

Original Research

The trajectory of psychological distress and problematic Internet gaming among primary school boys: a longitudinal study across different periods of COVID-19 in China

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Abstract

Background: Children are a vulnerable population in terms of the impact of COVID-19 on their psychological well-being. When restricted to their homes, children are susceptible to problematic Internet gaming (PG). Primary school boys are particularly at risk of PG, which may lead to negative psychological effects, such as distress. Emerging research has identified perceived weight stigma (PWS) as a variable closely associated with both PG and psychological distress, particularly during the COVID-19 pandemic. The purpose of this study was to evaluate the trajectory of psychological distress among this vulnerable population from a longitudinal perspective, evaluating the role of PG and PWS. **Methods**: Self-report measures were used to assess psychological distress, PG, and PWS among primary school boys (grades 4 to grade 6; N = 283). Data were collected across three waves: before the pandemic, during school closure, and following the lifting of restrictions. **Results**: The trajectory of psychological distress among primary school boys was concave, indicating their mental health was negatively impacted during home restriction but recovered after the lockdown ended (linear change = 0.98, p < 0.01; quadratic change = -0.19, p < 0.01). PG was a significant covariate in terms of the trajectory of psychological distress (b = 0.02, p < 0.01), and moderated the time factor for boys' psychological distress over time (b of PWS × linear change = 0.04, p = 0.006; b of PWS × Quadratic change was negative at -0.01, p = 0.002). **Conclusions**: Although mental health gradually improved as home restrictions subsided, future studies are required to address changes in mental health upon return to school for students reporting higher levels of weight stigma.

Keywords: Psychological distress; Problematic Internet gaming; COVID-19; Perceived weight stigma; Longitudinal study

1. Introduction

The coronavirus disease (COVID-19) pandemic has resulted in substantial harm to individuals on a global scale, including negative impacts on both physical health [1,2] and, due to the highly infectious nature of the virus and resulting quarantine policies, psychological well-being [3–7]. A recent meta-analysis reported the prevalence of depression among the general population was seven times higher during the COVID-19 outbreak as compared to the global estimated prevalence of depression in 2017, drawing attention to the importance of mental health in COVID-19 care [4].

1.1 Trajectory of mental health during COVID-19

While the negative impacts of COVID-19 on mental health are undeniable, assessing the impact of the pandemic on individuals' mental health is relatively subjective when compared to the objective diagnoses available for assessing physical health outcomes [4,8]. In addition to this subjec-

tivity and variability in assessment, the dynamic nature of psychological well-being [9] and stigmas associated with mental health during the pandemic [10] may account for the mixed results from empirical research attempting to address the impact of the pandemic on mental health [4]. Therefore, when evaluating the psychological impact of the pandemic on individuals, the factor of time must be considered. First, the inclusion of time in the analysis of psychological well-being allows an evaluation of the duration of mental health symptoms, which is a critical criterion for both judging the severity of individuals' psychosocial and physiological impairment and differentiating chronic underlying psychological conditions from acute reactions to the pandemic [5,11,12]. Furthermore, from the perspective of developmental psychopathy [13], several effects are associated with the role of time on mental health during COVID-19, including cumulative risk, which involves the increase in potential risk factors that occur over time, such as parental job loss or conflict in the home. Alternatively, time can also lead to

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resilience, characterized by coping or adaptation during the pandemic [14]. As such, considering the dynamic and subjective nature of individuals' perceptions of the pandemic, and the importance of time in evaluating the nature and severity of psychological symptoms, long-term longitudinal monitoring is necessary for identifying and evaluating the factors impacting psychological well-being during the pandemic [13,14].

Recently, the use of longitudinal designs has been adopted by some researchers in evaluating the effects of COVID-19 on mental health [3,6,11,15,16], with some studies focusing on the effects of quarantine at the beginning of the COVID-19 outbreak. A follow-up study of Spanish adults [17] demonstrated that symptoms of depression increased significantly during quarantine (over a period of one month), suggesting the importance of a longitudinal approach to the evaluation of mental health deterioration, as well assessment of the impact of specific interventions for improving mental health under such conditions [17]. However, the findings of other longitudinal studies from China [6], Argentina [11] and the United Kingdom [18] found no deterioration in symptoms of anxiety or depression during the quarantine. Given these conflicting results, further evidence is required to better understand the trajectory of mental health during COVID-19. Moreover, since the aforementioned studies evaluated the psychological well-being during quarantine, they lacked a comparable, pre-COVID-19 baseline, making it difficult to draw conclusions on the true effects of quarantine measures.

Some studies have adopted secondary data to evaluate the differences in mental health indicators before and during COVID-19 [16,19–21], with the advantages of a nationally representative sample and baseline data collected before the pandemic outbreak. For example, an evaluation of four waves of data from a nationally representative sample of adults in the United Kingdom found that the prevalence of mental illness increased significantly from 24.3% in 2017–2019 to 37.8% in April 2020, 34.7% in May 2020, and 31.9% in June 2020 [16]. Similar results using secondary data also found an increase in psychological distress from pre-COVID levels for U.S. [20] and French [21] adults.

However, although baseline data was used in studies among adults [16,19–21], these findings must be interpreted with caution, as the baseline measurements were collected at points in time much earlier than the outbreak of the pandemic (from 2014 to 2019). Of the very few longitudinal studies that utilized baseline measurements very close to the time of the outbreak, such as a study of Chinese college students which found a 181.94% increase in anxiety and a 1413.01% increase in depression [3]. However, there still remains a gap in the literature for the effects of COVID-19 in terms of the trajectory of mental health among children.

1.2 Boys as a vulnerable population

Although the impact of COVID-19 on mental health has been investigated among adults [16,20,21], there is a lack of research on the trajectory of mental health among children. Children are considered one of the most vulnerable populations in terms of the influence of COVID-19 on mental illness [22,23]. In fact, the effects of quarantine on children, based on a sample of 1143 parents, indicated that 85.7% reported emotional or behavioral changes [24]. Some factors that make children more vulnerable to the psychological effects of COVID-19 include: the importance of school schedules for promoting healthy routines, physical activity, and sleep, children's need for socialization, and the loss of family income resulting from parents leaving their job to take care of the child [24]. Likewise, the impact of school closure, in particular, can have longer lasting impacts on learning outcomes and overall well-being [25]. Moreover, some evidence suggests that boys, in particular, are more sensitive to adverse situations [26], such as those resulting from the pandemic, and tend to receive less sleep than girls [27] To bridge this gap, the present study investigates longitudinal changes in psychological distress among this vulnerable population (primary school boys) across different periods of COVID-19 (i.e., pre-COVID, during school closure, and following school closure).

1.3 Problematic Internet gaming

During the pandemic, strict lockdown measures were adopted by many governments around the world, resulting in school closures which required children to remain at home, thereby providing more opportunities for children to engage in Internet gaming [28,29], with lockdown or school closure conditions considered a risk factor for the devleopment of problematic Internet gaming [30]. In fact, the literature has reported that Internet gaming is a significantly stronger risk factor of problematic Internet use (PIU) in boys as compared than girls [31] and that PIU has a detrimental effect on mental health [29,32]. Boys tend to be more susceptible to severe Internet gaming addiction than girls, with low self-esteem and low life satisfaction being strong predictors of problematic Internet gaming [33]. Studies on PIU during COVID-19 have identified Internet gaming as a coping strategy for individuals to reduce stress and anxiety, potentially leading to addiction [34,35], including among adolescents and children [36]. Therefore, in evaluating the trajectory of boys' mental health during COVID-19, we examine the relationship between problematic Internet gaming (PG) and psychological distress.

1.4 Perceived weight stigma

Perceived weight stigma (PWS) refers to an individual's perception of being devalued or discriminated against due to being overweight [37], with some studies indicating that PWS also occurs among individuals with objectively normal weights (i.e., according to their body mass index)

[38,39]. Research indicates that PWS contributes to unhealthy behaviors and increases the risk of depression or anxiety [37,39,40]. The mechanism through which PWS impacts adults' psychological well-being in the context of the COVID-19 pandemic has been related to increased sensitivity and concern given the role of obesity as a risk factor for COVID-19 complications [41]. However, there has been little research on the role of PWS among children, particularly boys [42], who are less likely to be aware of obesity as a risk factor. As such, other studies on PWS may explain the potential impact of PWS among children on psychological well-being during COVID-19, since PWS is associated with lower quality of life and self-esteem [43], factors which may increase the severity of psychological distress when stressors, such as school closure and home restrictions are imposed. Moreover, maladaptive coping, including negative self-talk, isolation, and avoidance, has been proposed as a key factor mediating PWS and poor psychological well-being, including depression, anxiety, and stress [44]. In the context of COVID-19, other forms of maladaptive coping, such as "eating to cope", were explanatory in terms of the relationship between pre-COVID PWS and depressive symptoms during COVID [41]. Other recent research has found a link between psychological distress (including fear, stress, and depression) and PWS [45] during COVID-19, with both PWS and problematic Internet-related behaviors, such as PG, serving as predictors of psychological distress among schoolchildren. Therefore, we believe that it is important to evaluate the role of PWS in terms of primary school students' mental health during school suspension and restriction at home, particularly since societal interventions during COVID-19, including lockdowns and isolation, may result in negative psychosocial impacts leading to changed eating habits, maladaptive coping, or stress that can worsen both obesity and psychological well-being [46]. Therefore, the effect of boys' perceived weight stigma (PWS), as measured before the lockdown, on boy's mental health trajectory was also tested.

In sum, in order to evaluate the longitudinal changes in mental health among primary school boys during COVID-19, the following specific research questions will be addressed:

RQ1: What is the trajectory of psychological distress among primary school boy's across different periods of COVID-19 (pre-pandemic, school closure, and following school closure)?

RQ2: Is there a relationship between PG and longitudinal change in psychological distress?

RQ3: Does PWS (measured before the pandemic) effect primary school boy's baseline psychological distress?

RQ4: Does PWS (measured before the pandemic) influence the growth rate of psychological distress?

2. Materials and methods

2.1 Data collection context, procedure and participants

As part of an ongoing longitudinal project in China, students' self-report data were collected from different three waves: before the COVID-19 outbreak pandemic (Time 1; collected from early to mid-January, 2020), during the school closure period at the initial stages of the COVID-19 outbreak (Time 2; collected in mid-March, 2020), and following the lifting of restrictions (Time 3; collected in early June, 2020). The selection of these three times corresponds to the situation in China. While the pre-COVID data was collected under a project initiated and approved before the COVID-19 outbreak, the collection of data during and after school closure and related restrictions was purposive, in order to evaluate the differences in variables from pre-COVID data already collected and data collected during the outbreak (which was serious at a point two months after Time 1) and after the lifting of restrictions, which took place nearly three months later.

In China, at Time 1, final academic achievement tests were being administered in primary schools and winter vacation was approaching. Although COVID-19 cases had been found in Wuhan at that time, local governments had not taken specific preventive measures [47]. During Time 2, the Chinese government adopted strict home physical movement restrictions to address the severity of the outbreak. All school campus was closed and primary school students were only able to take online courses [48]. At Time 3, the pandemic was deemed by the government to be under control and most cities had returned to normal life [49]. Although primary school students were still unable to enter school campuses, they were able to enter and leave the community freely and were not restricted in outdoor activities.

Through the comparison of three time points, we were able to evaluate the change of the trajectory of the influence the COVID-19 pandemic on psychological distress and the covariance of this trajectory with PG among primary school boys. From a theoretical sampling perspective, we adopted a purposive-convenience sampling method [50] in collaboration with three primary schools, located in the suburbs of a large city in Sichuan province. The three primary schools were recruited through an established and approved research project and, as such, were familiar to the researchers and the oversight agency. The annual income of each family from these three schools was between 50,000 and 180,000 CNY with an average annual income of around 80,000 CNY. The majority of parents in these participating schools had a high school degree (around 85%) and only a small number had a bachelor's degree (around 5%). Generally, the socioeconomic status of families living in the area from which the participants were recruited is homogeneous.

As part of a longitudinal project, we conducted regular monitoring of the mental health of primary school students every two to three months starting from October 2019, which was before the outbreak of COVID-19. With the assistant of the principals of the three schools, a sample of schoolchildren from randomly selected classes were invited to participate in this longitudinal study. A total of 283 primary school boys participated at the beginning of the study. An initial survey was conducted using a paper-based questionnaire and included a declaration of informed consent, completed by parents. At time 2, 277 of 283 participants (attrition rate of 2%) agreed to participate in the secondwave of the survey. At time 3, 272 out of the remaining 277 boys agreed to participate in the third-wave study (attrition rate of 1.8%). Since students were not allowed to enter their school, an online survey was administered for the second and third wave of the survey. School teachers assisted in sending links to the online questionnaire to parents' smartphone/laptops. For these surveys, electronic informed consent was obtained on the first page of the online survey. Data were collected on students' perceived weight stigma (PWS) only for the first wave, as the role of this variable in the data analysis was to evaluate any interaction with the growth rate of the trajectory of psychological distress. Moreover, PWS baseline scores were collected based on the objectives of the ongoing longitudinal project under which this research was supported and recent findings that PWS, even during COVID-19, is relatively stable [51]. Data on psychological distress and problematic Internet gaming (PG) were collected for each of the three waves.

2.2 Instruments

In addition to measures of psychological distress, problematic Internet gaming, and perceived weight stigma, participants' age and health status were evaluated (the response item was: Have you been sick recently (such as cold, typhoid fever, diarrhea, etc.)?). Data on students' age and health condition (sick or not sick) were measured and included as covariates in later statistical analyses. All measures were administered in the participants' mother language of Mandarin Chinese.

2.2.1 Psychological distress

We adopted the Depression and Anxiety and Stress Scale-21 (DASS-21) to measure participants' psychological distress. The DASS-21 includes 21 items and is evenly divided into three subscales: depression, anxiety, and stress [52]. Scoring of the DASS-21 involves responses to a fourpoint Likert scale (0 = does not apply to me at all, 3 = applies to me most of the time) with higher scores indicates a higher levels of depression, anxiety, and stress. Given abundant evidence indicating that children cannot clearly differentiate among these three emotional disorders [53,54], we used a summed score from all items to represent overall psychological distress level, with summed scores serving as indicators for longitudinal analysis. The Chinese version of DASS-21 has sound psychometric properties among adolescents [55] and college students [56] while, according to

the best of the present authors' knowledge, there has been no psychometric examination of DASS-21 among Chinese primary school students. The internal consistency of the Chinese DASS-21 was acceptable in a previous study, with a Cronbach's α higher than 0.90 [56]. In our study, Cronbach's α was also excellent (the overall Cronbach's α in Time 1, Time 2, and Time 3 was 0.92, 0.93, and 0.93 respectively). Sample items for each subscale include: "I couldn't seem to experience any positive feelings at all" (depression); "I was aware of dryness of my mouth" (anxiety); and "I tended to over-react to situations" (stress).

2.2.2 Problematic Internet gaming (PG)

The nine-item Internet Gaming Disorder Scale (IGDS-SF9), was used to measure the intensity of respondents' of problematic Internet gaming (PG). The IGDS-SF9 scale was developed by Pontes and Griffiths [57]. The factor structure of the IGDS-SF9 is uni-dimensional with strong support from a recent systematic review [58]. The items of IGDS-SF9 were scored on a five-point Likert-type scale from 1 (Never) to 5 (Very often), with higher scores indicating a greater degree of problematic online gaming. The psychometric properties of the Chinese version of the IGDS-SF9 have been examined with longitudinal data, demonstrating suitable validity and reliability [59].

Moreover, a previous study also showed that the Chinese version of the IGDS-SF9 was suitable for use with primary school students [60]. In a recent systematic review, Cronbach α values for the IGDS-SF9 were found to be between 0.81 to 0.96 [58]; while, in the present study, the internal consistency of the IGDS-SF9 was also ideal across different data collection waves (Cronbach's α was 0.87 for Time 1, 0.92 for Time 2, and 0.93 for Time 3). Sample items include: "Do you play in order to temporarily escape or relieve a negative mood (e.g., helplessness, guilt, anxiety)?" and "Do you feel more irritability, anxiety or sadness when you try to either reduce or stop your gaming activity?".

2.2.3 Perceived weight stigma

The Perceived Weight Stigma Scale (PWSS) adapted from Schafer et al. [40] was used to measures the baseline level of PWS among the participants in this present study. Ten dichotomous items (0 = no and 1 = yes) were asked of the respondents regarding specific interpersonal situations and contexts wherein they may report feelings of discrimination. The PWSS is commonly used among students under the age of 18 [37,61]. A sample item from the PWSS is "People act as if you are inferior because of your weight." We summed the scores of the ten items, with higher scores indicating higher levels of PWS. The Chinese version of the PWSS has demonstrated good criterion validity (i.e., high correlations with other questionnaires of perceived weight stigma [61] and high correlation of PWSS with psychological distress [37]). The internal consistency (Cronbach's α) of the PWSS in the present study was 0.79 for Time 1.

		Mean (SD)		Effect size (η_p^2)	
-	Time 1: Before the outbreal	Time 2: COVID-19 outbreak	Significance test ^a		
	(n = 283)	(n = 277)	(n = 272)		
				$F(1.42, 384.97)^{b} = 53.67$	
Age	10.76 (0.74)	10.92 (0.82)	11.19 (0.72) T	p < 0.001	0.165
				Time 3 > Time 2 > Time 1	
Psychological distress	0.24 (0.22)	1.41 (0.50)	F (1.56, 1.41 (0.50) 0.22 (0.32) Tin Tin	$F(1.56, 423.74)^b = 1192.25$	
				p < 0.001	0.915
	0.24 (0.55)	1.41 (0.30)		Time $2 >$ Time 1	0.813
				Time 2 > Time 3	
PG	1.48 (0.64)	1.44 (0.58)	1 42 (0 (2)	$F(1.92, 520.95)^b = 1.04$	0.004
			1.42 (0.63)	p = 0.353	0.004
PWS	2.31 (2.39)	Not applicable	Not applicable		

Table 1. Descriptive statistics and significance testing for age, psychological distress, problematic Internet gaming, and perceived weight stigma by time.

PG, problematic Internet gaming; PWS, perceived weight stigma; a, pairwise comparison was conducted using the Bonferroni procedure; b, due to violation of assumed sphericity, adjusted statistics using the Greenhouse-Geisser correction were reported.

2.3 Data analysis strategy

Descriptive statistics were first provided in terms of the variables of interest (psychological distress, PG, and PWS). Repeated-measures ANOVA was used to compare differences between these variables among different waves. Furthermore, Pearson correlations were also provided for these variables. Hierarchical linear modeling (HLM) was used in order to evaluate the research questions, given that the time-series data of psychological distress can be viewed as being nested within an individual. HLM is a widely used approach to analyze the longitudinal data [62-64]. The aim of HLM is to evaluate and explain the changes within individuals over time and includes multi-level data. In the HLM analysis of the present study, longitudinal data was set at level 1 (i.e., psychological distress as a dependent variable, and PG as an explanatory variable), and betweensubject variables were set at level 2 (i.e., PWS). Combining level 1 and level 2, we can evaluate the nature of the trajectory of the longitudinal data and examine the effects of individual-level characteristics on linear or nonlinear patterns of change. In this manner, HLM is a flexible approach for analyzing longitudinal data since this analysis can adequately overcome the problem of sample attrition sample [65,66]. Specific procedures were described below.

To test our research questions, an unconditional growth model was first used to examine the changes in the trajectory of psychological distress (RQ1). Two potential models (i.e., an unconditional linear growth model and an unconditional quadratic growth model) were compared using a chi-square test of deviance with full information maximum likelihood (FIML) estimation [66]. In these models, only time factors were included while the level 2 model was unconditional (i.e., the effect of PWS was not yet examined). If the chi-square test was significant ($\alpha < 0.05$), the unconditional quadratic growth model would be retained. Otherwise, if the chi-square test was insignificant, an unconditional linear growth model would be deemed more appropriate for explaining an individual's trajectory [67,68]. For RQ2, a time-varying covariate model was adopted [66, 68]. In this model, the control variables (i.e., age and health status) were included and the covariation between PG (grand-mean centered) and psychological distress was examined. Finally, a conditional model with the added control variables was used for the remaining two research questions, in which a time-varying predictor (PG) was added to level 1 and a time-invariant predictor (i.e., PWS) was added to the level 2 equation. More specifically, PWS was used to test its relationship with psychological distress at Time 1 and served as a moderator to test the effect of the interaction of PWS \times time (i.e., linear change or quadratic change) on boy's psychological distress trajectory. That is, the full model can be used to examine the influence of PWS on primary school boys' mental health before the COVID-19 outbreak (RQ3) and whether or not PWS moderates the growth rate of psychological distress

(RQ4). If the coefficient for PWS on psychological distress at Time 1 was significant, the association between PWS and psychological distress was established for Time 1; while if the interaction term of PWS \times time factor is significant, the level of PSW before the outbreak of the pandemic changes the growth rate of mental distress. The determination of acceleration or deceleration of the growth rate is evaluated by the coefficient of the time factor and the coefficient of the interaction term [66,69].

3. Results

3.1 Descriptive data results

Descriptive results for the mean and standard deviation of each variable are displayed in Table 1. Overall psychological distress scores increased during the second wave (school closures) and then decreased during the third wave (lifting of restrictions) (see Fig. 1), with mean values of 0.24 (Time 1), 1.41 (Time 2), and 0.22 (Time 3). Results from repeated-measures ANOVA (F (1.56, 423.74) = 1192.25, p < 0.001), demonstrated a large effect size ($\eta_p^2 = 0.165$) [70] and the severity of psychological distress was highest in Time 2, with no significant differences found between Time 1 and Time 3. In terms of PG, boy's problematic Internet gaming behavior did not change significantly across the three waves. The mean for baseline PWS was 2.31 (SD = 2.39), indicating that primary school boys reported relatively low levels of perceived weight stigma (only two to three out of ten items indicating an experience of perceived weight stigma). Finally, except for psychological distress in Time 1 (skewness was 3.19 and kurtosis was 16.76), the skewness and kurtosis of the other variables (skewness ranged from 0.89 to 2.46; kurtosis ranged from -0.10 to 7.34) did not violate the assumptions of normally distribution according to Kline's criterion [71] (i.e., Skewness less than 3 and kurtosis less than 10).



Fig. 1. Observed scores on DASS-21 for the three waves of data collection (n = 280).

The results from Pearson correlations are provided in Table 2. The three waves of data for psychological distress

	1	2	3	4	5	6	7
(1) Psychological distress ^{1st}	1						
(2) PG^{1st}	0.25**	1					
(3) PWS^{1st}	0.45**	0.37**	1				
(4) Psychological distress ^{2nd}	0.32**	0.56**	0.45**	1			
(5) PG^{2nd}	0.51**	0.39**	0.25**	0.17**	1		
(6) Psychological distress ^{3rd}	0.53**	0.13*	0.31**	0.20**	0.26**	1	
(7) PG^{3rd}	0.39**	0.20*	0.19**	0.1	0.29**	0.55**	1

Table 2. Correlation matrix for study variables; n = 283 (Time 1), 277 (Time 2), 274 (Time 3).

PG, problematic Internet gaming; PWS, perceived weight stigma; **p < 0.01, *p < 0.05.

were significantly positively associated with each other (r = 0.32 to 0.53, p < 0.01) as was the case for PG (r = 0.20to 0.39, p < 0.01). Moreover, the correlation between psychological distress and PG was significant across all three waves (Time 1 = 0.25, Time 2 = 0.17, and Time 3 = 0.55, p < 0.01). For PWS, students' perceived weight stigma experience in the first wave was significantly and positively associated with psychological distress and PG for every wave (r = 0.19 to 0.45, p < 0.01).

3.2 Trajectory of psychological distress across the three waves (RQ1)

In order to perform HLM analysis, we must first decide which types of the trajectory best fit the data in explaining the longitudinal change of psychological distress. The results indicated that an unconditional quadratic growth model better described individual changes in psychological distress across different waves, since the chi-square test of deviance was significant ($\Delta \chi^2_{(1)} = 936.68, p < 0.01; \chi^2$ of the unconditional linear growth model = 1616.01, df = 4; χ^2 of the unconditional quadratic growth model = 679.33, df = 5). As such, equation (1), below, was adopted. In this equation, psychological distress $_{ti}$ is the i-th participants' DASS-21 score at the t-th time point; π_{1i} (linear change)_{ti} and π_{2i} (quadratic change)_{ti} represents linear and quadratic trajectories over time. In this analysis, with time centered at the baseline as a reference point, (linear change)_{ti} was 0 (Time 1), 2 (Time 2), and 5 (Time 3). This code reflects the interval of months between these waves. For (quadratic change)_{ti}, the values were 0 (Time 1), 4 (Time 2), and 25 (Time 3). π_{0i} was the intercept value representing the participants' psychological distress in the first wave.

Level 1:

*Psychological Distress*_{ti} = $\pi_{0i} + \pi_{1i}$ (linear change)_{ti} + π_{2i} (quadratic change)_{ti} + + e_{ti}

Level 2:

$$\pi_{0i} = \beta_{00} + r_{0i}$$

 $\pi_{1i} = \beta_{10}$

$$\pi_{2i} = \beta_{20}$$

The result of the unconditional growth model (see Table 3) indicated that there was a significant increase in psychological distress (b = 0.98, p < 0.01) while the quadratic term also approached significance (b = -0.19, p < 0.01). Due to the positive coefficient for linear change and the negative coefficient for quadratic change, HLM revealed a sharped increase in psychological distress between Time 1 and Time 2, with the effect of time slowing and the model graph concave in shape. That is, primary school boys' mental health was negatively impacted during home restrictions (Time 2) but recovered after restrictions were lifted (Time 3). We further calculated the slope of the line tangential to the curve as the instantaneous rate of change at that time point. According to the principles of calculus, this simple slope is $\beta_{10} + 2 \times \beta_{20} \times Time_{ti}$ [66]. As such, the instantaneous rate of change from Time 1 to Time 2 was 0.22 (0.98 + 2 \times -0.19 \times 2) and from Time 2 to Time 3 was -0.92 $(0.98 + 2 \times -0.19 \times 5).$

3.3 Relationship between PG and longitudinal change in psychological distress (RO2)

To evaluate RQ2, a time-varying covariate model with the added control variables (i.e., health status and age) was used. Please refer to equation (2) and Table 3. In addition to the unconditional growth model used in equation (2), control variables and a time-varying covariate (PG) were added to Level 1. The results of the model demonstrated that the participants' PG demonstrated significantly covariance with their psychological distress (b = 0.02, p < 0.01). (2)

Level 1:

Psychological Distress_{ti} = $\pi_{0i} + \pi_{1i}$ (linear change)_{ti} + π_{2i} (quadratic change)_{ti} + π_{3i} (Health Status)_{ti} + $\pi_{4i}(Age)_{ti} + \pi_{5i}(PG)_{ti} + e_{ti}$

Level 2:

$$\pi_{0i} = \beta_{00}$$

 $\pi_{1i} = \beta_{10}$
 $\pi_{2i} = \beta_{20}$
 $\pi_{2i} = \beta_{20}$

(1)

 $+ r_{0i}$

 $\pi_{3i} = \beta_{30}$ $\pi_{4i} = \beta_{40}$ $\pi_{5i} = \beta_{50}$

		Table 5. S	ummary o		inever growin	mouel rest	mus.		
	Unconditi	ional growth	model	Time-v	Time-varying covariate model			Conditional growth model	
		(1)			(2)			(3))
Fixed effect	Coefficient St	andard error	t	Coefficient	t Standard error	t	Coefficien	t Standard error	t
Mean of the initial stage π_{0i}									
Intercept β_{00}	0.24	0.02	12.34***	0.22	0.02	9.01***	0.23	0.02	9.55***
β_{01} (PWS)							0.05	0.01	3.26***
Mean of linear change π_{1i}									
Intercept β_{10}	0.98	0.03	38.01***	1.01	0.03	33.09***	1.00	0.03	34.33***
β_{11} (PWS)							0.04	0.02	2.50*
Mean of <i>Quadratic</i> change π_{2i}									
Intercept β_{20}	-0.19	0.05	-38.39***	-0.20	0.01	-35.33***	-0.20	0.01	-36.66***
β_{21} (PWS)							-0.01	0.003	-2.79**
Time-varying covariate (Health Status))								
Intercept β_{30}				0.03	0.03	0.89	0.02	0.04	0.54
Time-varying covariate (Age)									
Intercept β_{40}				-0.01	0.02	-0.27	0.00	0.02	0.16
Time-varying covariate (PG)									
Intercept β_{50}				0.02	0.004	3.81***	0.01	0.004	3.24**
Random effect	Variance	χ^2	р	Variance	χ^2	р	Variance	χ^2	р
Level 1 variance e_{ti}	0.10			0.11			0.10		
Initial stage γ_{0i}	0.05	669.14	< 0.001	0.03	492.16	< 0.001	0.02	425.45	< 0.001

Table 3. Summary of HLM multilevel growth model results.

*** p < 0.001; ** p < 0.01; *p < 0.05; PWS, perceived weight stigma; PG, problematic Internet gaming.

3.4 Role of PWS on baseline and growth rate of psychological distress (RQ3 and RQ4)

In terms of RQ3 and RQ4, a conditional model was adopted as shown in equation (3). The results (see Table 3) indicate that PWS contributed significantly and negatively to boys' mental health for Time 1 (b = 0.05, p < 0.050.01). Moreover, the results also revealed that PWS moderated the effect of the time factor on boys' psychological distress. Specifically, boys perceiving more weight stigma increased in terms of psychological distress across waves (i.e., PWS \times linear change: b = 0.04, p = 0.006). The coefficient for the term PWS \times quadratic change was negative (b = -0.01, p = 0.002), demonstrating that the shape was concave. More specifically, pre-COVID PWS served to intensify the increase in psychological distress between Time 1 and Time 2 and intensify the decrease between Time 2 and Time 3, based on the negative coefficient for the intercept of quadratic change (b = -0.20, p < 0.01). As such, psychological distress would worsened during the pandemic outbreak for boys reporting more experience of weight stigma before the COVID-19 outbreak. However, as the situation improved (Time 3), psychological distress recovered more substantially, for boys with higher pre-COVID PWS as compared to boys with lower levels of PWS. See Fig. 2 for an illustration of the differences between high and low PWS boys from Time 1 to Time 3 and Table 4 (Ref. [70]), which includes mean DASS-21 scores for both high and low PWS groups.

Level 1: (3) Psychological Distress_{ti} = $\pi_{0i} + \pi_{1i}$ (linear change)_{ti} + π_{2i} (quadratic change)_{ti} + π_{3i} (Health Status)_{ti} + $\pi_{4i}(Age)_{ti} + \pi_{5i}$ (PG)_{ti} + e_{ti}

Level 2

$$\pi_{0i} = \beta_{00} + \beta_{01} (PWS)_i + r_{0i}$$

 $\pi_{1i} = \beta_{10} + \beta_{11} (PWS)_i$
 $\pi_{2i} = \beta_{20} + \beta_{21} (PWS)_i$
 $\pi_{3i} = \beta_{30}$
 $\pi_{4i} = \beta_{40}$
 $\pi_{5i} = \beta_{50}$



Fig. 2. The trajectory for high and low PWS boys across different periods of COVID-19. PWS, perceived weight stigma; In the 10-items of PWS, those with 5 or more responding "yes" are classified as high PWS (n = 61).

4. Discussion

4.1 Trajectory of primary school boys' psychological distress across different periods of COVID-19

The present study evaluated the trajectory of psychological distress among primary school boys across different periods of COVID-19 (before the pandemic, during school closure, and following the lifting of restrictions). The evidence indicates a significant impact of school closure and home restrictions in terms of boys' psychological distress, with an accompanying reduction in psychological distress after the lifting of restrictions. This information provides a clear contribution to the literature, as this study is the first of its kind to focus on the impact of COVID-19 restrictions on the vulnerable population of primary school boys. Moreover, while previous studies have evaluated the effects of quarantine or similar restrictions on adult populations, none have been able to adequately compare levels of psychological distress with longitudinal data from pre-COVID and post-COVID restrictions. As such, the unique data set offered by the present study was able to highlight both the susceptibility of primary school boys to COVIDrelated restrictions and their resilience and recovery following the removal of restrictions [14]. It is noteworthy that the level of psychological distress reported by primary school boys during Time 2 (school closure and home restrictions), as reported by the DASS-21 were even higher than those of Chinese adults and undergraduate students collected during the same time period [6,72]. This addresses gaps in the literature regarding the potential long-term negative effects of COVID-19 on younger students' mental health in particular, as compared to adults [23,73].

Possible interpretations of this sensitivity of primary school boys to COVID-19 measures can be explained by the role of physical activity, which can be considered as a protective factor against psychological distress, such as depression, particularly since boys exhibit higher levels of physical activity than girls [74,75]. As such, increased psychological distress may have resulted from the denial of boys' needs to be more physically active. Additionally, other cumulative risks [13], apart from lack of physical activity, may have resulted from the loss of family income, stress within the family, and an increasing sense of isolation, which is associated with maladaptive coping behaviors. The relatively complete recovery of primary school boys' psychological well-being following the removal of restrictions (e.g., adults were allowed to go back to their workplaces and residents could freely enter or leave their communities) can also be explained by the increase in opportunities for physical activity and a certain degree of social interaction, as well as the removal of the aforementioned cumulative risks at the family and individual level. Potential implications from these findings include the importance of promoting physical activity and social connection during quarantine or home restriction measures, potentially through the use of online resources and social media,

	Mean	(SD)	Significance test ^a	Effect size (Cohen's d) ^{b}	
	Low PWS (n = 222)	High PWS $(n = 61)$	Significance test		
Before the outbreak	0.19 (0.23)	0.44 (0.52)	t = 3.59, p < 0.001	0.80 (Large effect)	
COVID-19 outbreak	1.32 (0.44)	1.79 (0.54)	t = 5.67, p < 0.001	1.02 (Large effect)	
COVID-19 under control	0.19 (0.28)	0.34 (0.44)	t = 2.52, p = 0.01	0.47 (Medium effect)	

Table 4. DASS-21 scores for high and low PWS groups.

PWS, perceived weight stigma; From the 10 items of the PWSS, answers of "yes" on 5 or more is classified as high PWS;

 a due to violation of equality of variance, adjusted statistics using the Welch's *t*-test correction was reported; b based on Cohen's criterion [70].

in order to mitigate the relatively intense psychological effects of these restrictions on young boys.

4.2 The influence of problematic Internet gaming on psychological distress

PG was a key risk factor, and served as a significant covariant in terms of primary school boys' trajectory of psychological distress, with higher levels of problematic Internet gaming associated with even more serious effects on psychological distress. PG may serve as a coping mechanism, particularly for young boys, but as a maladaptive coping mechanism, problematic Internet gaming can exacerbate the effects of home restrictions on boys' psychological well-being. This finding confirms the findings of a review of mental health during COVID-19 which speculated that the nature and extent of the impact on children and adolescents depended on several vulnerability factors [76], and highlighted the necessity of health coping mechanisms. In the absence of healthy coping mechanisms, and productive outlets such as physical activity, boys are more susceptible to increased Internet gaming [29], which is a risk factor for problematic Internet use predominantly among boys predominantly, as compared to girls [31]. Our finding of a significant covariance between PG and psychological distress during COVID-19 confirms other findings in the literature [77-79] for the specific, vulnerable population of primary school boys. Based on earlier findings, we can surmise that PG, as a solitary activity, and one that can lead to addiction and further isolation, impairs the development of individual intrapersonal and social functioning and limits social support from peers [57] which in turn negatively affects boys' mental health [29,32]. Of interest is the finding that the strongest correlation between PG and psychological distress was found following the lifting of COVID-19 restrictions, which may indicate the need for further consideration of the role of PG in the post-pandemic period. Potentially, the strengthened association between PG and psychological distress was fostered during COVID-19 restrictions, when children more vulnerable to addictive behaviors habituated to extensive Internet gaming. This effect may have been exacerbated by parents' return to work, which left children with less supervision, preventing children who had developed more intense PG more vulnerable and less able to adapt to life following an extended time restricted to their home, thus strengthening the association between PG and mental illness. More empirical evidence is needed to explore this particular finding. Overall, the implications from our findings are that preventative measures be put in place to limit primary school boy's access to Internet gaming and to provide better, more adaptive coping mechanisms for dealing with the stress of home restrictions, such as promoting the problem-focused coping strategies (such as time management training and provision of social support) and emotion-focused coping strategies (such as mind-fulness or journaling) as alternatives to PIU behaviors, such as PG [36].

4.3 Role of perceived weight stigma on psychological distress

The present study is unique in evaluated the effect of PWS on psychological distress, particularly among primary school boys. Based on our findings, PWS is clearly and negatively associated with mental health on baseline (pre-COVID measures). Moreover, PWS served as a moderator to intensify the effect of COVID-19 home restrictions on primary school boys' psychological distress. Thus, preexisting stigmas not only harmed boy's psychological wellbeing prior to COVID-19 outbreak but also accelerated both the deterioration of mental health during lockdown period and the recovery of mental health following the lifting of restrictions. However, given the small beta coefficients for PWS in the HLM models, and the relatively large standard deviations for high and low PWS group means, this result should be interpreted with caution. While the effect is significant in statistical terms, the clinical interpretation may be that the impact was relatively minor in scale. In terms of the role of PWS in intensifying the effects of COVID-19 measures on psychological distress, it is wellestablished that PWS is negatively associated with mental health [39,79] during normal times, with some studies suggesting that PWS elevates emotional disorders during COVID-19 restrictions or quarantines [37,41,51]. PWS involves the use of maladaptive coping strategies, such as negative self-talk, isolation, and avoidance, which impact psychological well-being [44]. In the context of COVID-19, other forms of maladaptive coping, such as "eating to

cope," may explain the relationship between pre-COVID PWS and depressive symptoms during COVID [41]. However, in terms of the role of PWS in accelerating the recovery of psychological well-being following the lifting of restrictions, we speculate that this may be due to the fact that, although restrictions were removed, the school campus was closed still closed, and the main source of stigmatization was also largely reduced, since the experience of weight stigma among children comes mainly from school [80]. Since students were able to move freely and were no longer confined to their homes, students who had experienced weigh stigmatization prior to the pandemic had a potentially faster recovery in mental health following the lifting of restrictions, since they were allowed to engage in physical activities but were not exposed to school-based peer stigmatization, and may have also been exposed to less stigmatizing social media content [51]. The implications of these findings, as with those for PG, are that better coping strategies should be provided to children who are restricted to their homes, as well as encouragement to engage in some physical activity at home, which can both boost psychological well-being and mitigate the impact of a sedentary lifestyle on obesity factors.

4.4 Theoretical contributions and implications

The focus of this study was on boys as a vulnerable population [26], who are particularly prone to problematic internet gaming [31,33] and have demonstrated a degree of susceptibility to the effects of perceived weight stigma, which is an under-researched issue among boys [42]. Given the stressor of COVID-19 in terms of lockdowns, school closures [24,25], and other restrictive measures, the dynamics of the relationship between these vulnerabilities (PG and PWS) and the psychological and social impact of COVID-19 should be evaluated from a vulnerability-stressor approach, which can explain the emergence of psychological distress during negative events, such as COVID-19 and associated restrictions [81]. Thus, from the longitudinal approach adopted by this study, evaluating the role of PG and PWS vulnerabilities among boys in terms of psychopathological outcomes during the stresses caused by COVID-19 restrictive measures, we can contribute to a broader theoretical understanding of key factors that should be considered in future applications of a vulnerability-stress model for psychological well-being and resilience [82] among this population, which has included other factors related to preexisting physical and mental health conditions, and socioeconomic disadvantages [83]. The adoption of a longitudinal approach to evaluating these vulnerabilities and stressors contributes empirical evidence to support the application of a vulnerability-stressor approach to evaluation of factors relevant to the developmental psychopathy of young men and boys, which supports some findings reported in prior cross-sectional [84] and longitudinal research [81]. Expanding upon previous research, our findings also align



with findings regarding the role of maladaptive coping [14,44,84], which should be considered in the context of a vulnerability-stress approach to evaluating the developmental psychopathology of boys over the course of negative life events. Given the results reported above, we suggest that further research include the variables problematic gaming and perceived weight stigma, which are two emerging vulnerabilities that deserve further attention and inclusion in more comprehensive models of risk and protective factors related to psychological well-being, with an emphasis on the potential role of both adaptive and maladaptive coping mechanism which can yield further insights for developing research, practice, and policy.

4.5 Limitations and future directions

Certain limitations must be considered. First, due to our approach to the estimation of parameters, we did not estimate the random effect of the rate of change and only discussed fixed effects from the time factors. This may have neglected some significant variations among individuals. Second, the data was collected from one city in China and may not be representative of the country and may not be generalizable to other countries or cultures. Finally, this study emphasized the role of PG and PWS in terms of the trajectory of psychological distress during COVID-19, but did not include an evaluation of other potential factors which may have affected this trajectory. However, due to the lack of pre-COVID data, future studies are limited in the degree to which the longitudinal trajectory of psychological well-being can be evaluated. Nevertheless, since some parts of the world are still undergoing restrictions or mandates related to COVID-19, it is important to collect data on a variety of factors in order to conduct a comparison with the mental health outcomes of boys once these restrictions have been relaxed. The factors of PG and PWS are important for the evaluation of boys psychological well-being, not only during pandemics, but across other times and conditions, such as vacations, hospital stays, or relocations. As such, an evaluation of interventions, based on positive coping strategies, is recommended for boys who are at risk of psychological distress, particularly when PG and PWS are potential negative influences.

5. Conclusions

This study has addressed a gap in the literature through the use of pre-COVID data from primary school boys, finding that psychological distress increased from a baseline level before home restrictions to significantly higher levels during home restrictions, even compared to the adult population, with a decline in psychological distress after restrictions were lifted. This demonstrates both the susceptibility of boys to COVID-19 restrictions and their resilience and ability for self-recovery, which echoes findings from other studies examining the phenomenon of post-traumatic stress disorder (PTSD) [82]. The role of problematic Internet gaming (PG) as a risk factor for psychological distress during different waves of COVID-19 measures was also demonstrated, with a strong covariance of PG with psychological distress, even following the lifting of restrictions. This suggests that PG serve as a maladaptive coping mechanism resulting from cumulative risks, including lack of physical activity and stress within the household. Perceived weight stigma, as measured pre-COVID served to amplify the effects on psychological distress over time, with larger increases in psychological distress during home restrictions and larger decreases following the lifting of restrictions. This suggest that PWS may also involve maladaptive coping mechanisms, such as overeating, negative self-talk, or isolation. As such, we recommend that, during periods of quarantine, lockdown, or home isolation, opportunities for proactive and positive coping strategies be provided, including problem-focused coping strategies (such as provision of social support) and emotion-focused coping strategies (such as mindfulness or journaling), as well as the encouragement of physical activity in the home. This study contributes to both theory and practice by adopting a longitudinal approach to the evaluating of the key risk factors of PG and PWS for the specific and vulnerable population of primary school boys. Future studies on additional risk factors for young boys and additional analysis of the relationship between PG and PWS and psychological distress after further reduction of restrictions is encouraged.

Author contributions

I-HC was responsible for conducted the investigation, seeking resources, writing the original draft, and funding acquisition; Y-CL contributed to the conceptualization, arrangement and supervision; C-YL and W-CW contributed to the conceptualization; JHG contributed to writing-reviewing, editing, visualization, and project supervision.

Ethics approval and consent to participate

This present study involving human participants was reviewed and approved by the Institutional Review Board of the Jianxi Psychological Consultant Association (IRB ref: JXSXL-2020-J013). Online consent was obtained instead of written consent because, during lockdown period involved in this study, physical contact was not possible.

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Conflict of interest

The authors declare no conflict of interest.

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