11	0.03	-0.11***	
Step 2				0.13***
Depression (T1)	0.37	0.03	0.36***	
Step 3				0.01**
COVID-19-related stressors (T2)	0.09	0.03	0.08**	
Step 4				0.06***
LH strategies (T2)	-0.27	0.03	-0.25***	

** $p < 0.01$.
*** $p < 0.001$.

adding LH strategies (T2) (Step 4) – that is, LH strategies (T2) negatively predicted depression at Time 2 ($\beta = -0.25, p < 0.001$).

3.3. The mediating role of LH strategies (T2)

The mediation model provided an acceptable fit to the data with CFI = 0.97, TLI = 0.94, RMSEA = 0.04, $\chi^2(7) = 15.46, p = 0.03$. Model results indicate that COVID-19-related stressors negatively predicted LH strategies (T2) after controlling for LH strategies (T1) ($\beta = -0.11, p < 0.01$). After controlling for depression (T1), the LH strategies (T2) negatively predicted depression at Time 2 ($\beta = -0.18, p < 0.001$). Specifically, when the variable for LH strategies (T2) was added to the model, COVID-19-related stressors were not significantly associated with depression at Time 2. All covariates were included in the model, showing a positive association between gender and LH strategies (T2) ($\beta = 0.15, p < 0.05$), and a negative association between SES and

depression at Time 2 ($\beta = -0.07, p < 0.05$).

In addition, Bootstrap was used to test for indirect effects. The confidence interval for the indirect effect of COVID-19-related stressors predicting depressive symptoms at Time 2 via LH strategies (T2) did not contain zero (indirect effect = 0.02, $p < 0.05$, 95% CI [0.004, 0.034]), indicating a significant mediation/indirect effect (see Fig. 2).

3.4. The multiple-group analysis by gender

We used multiple-group analyses to address whether gender differed in the indirect and the direct paths. First, we ran an unconstrained model, in which no path was constrained to be equal across gender, $\chi^2(10, N=952) = 14.04, p = 0.17$. Then, indirect and direct path coefficients were constrained sequentially. The Chi square statistic did not change significantly between the two models and the unconstrained model (direct path: $\Delta\chi^2(2, N=952) = 1.12, p > 0.05$; indirect path and direct path: $\Delta\chi^2(3, N=952) = 1.79, p > 0.05$), indicating that both direct and indirect path coefficients were invariant across gender. The results of all

Table 4
The results of multiple-group analyses ($N = 952$).

Model	$\chi^2(df)$	<i>p</i>	CFI	TLI	RMSEA	$\Delta\chi^2(df)$	<i>p</i>
No constraints Model	14.04 (10)	0.17	0.98	0.96	0.03		
Indirect path constrained	15.16 (12)	0.23	0.99	0.97	0.02	1.12(2)	>0.05
Indirect path and direct path constrained	15.83 (13)	0.26	0.99	0.98	0.02	1.79(3)	>0.05

Note: χ^2 = chi-square statistic, TLI = Tucker–Lewis index, CFI = comparative fit index, RMSEA = root-mean-square error of approximation.

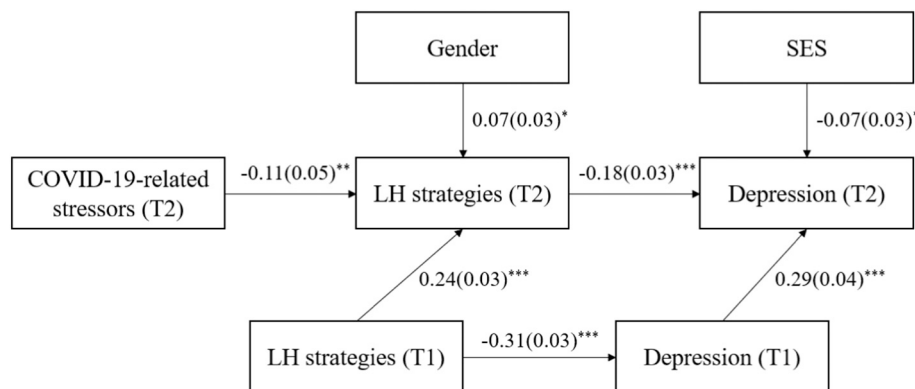


Fig. 2. Path models testing mediation of pathway from COVID-19-related stressors to depression (T2) by LH strategies (T2), controlling for gender, SES, LH strategies (T1) and depression (T2). * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. $N = 979$.

multiple group analyses are presented in [Table 4](#).

4. Discussion

This study tested whether exposure to COVID-19-related stressors related to depressive symptoms in Chinese adolescents, and examined LH strategies as a mediating mechanism in the relation. Our findings showed that COVID-19-related stressors were significantly and positively associated with adolescent depression in adolescents, controlling for prior levels of depression. After controlling for depression and LH strategies 9 months earlier, LH strategies during the pandemic still played a mediating role in the relationship between COVID-19-related stressors and depression. In addition, we found no gender differences in direct and indirect effects of COVID-19-related stressors on depression.

This study replicated the prior finding that a higher level of stressors was associated with more depressive symptoms in adolescents during the COVID-19 pandemic. This result is consistent with previous studies conducted in the context of the pandemic ([Havnen et al., 2020](#); [Yan et al., 2021](#)), and provides empirical support for the utility of stress-depression theory ([Abramson et al., 2002](#)) to explain individual differences in adolescents' psychological distress during the Covid-19 pandemic. This finding suggests that psychological interventions should consider adolescents' stress from the pandemic, regardless whether they were in a high-risk area for the pandemic. Additionally, LH strategies were significantly linked to depression in the present study, suggesting that LH strategies could influence not only behaviors ([Ellis et al., 2012](#)), but also emotional states such as depression.

The results of our mediation analyses showed a significant indirect relation between COVID-19-related stressors and depressive symptoms via adolescents' LH strategies. According to the cognitive vulnerability-stress models of depression, stress-influenced cognitive style is a key factor connecting stress and depression ([Abramson et al., 2002](#); [Vollmayr and Henn, 2003](#)). Because COVID-19 stress is chronic and wide-reaching, the LH strategy perspective is useful for understanding the long-term effect of stress on depression. Past studies have shown a stable effect of environmental stressors (e.g., economic hardship; unpredictable and adverse life events) on LH strategies ([Chang et al., 2019](#); [Ellis et al., 2009](#); [Griskevicius et al., 2011](#)). And different LH strategies will lead to different time-oriented cognitive styles, which might cause an increase in depression. Specifically, when experiencing high levels of COVID-19-related stressors, individuals tend to speed up LH strategies, preferring to focus on the current difficulties and their lack of hope about the future, which may in turn lead to more depressive symptoms. Therefore, families and schools should guide adolescents to pay less attention to present difficulties and focus more on the future, which may help to ameliorate the long-term effects of pandemic stress.

In the present study, no gender differences were found in the direct and indirect pathways of stress on depression, suggesting the cross-gender consistency in the mediation model. Previous studies have found gender differences in both LH strategies ([Ellis et al., 2012](#); [Salas-Rodríguez et al., 2021](#)) and depressive symptoms ([Nolen-Hoeksema and Girgus, 1994](#); [Thapar et al., 2012](#)) in adolescents. However, a meta-analytic research review article study concluded mentioned that gender differences in depression tend to emerge after the age of 15 ([Nolen-Hoeksema and Girgus, 1994](#)). The young age of participants in this study may explain why no gender differences were observed. Although some empirical studies did not find gender differences in depression in adolescents during the COVID-19 pandemic ([Cao et al., 2020](#); [Havnen et al., 2020](#)), the gender effect may need to be further studied.

At the time of this study, the global COVID-19 pandemic is still ongoing, and the negative effects of the pandemic will continue for a long time. Most previous studies have focused on the impact of COVID-19 pandemic on individuals' depressive symptoms ([Loades et al., 2020](#); [Zhou et al., 2020](#)) and examined factors that may moderate the links

between the pandemic and depression (e.g., coping style and resilience; [Havnen et al., 2020](#); [Yan et al., 2021](#)). In contrast, our study focused on the short-term effects of COVID-19-related stressors on depression, and the potential mediating role of LH strategies, providing direction for intervention practices during the COVID-19 pandemic. Our results suggest that paying more attention to adolescents' LH strategies and helping them to adopt a future-oriented cognitive style may reduce psychological distress related to COVID-19.

There are some limitations to the present study. First, this study focused on middle school students in a Chinese province where the COVID-19 pandemic was not very severe. This may have led to a relatively low level of pandemic stress among adolescents in the sample, which affects the generalizability of the results. However, most adolescents were in relatively safe environments during the pandemic in China, and the goal of our study was to find some theoretical and empirical evidence to help them. Second, depression levels after the COVID-19 outbreak (T2) were lower than before it (T1), a finding that is consistent with the results of a previous study using a Dutch sample ([van der Velden et al., 2021](#)). On the one hand, many studies indicated that the pandemic control measures and social isolation had negative impacts on adolescents' mental health ([Brooks et al., 2020](#); [Loades et al., 2020](#)). On the other hand, a higher level of academic stress is associated with more depressive symptoms among Chinese adolescent ([Jiang et al., 2021](#)), the alleviation of academic stress due to school closures may be beneficial for mental health ([Bruining et al., 2021](#)). These two impact paths are relatively independent, further studies need to compare how changes in academic stress affect depression before and during the pandemic. Third, differences of prevention measures for different countries may be related to differences in findings. Thus, the diversity and variations in prevention measures should be given more attention. Finally, the interval between the two measurements was nine months, which may introduce other confounding factors, such as the fact that some students had already graduated from middle school by the time of the second measurement. Although the family SES was controlled in our analyses, further consideration is needed for individual characteristics relevant to mental health, such as the presence of mental or physical comorbidity, and taking treatment for depression.

5. Conclusion

This two-wave longitudinal study explored the relation between COVID-19-related stressors and depressive symptoms in Chinese adolescents and the mediating mechanisms. Results showed that COVID-19-related stressors were associated with adolescents' use of faster LH strategies, which in turn, were associated with higher depressive symptoms. There were no gender differences in the indirect relations between COVID-19-related stressors and depression via LH strategies. Our findings contributed to the applicability of life history theory to adolescent mental health in the context of pandemic, and provide directions for interventions.

CRedit authorship contribution statement

Z. Yang and Y. Luo conceived and designed the analysis and wrote the paper. Q. Zhou, F. Chen, Z. Xu, L. Ke and Y. Wang reviewed the manuscript and contributed to the writing. All authors have contributed to and have approved the final manuscript.

Role of funding

The funders had no role in the study.

Declaration of competing interest

None.

Acknowledgements

This work was supported by the Major Program of the National Social Science Fund of China [Grant Number: 20&ZD153]. There are no conflicts of interest to declare. Our gratitude is expressed to the parents in China for their willing participation.

Appendix A. Supplementary materials

Supplementary materials to this article can be found online at <http://doi.org/10.1016/j.jad.2022.02.060>.

References

- Abramson, L.Y., Alloy, L.B., Hankin, B.L., Haefel, G.J., MacCoun, D.G., Gibb, B.E., 2002. Cognitive Vulnerability-stress Models of Depression in a Self-regulatory and Psychobiological Context.
- Avenevoli, S., Swendsen, J., He, J.P., Burstein, M., Merikangas, K.R., 2015. Major depression in the National Comorbidity Survey-Adolescent Supplement: prevalence, correlates, and treatment. *J. Am. Acad. Child Adolesc. Psychiatry* 54, 37–44.e2. <https://doi.org/10.1016/j.jaac.2014.10.010>.
- Bernaras, E., Jaureguizar, J., Garaigordobil, M., 2019. Child and adolescent depression: a review of theories, evaluation instruments, prevention programs, and treatments. *Front. Psychol.* 10 <https://doi.org/10.3389/fpsyg.2019.00543>.
- Bowen, N.K., Guo, S., 2012. *Structural Equation Modeling*. Oxford University Press, New York.
- Brailovskaia, J., Teismann, T., Friedrich, S., Schneider, S., Margraf, J., 2021. Suicide ideation during the COVID-19 outbreak in German university students: comparison with pre-COVID-19 rates. *J. Affect. Disord. Rep.* 6, 100228 <https://doi.org/10.1016/j.jadr.2021.100228>.
- Brooks, S.K., Webster, R.K., Smith, L.E., Woodland, L., Wessely, S., Greenberg, N., Rubin, G.J., 2020. The psychological impact of quarantine and how to reduce it: rapid review of the evidence. *Lancet* 395, 912–920.
- Bruining, H., Bartels, M., Polderman, T.J.C., Popma, A., 2021. COVID-19 and child and adolescent psychiatry: an unexpected blessing for part of our population? *Eur. Child Adolesc. Psychiatry* 30, 1139–1140. <https://doi.org/10.1007/s00787-020-01578-5>.
- Cao, W., Fang, Z., Hou, G., Han, M., Xu, X., Dong, J., Zheng, J., 2020. The psychological impact of the COVID-19 epidemic on college students in China. *Psychiatry Res.* 287, 112934 <https://doi.org/10.1016/j.psychres.2020.112934>.
- Chang, L., Lu, H.J., Lansford, J.E., Skinner, A.T., Bornstein, M.H., Steinberg, L., Dodge, K.A., Chen, B., Bin, Tian, Q., Bacchini, D., Deater-Deckard, K., Pastorelli, C., Alampay, L.P., Sorbring, E., Al-Hassan, S.M., Oburu, P., Malone, P.S., Di Giunta, L., Uribe Tirado, L.M., Tapanya, S., 2019. Environmental harshness and unpredictability, life history, and social and academic behavior of adolescents in nine countries. *Dev. Psychol.* 55, 890–903. <https://doi.org/10.1037/dev0000655>.
- Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., Han, Y., Qiu, Y., Wang, J., Liu, Y., Wei, Y., 2020. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet* 395, 507–513.
- Clayborne, Z.M., Varin, M., Colman, I., 2019. Systematic review and meta-analysis: adolescent depression and long-term psychosocial outcomes. *J. Am. Acad. Child Adolesc. Psychiatry* 58, 72–79. <https://doi.org/10.1016/j.jaac.2018.07.896>.
- Doom, J.R., Vanzomeren-Dohm, A.A., Simpson, J.A., 2016. Early unpredictability predicts increased adolescent externalizing behaviors and substance use: a life history perspective. *Dev. Psychopathol.* 28, 1505. <https://doi.org/10.1017/S0954579415001169>.
- Dunkel, C.S., Hammersley, J.J., Waters, M.L., van der Linden, D., Merrie, L.A., Walen, A.L., 2021. The effect of early childhood intervention on risk-taking, mental health, and cognitive ability: the mediating role of life history strategy. *Evol. Behav. Sci.* 15, 27–41. <https://doi.org/10.1037/ebv0000248>.
- Edwards, J.R., Lambert, L.S., 2007. Methods for integrating moderation and mediation: a general analytical framework using moderated path analysis. *Anal. Psychol.* 12, 1–22. <https://doi.org/10.1037/1082-989X.12.1.1>.
- Ellis, B.J., Del Giudice, M., Dishion, T.J., Figueredo, A.J., Gray, P., Griskevicius, V., Hawley, P.H., Jacobs, W.J., James, J., Volk, A.A., 2012. The evolutionary basis of risky adolescent behavior: implications for science, policy, and practice. *Dev. Psychol.* 48, 598.
- Ellis, B.J., Figueredo, A.J., Brumbach, B.H., Schlomer, G.L., 2009. Fundamental dimensions of environmental risk: the impact of harsh versus unpredictable environments on the evolution and development of life history strategies. *Hum. Nat.* <https://doi.org/10.1007/s12110-009-9063-7>.
- Fergusson, D.M., Woodward, L.J., 2002. Mental health, educational, and social role outcomes of adolescents with depression. *Arch. Gen. Psychiatry* 59, 225–231. <https://doi.org/10.1001/archpsyc.59.3.225>.
- Figueredo, A.J., Vasquez, G., Brumbach, B.H., Schneider, S.M.R., 2004. The heritability of life history strategy: the k-factor, covitality, and personality. *Soc. Biol.* 51, 121–143.
- Griskevicius, V., Tybur, J.M., Delton, A.W., Robertson, T.E., 2011. The influence of mortality and socioeconomic status on risk and delayed rewards: a life history theory approach. *J. Pers. Soc. Psychol.* 100, 1015.
- Hankin, B.L., 2008. Cognitive vulnerability-stress model of depression during adolescence: investigating depressive symptom specificity in a multi-wave prospective study. *J. Abnorm. Child Psychol.* 36, 999–1014. <https://doi.org/10.1007/s10802-008-9228-6>.
- Havnen, A., Anyan, F., Hjemdal, O., Solem, S., Gurigard, M., Hagen, K., 2020. Resilience moderates negative outcome from stress during the COVID-19 pandemic: a moderated-mediation approach. *Int. J. Environ. Res. Public Health* 1–13.
- Hill, K., Kaplan, H., 1999. Life history traits in humans: theory and empirical studies. *Annu. Rev. Anthropol.* 28, 397–430.
- Hu, L., Bentler, P.M., 1999. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct. Equ. Model. a Multidiscip. J.* 6, 1–55.
- Jiang, S., Ren, Q., Jiang, C., Wang, L., 2021. Academic stress and depression of Chinese adolescents in junior high schools: moderated mediation model of school burnout and self-esteem. *J. Affect. Disord.* 295, 384–389. <https://doi.org/10.1016/j.jad.2021.08.085>.
- Li, H., Cao, Y., 2021. Facing the pandemic in the dark: psychopathic personality traits and life history strategies during COVID-19 lockdown period in different areas of China. *Curr. Psychol.* <https://doi.org/10.1007/s12144-021-01549-2>.
- Liu, Y., Wang, M., Villberg, J., Torsheim, T., Tynjälä, J., Lv, Y., Kannas, L., 2012. Reliability and validity of family affluence scale (FAS II) among adolescents in Beijing/China. *Child Indic. Res.* 5, 235–251. <https://doi.org/10.1007/s12187-011-9131-5>.
- Loades, M.E., Chatburn, E., Higson-Sweeney, N., Reynolds, S., Shafran, R., Brigden, A., Linney, C., McManus, M.N., Borwick, C., Crawley, E., 2020. Rapid systematic review: the impact of social isolation and loneliness on the mental health of children and adolescents in the context of COVID-19. *J. Am. Acad. Child Adolesc. Psychiatry* 59, 1218–1239.e3. <https://doi.org/10.1016/j.jaac.2020.05.009>.
- Lu, H.J., Chang, L., 2019. Aggression and risk-taking as adaptive implementations of fast life history strategy. *Dev. Sci.* 22, e12827.
- MacKinnon, D.P., Lockwood, C.M., Williams, J., 2004. Confidence limits for the indirect effect: distribution of the product and resampling methods. *Multivariate Behav. Res.* 39, 99–128.
- Main, A., Zhou, Q., Ma, Y., Luecken, L.J., Liu, X., 2011. Relations of SARS-related stressors and coping to Chinese college students' psychological adjustment during the 2003 Beijing SARS epidemic. *J. Couns. Psychol.* 58, 410.
- Muthén, L.K., Muthén, B., 2017. *Mplus User's Guide: Statistical Analysis With Latent Variables, User's Guide*. Muthén & Muthén.
- Nolen-Hoeksema, S., Girgus, J.S., 1994. The emergence of gender differences in depression during adolescence. *Psychol. Bull.* 115, 424. <https://doi.org/10.1037//0033-2909.115.3.424>.
- Olderbak, S., Gladden, P., Wolf, P.S.A., Figueredo, A.J., 2014. Comparison of life history strategy measures. *Pers. Individ. Dif.* 58, 82–88. <https://doi.org/10.1016/j.paid.2013.10.012>.
- Qi, M., Zhou, S.J., Guo, Z.C., Zhang, L.G., Min, H.J., Li, X.M., Chen, J.X., 2020. The effect of social support on mental health in Chinese adolescents during the outbreak of COVID-19. *J. Adolesc. Health* 67, 514–518. <https://doi.org/10.1016/j.jadohealth.2020.07.001>.
- Salas-Rodríguez, J., Gómez-Jacinto, L., Hombrados-Mendieta, M.I., 2021. Life history theory: evolutionary mechanisms and gender role on risk-taking behaviors in young adults. *Pers. Individ. Dif.* 175, 110752 <https://doi.org/10.1016/j.paid.2021.110752>.
- Thapar, A., Collishaw, S., Pine, D.S., Thapar, A.K., 2012. Depression in adolescence. *Lancet* 379, 1056–1067. [https://doi.org/10.1016/S0140-6736\(11\)60871-4](https://doi.org/10.1016/S0140-6736(11)60871-4).
- van der Velden, P.G., Hyland, P., Contino, C., von Gaudecker, H.M., Muffels, R., Das, M., 2021. Anxiety and depression symptoms, the recovery from symptoms, and loneliness before and after the COVID-19 outbreak among the general population: findings from a Dutch population-based longitudinal study. *PLoS One* 16, e0245057. <https://doi.org/10.1371/journal.pone.0245057>.
- Vollmayr, B., Henn, F.A., 2003. Stress models of depression. *Clin. Neurosci. Res.* 3, 245–251.
- William Li, H.C., Chung, O.K.J., Ho, K.Y., 2010. Center for Epidemiologic Studies Depression Scale for children: psychometric testing of the Chinese version. *J. Adv. Nurs.* 66, 2582–2591.
- Yan, L., Gan, Y., Ding, X., Wu, J., Duan, H., 2021. The relationship between perceived stress and emotional distress during the COVID-19 outbreak: effects of boredom proneness and coping style. *J. Anxiety Disord.* 77, 102328 <https://doi.org/10.1016/j.janxdis.2020.102328>.
- Zhang, W., Liu, H., Jiang, X., Wu, D., Tian, Y., 2014. A longitudinal study of posttraumatic stress disorder symptoms and its relationship with coping skill and locus of control in adolescents after an earthquake in China. *PLoS One* 9, e88263.
- Zhou, S.-J., Zhang, L.-G., Wang, L.-L., Guo, Z.-C., Wang, J.-Q., Chen, J.-C., Liu, M., Chen, X., Chen, J.-X., 2020. Prevalence and socio-demographic correlates of psychological health problems in Chinese adolescents during the outbreak of COVID-19. *Eur. Child Adolesc. Psychiatry* 29, 749–758. <https://doi.org/10.1007/s00787-020-01541-4>.