

MENTAL HEALTH OF ADOLESCENTS DURING THE PANDEMIC: CONSEQUENCES OF SOCIAL ISOLATION

EDITED BY: Miao Qu, Mei Hong Xiu and Atsushi Kamiya
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MENTAL HEALTH OF ADOLESCENTS DURING THE PANDEMIC: CONSEQUENCES OF SOCIAL ISOLATION

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A Framework-Based Approach to Assessing Mental Health Impacts of the COVID-19 Pandemic on Children and Adolescents

Ping-I Lin^{1,2}, Gautam Srivastava³, Linda Beckman⁴, Yunhwan Kim⁵, Maria Hallerback⁶, Drew Barzman⁷, Michael Sorter⁷ and Valsamma Eapen^{1,2*}

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The COVID-19 pandemic has yielded extensive impacts globally in the year of 2020. Although the mental health of children and adolescents may be particularly susceptible to stressors stemming from the pandemic and anti-contagion policies, most ongoing efforts are geared toward curbing the viral spread. In the current perspective, we have identified four domains of factors corresponding to an ecological framework that may directly or indirectly influence the mental health of children and adolescents during the pandemic. The evidence suggests that anti-contagion policies might trigger cascades that impact the mental health of children and their families through multiple different sectors that used to form a safety net for youths. Additionally, children with neuropsychiatric disorders could experience exacerbated symptoms during the pandemic. Furthermore, the risk of domestic violence has surged during the pandemic, which further compounds the imminent mental health crisis. A mental health pandemic could be inevitable if no proactive prevention strategies were in place. Therefore, we recommend understanding each individual mental health risk pathway via the ecological framework in order to develop integrative prevention and intervention strategies.

Keywords: COVID-19, mental health, children, adolescents, anti-contagion policy

INTRODUCTION

Concerns about the impact of coronavirus disease 2019 (COVID-19) on a vulnerable population, such as children and adolescents, have been increasingly noted around the world. Anti-contagion measures to curb the spread of SARS-CoV-2 virus, such as school closures, lockdowns, and travel restrictions, have led to changes that disrupt daily routines and resources, which in turns could impact mental health of children and adolescents. From the biological perspective, the SARS-CoV-2 virus can severely disrupt brain function via immune responses leading to a cytokine storm (1). Recent evidence also demonstrates that some genetic networks may play a role in both COVID-19 and psychiatric disorders such as post-trauma stress disorder, bipolar disorder, and schizophrenia (2). From the psychological perspective, the association between emotional reaction such as loneliness and depression in children and adolescents, has been reported (3). Little is known

about how the COVID-19 pandemic plays a role in the mental health of children and adolescents.

In the current review, we discuss four domains of factors relevant to the mental health of children and adolescents: (1) educational support, (2) health care system, (3) community support, and (4) family support. The elements in these four domains can be classified into higher-demand (e.g., the need for more technological support for online learning and telemedicine) vs. lower-resource (e.g., less financial support due to parental unemployment) components affected by the pandemic (**Table 1**). How these four domains interact with each other to influence mental health of children and adolescents during and after the COVID-19 pandemic can be examined using the Bronfenbrenner's ecological framework (4). This ecological system includes: (1) the *microsystem*, in which the individual can directly interact with its components, such as family members and peers, (2) the *mesosystem*, which involves the interaction of two, or more components in the microsystem (e.g., interplay between school, family, and healthcare providers), (3) the *exosystem*, which exerts more distal or indirect effects on the individual (e.g., parents' experience, etc.), and (4) the *macrosystem* consisting of those components that determine how public affairs are operated (e.g., economic condition of the society)—which can impact the individual well-being via collective environmental effects. How the four domains correspond to the different levels of the ecological framework is illustrated in **Figure 1**. This ecological framework can provide a theoretical ground for the relationship between these four domains and why they should be integrated into the modified anti-contagion measures should the similar event occur in the future. Furthermore, an understanding of the interplay between these components in the four domains can inform researchers and clinicians of how to evaluate mental health issues among children and adolescents to formulate prevention/intervention strategies accordingly.

EDUCATIONAL SUPPORT: IMPACT OF SCHOOL CLOSURES AND ONLINE LEARNING ON MENTAL HEALTH

One of the non-pharmacological interventions (NPIs) that aim to slow down the spread of infections, such as influenza, is school closures (5–8). Approximately 80–90% of children experienced school closures during the COVID-19 pandemic around the world in 2020 (9, 10). However, the effect of school closures on the spread of COVID-19 remains debatable since children exposed to the SARS-CoV-2 virus may be asymptomatic or show minimal symptoms, and given the fact that basic reproduction number (R_0) for the spread of COVID-19 among school-aged children in a classroom has been estimated to be <1 (11). However, school closures may adversely impact the well-being of children (12), and may reduce the availability of health-care workforce, which in turn can negatively impact health outcomes (13). A recent modeling study suggests that school closures can only reduce mortality rates by 2–4% (14). However, this reduction in mortality rates was estimated based on the

TABLE 1 | Factors in the four domains classified into “higher demands” vs. “lower resources” categories are shown.

Domain	Higher demands	Lower resources
School	Technological support for online learning	Face-to-face interactive learning Peer support Special educational support School mental health counseling Sports activities at school
Family	Mental health support for parents Technological support for online learning Interventions implemented by parents	Household financial stability Outdoor family activities
Healthcare system	Telemedicine	Face-to-face healthcare service
Community	Financial support	Interactive social events Freedom to travel Community-based support

assumption that school closures were the only intervention implemented in a society, which is not the case in the vast majority of countries (15).

Emerging literature has addressed the concern about the detrimental impact of school closures on mental health among children and adolescents. These concerns may fall into two categories: changes in lifestyle and exacerbation of existing vulnerability. School closures impose restrictions on two types of activities that are critical for favorable mental health among children and adolescents: social and physical activities. Building, maintaining, and enjoying social connections with peers form a critical developmental task during childhood and adolescence (16), which exert a significant impact on their mental health (17). Schools can provide ample opportunities for social connections, which are severely, if not entirely, jeopardized by school closures due to the COVID-19 pandemic (18). The second type of activities relates to physical activities. A review study presents a consistent relationship between physical activity and mental health among children and adolescents (19). For example, school closures during the COVID-19 pandemic not only decrease the time for established physical activities, but also increase time and opportunities for sedentary behaviors (20). Indeed, one empirical study on Italian children and adolescents with obesity reports that, 3 weeks after COVID-19 lockdown, the participants spent significantly less time on sports (i.e., 2.30 h less per week) while their screen time increased significantly (i.e., 4.85 h more per week) (21). Another empirical study on children and adolescents in Italy and Spain reported on the parental perception that, as a result of the COVID-19 quarantine, their children experienced a range of emotional difficulties and more than half of their children spent <30 min per day on physical activities (22). Schools can provide augmenting support for students' difficulties in various contexts (9, 10). Multiple layers of socializing agents

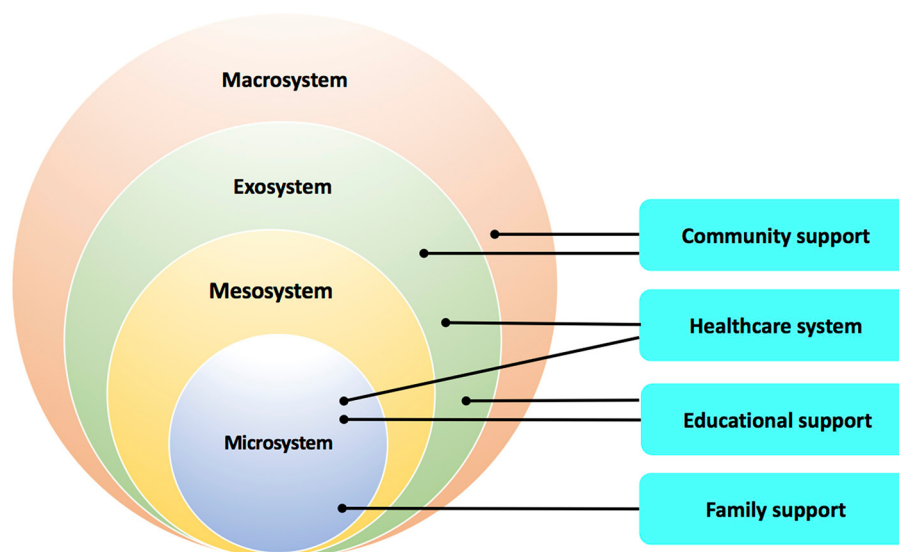


FIGURE 1 | The domains of factors impacted by the COVID-19 pandemic corresponding to the four levels of the ecological framework are shown. Each domain could be involved in more than one level of the ecological framework.

influence a child's development, and schools and teachers are one of the most influential socializing agents for children and adolescents (23). When children and adolescents do not receive proper care from their guardians, and/or when they are under certain risks at home, schools, and teachers can serve as a safeguard and buffer against potential negative consequences (24). For example, schools can be a haven for the students who suffer from abuse or neglect (25). Schools provide support for leisure activities for the students who cannot afford them due to financial hardships (26). In addition, schools can provide mental health counseling for children and adolescents in need (27). School closures during the COVID-19 pandemic have caused a hiatus in resources that youths would otherwise benefit from Lee (9), Van Lancker et al. (10), and Golberstein et al. (28).

The mental health of children with special educational needs (e.g., individuals with neurodevelopmental disorders) as well as their caretakers is also impacted by the pandemic. In a study by Asbury et al., parents of children (5–18 years old) with Special Educational Needs and Disabilities in the UK were asked to describe the impact of COVID-19 on their mental health and that of their child (29). Both parents and children were found to be experiencing loss, worry and changes in mood, and behavior as a result of the rapid social changes that have occurred. Some parents reported feeling overwhelmed and experienced stress to enhance a child's understanding and awareness of personal health and safety. Compared to their neurotypical peers, distant learning programs appear to be more challenging for these children.

Although technology with a focus on digital tools has become an essential strategy for learning activities during the pandemic, it also poses challenges for some individuals. For example, the internet speed may not accommodate with online meetings when there are multiple users at the same household. Online learning may also make it more challenging to be actively

engaged in either lectures or interactive discussions and affect their learning outcomes. As Drane and colleagues stated, children living in financially disadvantaged communities could be subject to long-term educational disengagement, digital exclusion, poor technology management, and increased psychosocial challenges during the pandemic (30). These challenges, partly due to family's capacity of resources and partly due to individual reasons, could trigger more stress for students as well as parents/carers.

HEALTH CARE SYSTEM

Impact of The Overwhelmed Medical Care System on Mental Health Care Quality

The health care systems have been overwhelmed by the near impossibility of responding to the needs of a multitude of seriously infected patients (31). Since the World Health Organization (WHO) declared a public health emergency on January 30, 2020 (WHO, 2020), relentless efforts have been made to contain the pandemic, which has included treating innumerable patients with limited resources and efforts to find effective treatments such as a vaccine or other drugs, all of which have overwhelmed the medical care system unprecedentedly (32). This has caused gross neglect of other health priorities, such as care of chronic diseases, most notably, mental health care. Paradoxically, the importance of the latter has increased several times, further compounded by the negative impact of the containment measures taken to subdue the virus.

For children or adolescents with neuropsychiatric disorders or any mental health issues, changes in modes of or access to mental health care may be more disruptive than their unaffected peers. Closures of schools and outpatient units, restrictions of hospital policies, along with decreased attention from parents amidst the pandemic, might exacerbate existing

neuropsychiatric conditions of affected children (28). Visiting physicians regularly, acquiring prescribed medications, and visits at emergency departments, have become much more difficult. Some children or adolescents with psychiatric disorders are contracted with COVID-19 because these patients may present with impulsivity, irritability, or poor judgement due to cognitive impairments, which may adversely impact personal hygiene behaviors to increase the risk of infections (33, 34). Previous evidence indicates that severely mentally ill patients have an increased risk of pneumonia, thus making the present pandemic more severe and fatal for them (35). Additionally, individuals with intellectual disability are found to have higher mortality rates associated with COVID-19 (36), which may be partially attributable to feeding difficulty due to deteriorating muscle tone and behavioral dysregulation (37) and challenges in engaging them in proper health care. These findings have lent support to the hypothesis postulated by Sartorius that mental health comorbidities to other infectious diseases will be the main challenge for medicine in the twenty-first century (38).

One recent study observed exacerbated mood and behavioral symptoms in children with psychiatric diagnoses, such as attention deficit and hyperactivity disorder (ADHD) during the pandemic (39). According to this study based on parental reports, ADHD behaviors were significantly worsened in comparison to their normal state. Also, the children's negative mood state was associated with ADHD symptoms. The authors further found that a parent's mood state also had an impact on children's ADHD symptom. Therefore, the pandemic-associated challenges might also increase stress levels of parents, which in turn affected how parents handled ADHD symptoms of children.

Choi et al. observed that the unprecedented global health scenario created by the COVID-19 pandemic has ushered in a "Second Pandemic" of the mental health crisis in the global health system and community (40). The latter will substantially affect all children, adolescents, adults, old people, and thus has to be addressed simultaneously, despite a highly overwhelmed medical care system. Dalton et al. found that healthcare workers are experiencing an unprecedented demand for caring for a predominantly adult patient population, thus magnifying the invisibility of children's urgent psychological needs who account for over 42% of the world's population (41).

Impact of Access to Mental Health Services

School closures are likely to put some of the school-based mental health programs on hold. Children needing treatments may have to seek support from Emergency Departments or clinicians at private clinical settings—who may have no prior knowledge or access to the relevant information including reports from schools, due to privacy regulations, and thus may not be able to provide optimal support for the school-aged children (28). For children and adolescents with ADHD, the changes in their daily life due to restrictions may be challenging. The stress may lead to more behavioral problems. Further, since schools are closed, students may need to organize their studies and attend online classes which they

may find difficult to manage due to poor organizational ability, distractibility, and poor focus. Hence professional bodies such as the European ADHD Guidelines Group (EAGG) has published guidance on the assessment and management of ADHD during the COVID-19 virus pandemic (42). The EAGG are recommending that pharmacological treatment of ADHD should continue as usual. Further, individuals should, if indicated, be offered the opportunity to start medication. Telephone and appropriate online video technology should be used and routine cardiovascular clinical examination and face-to-face visits can be postponed. To reduce oppositional defiant and disruptive behaviors, families are recommended to use behavioral parenting strategies.

Another group of children that may also be substantially impacted by the pandemic are those diagnosed with autism spectrum disorder (ASD). The impact of the pandemic is attributable not only to disruptions of in-person health service but also the core features of ASD: an obsession with routine (43). A recent parent survey shows that more than three-fourths of parents felt that managing ASD children's behavioral disturbances became more difficult amidst the pandemic than the pre-outbreak period. Additionally, the survey reveals that at least one in every three children has presented with more frequent or more intense behavioral problems (44).

COMMUNITY SUPPORT: SOCIOECONOMIC CHALLENGES IMPOSED BY THE PANDEMIC

Stressors such as inadequate information, lack of in-person contact with classmates, friends, and teachers, lack of personal space at home, economic downturn, and family financial loss, increased alcohol consumption in the household, can all have problematic and enduring effects on children and adolescents than the infection itself (28, 45). The COVID-19 pandemic may hence worsen existing mental health problems and lead to more cases among children and adolescents because of the combination of different stressors. For example, learning from previous pandemics, Sprang and Silman found that the mean post-traumatic stress scores were four times higher in children who had been quarantined than in those who were not quarantined (46). Furthermore, the interaction between lifestyle changes and psychosocial stress caused by home confinement could further aggravate the detrimental effects on child physical and mental health, which could cause a vicious circle (47).

In the event of home confinement, parents are often the closest and best resource for children. Close and open communication with children is the key to identifying any physical and psychological issues and comforting children in prolonged isolation. Children are constantly exposed to epidemic-related news, so having direct conversations with children about these issues could alleviate their anxiety (48). However, parents of children who are hospitalized for COVID-19 experience a great deal of stress, depression, and anxiety (48). These phenomena reflect a dearth of community-based resources to ameliorate mental health impacts due to extensive

anti-contagion policies. Establishing community-based resources amidst the pandemic requires timely efforts of linking different sectors, such as school-based and health care services as well as governmental agencies to provide educational, health, and financial supports for affected individuals, particularly for those from disadvantaged populations.

FAMILY SUPPORT

Mental Health of Parents or Caretakers

Family support has been impacted by the pandemic because of the mental health of parents (or caretakers). In a study by Yuan et al. (48), 50 parents of children hospitalized during the COVID-19 epidemic (EH), and 50 parents of children hospitalized during the non-epidemic period (NEH) were included and scores for anxiety, depression, and dream anxiety were compared. The anxiety score of EH parents was significantly higher than that of parents of NEH children. Similarly, the depression scores of parents of EH children were also significantly higher than that of NEH children. Simultaneously, the VDAS scores and SF-36 scores of parents of EH children were significantly higher than that of NEH children. The mental health problems of parents of EH children were more serious, and their anxiety and depression were more severe, than the mental health problems encountered by parents of NEH children.

An alarming trend of the adverse consequence of the pandemic is domestic violence, which is associated with a range of factors including economic stress, disaster-related instability, increased exposure to exploitative relationships, and reduced options for support (49). Recently, anecdotal evidence from several countries has shown increases in intimate partners, women and violence toward children due to isolation and quarantine. Furthermore, already vulnerable children with special needs might experience such impacts much more acutely than the general child population (50). The increasing domestic violence may be attributable to stress associated with financial constraints and health concerns, which can be exacerbated by increasing substance misuse during the COVID-19 pandemic (51, 52).

Mental Health of Children and Adolescents

Pisano et al. using a questionnaire study with 6,510 children (4–10 years old), reported that one in four children (26.48%), showed regressive symptoms such as the demand for physical proximity to their parents during the night and almost one in five (18.17%) manifested fears that they never had before (53). Half of the children (53.53%) showed increased irritability, intolerance to rules, whims and excessive demands, and one in five presented with mood changes (21.17%) and sleep problems including difficulty falling asleep, agitation, and frequent waking up (19.99%). One in three (34.26%) displayed nervousness about the topic of the pandemic when it was mentioned at home or on TV. Almost one in three (31.38%) seemed calmer and one in two (49.57%) seemed wiser and more thoughtful. Almost all (92.57%) seemed able to adapt to the pandemic restrictions; even though one in two (43.26%) seemed more listless in terms of the

activities they used to perform before the pandemic including playing, studying, and gaming.

Orgiles et al. surveyed 1,143 parents of Italian and Spanish children aged 3–18 years, providing information about how the quarantine affects their children and themselves, compared to before the home confinement (22). The results showed that 85.7% of the parents perceived changes in their children's emotional state and behaviors during the quarantine. The most frequent symptoms were difficulty concentrating (76.6%), boredom (52%), irritability (39%), restlessness (38.8%), nervousness (38%), feelings of loneliness (31.3%), uneasiness (30.4%), and worries (30.1%). As expected, children of both countries used monitors more frequently, spent less time doing physical activity, and slept more hours during the quarantine. Furthermore, parents tended to report more emotional problems in their children when they spend less time together compared to other families.

DISCUSSIONS

The ecological framework can be useful in expanding the scope of research questions and making cross-disciplinary connections. Consistent with an ecological perspective, our review of research addresses key characteristics of children and adolescents in the COVID-19 pandemic. These four domains, which include family, school, healthcare, and community, contains the most essential components that can affect or reflect the pandemic's impact on mental health issues of children and adolescents. The ecological framework allows us to examine the relationship between these components/domains, which can help clinicians identify predisposing, precipitating, and perpetuating factors, associated with the pandemic and strategize intervention and intervention plans accordingly.

The recommendations based on this framework are composed of two steps of information processing and evaluation. *Step one* is to categorize potential risk factors associated with mental health issues. As mentioned earlier, the components associated with mental health issues in the four domains affected by the pandemic can be classified into “higher-demand” vs. “lower-resource” categories. Higher-demand components may not only require an increased amount of existing resources but also depend on new solutions to fulfill the need. Similarly, lower-resource components may require alternative sources to fill need gaps. **Table 1** provides a template for the risk-assessment matrix for clinicians. This approach can allow us to identify and prioritize points of intervention (or even prevention). *Step two* is to understand the “risk pathway” (i.e., how sequential events or responses that lead to mental health consequences) through the conceptual ecological framework consisting of microsystem, mesosystem, exosystem, macrosystem, and, finally, chronosystem.

Children and adolescents, particularly those with neuropsychiatric conditions, may provide an example of how the ecological framework can be used to understand the “mental health risk pathway” in the context of COVID-19 pandemic. Their vulnerability can be attributable to limited access to support from communities due to anti-contagion

policies and overwhelmed health care systems. Simultaneously, families are dealing with further challenges due to self-isolation or quarantine such as parents “working from home,” physical space limitations, or having to care for family members who may have acquired the infection or are at high risk for COVID-19 infection etc. Other stressors may include fear of infection, limited access to health care, inadequate food and medical supplies, loss of employment and financial problems, relationship stress, to name a few of them. Furthermore, parental stress can negatively influence parenting ability and may lead to domestic violence or other maladaptive coping which in turn can negatively impact the parent-child relationship and interactions. This scenario exemplifies how microsystem (e.g., parents under stress), mesosystem (e.g., reduced support from collaborations between school and family), and macrosystem (e.g., economic downturn leading to unemployment of parents), could interact with each other form a vicious cycle. Finally, how chronosystem (i.e., the effect of time) may be changed as the pandemic unfolds and universal vaccination is underway should be continuously monitored.

These stressors need to be ameliorated by cross-disciplinary strategies governed by integrative policies. It is hence critical to provide mental health care service to simultaneously address the concerns of both children and their families and implement strategies to proactively engage multiple stakeholders. A better understanding of the relationship between these stressors (e.g., either linear, circular, or reciprocal relationship) can help us identify the point of intervention and generate novel hypotheses to delineate mental health risk pathways. Such strategies may include the collaborations between clinical settings, community-based agencies that provide recourses for individuals and

families, and school-based support systems, to form special task forces that can coordinate trans-institutional supports. Specifically, novel telemedicine platforms that can enhance and support patients’ adherence to interventions despite the anti-contagion policies and enhance cross-talks between different resources have become increasingly important.

To sum up, the causes of impacts of the COVID-19 pandemic on the mental health of children and adolescents are manifold. Therefore, an integrative approach is needed to tackle these issues with joint efforts to increase the resilience of youths and society as a whole. Recent evidence suggests that the multiple waves of this pandemic might become inevitable until vaccination can effectively keep the large-scale viral spread under control. Therefore, how to integrate these cross-disciplinary strategies into mental health for children and adolescents via the ecological framework shall be established as a long-term implementation plan.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

AUTHOR CONTRIBUTIONS

P-IL and VE were in charge of the conceptualization process for this manuscript. All authors contributed to the article and approved the submitted version.

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What Factors Are Most Closely Associated With Mood Disorders in Adolescents During the COVID-19 Pandemic? A Cross-Sectional Study Based on 1,771 Adolescents in Shandong Province, China

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Background and Aims: COVID-19 has been proven to harm adolescents' mental health, and several psychological influence factors have been proposed. However, the importance of these factors in the development of mood disorders in adolescents during the pandemic still eludes researchers, and practical strategies for mental health education are limited.

Methods: We constructed a sample of 1,771 adolescents from three junior high middle schools, three senior high middle schools, and three independent universities in Shandong province, China. The sample stratification was set as 5:4:3 for adolescent aged from 12 – 15, 15 – 18, 18 – 19. We examined the subjects' anxiety, depression, psychological resilience, perceived social support, coping strategies, subjective social/school status, screen time, and sleep quality with suitable psychological scales. We chose four widely used classification models-k-nearest neighbors, logistic regression, gradient-boosted decision tree (GBDT), and a combination of the GBDT and LR (GBDT + LR)-to construct machine learning models, and we utilized the Shapley additive explanations value (SHAP) to measure how the features affected the dependent variables. The area under the curve (AUC) of the receiver operating characteristic (ROC) curves was used to evaluate the performance of the models.

Results: The current rates of occurrence of symptoms of anxiety and depression were 28.3 and 30.8% among the participants. The descriptive and univariate analyses showed that all of the factors included were statistically related to mood disorders. Among the four machine learning algorithms, the GBDT+LR algorithm achieved the best performance for anxiety and depression with average AUC values of 0.819 and 0.857. We found that the poor sleep quality was the most significant risk factor for mood disorders among Chinese

adolescents. In addition, according to the feature importance (SHAP) of the psychological factors, we proposed a five-step mental health education strategy to be used during the COVID-19 pandemic (sleep quality-resilience-coping strategy-social support-perceived social status).

Conclusion: In this study, we performed a cross-sectional investigation to examine the psychological impact of COVID-19 on adolescents. We applied machine learning algorithms to quantify the importance of each factor. In addition, we proposed a five-step mental health education strategy for school psychologists.

Keywords: COVID-19, mood disorders, sleep quality, resilience, adolescents, GBDT, SHAP value

INTRODUCTION

Since it was first reported by the World Health Organization (WHO) on December 31, 2019, the coronavirus disease 2019 (COVID-19) has cumulatively infected more than 130 million people, and it caused nearly 3 million deaths worldwide as of April 14, 2021 (1). Extensive research has shown that major adverse social events, such as terrorist attacks (2, 3), economic crises (4, 5), natural disasters (6, 7), and pandemics (8–10), can have a severe impact on people's mental health. As the most severe pandemic in recent decades, COVID-19 rapidly spread across the world, and the social impacts have far exceeded those of other pandemics, including the severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS), and novel influenza A (H1N1) pandemics. Therefore, the issue of mental health during the COVID-19 pandemic has received considerable critical attention.

Adolescents are members of society that are vulnerable to the psychological impacts of COVID-19. Many countries have closed schools to prevent the spread of the disease, resulting in multiple consequences for adolescents' daily lives: increased screen time, worry for their families and countries, social distancing, and home confinement. Given that adolescence is a critical neurobiological period in the development of higher-order cognition, stressful experiences, such as lockdowns and social isolation, can lead to the early development of multiple psychiatric disorders (11). Hawke et al. performed a retrospective study that compared adolescents' mental health before and after the onset of the COVID-19 pandemic in Canada and found that the symptoms of depression and anxiety significantly increased (12). In China, 43.7, 37.4, and 31.3% of high school students showed symptoms of anxiety, depression, or a combination of depression and anxiety during the COVID-19 lockdowns (13).

COVID-19 cases recently rose for a seventh consecutive week with a rate of over 4.5 million new cases per week (1). According to a predictive model based on the Italian population, even if a combination of fast vaccination rollouts and restrictive non-pharmaceutical interventions is implemented, there will still be an estimated 18,000 deaths from April 2021 to January 2022 (14). Prolonged or intermittent lockdowns are predicted to last until 2022 (15). There is an urgent need to recognize the mechanisms that potentially influence adolescents' mental health. Many psychosocial factors, such as psychological resilience and

social support, have been demonstrated as crucial regulators in multisystemic processes that can contribute to positive outcomes (16, 17). In addition, demographic characteristics, sleep quality, and screen time were reported to influence a wide range of cognitive and emotional functions (18–22). However, the importance of these factors in the development of mood disorders in adolescents during the pandemic still eludes researchers, and practical strategies for mental health education are limited.

To this end, we performed a cross-sectional investigation based on 1,771 adolescents from six independent middle schools and three independent universities in Shandong province to examine the psychological impacts of COVID-19 on adolescents. We focused on psychological resilience, perceived social support, coping strategies, subjective social/school status, screen time, and sleep quality, constructed machine learning models for these factors, and applied the SHAP (Shapley additive explanations value) to quantify the impact of each factor. In addition, we proposed a five-step mental health education strategy for school psychologists.

MATERIALS AND METHODS

Ethics Statement

The Ethics Committee of Shandong University approved this human-involved survey (ECSBMSSDU2021-1-067). Throughout the whole study, we strictly followed the Declaration of Helsinki, did not collect or involve any subject-identifying information, and electronically obtained informed consent from all of the participants.

Data Collection

We performed this cross-sectional study to examine the mental status of Chinese adolescents during the COVID-19 pandemic and to explore the potential mechanisms of the impact of COVID-19 on adolescents' mental health. We collected data between 20 April and 30 April, 2021 by using an online questionnaire website (www.wenjuan.com). According to a statement from the WHO, individuals aged 10 – 19 years were defined as adolescents (23). According to the ethics requirements of Shandong University, children-involved psychological investigation is strictly limited, so we did not include children in this study, which is one of our limitations.

The adolescents who were aged between 12 and 19 years old were invited. We hypothesized that younger adolescents were more susceptible to mood disorders. Therefore, the designed sample stratification was set as 5:4:3 for adolescent from junior high school, senior high school, and university. We recruited participants from three junior high schools (predominantly aged between 12 and 15 years old), three senior high schools (predominantly aged between 15 and 18 years old), and three colleges (predominantly freshmen of 18 – 19 years old) (considering that the academic level of the school might influence students' mental status, we selected schools of different levels on a 1:1:1 scale). The details of the included schools are provided in **Supplemental Table 1**. In compliance with the requirements of the Ethics Committee of Shandong University, adolescents who have recently suffered severe negative life events or were diagnosed with severe psychological disorders were not to be recruited in the study as subjects. In this study, we defined "effective questionnaire" as the retrieved questionnaires which had been completed without blanks and having no obvious or doubtful responses. For example, if a subject chose the first option in all questions, this questionnaire was defined as ineffective as this type of consistent responses across all questions are considered rare and doubtful. We in all invited 1,776 subjects to participate in this investigation, among which 260/1,776 subjects completed the paper questionnaires and 1,511/1,776 subjects completed the online questionnaires. All of the paper questionnaires were effective. Two online received responses left blanks and three cast obvious mistakes. Therefore, we collected 1,771 effective questionnaires in total. The actual sample stratification was around 5:4:3 (865:511:395) for adolescents from junior high school, senior high school, and university.

DESIGNED QUESTIONNAIRE

Basic Personal Characteristics

We collected the participants' demographic characteristics, including their gender (male/female) and grade (from grade 7 to grade 12, plus the freshman year in college). We investigated the impact of COVID-19 on the participants' families, including having relatives or friends who had been infected (yes/no) and having relatives or friends who had been quarantined (yes/no).

We also investigated two aspects of personal living styles: physical activity and screen time. Physical activity was assessed according to the average time spent participating in moderate to vigorous physical activity over the last week. The amount of physical activity was categorized into four levels: ≤ 30 , 30 – 60, 60 – 120, and more than 120 min. According to the WHO, physical activity includes play, games, sports, transportation, chores, recreation, physical education, or planned exercise in the context of family, school, and community activities for children and young people (24). Screen time was assessed according to the average time per day spent on electronic devices (including televisions, smartphones, tablets, and computers), and this was categorized into four levels: ≤ 30 , 30 – 60, 60 – 120, and more than 120 min. During this investigation, the subjects from six middle schools and three universities were all studying at school but not online. Therefore, they did not have to use electric devices

to attend classes. Besides, if they utilized computers or smart phones to study in their rest time, this time was included in the screen time.

Assessment of Anxiety and Depression

We utilized the General Anxiety Disorder-7 (GAD-7, Chinese version) to assess the symptoms of anxiety experienced in the previous 2 weeks. The GAD-7 is a self-reported and simple anxiety measurement with high reliability and validity (25), and its Cronbach's α coefficient in Chinese adolescents was previously found to be 0.917 (26). The GAD-7 includes seven four-point Likert scales (ranging from "not at all" [0 points] to "nearly every day" [three points]) that describe the typical symptoms of GAD. Individuals with scores of 5 – 9, 10 – 14, 15 – 21 showed mild, moderate, or severe anxiety symptoms, respectively. In the current study, the Cronbach's α coefficient was 0.916.

We utilized the Patient Health Questionnaire-9 (PHQ-9, Chinese version) to assess the depressive symptoms experienced in the previous 2 weeks. The PHQ-9 is a self-reported depression measurement with high reliability and validity (27), and its Cronbach's α coefficient in Chinese adolescents was previously found to be 0.869 (26). The PHQ-9 includes nine four-point Likert scales (ranging from "never" [0 points] to "almost every day" [three points]) that describe the typical symptoms of depression. Individuals with scores of 5 – 9, 10 – 14, 15 – 19, or 20 – 27 showed mild, moderate, moderately severe, or severe depressive symptoms, respectively. In the current study, the Cronbach's α coefficient was 0.918.

Assessment of Sleep Quality

We utilized the Self-Rating Scale of Sleep (SRSS) to assess sleep quality. The SRSS is a self-reported sleep quality measurement tailored for Chinese people (28). Its reliability and validity have been proven by several previous studies (29, 30). The SRSS includes ten items with a score ranging from the best sleep quality (one point) to the worst sleep quality (five points). Individuals with total scores of 23 – 29, 30 – 39, or 40 – 50 showed mild, moderate, or severe sleep disturbance, respectively. In the current study, Cronbach's α was 0.784.

Assessment of Subjective Social Status

We utilized the Subjective Social Status-Adolescent (SSS-A, Chinese version) scale, which was derived from the MacArthur Subjective Social Status scale (31, 32). The SSS-A was developed explicitly for measuring adolescent's SSS with a high reliability and validity. The SSS-A includes two ten-point Likert scales ranging from "the lowest" (one point) to "the highest" (10 points) to evaluate the participants' subjective social status and campus status, respectively.

Assessment of Psychological Resilience

We utilized the Connor-Davidson Resilience Scale-10 (CD-RISC-10, Chinese version) to assess the participants' psychological resilience over the last month. The CD-RISC-10 is a self-reported psychological resilience measurement that includes ten five-point Likert scales that range from "not true at all" (0 points) to "true nearly all the time" (four points)

(33). The higher the total score, the higher the psychological resilience. Many previous studies have demonstrated its reliability (Cronbach's $\alpha > 0.9$) and validity (34, 35). In this study, the Cronbach's α was 0.950.

Assessment of Coping Strategies

We utilized a recently developed eight-item coping strategy measurement derived from the original Ways of Coping (36, 37), and tailored for Chinese adolescents. This measurement includes eight four-point Likert scales that range from "never used" (one point) to "used a great deal" (four points), including five adaptive coping strategies and three maladaptive coping strategies. The Cronbach's α was 0.78. The higher the total score, the better the coping strategy. In this study, the Cronbach's α was 0.862.

Assessment of Perceived Social Support

We utilized the Multidimensional Scale of Perceived Social Support (MSPSS, Chinese version) to investigate the social support of each participant; this is a self-reported and highly effective social support measurement (38). The reliability and validity of the MSPSS were proven in a population of Chinese adolescents (22, 39, 40). The MSPSS includes twelve seven-point Likert scales that range from "very strongly disagree" (one point) to "very strongly agree" (seven points), which could be classified into three subscales to evaluate the perceived social support from the family, friends, and a significant other, respectively. The higher the total score, the higher the perceived social support. Xu et al. reported that the Cronbach's α of the total scale and three subscales were 0.958, 0.905, 0.915, and 0.934, respectively. In the current study, the Cronbach's α was 0.966.

STATISTICS

Descriptive and Univariate Analysis

First of all, it is necessary to use univariate analysis methods in order to explore the basic relations between features and labels. To be specific, we applied the Chi-square test for the binary and polytomous unordered features. In particular, for features that had cells with a count of <5 , we used Fisher's exact test to assess the accuracy. For polytomous ordered features, we calculated Somer's d coefficients in order to measure the consistency (that is, whether the two variables tend to move in the same or opposite directions). On the other hand, in terms of consistent features, we applied the Mann-Whitney U test to determine whether the average value of each feature was different between two labels. According to the results of the univariate analysis, we preprocessed the dataset to improve the models' performance.

Machine Learning Models

It should be noted that this is a typical binary classification problem. Therefore, we chose four widely used classification models: k -nearest neighbors (KNN), logistic regression (LR), gradient-boosted decision tree (GBDT), and a combination of the GBDT and LR (GBDT+LR).

KNN: KNN is a widely utilized machine learning algorithm in the field of classification and regression prediction due to its simple implementation and outstanding performance (41).

The KNN method stores all available instances and classifies new instances based on a similarity measure (such as distance functions) (42).

GBDT: GBDT is a new algorithm that combines decision trees and holistic learning techniques. Its basic idea is to combine a series of weak base classifiers into a strong base classifier (43, 44). In the learning process, a new regression tree is constructed by fitting residuals to reduce the loss function until the residuals are less than a certain threshold, or the number of regression trees reaches a certain threshold. The advantages of GBDT are good training effect, less overfitting, and flexible handling of various data types, including continuous and discrete values (45).

LR: LR is a supervised machine learning algorithm for learning classification and regression problems. It is one of the most widely used methods in health sciences research, especially in epidemiology (46). Many previous studies have shown that LR is effective in analyzing risk/protective factors in the field of psychological research (47–49).

GBDT+LR: GBDT+LR is a very novel machine learning algorithm for classification and regression problems. The performance of LR model depends strictly on feature extraction since LR can only find a linear relationship. Under this circumstance, using GBDT to firstly process the variables by finding their locations in trees' leaf nodes and encoding them into new features contribute to solving this problem. It helps to combine the information of the features automatically and improve the performance of the following LR model (50).

Parameter Selection

To determine the optimal parameters, we used the `sklearnGridSearchCV` module to perform a grid search, the details of which are listed in the following. Firstly, we set up the optional ranges of all parameters. Secondly, we used five-fold cross-validation to test the AUC (area under the curve) on the validation dataset with the parameters in every possible combination. The combination that had the highest AUC value was considered the best. Five-fold cross-validation involved randomly dividing all of the datasets into five equal subsets and using four of them as the training dataset to fit the model. The effect of the model was measured with the AUC value, which we obtained by applying the model on the one subset that was left as a validation dataset.

Model Evaluation

The AUC of the receiver operating characteristic (ROC) curves, sensitivity, and specificity (sensitivity = $TP / (TP + FN)$, specificity = $TN / (TN + FP)$, where TP represents true positive assignments, TN represents true negative assignments, FP represents false positive assignments, and FN represents false negative assignments) were used to evaluate the machine learning models.

To evaluate the effects of the machine learning models, we randomly split the dataset more than 100 times, with 85% as the training set and 15% as the test set. After splitting the dataset, we applied the four models mentioned above to fit the training set. By repeating the random splitting of the dataset, we countered the randomness of the results. Then, we calculated the sample mean

TABLE 1 | Descriptive analysis of the 1,771 samples.

Variable (<i>n</i> = 1771)	All Participants (%)	Anxiety		<i>P</i> -value	Depression		<i>P</i> -value
		NO (%)	YES (%)		NO (%)	YES (%)	
Gender							
Male	917 (51.8)	686 (74.8)	231 (25.2)	0.002	658 (71.8)	259 (28.2)	0.017
Female	854 (48.2)	583(68.3)	271 (31.7)	C	568 (66.5)	286 (33.5)	C
Grade							
7 th in middle school	196 (11.1)	145 (74.0)	51 (26.0)	0.000	146 (74.5)	50 (25.5)	0.000
8 th in middle school	596 (33.7)	428 (71.8)	168 (28.2)	C	417 (70.0)	179 (30.0)	C
9 th in middle school	73 (4.1)	37 (50.7)	36 (49.3)		46 (63.0)	27 (37.0)	
10 th in middle school	302 (17.1)	225 (74.5)	77 (25.5)		208 (68.9)	94 (31.1)	
11 th in middle school	78 (4.4)	58 (74.4)	20 (25.6)		54 (69.2)	24 (30.8)	
12 th in middle school	131 (7.4)	79 (60.3)	52 (39.7)		67 (51.2)	64 (48.9)	
Freshman in college	395 (22.3)	297 (75.2)	98 (24.8)		288 (72.9)	107 (27.1)	
Having relatives or friends who have been infected							
Yes	9 (0.5)	2 (22.2)	7 (77.8)	0.003	1 (11.1)	8 (88.9)	0.001
No	1,762 (99.5)	1,267 (71.9)	495 (28.1)	F	1,225 (69.5)	537 (30.5)	F
Having relatives or friends who have been quarantined							
Yes	116 (6.6)	63 (54.3)	53 (45.7)	0.000	64 (55.2)	52(44.8)	0.001
No	1,655 (93.5)	1,206 (72.9)	449 (27.1)	C	1,162 (70.2)	493(29.8)	C
Physical activity							
<30 min	547 (30.9)	354 (64.7)	193 (35.3)	0.000	332 (60.7)	215 (39.3)	0.000
30 – 60 min	816 (46.1)	611 (74.9)	205 (25.1)	S	606 (74.3)	210 (25.7)	S
60 – 120 min	251 (14.2)	181 (72.1)	70 (27.9)		179 (71.3)	72 (28.7)	
> 120 min	157 (8.9)	123 (78.3)	34 (21.7)		109 (69.4)	48 (30.6)	
Screen time							
<30 min	570 (32.2)	427 (74.9)	143 (25.1)	0.023	408 (71.6)	162 (28.4)	0.014
30 – 60 min	392 (22.1)	281 (71.7)	111 (28.3)	S	282 (71.9)	110 (28.1)	S
60 – 120 min	265 (15.0)	186 (70.2)	79 (29.8)		182 (68.7)	83 (31.3)	
<120 min	544 (30.7)	375 (68.9)	169 (31.1)		354 (65.1)	190 (34.9)	
Sleep quality (mean [standard deviation])	18.75 (5.4)	17.27 (4.4)	22.51 (5.8)	0.000	16.9 (4.0)	22.92 (5.8)	0.000
				M			M
Subjective social status (mean, [standard deviation])							
Social status	5.8 (2.0)	5.92 (2.0)	5.51 (2.0)	0.000	5.98 (1.9)	5.41 (2.0)	0.000
				M			M
School status	6.18 (2.1)	6.4 (2.1)	5.62 (2.1)	0.000	6.49 (2.0)	5.46 (2.1)	0.000
				M			M
Psychological Resilience (mean (standard deviation))	25.57(9.1)	27.22(9.3)	21.4(7.1)	0.000	27.6(9.1)	21(7.1)	0.000
				M			M
Perceived social support (mean [standard deviation])							
Social support from the family	17.27 (5.3)	18.06 (5.2)	15.28 (5.1)	0.000	18.4 (5.0)	14.74 (5.2)	0.000
				M			M
Social support from the friends	16.83 (5.2)	17.56 (5.2)	14.98 (5.0)	0.000	17.84 (5.1)	14.56 (4.9)	0.000
				M			M
Social support from a significant other	16.73 (5.2)	17.53 (5.1)	14.71 (5.0)	0.000	17.82 (5.0)	14.28 (4.9)	0.000
				M			M
Total social support	50.83 (14.8)	53.16 (14.6)	44.96 (13.5)	0.000	54.06 (14.2)	43.58 (13.4)	0.000
				M			M
Coping strategy (mean [standard deviation])							
Adaptive coping strategy	15.56 (3.5)	16.12 (3.5)	14.13 (3.3)	0.000	16.24 (3.5)	14.02 (3.2)	0.000
				M			M
Maladaptive coping strategy	6.75 (2.4)	6.57 (2.4)	7.22 (2.3)	0.000	6.54 (2.5)	7.24 (2.3)	0.000
				M			M

C, Chi-square test; F, Fisher's test; S, Somer's d test; M, Mann-Whitney test.

\bar{X} and sample standard deviation S of the AUC value, sensitivity, and specificity of these models for the test set. The formulas listed below estimate the mean and the asymptotic 95% confidence intervals (95% CI) of these indices.

$$\mu = \bar{X}$$

$$95\%CI = (\bar{X} - 1.96*S, \bar{X} + 1.96*S)$$

Software

Our datasets were collected and descriptively analyzed using Excel 2016. Univariate analysis was performed using IBM SPSS Statistics 25. The machine learning models were constructed using the scikit-learn 0.24.2 package. A P -value of <0.05 was considered statistically significant.

RESULTS

The Rate of Occurrence of Anxiety and Depression Symptoms

The GAD-7 and PHQ-9 were utilized to evaluate the anxiety and depression among 1,771 participants. The rate of occurrence of anxiety symptoms was 28.3% (502/1,771). A total of 21.7% (385/1,771) of the participants showed mild anxiety symptoms, 4.5% (79 / 1,771) of the participants showed moderate anxiety symptoms, and 2.1% (38/1,771) of the participants showed severe anxiety symptoms. The rate of occurrence of depression symptoms was 30.8% (545/1,771). A total of 21.2% (375/1,771) of the participants showed mild depression symptoms, 5.6% (100/1,771) of the participants showed moderate depression symptoms, 2.7% (47/1,771) of the participants showed moderate to severe depression symptoms, and 1.3% (23/1,771) showed severe depression symptoms. In addition, 20.1% (356/1,771) of the participants showed both anxiety and depression symptoms. Then, we divided the 1,771 participants into two groups according to whether they were anxious or depressed for further factor analysis.

Descriptive and Univariate Analyses of Demographic Characteristics, Personal Living Styles, and Psychological Factors

The results of the descriptive analysis of the 1,771 participants are presented in **Table 1**. As for the demographic characteristics, we found that adolescents who were female, were in graduating grades, and had relatives/friends that had infected by/quarantined with COVID-19 were more likely to experience anxiety/depression ($P < 0.05$). As for personal living styles, more physical activity and less screen time could prevent adolescents from experiencing anxiety/depression ($P < 0.05$). Among the included psychological factors, sleep quality, resilience, subjective social/school status, perceived social support (from family/friends/significant others), and adaptive coping strategies were protective factors, and maladaptive coping strategies were a risk factor ($P < 0.05$). The results of the descriptive analysis showed that all of the factors were statistically associated with mood disorders in the adolescents, which was rational and consistent with previous research. However, as we previously

speculated, simple descriptive statistical methods cannot quantify the impact of each factor on anxiety/depression in adolescents, which limited the clinical significance of these factors. Therefore, we introduced machine learning methods in order to further analyze the importance of each factor.

Data Preprocessing

As shown in **Table 1**, adolescents in the 7th, 8th, 10th, and 11th grades, as well as those in the first year in college, had similar psychological statuses. The psychological conditions of adolescents in the 9th and 12th grades were significantly worse than those of other adolescents. It was not hard to find the reason: In China, 9th and 12th grade students are faced with the stress of gaining admission to higher education, i.e., senior high schools or colleges, thus causing relatively worse psychological statuses. Therefore, we converted the grade variable into the graduation grade variable. Adolescents who were in grades nine and 12 received a “Yes”, and those who were not received a “No”. For the two ordered variables, physical activity and screen time, and the other continuous variables, we found that the psychological conditions of students had approximately monotonic trends as these variables increased. Thus, no extra processes were performed for these features. In addition, the value of the total social variable was actually the sum of the values of the three variables above, which apparently indicated the existence of collinearity. Thus, we deleted this variable (total social support) and did not take its influence into account.

Machine Learning Model Construction and Evaluation

As shown in **Figure 1** and **Table 2**, we found that the GBDT+LR model had the best performance for both the GAD-7 (average AUC = 0.819) and PHQ-9 (average AUC = 0.857). Because GBDT is a boosted decision tree model, it was difficult to accurately assess the impact of each feature on the dependent variables. We applied the SHAP package to calculate the SHAP, which measures how features affect the dependent variables of every factor. To be more specific, the SHAP is able to explain the results of machine learning models based on game theory (51). **Figures 2A,B** show the distribution of each feature and the impact of each feature on the adolescents' mental health for two directions. We found that poor sleep quality, low psychological resilience, maladaptive coping strategy, low social support, being at graduation grades, being female, having relatives/friends who have been quarantined/infected, low perceived social status had negative impact on adolescents' mental health. We then calculated the mean of |SHAP| (absolute value of SHAP) to show the total impact of each feature (or feature importance) on the mental health of adolescents (no matter whether the directions were the same or the opposite). As shown in **Figures 2C,D**, the mean (|SHAP|) ranking list was sleep quality, resilience, adaptive coping strategies, social support from family, social support from others, maladaptive coping strategies, graduation grades, social support from friends, gender, and others for anxiety. Similarly, the mean (|SHAP|) ranking list was sleep quality, resilience, adaptive coping strategies, social support from family, social support from friends, school

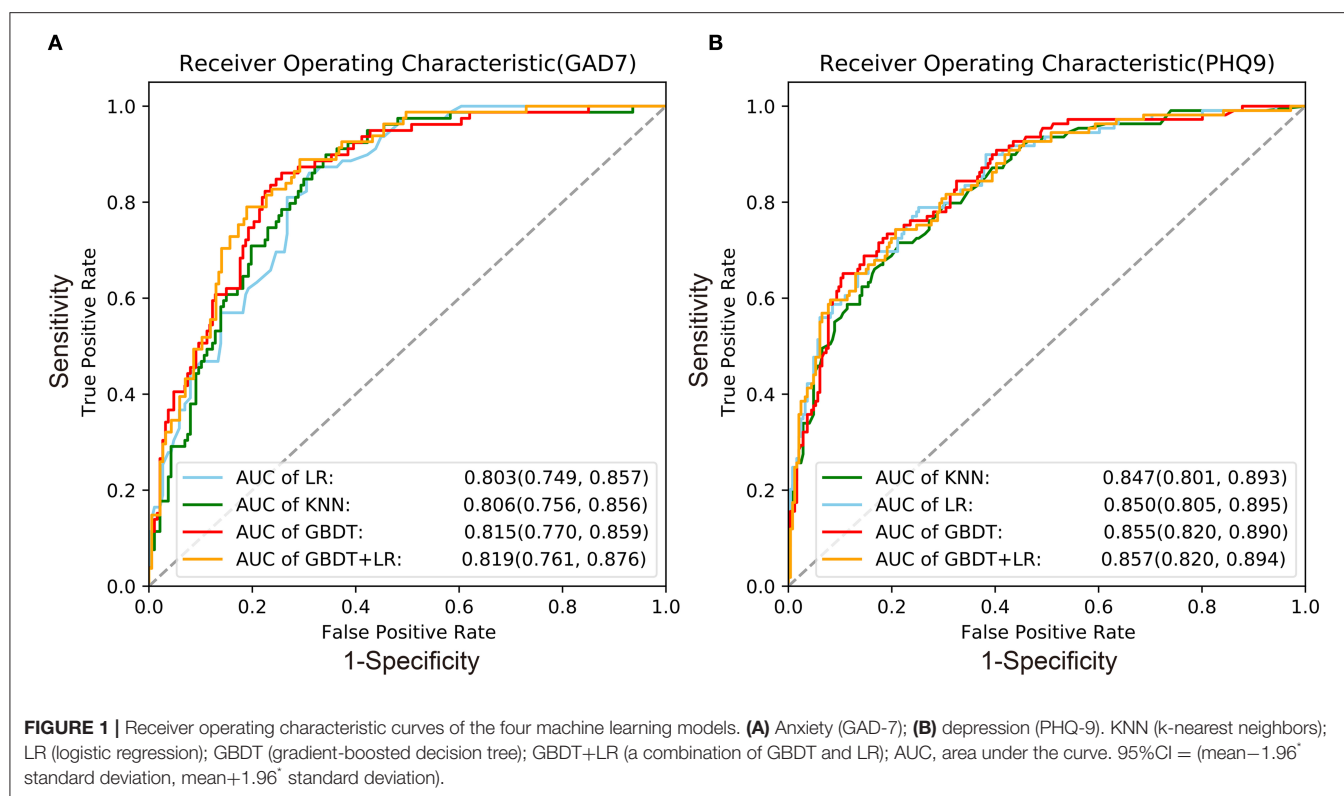


TABLE 2 | Evaluation of the four machine learning algorithms for anxiety and depression.

Models	AUC (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)
Anxiety			
LR	0.80 (0.75, 0.86)	0.72 (0.66, 0.78)	0.72 (0.67, 0.78)
KNN	0.80 (0.76, 0.86)	0.73 (0.67, 0.79)	0.73 (0.67, 0.79)
GBDT	0.81 (0.77, 0.86)	0.73 (0.69, 0.78)	0.73 (0.69, 0.78)
GBDT+LR	0.82 (0.76, 0.88)	0.74 (0.68, 0.80)	0.74 (0.68, 0.80)
Depression			
LR	0.85 (0.81, 0.90)	0.77 (0.72, 0.83)	0.77 (0.72, 0.83)
KNN	0.85 (0.80, 0.89)	0.75 (0.70, 0.81)	0.75 (0.70, 0.81)
GBDT	0.86 (0.82, 0.89)	0.77 (0.72, 0.81)	0.77 (0.73, 0.82)
GBDT+LR	0.86 (0.82, 0.89)	0.77 (0.72, 0.82)	0.77 (0.72, 0.82)

AUC, area under curve; KNN (k-nearest neighbors); LR (logistic regression); GBDT (gradient-boosted decision tree); GBDT+LR (a combination of GBDT and LR); CI, confidence interval. 95% CI = (mean–1.96* standard deviation, mean+1.96* standard deviation).

status, maladaptive coping strategies, social status, social support from others, and others for depression. Based on these two lists of feature importance ranking, we proposed a five-step mental health education strategy to be used during the COVID-19 pandemic (sleep quality-resilience-coping strategies-social support-perceived social status).

Conventionally, logistic regression models have been used in psychological and other medical areas to measure the influence of every feature more precisely by calculating the odds ratio (OR).

Because the LR model also performed well on our datasets, here, we present the results from the LR model (Table 3).

DISCUSSION

In this cross-sectional study, we investigated the current mental status of Chinese adolescents. The rates of occurrence of anxiety and depression symptoms were 28.3 and 30.8%. Compared with the rates at the beginning of the outbreak (13), adolescents' mental status has improved, but the outlook is still not optimistic. Wang et al. performed a meta-analysis in 2018, collecting the adolescents' depression/anxiety data in China before the COVID-19. The pooled occurrence rate of depression is around 21.73% in overweight subjects and 17.96% in non-overweight subjects; the pooled occurrence rate of anxiety is around 39.80% in overweight subjects and 13.99% in non-overweight subjects (52). The occurrence rates were lower than 30.8% for depression and 28.3% for anxiety that we investigated in this study. Then, we used machine learning measures to screen for the factors that were most relevant to mood disorders among Chinese adolescents during the COVID-19 pandemic and utilized the SHAP to interpret our GBDT (anxiety) and GBDT+LR (depression) models to show the impact of each psychological factor.

Sleep quality had the closest relation with mood disorders among Chinese adolescents. Traditionally, psychiatrists/psychologists have treated insomnia and other sleep disorders as secondary symptoms that are mainly caused by psychiatric disorders, which account for >50% of insomnia

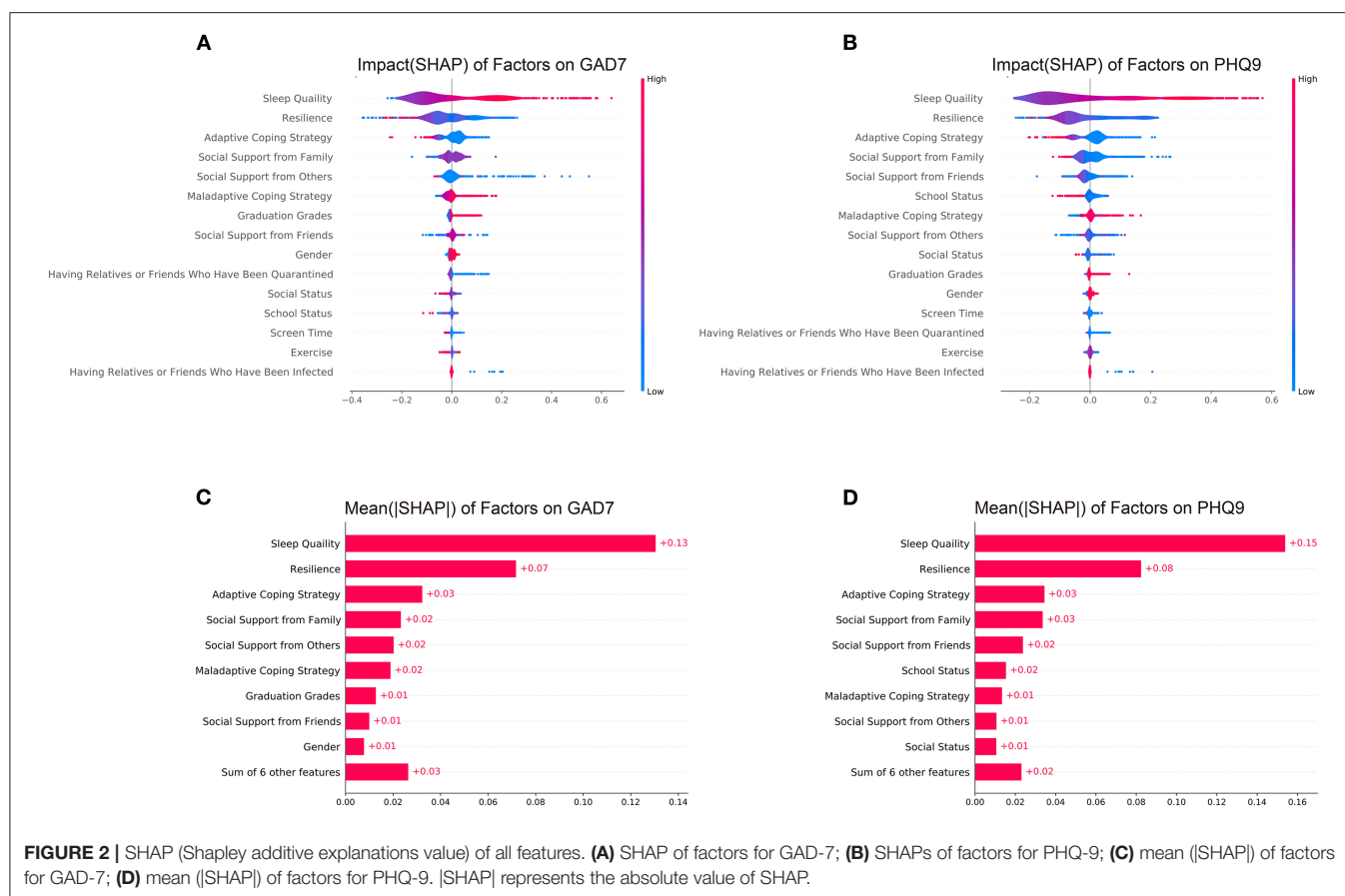


TABLE 3 | The results of the logistic regression model for anxiety and depression.

Factors	Anxiety		Depression	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Gender (reference: male)	1.38 (1.08,1.77)	0.011*	1.29 (0.99,1.67)	0.055
Graduation grade (reference: no)	1.76 (1.24,2.50)	0.002**	1.58 (1.09,2.29)	0.017*
Having relatives or friends	0.16 (0.02,1.32)	0.088	0.03 (0.00,0.47)	0.012*
Who had been infected (reference: no)				
Having relatives or friends	0.49 (0.32,0.76)	0.001**	0.63 (0.39,0.99)	0.047*
Who had been quarantined (reference: no)				
Physical activity	0.93 (0.81,1.07)	0.283	1.00 (0.87,1.16)	0.972
Screen time	0.99 (0.89,1.10)	0.836	0.94 (0.85,1.05)	0.292
Sleep quality	1.18 (1.15,1.21)	0.000***	1.25 (1.22,1.29)	0.000***
Social status	1.01 (0.93,1.08)	0.889	0.98 (0.90,1.06)	0.585
School status	0.97 (0.90,1.05)	0.448	0.92 (0.85,0.99)	0.026*
Resilience	0.97 (0.95,0.99)	0.001***	0.97 (0.95,0.99)	0.000***
Social support from others	0.98 (0.93,1.03)	0.412	0.99 (0.94,1.05)	0.719
Social support from family	1.01 (0.97,1.05)	0.797	0.96 (0.92,1.00)	0.080
Social support from friends	1.01 (0.96,1.06)	0.695	1.00 (0.95,1.04)	0.867
Adaptive coping strategies	0.91 (0.87,0.96)	0.000***	0.93 (0.88,0.97)	0.001**
Maladaptive coping strategies	1.10 (1.04,1.16)	0.001***	1.10 (1.04,1.17)	0.001***

OR, odds ratio; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; CI, confidence interval. 95% CI = (mean−1.96* standard deviation, mean+1.96* standard deviation).

cases. However, studies in adolescents indicate that sleep problems could directly contribute to subjective sleepiness (53), cognitive impairment (54), and mood disorders (55). Lo et al. performed a random controlled trial in 56 healthy adolescents and demonstrated that 1-week sleep restriction impaired adolescents' mood, and they did not fully recover even after two nights of sleep recovery (56). Therefore, sleep disorders and mood disorders affect each other: sleep disorders can accompany anxiety/depression, and anxiety/depression can further aggravate sleep disorders. In highly competitive societies, such as in China and other East Asian countries, adolescents (especially junior/senior high school students) face enormous academic pressure in the entrance examinations. They often voluntarily or are forced to spend more time studying at the expense of sleep. A very recent meta-analysis reported that the overall prevalence of sleep disturbance among Chinese adolescents was 26%, which was higher than that among university students (25.7%), and adults (20.4%) (57). Schools' student support services should take measures to ensure that students have adequate time for sleep and to enhance their sleep quality, including by reducing schoolwork stress and improving the living conditions in boarding schools. Furthermore, schools should find out if students have sleep disorders and provide psychological assistance in time.

The WHO reported that 50% of all psychological problems start by the age of fourteen, but most cases are undetected and untreated (58), and the outbreak of COVID-19 raised the risk of psychiatric disorders in adolescents. Early mental health education can prevent adolescents from having severe psychiatric outcomes. Practical mental health education implies that the psychological interventions are provided for all students without screening in order help students avoid risk factors and to enhance the protective factors. However, practical education strategies are limited. Based on the feature importance (SHAP) of the psychological factors, we proposed a five-step practical mental health education strategy for use during the COVID-19 pandemic. The first step is to emphasize the significance of healthy sleep and to teach students how to get good sleep and deal with sleep disorders (sleep quality). The second step is to foster adolescents' ability to bounce back with new learning and strength when facing adversity (resilience). The third step is to share with students strategies for the management of uncomfortable emotions by using healthy coping skills and avoiding unhealthy coping skills (coping strategies). The fourth step is to encourage students to build authentic relationships with their families, friends, teachers, and others (social support). The last step is to help students discover their core values and encourage students to ask for help when they encounter unfair treatment (social/school status). In practice, it is unnecessary to implement all five steps for all adolescents. Schools can set up online courses to complete the first, second, and third steps. For students who show symptoms of early mood disorders, school psychologists should provide them with accurate face-to-face psychological counseling and should finish the five steps. Besides, a very recent study demonstrated that expanding the testing capacity and applying strict control measures can effectively

decrease the total number of COVID-19 cases. Therefore, we highly recommend that schools could perform routine COVID-19 test for all the teachers and students (59).

We also found that some demographic characteristics and personal living styles were relevant to mood disorders. Adolescents who were female, were in graduation grades, and had relatives or friends who had been infected by COVID-19 or quarantined were more likely to develop mood disorders. In addition, adolescents who held relatively low subjective social and school status were susceptible to mood disorders. School psychologists should pay more attention to the mental health of students with these specific characteristics. Furthermore, schools can never discriminate against students due to their academic performance, family socioeconomic status, or gender, and they must propose a comprehensive and robust anti-bullying policy in order to protect students from bullying at school. Every adolescent should be free from discrimination or degrading treatment in school. As for personal living styles, we found that more physical activity and shorter screen time were related to healthier mental status. A wide range of investigations have shown that physical activity is beneficial for mental health in adolescents. Biddle et al. proved that there is a causal association between physical activity and cognitive functioning and depression (60). Currently, adolescents and children experience electronic devices as an indispensable part of their lives. Recent studies have linked screen time to mood disorders and even suicide among adolescents (61, 62), which could be mediated by inadequate sleep (63). Therefore, schools should encourage students to balance screen time and physical activity with other proper development and wellbeing activities.

This study has some strengths. First, the machine learning algorithms were reliable and appropriate. The AUCs were 0.819 for anxiety and 0.857 for depression, indicating that the factors that we screened had a close relationship with mood disorders in adolescents. Second, we collected the subjects without selection bias. The participants were from three independent junior high schools, three independent senior high schools, and three independent colleges (considering that the academic level of the school might influence students' mental status, we selected the schools of different levels on a 1:1:1 scale).

This study still has some limitations. Firstly, we did not explore the causal relationship between anxiety/depression and the screened factors because our statistical results are based on cross-sectional data, but not cohort data. A prospective cohort study is still needed. Secondly, our study was performed in Shandong province, China. The clinical value of our conclusions may be limited in other areas. Thirdly, this investigation was performed during Apr.20–Apr.30, 2021, when the COVID-19 in China had been well-controlled. Therefore, the results may have bias. Fourthly, due to ethic requirements, children (aged under 12) and adolescents who have recently suffered severe negative life events or were diagnosed with severe psychological disorders were not invited, which may also lead to selection bias. Finally, we did not perform a pre-survey to select included features. There might exist other significant psychological factors influencing adolescents' mental health. Besides, all the psychological scales

included in this study were self-reported. This may lead to systematic measurement errors that either inflate or deflate the observed relationships between constructs, generating both Type I and Type II errors.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Materials**, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The Ethics Committee of Shandong University. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this

study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

ZR and ZW Data collection was performed. YX Statistical analyses were performed. ZR and YX The manuscript was written. DL, YX, ZR, and ZW The study was designed and Contributed equally to this research. DL, RH, and CH The manuscript was revised. All authors read and approved the final manuscript.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsy.2021.728278/full#supplementary-material>

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COVID-19-Related Psychological and Psychosocial Distress Among Parents and Youth With Physical Illness: A Longitudinal Study

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Despite the initial thrust of research aimed at understanding the impact of the COVID-19 pandemic on youth with physical illness and their parents, knowledge gaps in the literature remain, providing the impetus for additional investigation. This study described changes in psychological distress from prior to during the COVID-19 pandemic for parents and youth with physical illness, compared parent-proxy and youth self-reported perceptions of COVID-19-related psychosocial health, and modeled factors associated with psychological and psychosocial distress. There were 147 parent–youth dyads (2–16 years) from MY LIFE—a longitudinal study of youth with physical illness. The Kessler-6 (K6) measured psychological distress for the time before the COVID-19 lockdown (December 19 to March 20) and during the pandemic (December 20 to March 21) among parents and youth. COVID-19-related psychosocial health was measured using the CRISIS. Parents and youth reported increases in K6 scores ($d = 0.62$ and 0.38). Parent-proxy reports on the K6 were lower vs. youth self-reports prior to and during the pandemic ($d = 0.63$ for both). In contrast, parents reported lower proxy CRISIS scores for worries ($d = 0.38$) and effects of social restrictions ($d = 0.52$). Pandemic parent K6 scores were associated with age, combined in-person and online schooling for youth, COVID-19-related worries, and effects of social restrictions. For youth, only COVID-19-related worries and effects of social restrictions were associated with K6 scores. Parent worries were associated with youth sex, parental stress, family functioning, online and combination learning, and social restrictions. Parental depression and worries were associated with effects of social restrictions. Youth worries were associated with online and combination learning, and social restrictions. Youth disability, online learning, and worries were associated with effects of social restrictions. Few clinical factors are associated with COVID-19-related psychological and psychosocial distress. Instead, parent/family factors and youth learning environment have prominent roles in predicting outcomes and have implications for the health, education, and social services systems.

Keywords: adolescent, children, chronic disease, coronavirus, mental health, multimorbidity, pandemic

INTRODUCTION

The COVID-19 pandemic has generated substantial individual and societal burden and has exposed systemic weaknesses across sectors working to address this global crisis. These burdens appear to differentially impact specific segments of the population, including children and youth with chronic physical illnesses (e.g., asthma, diabetes, epilepsy) and their families (1, 2). Evidence is mixed regarding elevated risk for and clinical presentation of COVID-19 for youth with vs. without physical illness (3, 4); however, more definitive are findings that youth with physical illness report they are more concerned about COVID-19 compared with their healthy peers (5, 6). This has sparked calls to action to prioritize the assessment of mental health among youth with physical illness (7) and especially during the COVID-19 pandemic, which has resulted in significant declines in health service use for youth, potentially perpetuating further deterioration of physical, mental, and psychosocial health (8).

Indeed, increased stress and declines in mental health associated with COVID-19 have been reported by parents and youth in the general population (9–11) and among those families who have a child with a physical or mental illness (6, 12–19). For instance, Hawke et al. aggregated general community and clinical samples of youth aged 14–28 years in Canada and found significant declines in mental health from prior to during the COVID-19 (10). This reported decline was large in magnitude ($\eta^2 = 0.31$) and that the deterioration of mental health was more pronounced in the community sample of youth ($\eta^2 = 0.02$). Durcan et al. reported elevated anxiety and depression during the pandemic among a Turkish sample of parents of youth aged 2–18 years with rheumatological conditions compared with parents of healthy youth ($d = 0.28$ and $d = 0.34$, respectively) (20). Youth with rheumatological conditions self-reported elevated symptoms of anxiety compared with their peers ($d = 0.33$). No significant differences in mental health were reported across the different types of rheumatological conditions, consistent with pre-pandemic studies that support non-categorical approaches (21, 22) to understanding the intersection between physical and mental illness in children and youth (23–27). Notably however, studies have showed that clinical factors such as illness duration, severity, or exacerbations during the pandemic have no or minimal association with COVID-19-related mental health among youth with physical illness (16, 20). Few studies have investigated psychosocial health (e.g., quality of life, hopefulness) among youth during the COVID-19 pandemic; available data, however, suggest that COVID-19 has negatively impacted psychosocial health among this population. For instance, a population-based study of youth aged 7–17 years in Germany showed that youth had a significant increase in self-reported low health-related quality of life from prior to during the pandemic ($d = 0.73$) and that this change in psychosocial health was similar for males and females; however, data on youth with physical illness was not reported (28).

Despite the initial thrust of research aimed at understanding the impact of the COVID-19 pandemic on youth with physical illness and their parents, knowledge gaps in the literature

remain, providing the impetus for additional investigation. First, given the relative infancy of the extant literature examining the impact of COVID-19 on the mental health of youth with physical illness, most studies are descriptive in nature (12–14, 19). This initial work was crucial in estimating the burden on these youth and their families and the next step in the research agenda requires analytic studies that model predictors for changes in mental health from prior to during the COVID-19 pandemic. This information is needed for health professionals and policy makers to identify at-risk youth and families and provide the supportive resources to prevent or minimize declines in mental health during the ongoing pandemic. Second, there is a pressing need for studies examining COVID-19-related psychosocial health. Prediction of individual and population outcomes directly related to the countermeasures implemented by governments and public health agencies to curb transmission of COVID-19 (e.g., lockdown ordinances, school closures) can be used to inform public health strategies as we move forward into subsequent waves of the current pandemic and for future global crises that would minimize psychosocial distress. Third, there is a paucity of information with regard to differences in the perception of COVID-19-related psychological distress and psychosocial health between youth with physical illness and their parents. While evidence suggests that agreement between parents and youth with chronic illness on such constructs is modest (29–33), it is unknown if such findings generalize in the context of a pandemic. Understanding parent and youth perspectives is fundamental to tailoring family-centered care—the gold standard for pediatric health care—especially in the context of COVID-19 and the shift of services provision from in-person to virtual formats (34–37).

To address these knowledge gaps, this longitudinal study described changes in psychological distress prior to and during the COVID-19 pandemic in parents and their children with chronic physical illness, compared parent-proxy and youth-reported perceptions of psychological distress and perceptions of COVID-19-related psychosocial health, and modeled factors predictive of psychological distress and psychosocial health among parents and youth.

MATERIALS AND METHODS

Design and Procedures

Data come from an on-going longitudinal study of a clinical sample of children with a chronic physical illness and their primary caregiving parent—Multimorbidity in Children and Youth Across the Life-course (MY LIFE). The design and cohort are described briefly, as the MY LIFE protocol is freely available (38, 39). Families were recruited from outpatient clinics at a pediatric hospital (Ontario, Canada) and baseline data collected from August 2017 until November 2019. Children were eligible if they were aged 2–16 years, diagnosed by a health professional with a physical illness, and had a parent who could understand English. Nurses introduced the study and invited families to meet with research staff, who further described MY LIFE and obtained permission to contact them at a later time. Research staff

scheduled in-person data collection (hospital or home) through structured interviews and self-reported questionnaires, or in rare cases, data were collected using mail packages, in which case structured interviews were conducted by telephone. In March 2020, all data collection from self-reported questionnaires shifted to mail packages on account of the COVID-19 pandemic. Of the 263 families enrolled in MY LIFE, 188 (71.4%) were in active follow-up and eligible for the current COVID-19 sub-study. In total, 161 (85.6%) consented to participate in the sub-study and 147 (78.2%) completed data collection. Parent reports were collected for all children ($n = 147$) and youth ≥ 13 years ($n = 48$) also provided self-reports. For this sub-study, psychological distress and COVID-19-related psychosocial health data were collected between December 2020 and March 2021 *via* an online survey (Qualtrics). March 2021 was used as a cut-point for data collection as it represented the 1-year anniversary of the COVID-19 pandemic in Canada and coincidentally, the onset of a third wave of COVID-19 infections in the country (40). For measures that asked about pre-pandemic experiences, participants were instructed to report on experiences during the 3 months prior to lockdown ordinances (i.e., December 2019 to March 2020). All participants provided informed consent, and MY LIFE received ethical approval.

Measures

Psychological distress in parents and youth was measured using the Kessler-6 (K6), a generic scale assessing the frequency in which individuals felt nervous, hopeless, restless/fidgety, depressed that nothing could cheer them up, everything was an effort, and worthless (41). Responses used a five-point scale ranging from 0 = “none of the time” to 4 = “all of the time” with total scores having a 24-point range. The K6 has robust psychometric properties in adult and youth populations (42, 43). Internal consistency was $\alpha = 0.90$ for parent-self report, $\alpha = 0.92$ for parent-proxy report, and $\alpha = 0.96$ for youth-self report.

COVID-19-related psychosocial health was measured using the Coronavirus Health Impact Survey (CRISIS) (44). Items on the CRISIS are rated on five-point scale from 1 = “not at all” to 5 = “extremely” and in some instances are recoded such that higher scores on the CRISIS indicate more severe/frequent symptoms or behaviors. COVID-19-related worry was measured using five items that assess worry of infection, influence on physical and mental health, and time spent reading or talking about COVID-19. Internal consistency for the worry subscale was $\alpha = 0.83$ for parent-self report, $\alpha = 0.85$ for parent-proxy report, and $\alpha = 0.77$ for youth-self report. The effect of COVID-19-related social restrictions was measured using eight items that asked about stress of restrictions and impacts on social relationships. Specifically, the questions were as follows: How stressful have the restrictions on leaving home been for you? Have your contacts with people outside of your home changed relative to before the COVID-19 crisis in your area? How much difficulty have you had following the recommendations for keeping away from close contact with people? Has the quality of the relationships between you and members of your family changed? How stressful have these changes in family contacts been for you? Has the quality of the relationships with your friends changed? How

stressful have these changes in social contacts been for you? How much has cancellation of important events (such as vacation, parties, weddings, etc.) in your life been difficult for you? Internal consistency for the social restrictions subscale was $\alpha = 0.74$ for parent-self report, $\alpha = 0.69$ for parent-proxy report, and $\alpha = 0.71$ for youth-self report. A single question on the CRISIS asked, “How hopeful are you that the COVID-19 crisis in your area will end soon?” Using the same five-point scale, higher scores on this item indicated more hope. Substance use during the COVID-19 pandemic was measured using five items that assessed frequency of use of alcohol, vaping products, tobacco products, cannabis, and hard drugs (e.g., opiates, heroin, cocaine, etc.). Internal consistency for the substance use subscale was $\alpha = 0.75$ for parent-self report. Two items examined the extent to which parents perceived that the COVID-19 pandemic created financial problems and concerns about stability of living situation.

Chronic physical illness among youth was categorized according to the International Statistical Classification of Diseases and Related Health Problems (ICD)-10. The categories were rheumatological, respiratory, neurological, hematological, gastroenterological, endocrine, and dermatological. Comorbid mental illness in youth was measured at baseline using the parent-reported Mini International Neuropsychiatric Interview for Children and Adolescents (MINI-KID). This structured clinical diagnostic interview is aligned with the ICD-10 and Diagnostic and Statistical Manual of Mental Disorders (DSM)-5 and was administered by trained research staff (45). The MINI-KID has been shown to be valid and reliable in clinical and population samples of youth (46, 47). The most common mental illnesses present in childhood and adolescence (major depressive episode, generalized anxiety disorder, separation anxiety disorder, social and specific phobia, attention-deficit/hyperactivity disorder, oppositional defiant, and conduct disorder) were assessed (48).

Youth disability and functioning was measured using the 12-item parent-reported World Health Organization Disability Assessment Schedule (WHODAS) 2.0. It measures disability in the domains of cognition, mobility, self-care, getting along, life activities, and participation (49). Higher scores on the WHODAS 2.0 indicate more impairment across these domains. Its psychometric properties are sound in child and adolescent populations, including those with physical or mental illness (50, 51). Its internal consistency was $\alpha = 0.88$ in this study sample.

Parent mental health and family environment were measured using parent-reported versions of the Center for Epidemiological Studies Depression Scale (CESD), Parental Stress Scale (PSS), and McMaster Family Assessment Device (FAD). The CESD is a 20-item measure of depressive symptomatology, which includes the domains of positive and negative affect, somatic symptoms, and interpersonal relations (52). Items are scored on a four-point scale (total ranges from 0 to 60), with higher scores indicating greater frequency and severity of depressive symptoms. The CESD is widely validated and its psychometric properties are strong in samples of adults, including parents of children with physical or mental illness (53, 54). The internal consistency was $\alpha = 0.92$ in this sample. The PSS is an 18-item measure of stress resulting from parenting across the domains of parental

rewards and satisfaction, stressors, and lack of control (55). Responses on the PSS are based on a five-point scale and the total score ranges from 18 to 90; higher scores indicate more symptoms of parental stress. It has been validated in parents whose children have physical or mental illness (55, 56) and its internal consistency was $\alpha = 0.86$ in this sample. The General Functioning subscale of the FAD was used to measure family pathology and functioning (57). This 12-item scale includes the domains of problem solving, communication, behavior control, affective involvement and responsiveness, and roles. Responses are scored on a four-point scale with the total score ranging from 0 to 36. The FAD is coded such that higher scores indicate better family functioning. The FAD has demonstrated robust psychometric properties (57, 58) and its internal consistency in this sample was $\alpha = 0.87$.

COVID-19 exposure was measured using the CRISIS. Items asked parents about exposure to individuals with a COVID-19 diagnosis within or outside of the family home. Parents were also asked if their children attended school fully in-person, fully online (i.e., remote learning), or a combination of both in-person and online. Sociodemographic factors were also collected and included parent and youth age and sex, parent educational attainment, and annual household income.

Analysis

Paired *t* tests were used to compare psychological distress prior to and during the COVID-19 pandemic, as well as to estimate differences in parent-proxy and youth-self reports of psychological distress and COVID-19-related worry and social restrictions. COVID-19-related hope was compared using the McNemar test. For all comparisons, effect sizes were computed to estimate magnitudes of association (Cohen's *d* and Kendall's τ). Agreement between parent and youth reports were estimated using the intra-class correlation coefficient and κ . Multiple linear regression models were computed to examine the demographic, clinical, family, and COVID-19-related factors associated with parent and youth psychological distress and COVID-19-related psychosocial health. These models were based on parent-self and parent-proxy reports. For the psychological distress models, pre-pandemic K6 score was included as predictor; thus, these models represent change in psychological distress from before to during the COVID-19 pandemic. Because only 48 youth provided self-reports, regression models could not be reliably computed. Instead, bivariable correlations were reported for associated factors. All hypothesis tests were two-sided and $\alpha = 0.05$. Data were analyzed using SPSS 21.

RESULTS

Sample Characteristics

The mean ages of children and parents in this study were 9.3 (4.1) and 40.2 (5.7) years, respectively. While there was an approximately equal distribution of sex among children (52.4% males), the majority of parents were female, specifically the biological mother (89.0%). There were some heterogeneity in the proportion of physical illnesses; the most common were rheumatological conditions (28.6%), respiratory conditions

TABLE 1 | Sample characteristics at baseline.

Characteristic	Mean (SD)	Frequency (%)
Child		
Age, years	9.3 (4.1)	
Male		77 (52.4)
Immigrant		12 (8.2)
Illness duration, years	5.1 (3.8)	
Illness severity, WHODAS 2.0	7.2 (7.3)	
Illness type		
Rheumatological		42 (28.6)
Respiratory		35 (23.8)
Neurological		6 (4.1)
Hematological		25 (17.0)
Gastroenterological		10 (6.8)
Endocrine		15 (10.2)
Dermatological		14 (9.5)
Any comorbid mental illness		50 (34.0)
Major depressive episode		10 (6.8)
Generalized anxiety disorder		13 (8.8)
Separation anxiety disorder		12 (8.2)
Social phobia		10 (6.8)
Specific phobia		13 (8.8)
Attention-deficit hyperactivity		20 (13.6)
Oppositional defiant disorder		5 (3.4)
Conduct disorder		3 (2.0)
Parent		
Age, years	40.2 (5.7)	
Female		130 (89.0)
Immigrant		24 (16.3)
Partnered		128 (87.7)
Postsecondary graduate		115 (78.8)
Household income \geq \$90,000		86 (58.9)
Depressive symptoms, CESD	9.8 (9.0)	
Parental stress, PSS	36.7 (8.7)	
Family functioning, FAD	28.1 (5.4)	

WHODAS 2.0, World Health Organization Disability Assessment Schedule; CESD, Center for Epidemiological Studies Depression Scale; PSS, Parental Stress Scale; FAD, McMaster Family Assessment Device.

(23.8%), and hematological conditions (17.0%). The least common type of physical illness was neurological (4.1%). One-third (34.0%) of children screened positive for a comorbid mental illness. Parents were typically partnered (married or common-law; 87.7%), completed postsecondary education (78.8%), and reported annual household incomes of \geq \$90,000 (58.9%). Additional sample characteristics are shown in **Table 1**. In total, 29 parents reported an exposure to a COVID-19 diagnosis (19.7%). Five families reported a COVID-19 diagnosis within the household (3.4%). One child in the study had a COVID-19 diagnosis.

Changes in Psychological Distress

As shown in **Table 2**, all informants (parent-self, parent-proxy, and youth-self) reported increased symptoms of psychological

distress, as measured by the K6, from prior to during the COVID-19 pandemic. The increase was largest for parent-self reports ($d = 0.62$, $p < 0.001$), followed by parent-proxy reports on all children ($n = 147$; $d = 0.39$, $p < 0.001$). Among the subset of parent-proxies whose children provided self-reports, a similar-sized increase in K6 scores was found ($n = 48$; $d = 0.30$, $p = 0.048$). Youth self-reported an increase in K6 scores that also corresponded to a medium-sized effect ($d = 0.38$, $p = 0.010$).

Comparisons Between Parent and Youth Reports

Parent-proxy reports on the K6 were significantly lower compared with youth self-reports prior to ($d = 0.63$, $p = 0.012$) and during the COVID-19 pandemic ($d = 0.63$, $p = 0.001$). Significant differences in parent-proxy and youth self-reports for COVID-19-related psychosocial health, as measured by the CRISIS were also found (Table 3). However, in contrast to the K6, parent-proxy reports were lower for worry ($d = 0.38$, $p = 0.011$) and effect of social restrictions ($d = 0.52$, $p = 0.001$). Parent-proxy reports also seemed to overestimate youth perceptions for hope that the COVID-19 pandemic will end soon ($\tau = 0.33$, $p = 0.007$).

Agreement between parent-proxy and youth self-reports were generally low across all measures. For the K6, the ICC = 0.47 (0.22, 0.67) prior to the COVID-19 pandemic, and ICC = 0.43 (0.17, 0.63) during the pandemic. For the CRISIS, worry was ICC

= 0.31 (0.03, 0.54), effect of social restrictions was ICC = 0.46 (0.20, 0.66), and hope was $\kappa = 0.31$ (0.12, 0.50).

Factors Associated With Psychological and Psychosocial Distress

In regression models of parent-self and parent-proxy reported psychological distress, no clinical factors were associated with K6 scores during the COVID-19 pandemic (Table 4). For parent-self reports, elevated pre-pandemic psychological distress ($b = 0.35$), older parent age ($b = 0.13$), elevated parent depressive symptoms ($b = 0.11$), and more COVID-19-related worries and effect of social restrictions ($b = 0.38$ and $b = 0.32$) were associated with elevated psychological distress during the pandemic. In contrast, having children in combination in-person and online learning was associated with lower psychological distress ($b = -2.02$). Similar results were found in the parent-proxy model; however, parent depressive symptoms ($b = 0.03$) and combination learning ($b = -0.61$) were not significantly associated with youth psychological distress during the pandemic.

Bivariable analyses showed that elevated youth-self reported psychological distress during the COVID-19 pandemic was associated with pre-pandemic psychological distress ($r = 0.68$), female sex (mean difference 5.3), more COVID-19-related worries ($r = 0.52$) and effect of social restrictions ($r = 0.57$), and less hope that the pandemic will end soon ($r = -0.44$). One clinical factor, illness severity (as measured by the WHODAS 2.0), was found to be associated with psychological distress ($r = 0.33$). All associations were significant at $p < 0.05$.

As shown in Table 5, elevated parent COVID-19-related worry was associated with having a male child ($b = 1.25$), more parental stress ($b = 0.12$), poorer family functioning ($b = -0.11$), online and combination learning ($b = 1.39$ and $b = 1.88$), elevated pandemic psychological distress ($b = 0.40$), and COVID-19-related social restrictions ($b = 0.13$), financial concerns ($b = 0.46$), and lower substance use ($b = -0.19$). Effects of COVID-19-related social restrictions were associated with elevated parental depressive symptoms ($b = 0.17$), pandemic psychological distress ($b = 0.52$), and COVID-related worry ($b = 0.23$), and substance use ($b = 0.20$).

TABLE 2 | Changes in psychological distress (K6).

Informant/Target	N	Pre-COVID-19	During COVID-19	d	p
Parent self	147	4.0 (3.6)	6.7 (4.9)	0.62	<0.001
Parent-proxy	147	3.5 (3.4)	4.7 (4.1)	0.39	<0.001
Parent-proxy ^a	48	4.7 (4.7)	5.5 (4.8)	0.30	0.048
Youth self	48	6.6 (5.7)	8.9 (7.2)	0.38	0.010

^aThese are the subgroup of parents who have a child who provided self-reported data. K6, The Kessler-6 measured psychological distress for the time before COVID-19 lockdown (December 19 to March 20) and during the pandemic (December 20 to March 21) among parents and youth.

TABLE 3 | Psychosocial health related to COVID-19 [Coronavirus Health Impact Survey (CRISIS)].

Construct	Parent self	Parent-proxy	Parent-proxy ^a	Youth self	d/ τ
Worry	15.6 (4.2)	11.8 (4.2)	13.3 (3.5)	11.7 (3.7)	0.38
Social restrictions	22.7 (5.3)	23.5 (5.2)	23.6 (4.8)	21.1 (4.4)	0.52
Hope					0.33
Not at all/slightly	48 (32.7)	40 (27.2)	7 (14.6)	19 (39.6)	
Moderately	38 (25.9)	33 (22.4)	15 (31.3)	10 (20.8)	
Very/extremely	61 (41.4)	74 (50.3)	26 (54.2)	19 (39.6)	
Financial concerns	3.6 (1.7)	–	–	–	–
Substance use	9.0 (4.3)	–	–	–	–

Data are mean (standard deviation), except for hope, which is reported as frequency (percent). Effects (Cohen's d or Kendall's τ) were based on the difference between parent-proxy and youth self-reports; effects were statistically significant at $p < 0.05$.

^aThese are the subgroup of parents who have a child who provided self-reported data.

TABLE 4 | Factors associated with parent and youth psychological distress (K6).

Factor	Parent (self-report)		Youth (parent-proxy)	
	Semi-adjusted	Fully adjusted	Semi-adjusted	Fully adjusted
Adjusted R^2_{sq}	0.34	0.66	0.45	0.69
Pre-COVID-19 distress, K6 ^a	0.41 (0.12)	0.35 (0.09)	0.78 (0.09)	0.61 (0.07)
Demographics				
Child age, years	−0.18 (0.11)	−0.09 (0.08)	−0.03 (0.08)	−0.03 (0.07)
Male child	0.33 (0.73)	−0.93 (0.55)	0.70 (0.55)	−0.35 (0.44)
Parent age, years	0.03 (0.07)	0.13 (0.05)	0.05 (0.06)	0.09 (0.04)
No postsecondary degree	1.53 (0.90)	−0.14 (0.69)	0.77 (0.68)	0.44 (0.53)
Income \geq \$90,000	−0.22 (0.78)	−0.06 (0.60)	−0.62 (0.59)	−0.87 (0.46)
Clinical				
Illness duration	0.08 (0.11)	0.06 (0.08)	−0.02 (0.08)	−0.01 (0.06)
Disability, WHODAS	0.12 (0.06)	0.04 (0.04)	0.05 (0.05)	0.07 (0.04)
Comorbid mental illness	−0.72 (0.87)	−0.56 (0.65)	−0.34 (0.66)	−0.77 (0.51)
Parent mental health				
Depression, CESD	0.14 (0.05)	0.11 (0.04)	0.01 (0.04)	0.03 (0.03)
Parental stress, PSS	−0.01 (0.05)	0.03 (0.04)	−0.01 (0.03)	−0.01 (0.03)
Family functioning, FAD	−0.10 (0.07)	−0.10 (0.05)	−0.02 (0.05)	0.01 (0.04)
COVID-19-related				
COVID-19 exposure		−0.53 (0.64)		−0.50 (0.50)
Learning environment				
In-person		Reference		Reference
Online		−1.12 (0.60)		−0.84 (0.47)
Combination		−2.02 (0.08)		−0.61 (0.60)
Worries ^a		0.38 (0.08)		0.14 (0.06)
Social restrictions ^a		0.32 (0.06)		0.34 (0.05)
Financial concerns ^a		0.32 (0.18)		–
Substance use ^a		0.10 (0.06)		–
Hope ^a		−0.07 (0.20)		−0.18 (0.16)

Data are presented as regression coefficient (standard error). Results in bold are statistically significant at $p < 0.05$. COVID-19-related financial concerns and substance use were not measured in parent-proxy reports and, thus, not included in the youth model.

^aIn the parent model, parents provided self-reported data on their own experiences for these variables, whereas in the youth model, parents provided proxy-reported data on the experiences of their child.

In the parent-proxy model, youth COVID-19-related worry was associated with lower parental education ($b = 2.44$), online and combination learning ($b = 1.62$ and $b = 2.15$), and social restrictions ($b = 0.17$). For the COVID-19-related social restrictions model, associated factors were male sex (1.79), lower illness severity ($b = -0.13$), parental depressive symptoms ($b = 0.11$), online learning ($b = 1.84$), elevated pandemic psychological distress ($b = 0.81$), and COVID-19-related worry ($b = 0.19$). According to youth-self reports, COVID-19-related worry and social restrictions were correlated ($r = 0.50$), and females reported higher scores on these CRISIS scales (mean difference 3.5 and 2.7, respectively).

DISCUSSION

Summary of Findings

In this clinical sample of youth with chronic physical illness and their parents, levels of psychological distress increased from before to during the COVID-19 pandemic. Parent-proxy

reports appear to underestimate psychological and psychosocial distress in youth, but overestimate youth perceptions of hope that the pandemic will end soon. Furthermore, clinical factors were generally not found to be associated with psychological or psychosocial distress; instead, parent mental health, COVID-19-related stressors, and learning environments that were online only or a combination of in-person/online were associated with parent and youth psychological and psychosocial distress during the pandemic.

Consistent with previous studies, parents of children with physical illness reported a medium-sized increase in psychological distress from prior to during the COVID-19 pandemic (13, 16, 19, 20, 34). This deterioration in the mental health of parents has pervasive sequelae, negatively affecting their well-being (59), and also the health and well-being of their children (60–62). Psychological distress has been shown to hinder caregiving responsibilities, which can result in poorer health outcomes for children with physical illness (63–65), many of which have complex care needs that may be compounded in the

TABLE 5 | Factors associated with parent and youth COVID-19-related psychosocial outcomes (CRISIS).

Factor	Parent (self-report)		Youth (parent-proxy)	
	Worries	Social restrictions	Worries	Social restrictions
Adjusted R _{sq}	0.47	0.41	0.19	0.43
Demographics				
Child age, years	−0.01 (0.09)	−0.11 (0.12)	−0.07 (0.11)	−0.12 (0.11)
Male child	1.25 (0.58)	1.41 (0.77)	1.17 (0.72)	1.79 (0.75)
Parent age, years	−0.09 (0.06)	−0.15 (0.08)	−0.10 (0.07)	−0.07 (0.07)
No post-secondary degree	1.36 (0.71)	0.91 (0.95)	2.44 (0.87)	−0.52 (0.94)
Income ≥\$90,000	0.41 (0.62)	−0.65 (0.82)	−0.30 (0.75)	1.11 (0.78)
Clinical				
Illness duration	−0.03 (0.08)	0.13 (0.11)	−0.01 (0.10)	−0.01 (0.12)
Disability, WHODAS	−0.02 (0.05)	−0.01 (0.06)	0.03 (0.06)	−0.13 (0.06)
Comorbid mental illness	0.58 (0.68)	0.60 (0.90)	−0.28 (0.83)	1.03 (0.87)
Parent mental health				
Depression, CESD	0.01 (0.04)	0.17 (0.05)	0.07 (0.05)	0.11 (0.05)
Parental stress, PSS	0.12 (0.04)	0.02 (0.05)	−0.08 (0.04)	0.05 (0.05)
Family functioning, FAD	−0.11 (0.06)	0.06 (0.07)	0.04 (0.07)	−0.06 (0.07)
COVID-19-related				
COVID-19 exposure	0.71 (0.67)	0.21 (0.89)	0.65 (0.83)	0.82 (0.88)
Learning environment				
In-person	Reference	Reference	Reference	Reference
Online	1.39 (0.63)	1.29 (0.84)	1.62 (0.77)	1.84 (0.81)
Combination	1.88 (0.83)	2.07 (1.10)	2.15 (0.98)	1.41 (1.04)
COVID-19 Distress, K6 ^a	0.40 (0.08)	0.52 (0.12)	0.10 (0.11)	0.81 (0.09)
Worries ^a	—	0.23 (0.12)	—	0.19 (0.09)
Social restrictions ^a	0.13 (0.07)	—	0.17 (0.08)	—
Financial concerns ^a	0.46 (0.19)	0.03 (0.26)	—	—
Substance use ^a	−0.19 (0.07)	0.20 (0.09)	—	—
Hope ^a	−0.08 (0.21)	−0.51 (0.27)	−0.07 (0.26)	0.39 (0.27)

Data are presented as regression coefficient (standard error). Results in bold are statistically significant at $p < 0.05$. COVID-19-related financial concerns and substance use were not measured in parent-proxy reports and thus, not included in the youth model.

^aIn the parent model, parents provided self-reported data on their own experiences for these variables, whereas in the youth model, parents provided proxy-reported data on the experiences of their child.

context of the COVID-19 pandemic. Intuitively, higher baseline depressive symptoms and current COVID-19-related worry and effects of social restrictions were associated with larger increases in psychological distress; these are unique, but related constructs that capture overlapping internalizing psychopathologies (66). In contrast, having children in combined in-person and online learning was associated with lower psychological distress during the pandemic. Evidence is mounting that parental burden during the COVID-19 pandemic stems, in large part, from having to support their children with at-home or remote online learning, while schools are closed (67–69). Combined in-person and online learning may afford parents a bit of relief of the burden of managing their children's learning during in-person schooling (68), and also provide a sense of control in their families' schedules when children are involved in online learning. This notion is speculative and further research—quantitative and qualitative—is needed to substantiate or refute this hypothesis as previous work has suggested that parents have reported

feeling less supported by schools and having limited contact with teachers during temporary periods of online learning (69).

Youth also experienced an increase in psychological distress, as reported by parent-proxies and themselves, though this change was relatively smaller compared with the change in psychological distress experienced by parents. This finding was consistent with previous studies in children and adolescents in the general population (6, 9, 11), as well as among youth with physical or mental illness (12, 15, 17, 28). While the increase in psychological distress was seen over a relatively short follow-up, evidence suggests that psychopathology in youth with physical illness (i.e., physical-mental comorbidity) is chronic in nature (26) and results in compounding negative effects on youth health and well-being (23). Given that this comorbidity appears early in life, there is the potential for poor health outcomes over the life-course and increased burden on the health system resulting from the often complex care needs of youth with physical-mental comorbidity (27, 70, 71).

While both parent and youth reports of elevated COVID-19-related worry and social restrictions were associated with increased psychological distress during the pandemic (consistent with previous studies) (16), only for youth was the association between low hope and elevated psychological distress found. This finding, consistent with previous research, offers a potential target for intervention to prevent declines in youth mental health, foster adaptive coping and resilience, and promote positive psychology during times of population crisis (72, 73). In collaboration with public health and social services, the education system is well-positioned to deliver universal preventive interventions for youth. By incorporating prevention proactively within curricula developmentally appropriate and evidence-based interventions can be applied, stigma associated with help-seeking for mental health services can be reduced, and better support be provided to vulnerable youth (74–77).

Among youth reports, the finding that females had elevated psychological distress was consistent with previous work highlighting sex differences related to internalizing symptoms (48, 78). Also, the finding that disability was associated with increased psychological distress during the pandemic reinforces the negative consequences of social restrictions for youth with physical illness and the interrelationship between disability, physical illness, and mental health among youth (50).

Family-level factors were implicated in psychosocial outcomes related to the pandemic; families reporting more stressful environments and worse functioning tended to have more worry about COVID-19. Financial concerns were also associated with COVID-19-related worry and likely the stress from such hardship, in combination with stressful parents and family dysfunction, are compounded in families who have a child with a physical illness or complex care needs (19, 68). Further, parent substance use was associated with lower levels of worry, but higher levels of the effect of social restrictions may suggest that parents are using substances to self-medicate their anxiety surrounding COVID-19 (79), as well as engage in negative coping behaviors in response to burn-out (28, 80, 81). In sum, these findings speak to the importance of adopting and refining family-centered models of care that integrate physical and mental health specialties for children with physical illness and their families, especially during times of global crisis (16, 36, 37, 82).

In contrast to the inverse association with psychological distress, online and combination learning environment was positively associated with COVID-19-related worry among parents. Such worry may result from parental concerns regarding muted educational progress and fewer future opportunities for children, especially those achieving academic milestones (e.g., beginning secondary or postsecondary school). These learning environments may also serve as constant reminders for parents that life has deviated from normalcy (e.g., switching between in-person and online learning due to transmission outbreaks) leading to rumination, a core symptom of anxiety disorder (66), on the pandemic. Ultimately, the compounding stressors of caregiving to their children with physical illness, supporting their education, and often managing careers—all

from home—contribute to burn-out and, a general sense of loss among parents (28, 67, 79, 80, 83, 84).

Based on parent-proxy reports, lower level of disability was associated with higher level of negative effects of COVID-19-related social restriction among youth with physical illness. This finding may be a function of a perceived sense of loss among youth who, in the context of their physical illness (85–87), maintain a relatively high level of functioning or minimal impairment. For these youth, the shutdown of organized sports, closure of parks and recreational facilities, as well as other closures in response to the COVID-19 pandemic essentially removed opportunities for physical activity and social interaction with peers (67, 69). The loss of such activities, which in the context of school closures, provided some routine for youth with physical illness and their families likely contributed to their reports of the effects of social restriction, requires additional study. In a related vein, online and combination learning were associated with parent-proxy reports of COVID-19-related worry and social restrictions among young. There is robust evidence that these learning environments, which reduce social interactions among youth (88, 89), may also contribute negatively to their mental health—an effect that may be compounded in youth with physical illness who may already experience individual and family burden (67, 68, 90–92).

Of interest is the discrepant finding between informants with regard to the association between youth sex and COVID-19-related social restrictions. For youth-self report, female sex was associated with increased perception of the negative effect of social restrictions, whereas for parent-proxy reports, this association was with male sex. This informant inconsistency may be related to differences in the interpretation of sex as a biological construct vs. gender as a sociocultural construct. Additional research, likely qualitative in nature, is needed to investigate this notion; however, this finding confirms the importance of including multiple informants and perspectives in the context of child and family research.

Study Limitations

There are some notable limitations to this study. First, recall bias may affect the validity of the findings as parents and youth were asked to retrospectively reflect on their psychological and psychosocial health prior to the COVID-19 lockdown ordinances. Thus, change in distress scores may be overestimated. Ongoing data collection in MY LIFE may permit the examination of post-pandemic psychological and psychosocial health in a prospective manner. Second, the absence of a control group prevents ascertainment as to whether the changes in psychological distress and psychosocial health are specific to youth with physical illness and their families, or whether the magnitude of such changes are similar to subgroups within the population. Given that few clinical factors were associated with psychological or psychosocial distress, it is reasonable to expect similar findings in the general population. Third, because a relatively small subsample of youth was age eligible to provide self-reports, this study was underpowered to reliably estimate measures of

association in adjusted models of psychological distress and psychosocial health.

CONCLUSION

Youth with chronic physical illness and their parents report substantial increases in symptoms of psychological distress from before to during the COVID-19 pandemic. Both also report elevated COVID-19-related worry and negative effects of social restrictions aimed at reducing transmission. Few clinical factors were associated with changes in psychological distress or COVID-19-related psychosocial health; instead parent/family factors and online or combined online and in-person learning environments were key risk factors in predicting poorer outcomes in this vulnerable population of youth and their families. Models of care that are family-centered are crucial to support the mental and psychosocial health of youth with physical illness and their families, especially during times of global crisis. Efforts within the health system to integrate physical and mental health care, as well as trans-sectoral efforts across the health, education, and social services systems must be redoubled to capture the value of youth perspectives to provide learning environments that accommodate the unique needs of youth with physical illness and their parents to reduce burden and promote the best possible health outcomes.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because the authors do not have ethical approval to share the study data. Requests to access the datasets should be directed to Mark A. Ferro, mark.ferro@uwaterloo.ca.

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ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Waterloo Human Research Ethics Board. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

MF conceptualized the study, led the acquisition of funding, supervised all aspects of data collection, led the analysis of the data, and drafted the manuscript. SM, JY, SR, EL, and JG contributed to study design, acquisition of funding, provided insight to the interpretation of findings, and edited the manuscript for intellectual content. All authors agree to be accountable for the content of the work.

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The Influence of Pubertal Development on Adolescent Depression: The Mediating Effects of Negative Physical Self and Interpersonal Stress

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The current study examined the influence of pubertal development stage on depression and its psychosocial mechanisms in a non-clinical population of 502 adolescents (244 boys and 258 girls) in China, graded 5 to 8. Results indicated that (1) pubertal development was positively correlated with depression, negative physical self and interpersonal stress. (2) There is a significant gender by pubertal development interaction on the measure of academic self-concept, which is accounted for by decreased academic self in boys but not in girls as a function of pubertal development. (3) Mediation analyses show that increased depression in late compared to pre-puberty is partly mediated by the enhancement of negative physical self and interpersonal stress. These findings suggest that the late stage of puberty is coupled by a higher risk of depression in adolescents partly through increased negative physical self and interpersonal stress.

Keywords: adolescent development, depression, negative physical self, interpersonal stress, academic self

INTRODUCTION

Adolescent depression is a common neuropsychiatric disorder. Epidemiological studies have shown that the onset of depression peaks in adolescence (1–3), and lifelong depression usually begins at puberty (4). Early studies of adolescent health showed that the incidence of depressive symptoms increases significantly after the age of 12 (5), and levels of depressive disorders were significantly higher in mid adolescence than in childhood (6, 7). Adolescent depression can affect normal growth, cause serious educational barriers, and impair social relationships with peers and families (8–12). In addition, adolescent depression is closely associated with adult depression, suicide ideation and behavior (12, 13). There are also gender differences in adolescent depression. Studies have shown that pre-pubertal boys have a higher proportion of depressive symptoms than counterpart girls (14), however, with the development of puberty, the depression level of girls gradually increases with their developmental stage, especially by ages 12 to 13 or in the middle of puberty (15). In brief, previous researches have suggested that compared with childhood, the risk of adolescent depression increases, with greater prevalence in girls than in boys.

Prior studies have proposed several explanations for this phenomenon (16–18). First, physiological changes associated with adolescent development may have an impact on adolescent depression. Adolescents need to face sudden physical changes in the onset of puberty. Rapid changes in hormone levels and other physiological characteristics bring emotional stress to adolescents and even result in adaptive disorders (e.g., depression, binge drinking) (2, 18, 19). This adaptive stress may vary at different pubertal stages. For example, depression in pre-pubertal children is less common than that in adolescents (6, 7, 20), while the rate of depression increased significantly in the mid-puberty (16). Girls have a higher rate of depression after Tanner III and boys have a higher rate of depression before that (14).

Secondly, adolescent development is also linked with multiple psychosocial stressors, such as physical self-dissatisfaction, interpersonal stress and academic stress (17, 21–23). Several studies have shown that negative physical self (17, 24–26), interpersonal stress (27, 28), and academic self-stress (29) all contribute to the increase in adolescent depression.

In more detail, studies have indicated that body image dissatisfaction can be especially harmful to adolescents who undergo dramatic physical changes (24). In addition, the quality of parent-child relationship declines temporarily and the conflict increases with adolescent development (30). Indirect peer stress (e.g., the emergence of school and class norms) increases from early to middle adolescence (27). Academic stress also increases with adolescent ages, as academic pressure is indicated to be one of the most common sources of stress for teenagers (29, 31). In summary, adolescence development is associated with adaptive stresses that are considered to contribute to depressive disorders.

However, pubertal development is the key event during adolescence (32). Epidemiological evidence has shown that the risk of psychosocial disorders starts to rise with pubertal transition, including depression and behavioral disorders like substance misuse (3). Nonetheless, most studies of adolescent development used age or grade as the criteria to define the timing of adolescence (33–35), with the impacts of puberty on depression and psychosocial stresses less studied. As we know, age and grade are not necessarily indicative of levels of physical maturation, which, by contrast, is embodied by pubertal developmental stage.

In this regard, despite current knowledge of the relation between adolescent development and adaptive stress or depression, it is necessary to determine how puberty, the land marking event of adolescence, influences depression in teenagers. As analyzed above, it is possible that psychosocial stressors, from body image concern, interpersonal stress to academic stress, may mediate the association between puberty and depression. However, the roles of these psychosocial variables in the association between pubertal development and depression need to directly illustrated.

In addition, prior studies have indicated sex difference in the prevalence of depression and certain psychosocial stress (e.g., interpersonal stress) during adolescence (16, 36, 37). Also, there is evidence that the pattern of sex difference in emotion processing varies as a function of pubertal stage (38). Therefore, this study first examined sex differences in the

impact of pubertal development on depression and perceived psychosocial stress. Then, according to the result, we further explored psychosocial factors that may mediate the relationship between pubertal development and adolescent depression, taking sex as a moderator. The mediation effect of each single stressor as well as the comprehensive effects of multiple stressors were examined, respectively.

METHODS

Participants

Five hundred and two ($N = 502$) teenagers from grade 5 to grade 8 in Chengjiang Primary School and Chongqing 23 th high school in China were recruited by random sampling. Among them (244 boys and 258 girls), 60 ($M_{age} = 11.23$, $SD = 0.93$) were classified as in the pre-pubertal, 145 ($M_{age} = 11.57$, $SD = 0.94$) in the early pubertal, 159 ($M_{age} = 12.0$, $SD = 1.15$) in the mid pubertal, and 138 ($M_{age} = 12.52$, $SD = 0.98$) in the late pubertal stage according to their scores in the Pubertal Developmental Scale [PDS, (39, 40)]. Written informed consent was obtained from every participant and their parents prior to the experiment, and the study was approved by the Human Ethics Committee of Southwest University and Sichuan Normal University.

Measures

Adolescent Developmental Stage

The pubertal developmental stages were assessed via the self-reports in the Pubertal Development Scale (PDS). The PDS is a 4-point and 5-item self-report scale that is divided into two subscales for puberty assessment in boys and girls, respectively (39, 41). The two subscales have three common items for assessing growth spurt, body hair development and skin changes in both sexes. Additionally, boys are asked to report facial hair growth and voice change, while girls report breast development and menarche [coded as 1 (not yet) or 4 (yes)]. And the internal-consistency reliability (Cronbach's alpha) of the PDS was 0.722 based on the current sample statistics ($N = 502$).

Depressive Symptoms

The degree of depressive symptoms was measured using the Beck Depression Inventory [BDI (42)]. BDI is a self-report questionnaire with 21 items to evaluate the presence and severity of depression in adolescents. The higher the score of the scale, the higher the degree of depression (43, 44). The highest total score was 63, which had a high convergence validity with the interviewer's score of depression severity. In this study, the Cronbach's alpha of the BDI was 0.933.

Perceived Stress

In this study, we measured adolescents' negative physical self, interpersonal stress, and academic self-stress.

Negative Physical Self

We used the Negative Physical Self Scale [NPSS (45)] to measure adolescents' negative physical self-concept. It has 48 questions divided into five dimensions, namely overall dissatisfaction, appearance, thin, short and fat, using a five-point rating scale with 0 indicating totally disagree, and 4 denoting fully agree. The

average score of each dimension was obtained by averaging the total scores across all the items for each subject. The higher score denotes more dissatisfied with one's physical self. The Cronbach's alpha of each subscale based on the current sample is: $\alpha_{\text{total}} = 0.929$, $\alpha_{\text{overall dissatisfaction}} = 0.701$, $\alpha_{\text{fat}} = 0.914$, $\alpha_{\text{thin}} = 0.817$, $\alpha_{\text{appearance}} = 0.915$, $\alpha_{\text{short}} = 0.904$.

Interpersonal Stress

We used the Adolescent Interpersonal Stress Scale (AISS) to measure adolescents' interpersonal stress. The AISS has 23 items and uses a 5-point scale ranging from 0 to 4, with higher score indicating greater stress. The AISS consists of four subscales: teacher stress, peer stress, family environment stress and parental discipline stress. The scores in each subscale and the total AISS scores were computed, respectively, for each subject. The Cronbach's alpha of the AISS is: $\alpha_{\text{total}} = 0.889$, $\alpha_{\text{teacher}} = 0.847$, $\alpha_{\text{peer}} = 0.780$, $\alpha_{\text{family environment}} = 0.542$, $\alpha_{\text{parental discipline}} = 0.637$.

Academic Self

Academic self was measured using the Adolescent Student's General Academic Self-Concept Scale (46). It has 20 items divided into four subscales: ability perception, behavioral inhibition, emotional experience and achievement value. The scale uses a 5-point scale, ranging from 1 (the description is completely unfit for me) to 5 (completely fit for me). The higher scores indicate better feeling in each specific area. The Cronbach's alpha of the scale is: $\alpha_{\text{total}} = 0.940$, $\alpha_{\text{ability perception}} = 0.833$, $\alpha_{\text{emotional experience}} = 0.881$, $\alpha_{\text{behavioral inhibition}} = 0.867$, $\alpha_{\text{achievement value}} = 0.827$.

Procedures

First, according to the predicted development level, students of grade 4–8 were randomly selected and tested with the Pubertal Development Scale (PDS). Then, the students were classified into different pubertal developmental stages according to the PDS scores. Furthermore, students of different stages and genders were asked to fill in the stress questionnaires, the Beck Depression Inventory and the Spielberger State-Trait Anxiety Inventory (STAI), with necessary guidance if needed. Finally, all the questionnaires were collected and souvenirs were distributed to the participants. Unusable questionnaires with random answers and unfinished questionnaires were deleted. A total of 502 students were randomly sampled from grade 4 to grade 8.

Data Processing

SPSS23.0 was used for data preprocessing, analysis of variance, and calculation of correlation among various variables. Mplus7.3 was used to test each structural equation model. According to the two-step sequence of Anderson and Gerbing (47), the measurement model needs to be checked before modeling. Firstly, the measurement models of the four latent variables were tested to evaluate the goodness of fit represented by their indicators. The confirmatory factor analysis and the maximum likelihood estimation method were used to test the model fitting for the datasets, and the bias-corrected bootstrap confidence intervals were used to test the mediating effects.

The multi-item inflation measurement error of latent variables was controlled according to the packaging strategy of Wu and Wen (48). In more detail, the one-dimensional scale was packaged into three indicators by the factor balance method, and the multidimensional scale was packaged into corresponding indicators according to the number of dimensions. The mean scores of corresponding items were calculated to represent the measurement scores of the index. Since the pubertal development stage is a categorical variable, dummy coding is used for this variable in the mediation test model (49).

The following four indices were utilized to evaluate the goodness of fit of the model: (a) chi-square statistic (χ^2), χ^2/df , (b) the standardized root mean square residual (SRMR), (c) the root mean square error of approximation (RMSEA), and (d) the comparative fit index [CFI, (50, 51)]. According to Wen and Marsh (2004), when $\chi^2/df < 5$, CFI, TLI > 0.90 , RMSEA < 0.08 , and SRMR < 0.08 , the model is considered to be well-fitted (52).

RESULTS

Statistical Description and Correlation Analysis of Each Variable

Correlation analysis showed that, variables were significantly correlated with one another (Table 1).

Then, the multivariate analysis of variance used gender and pubertal stage as independent variables, while depression, negative physical self, interpersonal stress and academic self as dependent variables. The results showed that the main effects of gender ($F_{(1,494)} = 5.910$, $p < 0.05$) and pubertal stage ($F_{(3,494)} = 2.636$, $p < 0.05$), as well as the gender by pubertal stage interaction ($F_{(3,494)} = 3.956$, $p < 0.01$) were significant on the academic self. The subsequent analyses showed a significant pubertal stage effect in boys ($p < 0.01$) and girls ($p < 0.02$). Boys in middle and late stages had lower academic self than in pre-pubertal stage ($p < 0.05$). For girls, the only significant comparison is the reduced academic self in late compared to the middle stage ($p < 0.05$) (Figure 1A). In another direction, boys showed lower academic self than girls in middle ($p < 0.01$) and late stage ($p < 0.05$) but not in the pre-and early stage ($p > 0.1$) (Figure 1B).

In addition, there was a significant main effect of pubertal stage on depression $F_{(3,494)} = 4.288$, $p < 0.01$. Post hoc comparisons showed that the depression level in late stage was significantly higher than that in pre- ($p < 0.01$), early- ($p < 0.01$), and mid-stages ($p < 0.01$), while no significant differences were observed amongst pre-, early and mid-stages ($p > 0.1$). There were no other significant main or interaction effects.

Measurement Model

Confirmatory factor analysis was used to test whether the measurement model could adequately fit the sample data. The full measurement model included four latent constructs (depression, interpersonal stress, academic self and negative physical self), which altogether generated sixteen observed variables. The results showed that the measurement model can fit the sample data well ($\chi^2 = 330.093$, $df = 98$, $\chi^2/df = 3.368$, CFI = 0.942, TLI = 0.929, RMSEA = 0.069, SRMR = 0.068).

TABLE 1 | Descriptive data and zero-order correlations across variables.

	M	SD	1	2	3	4	5
1. PDS	5.982	2.184	1				
2. Depression	0.494	0.535	0.225**	1			
3. NPS	1.025	0.573	0.184**	0.520**	1		
4. IPS	0.361	0.394	0.116**	0.521**	0.401**	1	
5. ACS	3.619	0.817	-0.127**	-0.382**	-0.289**	0.304**	1

PDS, Pubertal developmental stage; NPS, negative physical self; IPS, interpersonal stress; ACS, academic self. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

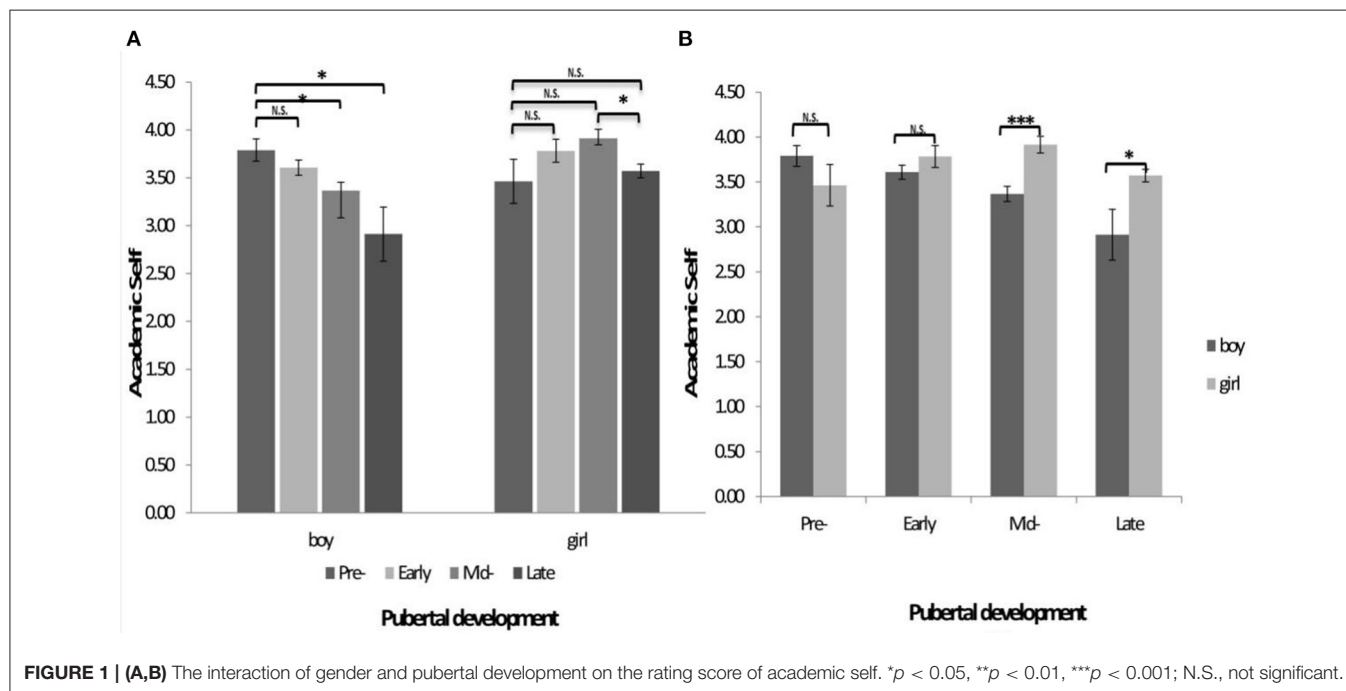


FIGURE 1 | (A,B) The interaction of gender and pubertal development on the rating score of academic self. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; N.S., not significant.

However, among the five indicators of negative physical self, the factor loading coefficients of the overall dissatisfaction and thin were lower than 0.45 (0.281 and 0.399, respectively), so these two indicators were deleted (52) to improve the model fitting ($\chi^2 = 170.894$, $df = 71$, $\chi^2/df = 2.410$, CFI = 0.973, TLI = 0.966, RMSEA = 0.053, SRMR = 0.046). Then, the standardized factor loadings of all the observed variables on the corresponding latent constructs were statistically significant ($p < 0.001$), indicating that the structural equation model can be used in the next step of analysis.

Common Method Bias Test

Using Harman single factor test, we analyzed the principal component factors of all the items in the questionnaire without rotation. The results showed that the variance of the maximum factor interpretation was 15.91% (<40%), which indicated that the common method bias of this study was not significant (53).

Structural Model

In the first step, as mentioned above, the direct effect of the predictor (pubertal stage) on the dependent variable (depression) without mediators was significant ($F_{(3,498)} = 4.288$, $p < 0.01$). The level of depression tended to increase as a function of pubertal

stage (pre: 0.384 ± 0.469 , early: 0.425 ± 0.506 , mid: 0.436 ± 0.507 , late: 0.684 ± 0.581), and depression was significantly higher in the late compared to other pubertal stages. Therefore, the pre puberty was used as the reference baseline, and three dummy variables of early, middle and late puberty were set as independent variables. Then, Model 1 and Model 2 were established with negative physical self (M1) or interpersonal stress (M2) as mediators. Model 3 was established with academic self as mediator and gender as moderator, given observation of a gender & puberty interaction effect on academic self. The results of the mediation model showed a satisfactory fitting of Model 1, Model 2 (Model 1: $\chi^2 = 60.195$, $df = 20$, $\chi^2/df = 3.010$, CFI = 0.977, TLI = 0.962, RMSEA = 0.063, SRMR = 0.033, Model 2: $\chi^2 = 42.004$, $df = 28$, $\chi^2/df = 1.500$, CFI = 0.993, TLI = 0.989, RMSEA = 0.032, SRMR = 0.023).

The bias-corrected bootstrap method was used to test the mediating effect (sampling = 1000). The results showed that the mediating effects of Model 1 and Model 2 were not significant in the early and mid-stage, while the mediating effects of negative physical self (Model 1) and interpersonal stress (Model 2) were significant in the late stage (Figures 2A,B). The mediating effect of academic self (Model 3) was not significant (Figure 2C). Monte Carlo power analyses were used to calculate

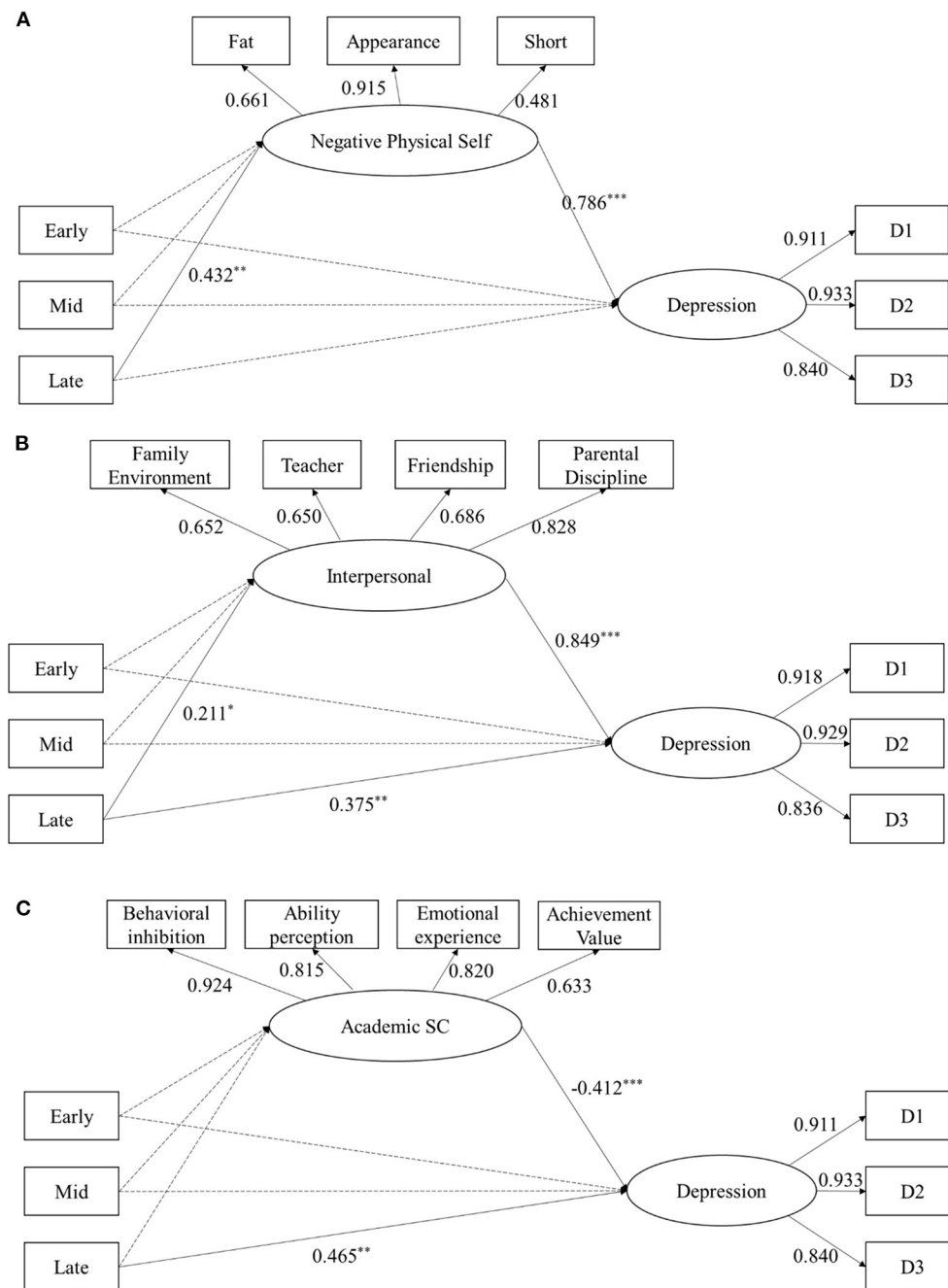


FIGURE 2 | Single factor mediation Model 1, Model 2 and Model 3 were established with negative physical self (A) or interpersonal stress (B) as mediator, respectively. Model 3 was established with academic self (C) as mediator and gender as moderator. Path coefficient was standardized. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, Early, Early puberty; Mid, Mid puberty; Late, Late puberty.

the statistical power of Model 1 and Model 2. Results showed that Model 1 (negative physical self) had a statistical power of 0.99, while Model 2 (interpersonal stress) had a statistical power of 0.74.

According to the results of the single factor mediation model, the multiple mediation model was established with negative physical self and interpersonal stress as mediators (Model 4). The

model fitting is satisfactory, $\chi^2 = 210.420$, $df = 54$, $\chi^2/df = 3.896$, CFI = 0.939, TLI = 0.915, RMSEA = 0.076, SRMR = 0.092. In Model 4, the mediating effect of interpersonal stress was not significant in the early and mid-puberty. The mediating effects of interpersonal stress [95% CI: (0.002, 0.283)] and negative physical self [95% CI: (0.134, 0.431)] were significant in the late pubertal stage (Figure 3).

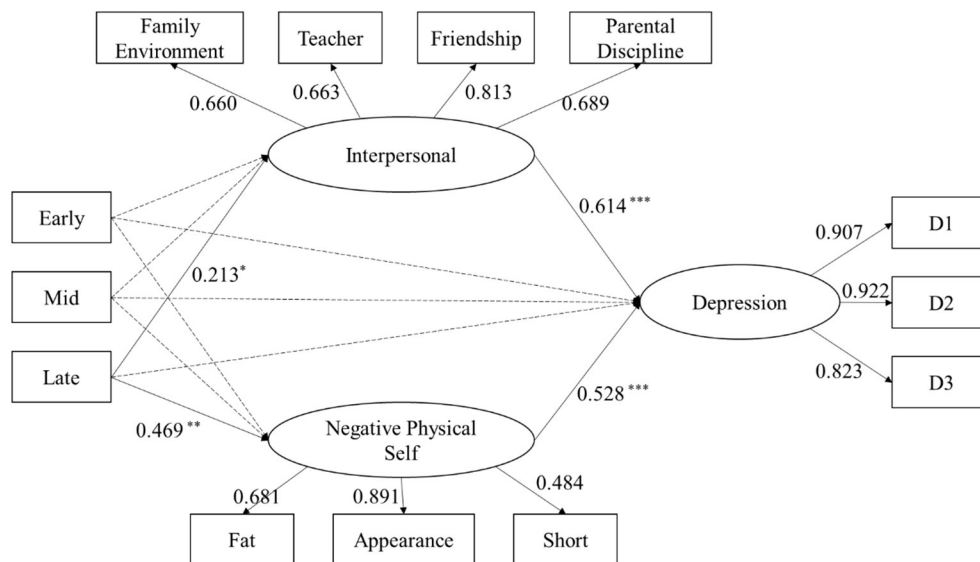


FIGURE 3 | Multiple mediation Model 4 between the pubertal stage and depression through interpersonal stress and negative physical self. Path coefficient was standardized. * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$; Early, Early puberty; Mid, mid puberty; Late, late puberty.

DISCUSSION

This research yielded three main results. First, through correlation analysis, we found that pubertal development is associated with an increase in the levels of depression and psychosocial stresses in adolescents. Specifically, the level of depression, psychosocial stresses such as negative physical self, interpersonal stress and perceived academic stress all increased with pubertal development. In addition, multiple psychosocial stressors were positively correlated with the level of depression, which implies that the stresses coupled by puberty development may contribute to the generation of depression. Second, concerning the gender differences in depression and stressors across pubertal stages, we only observed a significant pubertal stage and gender interaction effect on the ratings of academic self. Boys, instead of girls, faced higher academic stress with pubertal development, while the analysis of other stressors (interpersonal stress and negative physical self) did not show this pattern of effect. Moreover, our correlation analyses showed greater stresses in the measures of academic self, negative physical self and interpersonal stress with pubertal development. Third and most important, single factor mediation analysis showed that negative physical self and interpersonal stress mediates the increased depression in late compared to pre pubertal stages, respectively. The significant mediators of interpersonal stress and negative physical self are further replicated in the multiple-factor mediation model.

The Gender and Puberty Interaction on Academic Self-Concept

Our finding of higher academic stress in boys but not in girls with pubertal development is consistent with a couple of prior observations. For example, there was evidence showing an advantage of girls over boys in the four dimensions of the

academic self (54–56). First of all, research has shown that girls' academic performance is generally better than boys around the senior grades of primary school or early high school (56). Also, early study has shown that girls are more inclined than boys to internally attribute improved academic performance to their own efforts and abilities through positive perception (55). In addition, girls outperform boys in behavioral self-control (57). On the other hand, boys have more academic procrastination than girls, like delayed implementation and delayed remediation (54), and boys experience more negative academic emotions than girls.

The results suggest that the effects of pubertal development on negative physical self, interpersonal stress, and depression were consistent across boys and girls. One explanation for the lack of gender differences in these measures may be related to the range of ages of the subjects (10–14 years). Early studies have shown that there is no gender difference in depressive mood for adolescents at 12–14 years old (58), while gender differences appear from 14 to 15 years (14, 59). This coincided with our finding of rising depression in late compared to pre, early and mid-pubertal stages, while the latter three stages showed similarly low levels of depression across genders.

The Influence of Pubertal Development on Adolescent Depression via Negative Physical Self and Interpersonal Stress

Previous studies have shown that body dissatisfaction was a major predictor of low self-esteem, depression, and eating disorders in adolescents (60–62). In addition, the concept of "thinness as beauty for girls and strong as beauty for boys" usually prevails, leading to teenager's irrational expectations for figure, weight and increased physical self-dissatisfaction since entry into puberty. For example, it has been reported that stress from peers, parents

and social media predisposes teenagers to be easily dissatisfied with body image, thus promoting the risk of depression (27, 63).

On the other hand, adolescents have excessive comfort seeking and greater emotional dependence on their friends compared to people in other periods (64), which suggests that adolescents are more susceptible to interpersonal stress (e.g., relationship breakdown) than other age groups, which also increases the risk of depressive symptoms (64). Recent studies have shown that multiple physiological indicators (e.g., salivary alpha amylase, systolic blood pressure) of adolescents are significantly higher than those of children during peer rejection or social exclusion (64–66). In addition, parent-child conflict constitutes an important part of interpersonal stress at adolescence, since seeking affective and behavioral independence from parents is one of the key motivations in this period (30, 67).

CONCLUSION AND FUTURE DIRECTIONS

In summary, the current study identified negative physical self as a key mediator underpinning the predictive role of puberty in adolescent depression. This shows that negative physical self is a major stressor that contributes to adolescent depression during late pubertal period. However, the current cross-sectional design measured depression, pubertal stage and psychosocial stressors at the same phase. In this regard, though we observed reliable mediation effects of negative physical self and interpersonal stress on the association between puberty and depression, the causal relationship between adolescent depression, pubertal stage and psychosocial variables cannot be firmly inferred. Therefore, future studies need to administer a longitudinal design to a large

sample of subjects across different pubertal stages, to determine the influence of puberty on affective health and its related psychosocial mechanisms.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics committee of human research at Southwest University and Sichuan Normal University. Written informed consent to participate in this study was provided by the participant's legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

JY: conceptualized the study and research design. JY and DY: paper writing. LJ: data analysis and presentation. DY and YL: data connection. All authors contributed to the article and approved the submitted version.

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Prevalence and Correlates of Alexithymia and Its Relationship With Life Events in Chinese Adolescents With Depression During the COVID-19 Pandemic

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Objectives: The incidence of psychological and behavioral problems and depression among adolescents is increasing year by year, which has become an important public health problem. Alexithymia, as an important susceptible factor of adolescent depression, may continue to develop and strengthen under the stimulation of COVID-19-related stressors. However, no studies have focused on alexithymia in adolescent depression during the pandemic in China. This study aims to investigate the incidence and related factors of alexithymia in adolescent depression during the pandemic.

Methods: Three hundred adolescent patients were enrolled from October 2020 to May 2021. The general demographic information of all participants was collected, and the clinical characteristics were assessed by the 20-item Toronto Alexithymia Scale (TAS-20), the Adolescent Self-Rating Life Events Check (ASLEC) List, the Childhood Trauma Questionnaire (CTQ), and the Positive and Negative Suicide Ideation (PANSI) Inventory.

Results: The incidence of alexithymia was significantly higher among adolescents with depression (76.45%) during the pandemic. There were significant differences in school bullying, disease severity, ASLEC score, CTQ score and PANSI score between adolescents with and without alexithymia. In addition, learning stress, health and adaptation problems during the pandemic may be influential factors in alexithymia of adolescent depression ($P < 0.05$).

Conclusions: According to the results, we found a high incidence of alexithymia in adolescent depression during the pandemic. More support and attention from families, schools and society is needed to develop preventive and targeted psychological interventions as early as possible.

Keywords: depression, alexithymia, life events, COVID-19, adolescent

INTRODUCTION

Depression is one of the most common affective disorders among adolescents, which seriously affects quality of life and social functions, and has become one of the major diseases threatening the healthy growth of adolescents. The prevalence of adolescent depression varies from 9 to 25% in different studies and countries, which is increasing year by year (1–3). Compared with adult depression, adolescent depression has a longer duration, more episodes, higher recurrence rates, more severe symptoms and higher disability rates (4–6). About 50% of patients with recurrent adult depression reported their initial onset before the age of 18, and 48% of patients with early-onset depression had attempted suicide, compared with 26% of those with adult-onset depression (7). These highlight the importance of early and effective management of adolescent depression.

Alexithymia is a defect characterized by difficulties in identifying, distinguishing and expressing emotions (8, 9). It is a common psychosomatic phenomenon that is considered to be associated with various psychopathic symptoms such as depression, anxiety, somatization, hostility, and paranoia (10). It increases susceptibility to mental disorders, reduces the effectiveness of psychotherapy, and negatively affects the development and severity of psychopathological symptoms (11–14). Patients with depression usually use emotional suppression strategies to defend themselves from pain, and have difficulty identifying and describing emotions subjectively (15, 16). Therefore, patients with depression exhibit higher rates of alexithymia than patients with other mental disorders (17, 18).

The prevalence of alexithymia has been reported to be ~10% in the general population (19), and 7.3–29.9% in adolescents (20, 21). Alexithymia is considered as a cumulative process that begins in early childhood and continues to develop and reinforce in the social context (22). It is associated with negative life events in childhood, family environment, interpersonal relationships and social support (23–25). Among these, negative life events in childhood are considered to be the main risk factor for alexithymia, which hinders the ability to identify and express emotions, thereby increasing psychological distress of adolescents (26, 27).

As an intense stressor, the novel coronavirus disease (COVID-19) has caused great psychological distress due to its rapid transmission, high mortality, lack of effective treatments and large-scale quarantine measures (28–30). The psychological impact of the epidemic was reported to be rated as moderate or severe by 53.8% of participants, and 16.5% (28.8%) reported moderate to severe symptoms of depression (anxiety) (31). Due to immature immune systems, insufficient self-protection, and weak psychological tolerance, adolescents have become one of the most susceptible subgroups of COVID-19, with significant impact on their health, academic, economic and psychological status (32–34). Therefore, it is important to explore the relationship between alexithymia and life events in adolescents during the pandemic.

The purpose of this study is to investigate the prevalence of alexithymia and its relationship with life events in Chinese adolescent depression during the pandemic, so as to further

understand the possible effects of alexithymia on the formation and recurrence of adolescent depression, and to provide important clinical information for the formulation of preventive and targeted treatment plans.

METHODS

Participants

From October 2020 to May 2021, a total of 300 adolescent patients with depression from psychiatric outpatients and inpatients in 7 hospitals in Anhui Province (Chaohu Hospital of Anhui Medical University, Hefei Fourth People's Hospital, Fuyang Third People's Hospital, Suzhou Second People's Hospital, Bozhou Hospital Affiliated to Anhui Medical University, Maanshan Fourth People's Hospital, and the Second Affiliated Hospital of Bengbu Medical College) were enrolled in this study. Inclusion criteria: (1) "International Statistical Classification of Diseases and Related Health Problems (ICD-10-F32)" diagnosis of depression; (2) age between 13 and 18 years old with a certain level of comprehension. Exclusion criteria: (1) diagnosis of bipolar disorder and other types of mental disorders; (2) severe somatic diseases or a non-collaborator. Approved by the medical ethics committee of Chaohu Hospital affiliated to Anhui Medical University (202009-kyxm-04) before the start of the study, all subjects and their guardians had informed consent before the survey. Participants could terminate the study at any time. The real name system was used to facilitate clinical follow-up. All questionnaires were archived and the results were kept strictly confidential.

Design and Measurements

A face-to-face questionnaire was conducted by uniformly trained and qualified investigators from October 2020 to May 2021. The contents of this questionnaire include: (1) general demographic characteristics; (2) Mental health status: the 20-item Toronto Alexithymia Scale (TAS-20), the Adolescent Self-Rating Life Events Check (ASLEC) List, the Childhood Trauma Questionnaire (CTQ) and the Positive and Negative Suicide Ideation (PANSI) Inventory.

The general demographic characteristics, such as gender, age, only child (yes or no), total disease course, severity of illness (disease-free, basically disease-free, extremely light, mild, moderate, heavy, severe, or extremely heavy), relationship with classmates (good, average, or bad), relationship with teachers (good, average, or bad) and school bullying (yes or no).

The TAS-20 scale consists of 3 factors (difficulty identifying feelings, difficulty describing feelings and externally-oriented thinking). There are 20 items on a 5-point Likert scale ranging from 1 (totally disagree) to 5 (totally agree), with a total score of 20–100. The higher the score, the more severe alexithymia (35, 36). The total score of TAS-20 ≥ 61 is often used as the criterion of alexithymia (37). The Cronbach's α coefficient for the TAS-20 was 0.83, and the test-retest reliability coefficient was 0.87 (38).

The ASLEC scale includes 27 negative life events and assesses status over the last 6 months. It first determines whether the event occurred, and is categorized into 5 levels, from 1 (no

TABLE 1 | General demographic and clinical characteristics of adolescents with depression.

	The whole sample N = 293		Alexithymia N = 224		Non-alexithymia N = 69		Statistics	
	N	%	N	%	N	%	χ^2	P
Female	215	73.4	166	74.1	49	71.0	0.3	0.6
Only child	118	40.3	85	37.9	33	47.8	2.1	0.1
Relationship with classmates							−1.5	0.1
Good	53	18.2	38	17.1	15	21.7		
Average	177	60.8	133	59.9	44	63.8		
Bad	61	21.0	51	23.0	10	14.5		
Relationship with teachers							−0.3	0.7
Good	52	17.9	38	17.1	14	20.3		
Average	172	59.1	136	61.3	36	52.2		
Bad	67	23.0	48	21.6	19	27.5		
School bullying	138	47.1	116	51.8	22	31.9	8.4	0.004
Severity of illness							−2.2	0.03
Disease-free	0	0.0	0	0.0	0	0.0		
Basically disease-free	1	0.3	1	0.4	0	0.0		
Extremely light	7	2.4	5	2.2	2	2.9		
Mild	50	17.1	33	14.7	17	24.6		
Moderate	89	30.4	67	29.9	22	31.9		
Heavy	109	37.2	86	38.4	23	33.3		
Severe	37	12.6	32	14.3	5	7.2		
Extremely heavy	0	0.0	0	0.0	0	0.0		
	Mean	SD	Mean	SD	Mean	SD	T/Z	P
Age (years)	15.2	1.7	15.3	1.7	15.0	1.8	−1.0	0.3
Total disease course (month)	20.3	18.3	21.1	18.6	18.0	17.3	−1.2	0.2
ASLEC score	54.1	21.7	57.3	20.9	43.8	21.1	−4.6	<0.001
CTQ score	50.7	13.1	51.9	12.9	47.0	13.0	−2.6	0.01
PANSI score	78.3	23.0	80.3	22.6	72.1	23.4	−3.2	0.001

ASLEC, the Adolescent Self-Rating Life Events Check List; CTQ, the Childhood Trauma Questionnaire; PANSI, the Positive and Negative Suicide Ideation Inventory.

TABLE 2 | Independent factors associated with alexithymia by binary logistic regression analysis.

Variable	B	SE	Wald	P	OR	OR 95%CI
Dimension II	0.12	0.04	10.47	0.001	1.12	1.05–1.20
Dimension V	0.14	0.05	7.74	0.005	1.15	1.04–1.26

Dimension II, Learning stress factors; Dimension V, Health and adaptation problem.

impact) to 5 (extremely heavy impact), according to the degree of physical and psychological impact on adolescents. It contains 6 dimensions: interpersonal relationship factors (I), learning stress factors (II), punishment factors (III), loss of relatives, friends and property factors (IV), health and adaptation problem factors (V), and other factors (VI) (39). The Cronbach's α coefficient for the ASLEC showed a high internal consistency reliability of 0.849 (40).

As an internationally recognized assessment tool for childhood trauma, the CTQ is one of the most widely used self-report questionnaires to investigate different forms of abuse and neglect during childhood. It contains 28 items and 5 factors (emotional abuse, physical abuse, sexual abuse, emotional neglect and physical neglect). There are 3 items for effectiveness evaluation (41). The overall Cronbach's α coefficient for the

CTQ was 0.77, and the Cronbach's α coefficient for each subscale ranged from 0.41 to 0.68 (42).

The PANSI scale consists of 14 items, including 6 positive suicidal ideation and 8 negative suicidal ideation. Each item is assessed by a 5-point Likert scale, ranging from 1 (none) to 5 (most of the time). Positive suicidal ideation is scored in reverse and added to the scores of the negative suicidal ideation items to obtain a total score of suicidal ideation. The higher the score, the higher the degree of suicidal ideation (43). The Cronbach's α coefficient for the PANSI was 0.92 (44).

Statistical Analysis

SPSS23.0 statistical software was used to establish a database for analysis. Comparisons between the alexithymia and non-alexithymia groups regarding general demographic and

clinical characteristics were performed by independent sample *t*-test, Mann-Whitney *U*-test and chi-square-test. Binary logistic regression analysis was performed to identify independent correlates of alexithymia during the pandemic, using alexithymia as the dependent variable and variables that differed significantly between alexithymia and non-alexithymia groups in univariate analysis as independent variables. Two-tailed tests were used in all hypotheses with the significance level of 0.05.

RESULTS

General Demographic and Clinical Characteristics of All Participants

Three hundred questionnaires were received, of which 293 were valid, with a response rate of 97.7% (293/300). Among the 293 adolescent patients with depression, the average age was 15.2 ± 1.7 years, including 78 males (26.62%) and 215 females (73.38%), and the incidence of alexithymia was 76.45% (224/293) during the pandemic (see **Table 1** for details).

Comparison of General Demographic and Clinical Characteristics Between the Alexithymia Group and Non-alexithymia Group in Adolescents With Depression

A total of 224 individuals (76.45%) were identified as alexithymia based on the TAS-20 score > 61 . Comparisons between groups showed no significant differences in the prevalence of alexithymia among patients with different gender, age, only child, total disease course, and relationships with classmates and teachers ($P > 0.05$). There were significant differences in school bullying, disease severity, ASLEC score, CTQ score and PANSI score between adolescent patients with and without alexithymia during the pandemic ($P < 0.05$; see **Table 1** for details).

Independent Factors Associated With Alexithymia by Binary Logistic Regression Analysis

In the binary logistic regression analysis, school bullying, disease severity, total ASLEC score and its 6 dimensions scores (interpersonal relationship factors, learning stress factors, punishment factors, loss of relatives, friends and property factors, health and adaptation problem factors, and other factors), as well as CTQ and PANSI scores were used as potential factors for alexithymia. Greater learning stress ($P = 0.001$, OR = 1.122, 95% CI 1.047–1.204) and more serious health and adaptation problems ($P = 0.005$, OR = 1.147, 95% CI 1.041–1.264) in adolescent patients with depression were both independently associated with alexithymia during the pandemic (see **Table 2** for details).

DISCUSSION

As far as we know, this is the first cross-sectional study of alexithymia and its relationship with life events in Chinese adolescent patients with depression during the pandemic. The results showed that 76.45% of adolescent patients reported

alexithymia, which was significantly higher than the prevalence of alexithymia (26.75%) in adolescents with depressive symptoms before the outbreak (45). In addition, previous studies have shown that the prevalence of alexithymia ranges from 7.3 to 29.9% in adolescents (20, 21), from 9 to 17% in males and 5 to 10% in females of working age (46, 47), over 20% in the older age groups, and even over 30% in the oldest populations (48). The prevalence of alexithymia was highest (26.9%) in adults with depression compared to other psychiatric disorders (49).

Using different demographic data and self-assessment factors, our results suggested that school bullying, severity of depression and total scores of the ASLEC, CTQ, and PANSI scale were influential factors of alexithymia. Greater learning stress and more severe health and adaptation problems were independently associated with alexithymia in adolescents with depression during the pandemic. Previous studies have suggested that alexithymia may be a cumulative process that begins in early childhood, develops and reinforces in the social environment (22). After controlling for psychopathological factors, the association between alexithymia and childhood abuse and neglect variables remained (50). Negative life events may enhance the development of alexithymia by disrupting normal emotions, and some personality traits or behaviors associated with alexithymia may in turn increase psychological distress in adolescents (15, 25, 51). Individuals with alexithymia have difficulty recognizing and describing emotions, a reduced ability to distinguish between emotional states and physical sensations, and a lack of symbolic thinking. This leads to their inability to regulate emotions, which causes or aggravates physical and mental health problems (such as depression and anxiety), as well as poor health-related quality of life (13, 52).

The ability to identify and regulate emotions in adolescent patients with depression may play a key role in coping with stress, adapting to their environment, and improving academic performance. During the pandemic, adolescents have become one of the most vulnerable subgroups because of their immature immune system, lack of self-protection and weak psychological tolerance. Characteristics of COVID-19, such as acute onset, high mortality, long-term social isolation and its overwhelming negative news, also further aggravate the physical and mental impairment of adolescent patients. It was reported that 31.5% of the students had anxiety and fear during the epidemic, and they faced the impact of infection, stagnant family income, pressure on tuition fees and changes in teaching methods, which seriously affected their mental health and learning ability (33, 34). Previous studies have shown that 96% of the students have learning difficulties, 54.0% have memory difficulties, and 67.0% have attention problems. Ninety percentage have increased overall learning difficulties during the pandemic (53). Under greater learning pressure, adolescent patients are more likely to experience academic anxiety and burnout characterized by insecurity, avoidance and procrastination, as well as performance and environmental concerns (54), thus aggravating alexithymia.

In addition, the interpersonal communication style of patients with alexithymia are characterized by apathy, social avoidance and hostile behavior. They have a reduced ability to regulate their emotions through social interactions, and cannot spontaneously

express negative, happy and angry emotions (55, 56), thus affecting their social interactions and interpersonal relationships to a great extent (57). It is difficult for them to perceive and understand the communication and behavior of others, which aggravates the interpersonal problems and leads to a decline in social support. Social isolation is considered to be one of the strongest predictors of suicidal ideation and suicide attempts (58).

This study has the following shortcomings: (1) As this study was a cross-sectional survey, we were unable to clarify the causal relationships between variables or to study the effective mediating effect of variables. (2) As part of the data in this study were self-reported, the results were easily affected by the emotional changes of participants during the survey, resulting in the recall bias of negative life events. (3) The subjects of this study were adolescent patients with depression from psychiatric outpatients and inpatients in 7 hospitals. It was reported that since puberty, the rate of depression increased gradually in girls, almost 2–3 times than that of boys (59). Due to the influence of gender differences in adolescent depression, the male participants included in this study were lower than females. (4) Because of the acute onset of the epidemic, we were unable to measure the prevalence of alexithymia in adolescent patients before the outbreak, so we cannot exclude that patients had a high prevalence of alexithymia in the past. Although the TAS-20 scale is increasingly used with adolescents, the factor structure and psychometric properties of the Tas-20 may have systematic age differences (60), so our results may be biased. Therefore, further prospective cohort studies of adolescent patients are of great significance.

CONCLUSION

This study conducted a cross-sectional survey of alexithymia and its related factors in 300 adolescent patients with depression admitted to 7 hospitals in Anhui Province during the pandemic. The results showed that the incidence of alexithymia in adolescent patients increased significantly (76.45%) during the pandemic. COVID-19 as a strong stressor, facilitates the development of alexithymia by affecting the identification, expression and regulation of emotions through various negative life events. In turn, the personality traits or behaviors associated with alexithymia affect the physical and mental health of adolescent patients, reduce the ability to adapt to the environment, affect interpersonal relationships, and lead to social isolation, thus greatly increasing the risk of self-harm

and suicide. Therefore, families, schools, and society should give more support and attention to adolescent patients with depression during the pandemic, conduct targeted epidemic knowledge campaigns to reduce the negative impact of COVID-19-related stressors on the mental health of adolescent patients and to increase their confidence in fighting the epidemic. In addition, improving the family environment, perfecting the mental health service system in schools and communities, and further conducting prospective cohort studies of adolescent patients over 8 weeks and half a year are of great significance for the early formulation of preventive and targeted psychological interventions.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Medical Ethics Committee of Chaohu Hospital Affiliated to Anhui Medical University (202009-kyxm-04). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

YH, LX, FG, FS, CC, JW, XWe, and XLu completed the preliminary questionnaire design and data collection. XWa, XLi, and CG completed the data collation, statistical analysis, and the first draft. HL supervised in designing and critically read and revised the manuscript. All authors participated in revising and confirming the final manuscript.

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Psychological Impact of COVID-19 Epidemic on Adolescents: A Large Sample Study in China

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Background: The COVID-19 pandemic is a major public health emergency. However, little is known about the psychological impact of this pandemic on adolescents. We aim to assess the prevalence and influencing factors of depression, anxiety, and posttraumatic growth (PTG) among adolescents in a large sample study.

Methods: This cross-sectional study collected demographic data and mental health measurements from 175,416 adolescents covering 31 provinces, centrally administered municipalities, and autonomous regions in mainland China from February 23 to March 8, 2020. The status of depression, anxiety, and PTG was assessed by the nine-item Patient Health Questionnaire, seven-item generalized anxiety disorder questionnaire, and post-traumatic growth inventory.

Results: The prevalence of depression, anxiety, and PTG in adolescents was 35.9, 28.0, and 45.6%, respectively. The prevalence of depression and anxiety in the slight or severe epidemic areas was similar. Regression analysis showed that female sex and older age were associated with higher levels of depression, anxiety, and lower levels of PTG. Symptoms related to COVID-19, excessive attention to epidemic information, living in urban or severe epidemic areas, and conflicts with parents during home quarantine were risk factors for depression, anxiety, and PTG. Frequent communication with peers, exercise, and receiving public welfare psychological assistance were protective factors. Poor family economic status was a significant risk factor for depression and PTG.

Conclusion: Our findings suggested that positive and negative psychological reactions coexist in adolescents faced with the pandemic. The factors associated with psychological problems and PTG provide strategic guidance for maintaining adolescents' mental health in China and worldwide during any pandemic such as COVID-19.

Keywords: COVID-19, adolescents, depression, anxiety, posttraumatic growth

INTRODUCTION

The novel coronavirus disease 2019 (COVID-2019), which was declared a public health emergency of international concern by the World Health Organization (WHO), swept across 210 countries and territories with over 5.2 million cases and 337,736 deaths reported as of May 24, 2020 (1). China and many other countries closed their schools and relocated their classes online in response to the COVID-19 outbreak. Consequently, in China, more than 220 million children and adolescents were confined to their homes. Under these circumstances, adolescents experienced exceptional stress and challenges.

A recent study demonstrated that uncertainty about the personal and global effects of COVID-19 impacted the psychological condition of the Chinese public (2). Adolescents could be considered as a more vulnerable group because of their inadequate understanding of the epidemic, the erroneous information caused by cognitive immaturity, and the fact that excessive attention to epidemic information may potentially exacerbate stress, depression, and anxiety. Furthermore, adolescents establishing independence begin to prefer communicating with friends to parents, which may also influence their psychology. School activities and social relationships are the main methods of coping with these problems (3). However, during this unusual period, a lack of in-person contact with peers may negatively influence adolescents' mental health. Meanwhile, adolescents inevitably had the most contact with their parents, who were highly authoritative in many Chinese families (4), which tended to trigger parent-adolescent conflicts (physical or verbal conflict) and further aggravated the detrimental effects on their mental health. Moreover, staying at home for a long period may increase the risk of establishing unhealthy behaviors, such as relatively less physical activity and long screen time (5). Thus, the interaction between psychological stress and lifestyle changes during the COVID-19 outbreak may adversely affect adolescents' physical and mental health, which can cause a vicious cycle.

Although the sudden outbreak of COVID-19 resulted in negative consequences, positive changes were also observed in adolescents as an adaptive response to this global crisis. As proposed by Tedeschi and Calhoun (1995), posttraumatic growth (PTG) occurs after a potentially traumatic event, leading to enhanced personal strength, openness to new possibilities, deeper relationships with others, greater appreciation of life, and spiritual development (6). During the pandemic, adolescents quickly adapted to the online learning style, improved their self-sufficiency skills, and were more appreciative of their health, family, friends, and life. Some young people even participated in volunteer services to support the control of COVID-19 (7). These positive changes during the COVID-19 outbreak could be considered a reflection of PTG.

The present study conducted a survey from a large adolescent cohort in mainland China, aiming to (a) describe the prevalence and distribution of depression, anxiety, and PTG among adolescents during the pandemic, to explore whether challenges and opportunities coexist for adolescents in the face of the COVID-19 outbreak; and (b) investigate the risk and protective

factors of depression, anxiety, and PTG among adolescents. This study contributes to identifying high-risk groups and providing strategic guidance for adolescents' mental health in all countries affected by COVID-19.

MATERIALS AND METHODS

We conducted this online cross-sectional survey in mainland China from February 23 to March 8, 2020. Chinese adolescents aged 16–26 years old were invited to participate in the online survey through the Survey-Star platform. The electronic questionnaire was distributed through the WeChat group, and the participants were encouraged to pass it on to others. In total, 175,416 adolescents covering 31 provinces, centrally administered municipalities, and autonomous regions in mainland China (excluding Hong Kong, Macau, and Taiwan) were included in the present study during the COVID-19 outbreak.

The present study was approved by the Ethics Committee of the Harbin Medical University (HMUIRB20200002). The attributes, benefits, uses, and disadvantages of the study were explained to all participants. Each participant provided online informed and written consent to participate in the study.

Procedures

The nine-item Patient Health Questionnaire (PHQ-9) was used to measure participants' depressive symptoms. The PHQ-9 is a self-reported questionnaire consisting of nine items. Each item of the questionnaire is scored on a four-point scale ranging from 0 (not at all) to 3 (nearly every day). The total score was obtained by summing all items. Higher scores indicate more severe depressive symptoms, and the cutoff score for depression in the present study was 4. The PHQ-9 has previously been shown to have good reliability (Cronbach's $\alpha = 0.85$) and has been widely used among the Chinese population (8). In this study, Cronbach's α for all nine items was 0.906.

The seven-item Generalized Anxiety Disorder Questionnaire (GAD-7) was used to measure the anxiety symptoms of participants, which included seven items. The items are rated on a four-point scale ranging from 0 (not at all) to 3 (nearly every day). The seven items were summed to generate a total score ranging from 0 to 21. Higher scores indicate more severe anxiety symptoms, and the cutoff score for anxiety in the present study was 4. The GAD-7 has previously been shown to have good reliability and has been widely used in the Chinese population. In this study, the Cronbach's α value for all seven items was 0.91 (9).

The post-traumatic Growth Inventory (PTGI) was used to measure the positive changes of the participants during the COVID-19 epidemic, which was developed by Tedeschi and Calhoun (6). The scale included 21 items rated on a six-point scale ranging from 0 (no change) to 5 (very great degree of change). The scale had five dimensions: personal strength (four items), new possibilities (five items), relating to others (seven items), appreciation of life (three items), and spiritual change (two items). The scale score was calculated using the sum of all items with high scores indicating a higher level of PTG. The cutoff score for PTG was 60 (10). The scale demonstrated good

TABLE 1 | Post-traumatic growth scores and dimensions in the adolescents who experienced PTG ($N = 80,025$).

Dimensions	Minimum	Mean (SD)	Mean item score
Relation to others	1–35	23.80 (4.42)	3.40
New possibilities	5–25	16.54 (3.26)	3.31
Personal strength	1–20	14.18 (2.68)	3.54
Spiritual changes	0–10	7.12 (1.49)	3.56
Appreciation of life	1–15	10.15 (1.93)	3.38
Total score of PTG	60–105	71.79 (10.92)	3.42

PTG, posttraumatic growth; SD, standard deviation.

internal consistency, and the Cronbach's α value for all items was 0.958 in this study.

Sociodemographic data included the participants' gender, age, residential areas (rural/urban), situation of the COVID-19 epidemic in residence, whether cumulative confirmed cases were >500 (slight/severe), and family economic situation (poor/good). Moreover, the following further information was collected: symptoms related to COVID-19 during the past 14 days, including fever, cough, and fatigue (no/yes); attention to epidemic information per day (>5 h/ $3\text{--}5$ h/ <3 h); conflict with parents during home quarantine, including verbal or physical conflict (no/yes); communication with peers (seldom/sometimes/frequently); exercise for 60 min per day during the epidemic (no/yes); and receiving public welfare psychological assistance during the epidemic (no/yes).

Statistical Analysis

The Statistical Package for Social Sciences 22.0 (SPSS 22.0) was used for all statistical analyses. Continuous data were shown as mean \pm standard deviation. Categorical data were presented as percentages. T tests or one-way analysis of variance (ANOVA) were used to examine the associations between continuous variables. Categorical data were compared using the chi-square test. Multiple linear regression analysis was used to identify the factors associated with anxiety, depression, and PTG. Statistical significance was set at $p < 0.05$, which were regarded as significant for all tests (two-sided).

RESULTS

In total, we collected 175,416 valid questionnaires, namely, 80,695 (46.0%) males and 94,721 (54.0%) females. The average age of the study population was 20.50 ± 1.78 years (mean \pm SD), ranging from 16 to 26 years old. The mean scores for depressive symptoms, anxiety symptoms, and PTG were 4.15 ± 4.78 , 3.18 ± 3.61 , and 53.54 ± 21.44 , respectively. The prevalence of depressive and anxiety symptoms among Chinese adolescents was found to be 35.9 and 28.0%, respectively. Notably, 45.6% of adolescents experienced PTG during the COVID-19 epidemic. Furthermore, **Table 1** presents the scores for each dimension among adolescents who experience PTG. The dimensions with the highest means were spiritual changes, personal strength, relation to others, appreciation of life, and new possibilities.

The basic demographic data, distribution of depressive and anxiety symptoms, and PTG are shown in **Table 2**. The results showed that there were significant differences in depressive symptoms related to gender, residential area, situation of the COVID-19 epidemic in residence, symptoms related to COVID-19 during the past 14 days, attention to epidemic information per day, family economic situation, conflict with parents during home quarantine, frequent communication with peers, exercise during the epidemic, and receiving public welfare psychological assistance during the epidemic. Except for residential areas, other basic demographic variables showed significant differences in adolescents' anxiety scores. Except for age, other basic demographic variables showed significant differences in adolescents' PTG scores ($p < 0.05$).

The prevalence of depression, anxiety, and PTG during the COVID-19 outbreak in China stratified by the COVID-19 epidemic in residence is shown in **Figure 1**. Although statistically significant differences were found in the prevalence of depression and anxiety according to the COVID-19 epidemic, the differences were due to the large sample size ($N = 175,416$). **Figure 1** shows that the prevalence of depression was 34.4% in slight epidemic areas and 39.4% in severe areas. The prevalence of depression between the slight and severe epidemic areas was small and almost identical. Similar to depression, the prevalence of anxiety was 26.9% in slight epidemic areas and 30.7% in severe areas. Therefore, we indicated that there were no differences in the prevalence of depression and anxiety stratified by the COVID-19 epidemic in residence. Similar results were observed in case of PTG.

The prevalence of depression, anxiety, and PTG during the COVID-19 outbreak by symptoms related to COVID-19 during the past 14 days is shown in **Figure 2**. Statistically significant differences were found in the prevalence of depression, anxiety, and PTG between people who had symptoms related to COVID-19 during the past 14 days and those who did not ($p < 0.05$).

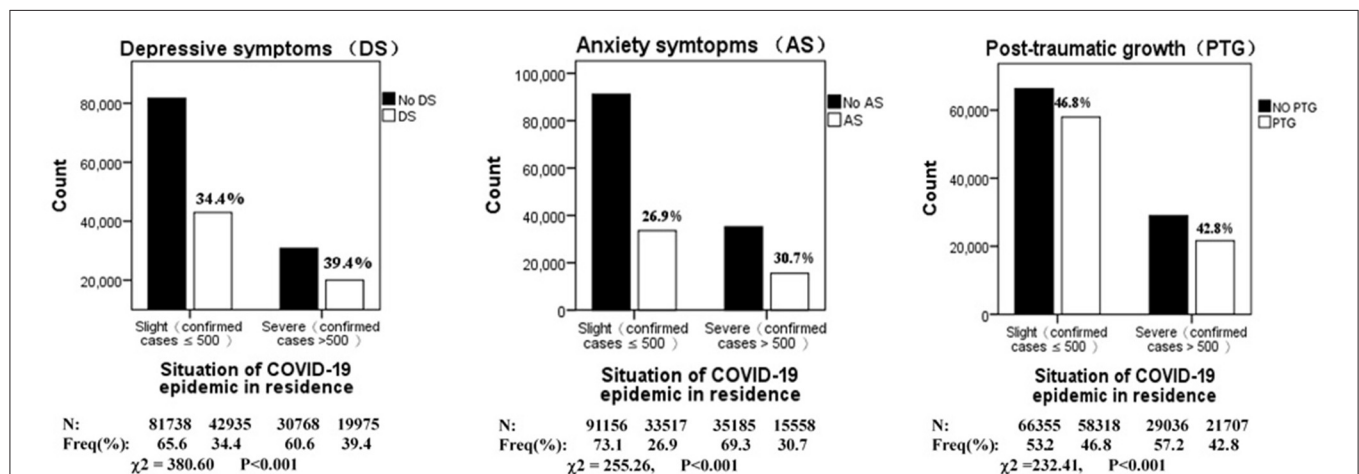
Multiple linear regression was conducted to determine the influencing factors of depressive symptoms among Chinese adolescents, and the model was highly significant ($R = 0.32$, $R^2 = 0.10$, $\text{Adj}R^2 = 0.10$, $p < 0.001$) (**Table 3**). Our results indicated that older age, female sex, living in urban areas, severe epidemic areas, symptoms related to COVID-19, poor family economic situation during the past 14 days, and having conflict with parents during home quarantine were risk factors for depression. Among the risk factors, symptoms related to COVID-19 had the strongest impact on depression. Focusing on epidemic information (<3 h/day), frequent communication with peers, exercising, and receiving public welfare psychological assistance were protective factors against depression experienced by the participants. Moreover, frequent communication with peers had the greatest positive influence on depression.

To further determine the factors influencing anxiety symptoms among Chinese adolescents, we conducted a multiple linear regression analysis, and the model was highly significant ($R = 0.25$, $R^2 = 0.06$, $\text{Adj}R^2 = 0.05$, $p < 0.001$) (**Table 4**). Multivariate analyses revealed that older age, female sex, living in urban areas, living in severe epidemic areas, symptoms related to COVID-19 during

TABLE 2 | Demographic data and the distribution of depressive symptoms, anxiety symptoms, and PTG.

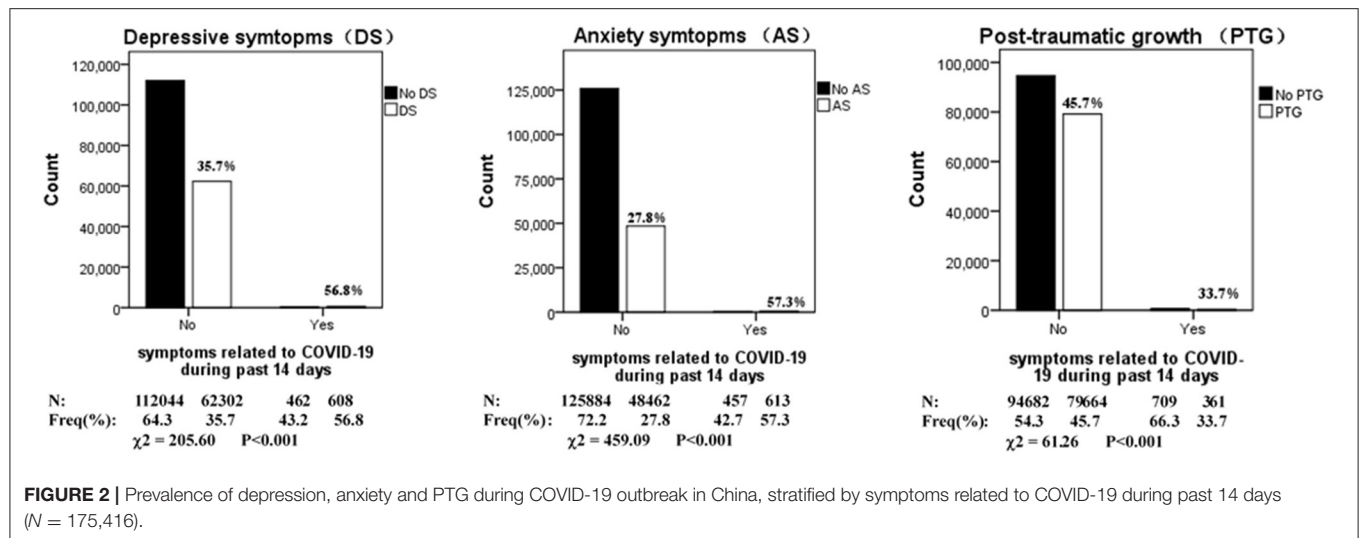
Variables		N	PHQ-9 score	T/F	GAD-7 score	T/F	PTGI score	T/F
Gender	Male	80,695	3.68 (4.97)	−37.99*	2.84 (3.89)	−36.40*	54.99 (22.96)	26.21*
	Female	94,721	4.55 (4.58)		3.47 (3.33)		52.30 (19.96)	
Age (years)	16–20	93,872	4.14 (4.75)	−1.07	3.08 (3.53)	−12.67*	52.67 (21.24)	−0.78
	21–26	81,544	4.16 (4.82)		3.30 (3.69)		53.51 (21.67)	
Residential areas	Rural	72,547	3.96 (4.64)	−13.28*	3.16 (3.54)	−2.29	53.59 (20.70)	6.48*
	Urban	102,869	4.27 (4.87)		3.20 (3.65)		53.31 (21.91)	
Situation of COVID-19 epidemic in residence	Slight	124,673	3.98 (4.69)	−22.75*	3.07 (3.55)	−20.26*	54.15 (21.32)	18.61*
	Severe	50,743	4.56 (4.98)		3.45 (3.74)		52.05 (21.65)	
Having symptoms related to COVID-19	No	174,346	4.13 (4.76)	−23.30*	3.16 (3.58)	−30.10*	53.57 (21.42)	7.95*
	Yes	1,070	7.54 (6.95)		6.49 (5.59)		48.34 (23.52)	
The attention to epidemic information per day	>5 h	663	8.00 (6.45)	2,510.71*	11.70 (7.96)	1,170.01*	35.98 (24.11)	−1,781.16*
	3–5 h	7,218	4.56 (4.55)		7.25 (6.19)		39.97 (21.37)	
	<3 h	167,535	3.10 (3.52)		3.99 (4.62)		54.19 (21.20)	
Conflict with parents during home quarantine	No	151,364	3.77 (4.46)	−85.90*	2.96 (3.41)	−65.26*	54.58 (21.10)	50.85*
	Yes	24,052	6.56 (5.89)		4.58 (4.40)		47.06 (22.41)	
Family economic situation	Poor	29,824	4.44 (4.98)	11.60*	3.32 (3.71)	7.23*	51.31 (21.69)	−19.78*
	Good	145,592	4.09 (4.74)		3.15 (3.59)		54.00 (21.36)	
Communication with peers	Seldom	13,862	6.80 (6.74)	3,874.60*	4.71 (5.10)	1,988.67*	41.24 (24.09)	−7,462.51*
	Sometimes	63,015	4.71 (4.82)		3.44 (3.59)		48.34 (19.91)	
	Frequently	98,539	3.42 (4.21)		2.80 (3.28)		58.60 (20.46)	
Exercise during the epidemic	No	75,421	4.43 (5.14)	21.28*	3.37 (3.91)	19.46*	49.09 (22.06)	−76.72*
	Yes	99,995	3.94 (4.48)		3.03 (3.35)		56.90 (20.32)	
Receive public welfare psychological assistance during the epidemic	No	85,044	4.54 (4.94)	33.53*	3.35 (3.68)	19.65*	52.76 (21.13)	−14.75*
	Yes	90,372	3.78 (4.60)		3.02 (3.54)		54.27 (21.70)	

PHQ-9, Nine-item Patient Health Questionnaire; GAD-7, 7-item Generalized Anxiety Disorder Questionnaire; PTGI, post-traumatic growth inventory; * $p < 0.05$.

**FIGURE 1 |** Prevalence of depression, anxiety and PTG during COVID-19 outbreak in China, stratified by situation of COVID-19 epidemic in residence ($N = 175,416$).

the past 14 days, and conflicts with parents during home quarantine were identified as risk factors for anxiety. Among these risk factors, symptoms related to COVID-19 had

the strongest impact on anxiety. Meanwhile, focusing on epidemic information (<3 h/day), communication with peers, exercising, and receiving public welfare psychological assistance

**TABLE 3 |** Results of multiple linear regression analysis of influencing factors for depressive symptoms.

Variables	B	SE	β	T	p
(Constant)	11.44	0.16		72.89	<0.0001
Gender	0.97	0.02	0.10	43.93	<0.0001
Age (years)	0.09	0.02	0.01	4.06	<0.0001
Residential areas	0.31	0.02	0.03	13.70	<0.0001
Situation of COVID-19 epidemic in residence	0.35	0.02	0.03	14.45	<0.0001
Having symptoms related to COVID-19	2.96	0.14	0.05	21.27	<0.0001
Family economic situation	-0.06	0.03	-0.01	-2.07	0.04
Conflict with parents during home quarantine	2.06	0.03	0.15	62.79	<0.0001
The attention to epidemic information per day	-2.06	0.05	-0.10	-42.71	<0.0001
Communication with peers	-1.24	0.02	-0.17	-70.89	<0.0001
Exercise during the epidemic	-0.45	0.02	-0.05	-20.13	<0.0001
Receive public welfare psychological assistance during the epidemic	-0.59	0.02	-0.06	-26.39	<0.0001

$R = 0.32$, $R^2 = 0.10$, $AdjR^2 = 0.10$.

TABLE 4 | Results of multiple linear regression analysis of influencing factors for anxiety symptoms.

Variables	B	SE	β	T	p
(Constant)	6.08	0.12		50.23	<0.0001
Gender	0.69	0.02	0.10	41.15	<0.0001
Age (years)	0.25	0.02	0.04	14.83	<0.0001
Residential areas	0.04	0.02	0.01	2.56	0.01
Situation of COVID-19 epidemic in residence	0.27	0.02	0.03	14.57	<0.0001
Having symptoms related to COVID-19	3.11	0.11	0.07	28.93	<0.0001
Family economic situation	0.01	0.02	0.01	0.23	0.82
Conflict with parents during home quarantine	1.26	0.02	0.12	49.76	<0.0001
The attention to epidemic information per day	-0.93	0.04	-0.06	-24.79	<0.0001
Communication with peers	-0.66	0.01	-0.12	-48.98	<0.0001
Exercise during the epidemic	-0.32	0.01	-0.04	-18.60	<0.0001
Receive public welfare psychological assistance during the epidemic	-0.25	0.01	-0.03	-14.39	<0.0001

$R = 0.25$, $R^2 = 0.06$, $AdjR^2 = 0.05$.

TABLE 5 | Results of multiple linear regression analysis of influencing factors for PTG.

Variables	B	SE	β	T	p
(Constant)	16.7	0.69		24.01	<0.0001
Gender	-3.84	0.09	-0.09	-39.6	<0.0001
Age (years)	0.20	0.09	0.01	2.03	0.04
Residential areas	-0.75	0.09	-0.02	-7.59	<0.0001
Situation of COVID-19 epidemic in residence	-1.37	0.11	-0.03	-12.82	<0.0001
Having symptoms related to COVID-19	-2.02	0.62	-0.01	-3.27	0.001
Family economic situation	1.12	0.13	0.02	8.76	<0.0001
Conflict with parents during home quarantine	-4.55	0.15	-0.07	-31.32	<0.0001
The attention to epidemic information per day	6.36	0.21	0.07	29.72	<0.0001
Communication with peers	8.06	0.08	0.24	104.15	<0.0001
Exercise during the epidemic	7.06	0.09	0.16	71.26	<0.0001
Receive public welfare psychological assistance during the epidemic	1.83	0.09	0.04	18.65	<0.0001

$R = 0.35$, $R^2 = 0.12$, $AdjR^2 = 0.12$.

during the pandemic were found to be protective factors for anxiety symptoms.

Next, we performed a multiple linear regression analysis to identify factors associated with PTG. As indicated in **Table 5**, the model was highly significant ($R = 0.35$, $R^2 = 0.12$, $AdjR^2 = 0.12$, $p < 0.001$). The results identified that sex, residential areas, COVID-19 epidemic in residence, symptoms related to COVID-19, family economic situation, conflict with parents during home quarantine, attention to epidemic information per day, communication with peers, exercising, and receiving public welfare psychological assistance during the epidemic were significant predictors of PTG in adolescents. Communication with peers played the most important role in PTG.

DISCUSSION

Our study was conducted during the rapid rise period of the COVID-19 outbreak (11), which covered 31 provinces, centrally administered municipalities, and autonomous regions in mainland China. This survey indicated that adolescents had a significantly higher prevalence of depression (35.9%) and anxiety (28.0%) during the COVID-19 outbreak compared with the national data in the normal period, which showed a lower incidence of depression (3.6%) and anxiety (4.3%) in adolescents (12). In other words, exposure to the pandemic had a psychological impact on adolescents, and close attention and great efforts were required to effectively address these emergency issues. Notably, 45.6% of adolescents experienced PTG. These results were consistent with our hypothesis that the pandemic offered both challenges and opportunities for adolescents. Furthermore, the current study explored the factors influencing the reduction of negative emotions and promotion of the capacity of PTG during public health emergencies.

The Influence Factors of Negative Emotions in Chinese Adolescents During the COVID-19 Pandemic

Adolescence is a key period for the development and improvement of cognition, emotion, and personality. During this critical stage, the depression and anxiety caused by such a stressful event would inevitably affect adolescents' physical health, social interaction, and academic achievement (13). From a personal perspective, our results found that sex, age, severity of the pandemic in the place of residence, and symptoms related to COVID-19 were associated with anxiety and depression. Female adolescents had increased anxiety and depression compared with males, and an association between female sex and psychological distress has been consistently found in previous studies (14). In addition to sex, adolescents aged 21–26 years old were found to have higher levels of depression and anxiety than adolescents aged 16–20 years old, which was consistent with a recent study indicating that adolescents with higher grades had a greater prevalence of depressive and anxiety symptoms (10).

Surprisingly, about 30% of adolescents in slight epidemic areas suffered depression and anxiety, which was similar in severely epidemic areas. This phenomenon can be explained by the emotional resonance effect, whereby the pandemic as a sudden stressful event caused adolescents' stress, anxiety, and depression to eventually transmit to others, regardless of the severity of the epidemic in their residential area. However, our results showed that the level of negative emotions in severe epidemic areas was higher than that in slight epidemic areas, which indicates that the degree of anxiety and depression is much more serious in severe epidemic areas. In addition, adolescents with symptoms related to COVID-19, such as fever and cough, felt fear and helplessness and were extremely worried about catching COVID-19. Especially in a state of isolation at home, the shortage of medical supplies and resources, or even quarantine, could aggravate their negative emotions (2). Meanwhile, our findings illustrated that if adolescents pay extreme attention to epidemic

information, regardless of the positive or negative information that exceeds the bottom line that their psychology can tolerate, it will naturally trigger vicarious trauma and cause serious mental problems (15). Therefore, it is crucial for adolescents to reasonably organize time and maintain an appropriate state of concern.

From the family's perspective, our findings demonstrated that conflict with parents during home quarantine was a risk factor for depressive and anxiety symptoms. Most Chinese adolescents aged 16–26 years old are from single-child families, and their parents are typically characterized by high authority, which can cause parent–adolescent conflicts (16). Our investigation revealed that the epidemic made adolescents spend more than 10 h per day with their parents, lasting nearly 2 months, which led to escalated conflicts in 14.1% of Chinese families in our study. According to the McMaster model of family functioning, family function can provide a healthy environment for adolescents in physical, psychological, and social development (17). Thus, parents are advised to focus on adolescents' personal choices and maintain good interactions with them to reduce the impact of long-term home isolation.

From a social perspective, regular online communication with peers is a protective factor in reducing the levels of anxiety and depression. Peers played the role of social support in adolescent development. According to the stress, social support, and buffering hypothesis, social support can relieve pressure and maintain an individual's physical and mental health under stress conditions (18). Therefore, online peer-to-peer communication should be encouraged to provide social support and buffer against the negative effects of home confinement.

From a national perspective, guidance on recommended health behaviors through various media needs to be delivered to the public, such as home exercises including gymnastics, yoga, and Tai Chi. The results of our study showed that active engagement in physical exercise can reduce anxiety and depression. Meanwhile, our results indicated that psychological counseling hotlines or online public welfare services should be provided to alleviate the emotional problems caused by the epidemic, especially for adolescents (19).

The Influence Factors of PTG in Chinese Adolescents During the COVID-19 Pandemic

During the pandemic, we investigated the activated first-level emergency response in all provinces and autonomous regions (20). Under such circumstances, although negative emotions were found in adolescents in our study, nearly half of them were not knocked down by the epidemic, which in turn activated their anti-frailty ability (21). Among these positive reactions, “spiritual growth” was one of the most prominent themes that emerged in adolescents, such as finding the meaning of life and appreciating their health, family, and friends. These positive cognitions, beliefs, and emotional changes were gained due to their attempts to cope with the pandemic (22), which established PTG in adolescents during the public health emergency (23).

Our results showed that men had higher levels of PTG than women. PTG theorists [e.g., (24)] suggested that gender differences in reported PTG are more vulnerable to emerge around puberty, which could further clarify the current mixed results (25). The reason for this may be that threat appraisals and family support partially mediated the relationship between sex and growth, as males experienced a lesser sense of danger and lesser family support than females, thus eventually increasing PTG (26).

Multiple linear regression analysis suggested that adolescents' family economic status is positively correlated with PTG, which was similar to a previous research indicating that a better family economic situation predicted a higher level of PTG (27). It is particularly important that PTG was greatly influenced by variables, including the relationship with parents and peers, exercising according to the guidance, and receiving online psychological assistance. During the pandemic, a harmonious family atmosphere can help adolescents change their irrational cognitive beliefs and have greater hope and optimism about the future. This was consistent with a recent study that revealed a higher level of warmth in parenting to be a possible mechanism facilitating PTG in the child's response to traumatic events (25). Furthermore, according to the PTG theoretical model (6), a “good peer relationship” was proposed for trauma intervention. Peer support providing a new cognitive schema or a new perspective on trauma may be conducive to reducing feelings of isolation (28). Our findings also demonstrated that health behavior guidance, psychological assistance, and crisis intervention can serve as valuable resources to help adolescents achieve PTG.

The Advantages and Limitations of This Study

As the COVID-19 epidemic continues to spread, our findings provide theoretical guidance for psychological support creation for countries and regions. Our findings indicate that equal attention should be given to adolescents to maintain their mental health in both slight and severe epidemic areas. We also suggest that adolescents should frequently communicate with peers online, enhance their interaction with parents, and engage in sustainable exercise to relieve the psychosocial stress caused by home confinement. When faced with psychological problems that cannot be resolved, adolescents should turn to the public welfare psychological platform to seek assistance. Parents need to pay more attention to adolescents' needs, respect their identity instead of controlling them, and try to create a harmonious family atmosphere. Furthermore, it is essential to establish an official online platform to provide information and mental health consultation for the public. Finally, the efforts of individuals, families, and society are highly recommended to win the confidence of adolescents and turn challenges into opportunities.

This study had some potential limitations. Firstly, this is a cross-sectional study, which means that we cannot infer causal relationships between the variables; additional longitudinal studies should be conducted in the future. Secondly, another limitation is the self-report measures, which may have a response

bias when assessing the psychosocial variables. Thirdly, there are various psychological effects of the COVID-19 pandemic; however, this study mainly focused on the aspects of anxiety, depression, and PTG. Furthermore, a more comprehensive research (e.g., suicide risk) on the COVID-19 pandemic should be carried out and relevant management plans should be provided as well. Finally, although the survey conducted online was suitable for rapid assessment, some response bias may have affected the results.

CONCLUSION

During the rapid rise period of the COVID-19 outbreak, we identified that 35.9% of adolescents experienced depression and 28.0% experienced anxiety. Surprisingly, about 30% of adolescents in a slight epidemic area reported anxiety and depression, which was almost similar to that in severe epidemic areas. However, the level of negative emotions was higher in severe epidemic areas. Our study also found that nearly half of the adolescents experienced PTG, which confirmed that challenges and opportunities coexist for adolescents faced with the pandemic. Female sex and older age were associated with higher levels of depression and anxiety and lower levels of PTG. Living in urban areas, symptoms related to COVID-19, excessive attention to epidemic information, and conflict with parents during home quarantine were independent risk factors for depression, anxiety, and PTG. Peer communication, exercising, and receiving public welfare psychological assistance were protective factors. Poor family economic status was a significant risk factor for depression and PTG. Our findings contribute to identifying high-risk groups in adolescents and provide a foundation for formulating psychological interventions to improve adolescents' mental health. This study demonstrated that adolescents, families, and society should make joint efforts to win the current war against COVID-19.

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DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of Harbin Medical University (HMUIRB20200002). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

JZ, YY, ZQ, and XY: conceived and designed the experiments. JH, JL, XL, and YZ: performed the experiments. TB and HC: data analyses. ZQ and SZ: contributed reagents, materials, and analysis tools. JZ and YW: wrote the manuscript. All authors have reviewed the manuscript and contributed to the manuscript and approved the submitted version.

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Associations Between Poor Sleep Quality, Anxiety Symptoms, and Depressive Symptoms Among Chinese Adolescents Before and During COVID-19: A Longitudinal Study

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Since the novel coronavirus disease 2019 (COVID-19) outbreak, adolescents' emerging mental health and behavior issues have been an international public health concern. This longitudinal study aimed to examine the situation of poor sleep quality, anxiety, and depressive symptoms among Chinese adolescents and to explore the associations between them before and during COVID-19. A total of 1,952 middle and high school students as eligible participants at baseline (pre-COVID-19, Wave 1; response rate: 98.79%), 1,831 eligible students were followed up at Wave 2 (October 2019 to December 2019, pre-COVID-19; retention rate: 93.80%), and 1,790 completed the follow-up at Wave 3 (during the COVID-19; retention rate: 97.80%). The mean age of the baseline students was 13.56 (SD: 1.46) years. The differences in anxiety and depressive symptoms between Wave 1, Wave 2, and Wave 3 were not statistically significant. The proportion of students with poor sleep quality increased over time, from Wave 1 (21.0%) to Wave 3 (26.0%, OR = 1.37, 95% CI = 1.17–1.60, $P = 0.001$) and from Wave 2 (21.9%) to Wave 3 (OR = 1.29, 95% CI = 1.11–1.51, $P < 0.001$). The cross-lagged generalized linear mixed models revealed that the concurrent and cross-lagged associations of poor sleep quality with anxiety symptoms across the three waves were significant ($P < 0.05$) and vice versa. Only a marginally significant positive cross-lagged association between poor sleep quality at Wave 2 and depressive symptoms at Wave 3 was found (standardized β estimate = 0.044, SE = 0.022, $P = 0.045$). Sleep quality was adversely affected during COVID-19, and the bidirectional associations of poor sleep quality with anxiety symptoms could not be neglected.

Keywords: mental health, adolescent, longitudinal study, COVID-19, sleep problems

INTRODUCTION

Adolescence represents a developmental transition period between childhood and adulthood, characterized by marked changes in biological systems and physical maturation of the body and brain, rendering adolescents vulnerable to mental health and behavior problems, including anxiety symptoms, depressive symptoms, and poor sleep quality (1). Anxiety and depressive symptoms are among the most prevalent mental health problems presented in adolescents, resulting in considerable distress to the individual (e.g., impaired school functioning or developing into mental disorders), and then are the main contributors to the global burden of disease in this population (2). However, the causes of anxiety symptoms and depressive symptoms remained unclear. Previous evidence has suggested that sleep is an important predictor of adolescents' subsequent anxiety and depressive problems (3). Sleep is a core behavior of adolescents, consuming up to a third or more of each day, and contributes a vital role in adolescent brain development (4). With the increased incidence and prevalence of poor sleep quality reported in adolescents from different countries, adolescent sleep health is increasingly becoming a global public health concern. Numerous studies have found that poor sleep quality was associated with the elevated risks of anxiety symptoms or depressive symptoms (5, 6). Some evidence has also shown that anxiety symptoms or depressive symptoms can reversely predict poor sleep among adolescents (7), indicating that the associations of poor sleep quality with anxiety symptoms or depressive symptoms may be complex and bidirectional.

Since the outbreak of the novel coronavirus disease 2019 (COVID-19), the emerging mental health and behavior issues related to this global event have been an international public health concern (8). Previous cross-sectional and longitudinal studies in China during the initial stages of the COVID-19 pandemic demonstrated elevated levels of mental health problems among the general population (9, 10). The effects of the COVID-19 pandemic and the policies to contain it can be considered a stressor exposure, and their effects on mental health and behavioral problems are probably to be profound and long-lasting. However, to what extent such effects will last generalize to which population is unclear. During the early stages of the COVID-19 pandemic, most governments around the world have temporarily closed schools. As the outbreak of the COVID-19 during Chinese schools' winter vacation, all the school students were at home. It was notable that China's Ministry of Education issued school closure policies for the entire country between January 20 and February 8, and announced on January 27, 2020 that the 2020 spring semester for schools would be postponed to late April due to the COVID-19 outbreak, affecting a large number of students across primary and post-secondary grades in China (11). Some recent studies have discussed the influences of school closures during the COVID-19 pandemic on Chinese adolescents' anxiety or depressive symptoms and sleep behavior (12, 13). Nonetheless, most of the available evidence is cross-sectional or short-term and does not address the longer-term effects of COVID-19 and related policies on adolescents' mental health and behavior. Moreover, there is a scarce study on the

longitudinal and reciprocal associations between poor sleep quality, anxiety symptoms, and depressive symptoms among Chinese adolescents before and during the COVID-19 pandemic. It is also notable that to minimize the negative impact of COVID-19 school closures on students, the government, National Health Commission, schools, families, and mental health professionals worked together to maintain students' routines and protect them from the impact of the pandemic (including guidelines, recommendations, or interventions during home confinement; online help services; a reduction in academic load) (14–16).

Therefore, longitudinal studies are needed to assess this gap in the literature. Cascade modeling, an analytic approach controlling within-time and across-time associations while estimating cross-lagged effects, is a strategy of examining the complex interplay in multiple factors across time (17). The purposes of this three-wave longitudinal study were to examine the situation of poor sleep quality, anxiety symptoms, and depressive symptoms among Chinese adolescents before and during COVID-19; to examine the concurrent and longitudinal associations among poor sleep quality, anxiety symptoms, and depressive symptoms among these adolescents at three-time points.

MATERIALS AND METHODS

Study Design and Participants

Data were drawn from the Longitudinal Study of Adolescents' Mental and Behavioral Well-being Research in Guangzhou, China (Registration No. ChiCTR1900022032) (18), which used a multi-stage stratified cluster random sampling method to recruit 1,976 grade 7 and grade 10 students. Full details of the study sampling method are reported elsewhere (18). In brief, six middle schools and four high schools in Guangzhou were selected according to the representative and proportion of middle school and high school across districts, convenience for the data collection, and previous study collaboration. Two classes from the 7th grade in middle school and the 10th grade in high school were randomly selected among the chosen schools. All students presenting in the selected classes were invited to participate voluntarily. In this study, a total of 1,952 students as eligible participants at baseline (January to March 2019, pre-COVID-19, Wave 1; response rate: 98.79%). Among the recruited 1,952 students, 1,831 students were followed up at Wave 2 (October 2019 to December 2019, pre-COVID-19; retention rate: 93.80%), and 1,790 completed the follow-up at Wave 3 (October 2020 to December 2020, during the COVID-19; retention rate: 97.80%). After almost 3 months of lockdown between Wave 2 and Wave 3, all the surveyed middle and high schools in Guangzhou were reopened on May 11. In order to protect the privacy of participants and reduce information bias, self-reported questionnaires were blind to teachers during the three waves. After the study had been fully explained in detail, written informed consent was obtained from each participant and one of the student's legal guardians. This study was approved by the Sun Yat-sen University, School of Public Health Institutional Review Board (Ethics Number: L2017060).

Measures

Anxiety Symptoms

Anxiety symptoms were measured by the Chinese version of the Generalized Anxiety Disorder 7-Item Questionnaire (GAD-7) (19), which has been validated and widely used in Chinese adolescents with acceptable psychometric properties (20, 21). The Cronbach's alpha was 0.89, 0.91, and 0.91 with the study sample in Wave 1, Wave 2, and Wave3, respectively. The respondents were asked to rate the frequency of anxiety symptoms over the last 2 weeks, with the response options given on a four-point Likert scale (0 = not at all, 1 = several days, 2 = more than half the days, and 3 = nearly every day). The sum of scores ranges from 0 to 21, with higher scores indicating a higher level of anxiety symptoms severity, with the GAD-7 score ≥ 5 used to interpret as having anxiety symptoms (19).

Depressive Symptoms

Depressive symptoms were assessed by the Chinese version of the Center for Epidemiology Scale for Depression (CES-D), which has been validated and extensively utilized in Chinese adolescents (22, 23). The Cronbach's alpha was 0.80, 0.83, and 0.84 with the study sample in Wave 1, Wave 2, and Wave3, respectively. The CES-D comprises 20 items about the frequency of symptoms of depression over the past week, and the response options were rated in a four-point Likert scale (from 0 = rarely or none of the time to 3 = most or all of the time). The total CES-D score ranges from 0 to 60, with higher scores indicating more severe depressive symptomatology. A total CES-D score ≥ 16 was considered as having depressive symptoms (24).

Poor Sleep Quality

The level of sleep quality was assessed by the Chinese version of the Pittsburgh Sleep Quality Index (PSQI), which is commonly used to measure sleep quality and disturbance over 1 month. The Chinese version of PSQI has been validated and widely used among Chinese adolescents (25). The PSQI consists of 19 items constituting seven subscales: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, sleep medication use, and daytime dysfunction. The scores for each subscale are weighted equally and range from 0 to 3 points, and the sum of the scores for these seven subscales yields a global PSQI score, which ranges from 0 to 21, with higher scores indicating worse sleep quality. A global PSQI score > 7 points indicates having poor sleep quality (25).

Other Variables

Demographic information including age, sex (1 = boy, 2 = girl), living arrangement (1 = living with both parents, 2 = living with a single parent, 3 = living with others), family relations (1 = good, 2 = average, 3 = poor), student-teacher relations (1 = good, 2 = average, 3 = poor), ever smoking (1 = yes, 2 = no), ever drinking (1 = yes, 2 = no) were also collected.

Statistical Analysis

All statistical analyses were conducted using Stata/MP (Stata Corp, LLC, College Station, TX) and Mplus version 8.3 (Muthén & Muthén, Los Angeles, CA, USA). First, descriptive analyses

were used to describe sample characteristics across three waves, and the Chi-square tests for categorical variables and the one-way ANOVA analyses for continuous variables were performed. Second, considering this study utilized a complex multi-stage sampling design, students were grouped into classes, generalized linear mixed models (GLMMs) in which classes were treated as clusters were constructed to test the changes in anxiety symptoms, depressive symptoms, and poor sleep quality over the three waves for the whole sample (26). Third, the unadjusted and adjusted GLMMs were also adopted to examine the association of poor sleep quality (main effects) with anxiety symptoms or depressive symptoms over the three waves, including examination of the poor sleep quality by time interaction. Fourth, the cross-lagged autoregressive GLMMs were further used to examine the concurrent and cross-lagged associations of poor sleep quality with anxiety symptoms and depressive symptoms, and the unadjusted and adjusted cross-lagged autoregressive GLMMs were conducted in multiple steps. The comparative fit index (CFI), the standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA) were used to measure model fit; CFI values > 0.90 and RMSEA values < 0.08 suggest acceptable model fit (27). Missing data were eliminated in the GLMMs. All statistical tests were two-sided, and a $P < 0.05$ was considered statistically significant.

RESULTS

Table 1 shows sample demographic characteristics across waves. At wave 1, 50.7% of the participants were boys, and the mean (SD) age of the total students was 13.56 (SD: 1.46) years, with the age range from 13 to 18 years. The majority of students lived with both parents (81.4%), 3.0% reported poor family relations, and 1.4% reported their student-teacher relations as inferior. The proportion of students who reported ever smoking was 1.4% and reported ever drinking was 32.7%, respectively. There was no statistically significant difference in the demographic characteristics of the participants between the three waves ($P > 0.05$).

The mean GAD-7 score of anxiety symptoms at Wave 1, Wave 2, and Wave 3 was 3.75 (SD: 4.31), 3.60 (SD: 4.32), and 3.56 (SD: 4.22), respectively. Then mean CES-D score of depressive symptoms at Wave 1, Wave 2, and Wave 3 was 13.62 (SD: 10.07), 13.69 (SD: 10.53), and 13.44 (SD: 10.28), respectively. The differences in anxiety and depressive symptoms between Wave 1, Wave 2, and Wave 3 were not statistically significant. The mean PSQI score of sleep quality at Wave 1, Wave 2, and Wave 3 was 4.94 (SD: 2.44), 4.66 (SD: 2.84), and 5.08 (SD: 2.91), respectively; the difference between Wave 3 and Wave 2 was statistically significant (OR = 1.55, 95% CI 1.27–1.90, $P < 0.001$). Moreover, we also observed that compared with the sleep situation in Wave 1, there was a significant worsening of sleep duration (OR = 1.47, 95% CI = 1.35–1.60), sleep disturbance (OR = 2.11, 95% CI = 1.86–2.38), use of sleep medication (OR = 1.48, 95% CI = 1.10–1.99), daytime dysfunction (OR = 3.59, 95% CI = 3.22–4.00) in Wave 3, and a significant improvement

TABLE 1 | Demographic characteristics of the participants across waves for all participants.

Variable	Wave 1 (n = 1,952)	Wave 2 (n = 1,831)	Wave 3 (n = 1,790)	P value*
Sex				
Boys	989 (50.7)	918 (50.1)	899 (50.2)	0.945
Girls	963 (49.3)	913 (49.9)	880 (49.2)	
Missing data	0	0	11 (0.6)	
Age, mean (SD), year	13.56 (1.46)	14.04 (1.43)	14.92 (1.55)	
Living arrangement				
Living with both parents	1,589 (81.4)	1,503 (82.1)	1,484 (82.9)	0.258
Living with a single parent	192 (9.8)	192 (10.5)	185 (10.3)	
Living with others	167 (8.6)	135 (7.4)	119 (6.6)	
Missing data	4 (0.2)	1 (0.1)	2 (0.1)	
Family relations				
Good	1,655 (84.8)	1,512 (82.6)	1,478 (82.6)	0.180
Average	230 (11.8)	235 (12.8)	229 (12.8)	
Poor	59 (3.0)	77 (4.2)	74 (4.1)	
Missing data	8 (0.4)	7 (0.4)	9 (0.5)	
Student-teacher relations				
Good	1,601 (82.0)	1,480 (80.8)	1,442 (80.6)	0.347
Average	306 (15.8)	313 (17.1)	324 (18.1)	
Poor	27 (1.4)	27 (1.5)	20 (1.1)	
Missing data	18 (0.9)	11 (0.6)		
Ever smoking a cigarette				
Yes	28 (1.4)	34 (1.9)	45 (2.5)	0.053
No	1,914 (98.1)	1,793 (97.9)	1,735 (96.9)	
Missing data	10 (0.5)	4 (0.2)	10 (0.6)	
Ever drinking alcohol				
Yes	639 (32.7)	606 (33.1)	559 (31.2)	0.494
No	1,303 (66.8)	1,217 (66.5)	1,216 (67.9)	
Missing data	10 (0.5)	8 (0.4)	15 (0.8)	

*The chi-square test was used for categorical variables and the one-way ANOVA analysis was used for age data.

in sleep latency (OR = 0.77, 95% CI = 0.71–0.84) in Wave 3. No significant differences were found between wave 1, wave 2, and wave 3 about subjective sleep quality and habitual sleep efficiency. The proportion of students with poor sleep quality increased over time, from Wave 1 (21.0%) to Wave 3 (26.0%, OR = 1.37, 95% CI = 1.17–1.60, $P = 0.001$) and from Wave 2 (21.9%) to Wave 3 (OR = 1.29, 95% CI = 1.11–1.51, $P < 0.001$), but not from Wave 1 to Wave 2 (OR = 1.05, 95% CI = 0.91–1.23, $P = 0.471$) (Table 2). Factors associated with anxiety symptoms, depressive symptoms, and poor sleep quality at Wave 1, Wave 2, and Wave 3 were presented in **Supplementary Material**.

As shown in Table 3, the unadjusted and adjusted GLMMs revealed the absence of a significant interactive effect of poor sleep quality by time on anxiety symptoms ($P > 0.05$) and depressive symptoms ($P > 0.05$) through the three-wave follow-up. Moreover, without adjusting for other variables, the total PSQI sleep quality scores were positively associated with anxiety symptoms and depressive symptoms ($P < 0.05$).

After adjusting for age, sex, living arrangement, family relations, student-teacher relations, ever smoking, and ever drinking, there was a significant main effect of the total

PSQI scores with anxiety symptoms (unstandardized β estimate = 0.69, 95% CI = 0.59–0.79, $P < 0.001$) and depressive symptoms (unstandardized β estimate = 1.61, 95% CI = 1.42–1.80, $P < 0.001$) through the three waves. Regarding each PSQI component, the adjusted GLMMs found that subjective sleep quality was positively associated with anxiety symptoms (unstandardized β estimate = 1.17, 95% CI = 1.01–1.37, $P < 0.05$) through the three waves.

To further observe the associations of poor sleep quality with anxiety symptoms and depressive symptoms, we examined cross-lagged GLMMs. Figure 1 depicted the results of the path models for poor sleep quality and anxiety symptoms with acceptable model fits that included all cross-lagged pathways. After adjusting for age, sex, living arrangement, family relations, student-teacher relations, ever smoking, and ever drinking, the adjusted autoregressive associations of both variables from Wave 1 to Wave 3 were positive and significant, indicating that baseline levels of poor sleep quality (standardized β estimate: ranging from 0.225 to 0.348) and anxiety symptoms (standardized β estimate: ranging from 0.488 to 0.506) were predictive of the same variable at follow-up. Moreover, the concurrent associations of

TABLE 2 | Changes in anxiety symptoms, depressive symptoms, and poor sleep quality over the three waves with odds ratios (ORs) and 95% confidence interval.

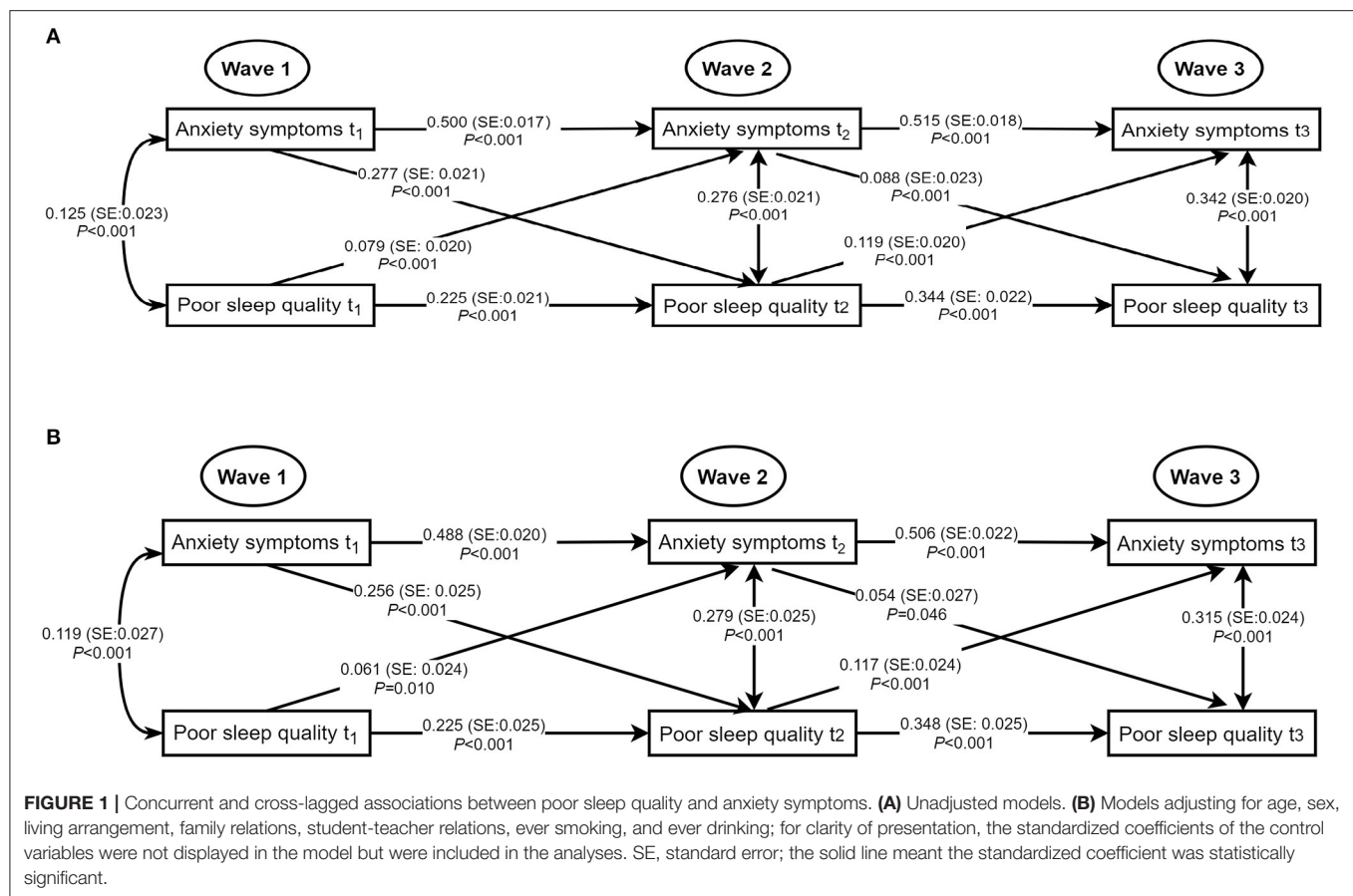
	Wave 1 (n = 1,952)	Wave 2 (n = 1,831)	Wave 3 (n = 1,790)	OR (95% CI), P		
	Wave 2-Wave 1 ^a			Wave 3-Wave 1 ^a	Wave 3-Wave 2 ^b	
GAD-7 scores, mean (SD)	3.75 (4.31)	3.60 (4.32)	3.56 (4.22)	0.86 (0.65~1.13), 0.269	0.82 (0.62~1.10), 0.184	0.96 (0.72~1.29), 0.797
Anxiety symptoms, yes, n (%)	637 (32.6)	579 (31.6)	589 (32.9)	1.02 (0.88~1.17), 0.803	0.95 (0.83~1.09), 0.507	1.08 (0.93~1.25), 0.312
CES-D scores, mean (SD)	13.62 (10.07)	13.69 (10.53)	13.44 (10.28)	1.07 (0.55~2.09), 0.837	0.84 (0.42~1.70), 0.633	0.78 (0.38~1.63), 0.518
Depressive symptoms, yes, n (%)	554 (28.4)	550 (30.0)	523 (29.2)	1.16 (0.94~1.44), 0.166	1.11 (0.89~1.39), 0.357	0.95 (0.76~1.19), 0.678
PSQI scores, mean (SD)	4.94 (2.44)	4.66 (2.84)	5.08 (2.91)	0.75 (0.63~0.90), 0.001	1.17 (0.97~1.41), 0.108	1.55 (1.27~1.90), <0.001
Subjective sleep quality, mean (SE)	0.99 (0.02)	1.00 (0.02)	1.00 (0.02)	1.03 (0.94~1.13), 0.573	1.02 (0.93~1.12), 0.690	0.99 (0.90~1.09), 0.884
Sleep latency, mean (SE)	0.74 (0.02)	0.73 (0.02)	0.70 (0.02)	0.98 (0.91~1.06), 0.608	0.77 (0.71~0.84), <0.001	0.79 (0.73~0.86), <0.001
Sleep duration, mean (SE)	0.48 (0.02)	0.56 (0.02)	0.72 (0.02)	1.15 (1.05~1.25), 0.002	1.47 (1.35~1.60), <0.001	1.28 (1.18~1.40), <0.001
Habitual sleep efficiency, mean (SE)	0.28 (0.02)	0.29 (0.02)	0.28 (0.01)	1.02 (0.92~1.13), 0.701	0.99 (0.90~1.10), 0.914	0.97 (0.88~1.08), 0.629
Sleep disturbance, mean (SE)	0.44 (0.01)	0.43 (0.01)	0.67 (0.01)	0.99 (0.87~1.12), 0.854	2.11 (1.86~2.39), <0.001	2.11 (1.86~2.40), <0.001
Sleep medication use, mean (SE)	0.02 (0.004)	0.03 (0.005)	0.04 (0.006)	1.20 (0.87~1.64), 0.270	1.48 (1.10~1.99), 0.009	1.25 (0.95~1.65), 0.109
Daytime dysfunction, mean (SE)	1.03 (0.01)	1.66 (0.02)	1.71 (0.02)	3.29 (2.96~3.65), 0.001	3.59 (3.22~4.00), <0.001	1.06 (0.98~1.14), 0.143
Poor sleep quality, yes, n (%)	409 (21.0)	401 (21.9)	466 (26.0)	1.05 (0.91~1.23), 0.471	1.37 (1.17~1.60), 0.001	1.29 (1.11~1.51), <0.001

TABLE 3 | Prospective associations of poor sleep quality with anxiety symptoms and depressive symptoms.

	Anxiety symptoms (GAD-7 scores)				Depressive symptoms (CES-D scores)			
	Model 1		Model 2		Model 1		Model 2	
	Unstandardized β estimate (95% CI)	<i>P</i>	Unstandardized β estimate (95% CI)	<i>P</i>	Unstandardized β estimate (95% CI)	<i>P</i>	Unstandardized β estimate (95% CI)	<i>P</i>
Time								
Wave 1	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)	
Wave 2	0.22 (−0.30~0.74)	0.626	0.24 (−0.27~0.75)	0.356	0.35 (−0.79~1.49)	0.550	0.13 (−0.97~1.23)	0.817
Wave 3	−0.14 (−0.68~0.41)	0.402	−0.04 (−0.59~0.50)	0.883	−0.08 (−1.28~1.13)	0.901	−0.24 (−1.44~0.96)	0.696
Interaction								
Poor sleep quality × Wave 1	1.00 (reference)		1.00 (reference)		1.00 (reference)		1.00 (reference)	
Poor sleep quality × Wave 2	−0.03 (−0.15~0.10)	0.684	−0.05 (−0.17~0.07)	0.410	0.09 (−0.18~0.35)	0.520	0.06 (−0.19~0.30)	0.641
Poor sleep quality × Wave 3	−0.03 (−0.15~0.09)	0.633	−0.03 (−0.15~0.09)	0.624	−0.05 (−0.31~0.21)	0.695	−0.05 (−0.29~0.20)	0.718
PSQI scores (1-score increase)	0.79 (0.69~0.89)	<0.001	0.69 (0.59~0.79)	<0.001	1.95 (1.75~2.16)	<0.001	1.61 (1.42~1.80)	<0.001
Subjective sleep quality (1-score increase)	1.14 (0.97~1.34)	0.120	1.17 (1.01~1.37)	0.043	1.22 (0.82~1.81)	0.328	1.32 (0.92~1.89)	0.130
Sleep latency (1-score increase)	0.99 (0.87~1.12)	0.842	1.04 (0.92~1.18)	0.498	0.98 (0.72~1.34)	0.895	1.14 (0.86~1.51)	0.364
Sleep duration (1-score increase)	1.06 (0.91~1.22)	0.458	1.09 (0.95~1.26)	0.205	0.92 (0.65~1.31)	0.650	1.00 (0.73~1.38)	0.994
Habitual sleep efficiency (1-score increase)	0.88 (0.73~1.05)	0.152	0.88 (0.74~1.04)	0.134	0.80 (0.52~1.23)	0.299	0.83 (0.56~1.23)	0.351
Sleep disturbance (1-score increase)	1.12 (0.90~1.38)	0.310	1.07 (0.88~1.31)	0.485	1.15 (0.69~1.92)	0.602	1.01 (0.64~1.62)	0.952
Sleep medication use (1-score increase)	1.16 (0.71~1.90)	0.555	0.98 (0.61~1.57)	0.919	1.37 (0.42~4.53)	0.601	1.12 (0.37~3.38)	0.839
Daytime dysfunction (1-score increase)	1.01 (0.88~1.16)	0.865	0.99 (0.87~1.13)	0.921	1.00 (0.72~1.40)	0.989	0.95 (0.70~1.29)	0.743

Model 1: The unadjusted generalized linear mixed models.

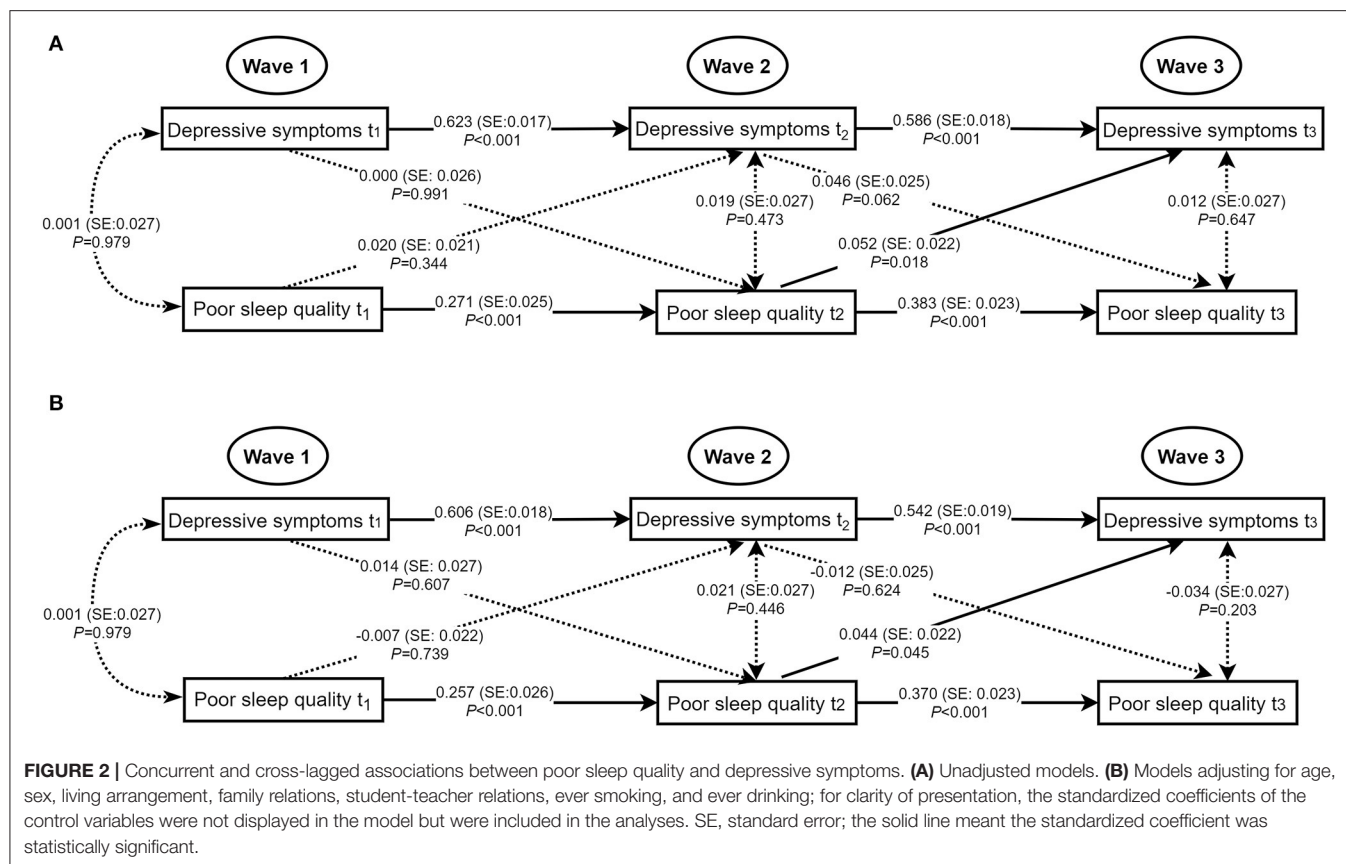
Model 2: The generalized linear mixed models adjusted for age, sex, living arrangement, family relations, student-teacher relations, ever smoking, and ever drinking.



implemented (e.g., school mental health consultation or mental health education) after school reopening. Consistent with our findings, a longitudinal study of adults in the UK demonstrated that anxiety and depressive symptoms remained stable across waves during the first 6 weeks of the COVID-19 pandemic (29); a recent longitudinal study among high school students in São Paulo also showed that adolescents delayed bed and wake-up times and had increased the global PSQI score during the COVID-19 pandemic (30). Moreover, our study also observed that regarding each component of PSQI, sleep duration, sleep disturbance, use of sleep medication, and daytime dysfunction got worse at Wave 3 among these adolescents, while sleep latency got better at Wave 3. These findings were partially similar to a previous study among adults (31), and suggested that families, schools, and clinicians should be informed about the adverse effects of the COVID-19 pandemic in relation to adolescent sleep quality.

Although the direct long-term influence of the COVID-19 pandemic on anxiety or depressive symptoms was not observed in this study, this study observed significant main longitudinal effects of poor sleep quality on anxiety symptoms and depressive symptoms through the three waves in with and without adjusted GLMMs. Moreover, prior studies also demonstrated that individuals with poor sleep quality were at a higher risk of depressive symptoms and anxiety symptoms

than those without (32). Poor sleep quality is nearly universal in individuals with mental health problems, and previous evidence has suggested individuals with depressive or anxiety symptoms would have sleep quality complaints (33). Therefore, this study also investigated the bidirectional associations of poor sleep quality with anxiety and depressive symptoms. This study revealed that after adjusting for age, sex, living arrangement, family relations, student-teacher relations, ever smoking, and ever drinking, poor sleep quality was positively associated with current as well as subsequent anxiety symptoms and vice versa. Only a marginally significant cross-lagged association between poor sleep quality at Wave 2 and depressive symptoms at Wave 3 was observed. Similarly, Kelly et al. showed that there were significant reciprocal associations of children's sleep/wake problems with anxiety and depressive symptoms using three waves data spanning 5 years (34). Robert et al. using data from a two-wave cohort study found that short sleep duration at baseline increased the risk of subsequent anxiety disorder twofold, but the reverse association was not significant (35). Shanahan et al. using a study of youth ages between 9 and 16, found that sleep problems predicted an increase in generalized anxiety disorders but only predicted depression when anxiety symptoms were also present, and vice versa (36). These results might be related to that several myriad mechanisms for the association between sleep problems and anxiety/depressive symptoms have



been posited, including genes, hormones, regulatory systems (e.g., the hypothalamic-pituitary-adrenal axis), and cognitive process (37, 38). Sleep problems are sometimes a symptom of anxiety or depression, and sufficient sleep may serve an important role in developing adolescent brain regions (e.g., the prefrontal lobe), which is responsible for emotional regulation and cognitive function (39). Conversely, anxiety or depressive symptoms are disabling conditions among adolescents that result in emotional suffering and poor sleep quality (40). In this study, only poor sleep quality at Wave 2 predicting depressive symptoms at Wave 3 may reflect students' sleep quality was adversely affected by the COVID-19 pandemic. A possibility for the unobserved concurrent or cross-lagged associations between poor sleep quality and depressive symptoms may be that the autoregressive association between previous depressive symptoms and subsequent depressive symptoms is too strong to cover the effects of poor sleep quality.

As already mentioned, whereas symptoms of anxiety and depression remained stable across the three waves, sleep quality was adversely affected, and the bidirectional associations between poor sleep quality and anxiety or depressive symptoms could not be neglected. Thereby, the implications of this study highlight that prevention or intervention strategies targeted at cultivating healthy sleep habits and improving sleep quality are helpful to develop good mental health among adolescents, particularly during COVID-19.

The findings also highlight the importance of regularly assessing adolescents' mental health status, especially in adolescents with poor sleep quality. Although this study extends exiting literature on the associations between poor sleep quality, anxiety symptoms, and depressive symptoms among Chinese adolescents before and during COVID-19, several limitations should also be considered. First, the school-based longitudinal study only included school students as the study sample and did not include adolescents absent from schools. Second, indicators of poor sleep quality, anxiety symptoms, and depressive symptoms were based on self-report, then this study only comments on these symptoms of mental health and behaviors rather than psychiatric disorders. Third, given that most Chinese middle school students or high school students will transfer to other schools after graduation, this longitudinal study only invited junior grade one and senior grade one students to avoid loss of follow-up due to students going on for further study.

In conclusion, this three-wave longitudinal study found that anxiety and depressive symptoms among Chinese adolescents remained stable before and during COVID-19, while sleep quality among adolescents gets worse at the time point when students have experienced almost 3 months of lockdown and school closure due to the COVID-19 pandemic. Moreover, the concurrent and cross-lagged associations between poor sleep quality and anxiety symptoms across the three waves

(before and during COVID-19) were statistically significant and vice versa. In contrast, only the cross-lagged effect of poor sleep quality at Wave 2 on depressive symptoms at Wave 3 was marginally significant. Considering the COVID-19 pandemic has been a global public health event, these study findings addressed that a proper surveillance system should be established in China to regularly assess adolescent mental health and behaviors. Schools and families should also be aware of the adverse effects of the COVID-19 pandemic, and positive education and intervention programs that cultivate adolescents' healthy sleep habits and positive emotion regulation are highly recommended to be developed to decrease risks of anxiety and depressive symptoms, especially among those with the current poor sleep quality.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Sun Yat-sen University, School of Public Health Institutional Review Board. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

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AUTHOR CONTRIBUTIONS

LG and WW: full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis, drafting of the manuscript, and statistical analysis. LG, WW, and CL: concept, design, administrative, technical, or material support. YG, XD, WL, and RW: acquisition, analysis, or interpretation of data. LG, WW, YG, XD, CL, RW, and WL: drafting of the manuscript. LG, WW, YG, and CL: supervision. All authors finally approve the submission of this paper.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsy.2021.786640/full#supplementary-material>

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Changes in Japanese Junior High School Students' Sense of Coherence Before and After the Onset of the COVID-19 Pandemic: A Longitudinal Study of Children and Mothers

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We conducted a longitudinal study to clarify the changes in the sense of coherence (SOC); that is, the ability to cope with stress successfully, of 166 Japanese junior high school students and their mothers before and after the onset of the COVID-19 pandemic. First, we analyzed changes in SOC at three time points for all students and divided them into two groups: Group 1 included students with SOC scores that increased or maintained before and after the onset of the pandemic and Group 2 included students with decreased SOC scores after the onset of the pandemic. Second, we conducted a comparative analysis between the two groups. Overall, results indicated that student's SOC scores increased. Additionally, interpersonal stress scores were lower after the onset of the pandemic than before. There were almost no differences in family relationships, financial conditions, or personality tendencies between the two groups. However, Group 2 did not regain their sense of belonging to school. In this group, the frequency of stress experiences in club activities after the onset of the pandemic, troubles with the opposite gender, and inability to catch up with the contents of the subject lecture were high. The accumulation of small stressors may have hindered the maintenance of a sense of school affiliation. Mothers of students in Group 2 either were full-time employees at baseline or had started a new job after the onset of the pandemic. Their children may have been affected by the household's damaged financial budget and changes in mother's working styles. As COVID-19 reduced the number of days students went to school, students' SOC could have reduced had they not felt a sense of presence or belonging due to the lack of participation in club activities, school events, etc. Teachers and mothers should communicate carefully with their students and children, respectively, to develop a sense of belonging.

Keywords: COVID-19, junior high school students, longitudinal study, mothers, sense of coherence, Japanese

INTRODUCTION

The Cabinet Secretariat of Japan (1) issued a state of emergency due on 7 April 2020 to COVID-19 (Secretariat, 2020), limiting the daily activities of all citizens to develop self-restraint. This included drastic changes to daily life, such as restricting unnecessary activities and allowing going out only for urgent activities, remaining homebound as much as possible, and wearing a mask and washing hands, to which people experienced confusion. On 28 February 2020, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) stated, “From the perspective of preparing for the risk of infection caused daily by many children and teachers gathering for a long time, all schools (elementary, junior high, high, and special needs schools) are requested to be closed all over the country” (2). Consequently, all schools under the jurisdiction of MEXT throughout Japan were temporarily closed. Specifically, 74% of kindergartens, 95% of elementary schools, 95% of junior high schools, 97% of high schools, and 96% of special schools were closed (3). The first state of emergency was lifted nationwide on 25 May. That is, for about 3 months, students were unable to attend school. This was the first time in Japan that all schools were suddenly closed for a long time, and confusion and anguish were reported in the media every day. This unprecedented event of closing the schools may have brought about serious changes among students, but it is unclear what changes occurred.

According to Japanese social customs, the year begins in April and ends in March. March is an important time for the school year ends, with graduation and closing ceremonies normally taking place then. In April, entrance and opening ceremonies are held, and a new academic life starts. School events, rituals, and ceremonies have positive psychological effects, such as motivation, hope, and re-evaluation of experiences (4, 5). However, due to the unprecedented long temporary closure, students were unable to experience these events. Additionally, even if it had been possible to go to school, distributed and staggered school attendance as well as refrain from club activities continued; the current situation was still far from normal school life. No one had experienced this and the drastic changes in daily life have had a great impact on the students. For example, the number of suicides among elementary, junior high, and high school students in Japan in 2020 increased by 100 (25.1%) from the previous year to 499 (6). The MEXT suggests that “social anxiety due to the spread of COVID-19 may have caused this” (6). However, the number of suicides is said to be the tip of the iceberg. Many children may have potentially been distressed, but reports on their situation and how the unprecedented long temporary leave has affected them are limited. There is an urgent need to understand the children’s current situation, identify children in extremely unstable situations, and promptly provide care and support to them.

Junior high school students in Japan are in the early stages of puberty, a period referred to as “thunder and storm” (7). In this extremely unstable stage of life, mental and physical growth is remarkable. Considering that suicide has been the leading cause of death among teenagers and individuals in their twenties for many years in Japan (8), it has been said that it is necessary to

enhance the “zest for life” among adolescents. Several studies regarding adolescent suicide prevention and strengthening ability to overcome difficulties have been conducted (9, 10). In these studies, “zest for life” has been conceptualized as a sense of coherence (SOC), which is the basic concept of Antonovsky’s (11) salutogenesis theory. SOC is described by Antonovsky as the ability to cope well with stress and protect one’s physical and mental health even in extremely stressful conditions, leading to healthy growth and development. Adolescent SOC is also said to predict adult SOC, and SOC is extremely useful as an index to approach adolescents (12). Omiya et al. (10) examined the factors related to the SOC of high school students, and the results showed that school sense of belonging, student and teacher acceptance, good family relationships, and mother’s SOC were positive factors for high school SOC. SOC consists of three subscales: manageability, comprehensibility, and meaningfulness (11), but the ongoing pandemic is neither understandable nor manageable in everyday life. Almost all club activities that the students have been working on every day have been canceled and developing a sense of meaning has become difficult. In these circumstances, the SOC of adolescent junior high school students is also affected by the pandemic, but there are no reports on the changes before and after the onset of the pandemic.

In addition to these effects, according to a survey by the Japan Gender Equality Bureau Cabinet Office (13) report, due to the pandemic, about 48% of workers in the metropolitan area shifted to telework, about 70% refrained from eating out at events, and about 70% of teens and people in their 20’s increased their internet use time. According to Ishida et al. (14), in Japan, one’s social network was not only shrinking face-to-face, but also via email and chat. In addition, it is reported that more than 80% of individuals experienced anxiety about the economic recession and lack of infection prevention supplies and information. Moreover, blue-collar workers experienced high levels of anxiety and women experienced stronger anxiety than men. In Japan, many women are forced to work part-time and as non-regular workers; the Japan Gender Equality Bureau Cabinet Office (13) reported that unemployment and suicide during the pandemic are increasing sharply among women. Such economic impacts may have directly affected households and livelihoods, but it is unclear how economic changes have affected adolescents.

Additionally, there is a call for maintaining social distance everywhere to prevent infection (15), and schools are taking every step to avoid crowding. Reportedly, students are instructed to eat silently at lunchtime every day at school. Traditionally, the Japanese school life is characterized by a strong sympathetic “everyone together” pressure, and in adolescence, children are highly concerned about others’ opinion and their mental health, and they often find it difficult to ask for assistance even in times of trouble (16). Now that the physical distance from others has increased drastically, it is possible that the psychological sense of distance with friends is also changing, and that it may be working positively or negatively for them. Particularly, living with a mask every day is likely to make it difficult to read facial expressions and understand emotions (17). That is, students’ current school and family life is completely different from the lives they had prior to the pandemic. Under these circumstances, it is necessary

to clarify the changes in the “zest for life,” or SOC, of junior high school students amid their vulnerable adolescence. If their SOC is decreasing, understanding how they differ from those whose SOC has increased or maintained is important to provide care and support promptly.

We clarified the changes in the SOC of junior high school students before and after the COVID-19 pandemic, particularly comparing those with decreased SOC with those whose SOC increased or remained consistent. Specifically, we thought that the implications for care and support for the decreased SOC group should be clarified.

MATERIALS AND METHODS

Participants

Students from two public junior high schools (junior high schools A and B) in the Tokyo metropolitan area consented to participate in the study with their parents (mainly mothers). With the cooperation of the first grade of junior high school A and the first and second grade of junior high school B, the questionnaire was distributed to students who consented to the survey. Data was collected at three separate time points. The survey acquired the baseline data in the spring of 2019 (March–April), then in the winter of 2019 (October–December), and finally in the summer of 2020 (July–September). The third data collection was after the onset of the pandemic. The parents responded to a baseline and the third survey. Parents were matched with children and 166 pairs were surveyed, from which parent–child data were obtained thrice from them. The parental consent rate for participation in this study was 56 and 46% of the total pairs who responded to all three times was.

Ethical Considerations

As per the ethical guidelines, since the participants were underage, we first explained the outline of the survey to the parents of the junior high school students in writing and distributed the survey form only to the students who signed their consent forms after obtaining handwritten consent from their parents. We explained to the students in writing and confirmed their intentions by setting a check box on the questionnaire as to whether they agreed to participate. We also explained that participation in the survey was voluntary, there was no disadvantage to non-participation, and they could withdraw at any time. Since this was a longitudinal survey, each student was given a 6-digit random personal ID number, which was used to manage the participant's data. For parent–child data matching, a common parent–child number was assigned to each pair in addition to the personal ID number. However, we explained in writing that these ID numbers were not personally identifiable and that anonymity was maintained. Documents that linked the personal ID number and student name were managed by one person in charge of each school and were locked in an archive so that the individual could not be identified from the answers. The student questionnaires were collected from the school, and then distributed to and collected from the parents through the students. I conducted a survey in accordance with the Declaration of Helsinki. Additionally, this study was approved

by the medical ethics review board of the University of Tsukuba (approval number: 1,343, approval date 30 January 2019).

Variables (Measures)

Demographic Variables

Students provided information regarding basic attributes such as their gender and grade.

Sense of Coherence

We used the Japanese abbreviated version of the SOC scale, comprising 13 items on a five-point scale, the reliability and validity of which have been verified by Togari et al. (18). This version of the scale is widely used in Japan's national sample surveys and studies involving high school students (9, 10). The SOC-13 has three subscales: comprehensibility (five items), manageability (four items), and meaning (four items). The Cronbach's alpha coefficient for SOC was from 0.789 to 0.903, for mothers and for children, for each time.

For Students (Common to All Three Surveys)

School Membership Scale

We used the Japanese version of the psychological sense of school membership scale, which was developed by American psychologist Goodenow (19) and the reliability and validity of the Japanese version were verified by Togari et al. (20). This scale has been validated for high school students in Japan. The authors of the current study and the junior high school teachers who collaborated on this study reviewed the content of the scale and determined that it could be used for junior high school students. We also contacted the original developers of the Japanese version of the scale, whose sample included high school students. They agreed and permitted the use of the scale on a sample of junior high school students. It consists of three subscales: the sense of acceptance by students (four items), the sense of acceptance by teachers (five items), and the sense of belonging (this comprises four items; it asks students about the degree to which they are proud of their school and their sense of place at school). The responses ranged on a five-point scale, with higher scores indicating better conditions. The Cronbach's alpha for this scale was from 0.788 to 0.891, for each time.

Mental Health Inventory; MHI

The MHI was developed by Berwick et al. (21) as a measure for finding mental health status (especially depression) using five items, and Yamazaki et al. (22) modified it in Japanese. The questions were, “I was quite nervous” and “I was so depressed that I couldn't help it” in five stages from “1. *I was always there*” to “5. *I wasn't at all*” in the past month. The higher the score, the better the mental state. The Cronbach's alpha for this scale was from 0.801 to 0.849 for each time.

Physical Symptoms

We asked about eight physical symptoms (headache, abdominal pain, insomnia, palpitation, dizziness, constipation/doorrjea, body pain and irritability) created by Ben-Sira (23). The responses range on a 4-point scale (*always, sometimes, not so much, not at all*), and the higher the score, the better the

condition. The Cronbach's alpha for this scale was from 0.822 to 0.911 for each time.

Baseline

Children's Report on Parenting in Adolescence Scale

Utsumi (24) developed a scale to measure parents' nurturing attitudes from the children's perspective. In other words, this scale reports children's perceptions of their parents' nurturing attitudes. This scale follows Schaefer's (25) theory and has been tested for internal consistency and reliability. We used three subscales: Acceptance (six items consisting of the child's perception of emotional support and warmth toward the parent's nurturing attitude), Psychological Control (six items related to parent's attempts to control behavior), and Monitoring (three items related to parent's tracking and paying attention to the child's whereabouts, activities, and adjustment). For each item, we asked them to respond on a five-point scale ranging from 1 (*Not applicable at all*) to 5 (*Very well applicable*). Cronbach's alphas for this subscale were 0.901, 0.876, and 0.801.

Interpersonal Hypersensitivity Tendency

During adolescence, complaints such as "I'm worried about what people think" and "I'm nervous in public" are frequent. Such anxiety manifests itself as school refusal or depression, leading to adolescents being diagnosed with "adjustment disorder" in psychiatry (26). In this study, we used the "interpersonal sensitivity" sub-scale from the "Interpersonal sensitivity/Privileged self-scale" developed by Muranaka et al. (27). The scale comprises two areas: "Sensitivity to evaluation (Cronbach's $\alpha = 0.858$)," which is being worried about others' evaluation (nine items), "Excessive reaction to evaluation (Cronbach's $\alpha = 0.814$)," which consists of items such as being sensitive to other people's words and being shocked by trivial words (five items). The responses of each of these items were based on a five-point Likert scale.

Recognition of Stress Experience

We used the "High School Student Life-Related Stress Scale" developed by Ishida et al. (28) and confirmed its reliability and validity for adolescent student life-related stress perception. The developers approved the adaptation of the scale for junior high school students. This scale consists of five domains: (1) teachers, (2) club activities, (3) academic performances, (4) friends and opposite gender, and (5) families. Each domain includes four to five items with a total of 19 items across all domains. Participants respond on a 4-point rating scale (1 = never experienced stress, 2 = occasionally experienced stress, 3 = experienced stress, and 4 = frequently experienced stress). We asked about negative perceptions about school life, such as "I was ignored by my classmates and felt unpleasant." Additionally, based on discussions among the authors of the present study and previous research (29), we included five stressor items related to club activities, as they are highly significant for Japanese junior high school students. Therefore, we used the adapted version of this scale comprising 24 items on a 4-point rating scale.

Mothers

Baseline

We asked about the subjective economic condition of the home using a five-point Likert scale from "1. *poor*" to "5. *rich*." The higher the score, the wealthier they were. Regarding working conditions, we asked them to choose from one of the three options, "working in regular employment," "working in non-regular employment," and "not working."

The Parental Attitude Scales

We used a scale developed by Kato et al. (30) whose reliability and validity in measuring the parenting attitudes of parents with children in a wide range of developmental stages from early childhood to late adolescence is verified. It comprises ten items of "acceptance/child-centered" (e.g., paying close attention to children), seven items of "inconsistent indecisive discipline" (e.g., changing the rules made for children), and eight items of "control" (e.g., I want my child to do what I want). It is rated on a scale of five from "1- *Almost not applicable*" to "5- *Very applicable*." Cronbach alpha was 0.815.

Life Events

With reference to the life events concept proposed by Natsume and Murata (31), 20 stressful life events were extracted through discussions among researchers. The questions asked, for example, "Have you experienced the following since the last survey?" and enquired on whether "the company [the participant] worked for went bankrupt," they "got divorced," or their "income decreased."

Analysis

Simple aggregation was performed for the basic attributes. Regarding the SOC scores of the students, the average scores

TABLE 1 | Attributes and characteristics of subjects (Baseline).

	<i>n</i>	(%) /SD
Students	166	
2019 1st grade (12–13 years old) Male	24	(52.2)
Female	22	(47.8)
2019 2nd grade (13–14 years old) Male	54	(45.0)
Female	66	(55.0)
Parents (Mother)	166	
Age, average, SD	44.9	4.2
Employment		
Regular employment	43	(25.9)
Non-regular (part-time job)	89	(53.6)
Unemployed	34	(20.5)
Marital status		
Divorce / bereavement	17	(10.2)
Married	149	(89.8)
Subjective economic conditions		
Poor / very poor	17	(10.2)
Average	79	(47.6)
Relatively rich, rich	70	(42.2)

TABLE 2 | Changes in student's SOC score at 3 points (From spring of 2019 to summer of 2020).

Measurement time	Students' score $n = 166$	
Total SOC Score $F_{(2,314)} = 7.799, p < 0.001$		
2019 spring (Baseline)	40.9	<p>n.s.</p> <p>$p < 0.001$</p> <p>$p = 0.006$</p>
2019 winter	40.7	
2020 summer (After the onset of pandemic)	42.8	
Subscale: Comprehensibility $F_{(2,318)} = 7.556, p = 0.007$		
2019 spring (Baseline)	14.9	<p>n.s.</p> <p>$p = 0.006$</p> <p>$p = 0.020$</p>
2019 winter	14.8	
2020 summer (After the onset of pandemic)	15.7	
Subscale: Manageability $F_{(2,316)} = 10.32, p < 0.001$		
2019 spring (Baseline)	12.1	<p>n.s.</p> <p>$p = 0.009$</p> <p>$p < 0.001$</p>
2019 winter	12.5	
2020 summer (After the onset of pandemic)	13.2	
Subscale: Meaningfulness $F_{(2,320)} = 2.27, p = 0.104$		
2019 spring (Baseline)	13.8	<p>n.s.</p> <p>n.s.</p> <p>n.s.</p>
2019 winter	13.4	
2020 summer (After the onset of pandemic)	13.8	

SOC, sense of coherence. One-factor analysis of variance (repetitive measurement) by Bonferroni method.

at the three-time points—spring of 2019 (baseline), winter of 2019, and summer of 2020 (after the onset of the pandemic)—were compared and analyzed by one-way analysis of variance (Bonferroni method). In addition to the total score, the three subscales were analyzed in the same way. A paired t -test was performed on the recognition of stress experience scores in winter of 2019 and summer of 2020 to examine whether there was a difference in the perception of stress experience (for teachers, club activities, academic performance, friends, family relationships) before and after the onset of the pandemic.

The 166 students were divided into two groups based on their SOC scores: the increased/maintained group and the decreased group. For the division of the two groups, the total SOC score at the third data collection time point (summer of 2020) was subtracted from the total SOC score at baseline (spring of 2019). If the result of the subtraction was positive or zero, the group was classified as “Group 1,” and if it was negative, the group was classified as “Group 2.” There were 6 people who scored 0 (no change), which was 3.6% of the total. The average SOC score of these six students was 44.3, which was higher than the average, so we concluded that they had maintained a good status before and during the pandemic. Therefore, these six students were classified as Group 1.

Subsequently, we compared the SOC scores of Groups 1 (59.6%) and 2 (40.4%) for spring of 2019 (baseline) and summer of 2020 after the onset of the pandemic, using a t -test. The SOC total score, MHI, physical symptoms, and school membership scale (examined by subscale) were then tested at each of two points: spring of 2019 (baseline) and summer of 2020 (after the onset of the pandemic). For mothers, we tested for household economic status and employment status at baseline. After the onset of the pandemic, we tested the proportion of mothers who responded with “yes” or “no” to the 20 items of stressful life event experiences between the two groups. A t -test was conducted for continuous variables and a χ^2 test was conducted for qualitative variables.

In addition, comparisons between the two groups were made using t -tests for baseline scores of the Interpersonal hypersensitivity tendency, Children's report on Parenting in Adolescence Scale (examined by subscale), and the Parental Attitude scale. After the onset of the pandemic, in the summer of 2020, comparisons were made between the two groups for scores of the school membership scale by subscales, and for the recognition of stress experience by five domains, including teachers and club activities.

A generalized estimating equation (32) was used as a model to estimate the effect on the mean of the population

outcome (population-averaged model). We used the generalized estimating equation-logistic model (GEE-L) to construct a binomial model with the dependent variable set to 0 for SOC decreased group and 1 for SOC increased/maintained group. In the first model (Table 4), the baseline values (spring of 2019) of the school membership scale, interpersonal hypersensitivity tendency, Children's report on parenting in Adolescence scale, and the Parental Attitude scale were entered. In the second model (Table 5), scores of the school membership scale and recognition of stress experiences, which they responded to in the summer of 2020, were included in each of the sub-domains.

To obtain more specific suggestions, student's recognition of stress experiences was compared between the two groups for each item using *t*-tests. Differences were considered significant at $p < 0.05$. In general, a significance of $p < 0.05$ is widely accepted, but in exploratory analyses, a relatively large significance level such as 0.1 is sometimes set (33). Since this data deals with very exploratory content, we wanted to mention the significance tendency of 0.1. SPSS Ver. 27.0 was used for statistical analysis.

RESULTS

Table 1 shows the attributes and characteristics of the 166 research participants. Among the students, 52.4% (87) were female and 47.6% (79) were male. The average age of the mothers was $44.9 \text{ years} \pm 4.2$, with the largest number of non-regular workers accounting for 53.6%. Regarding the economic situation

of households, most reported an average economic situation (47.6%).

A comparison of the mean scores of each variable between the baseline and after the onset of the pandemic (Table 2) showed that the SOC scores of all the students increased significantly as a whole after the onset of the pandemic ($p = 0.006$). As for the subscales, scores from the third data collection time point (post-pandemic) were significantly higher than scores at the baseline and second data collection time point (winter of 2019) for both comprehensibility and manageability ($p < 0.001$; $p = 0.020$). Regarding stress experiences at school and home, stress related to teachers ($p = 0.002$), club activities ($p = 0.010$), and friends ($p = 0.001$) were significantly lower after the onset of the pandemic than before (Figure 1). Among the students, 59.6% (99) had maintained or improved SOC scores (Group 1) while 40.4% (67) had decreased SOC scores (Group 2). A comparison of these two groups indicated that Group 2 had higher SOC scores at baseline ($p = 0.002$), but reversed scores in the second (winter of 2019) and third surveys (after the onset of pandemic), indicating a wide difference (Table 3).

Table 3 also shows that compared to Group 1, physical symptoms and mental health (MHI) worsened in Group 2 after the onset of the pandemic ($p = 0.027$, $p < 0.001$).

A comparison of parental baseline data between the two groups showed no difference in subjective family economic conditions, but at baseline, mothers in Group 2 ($p = 0.078$) showed a trend of being regular employees. "Furthermore, after the outbreak of the pandemic, the percentage of mothers in Group 2 who answered "yes" to the "I got a new job" item were higher than the percentage of those who answered the same in Group 1 ($p = 0.062$).

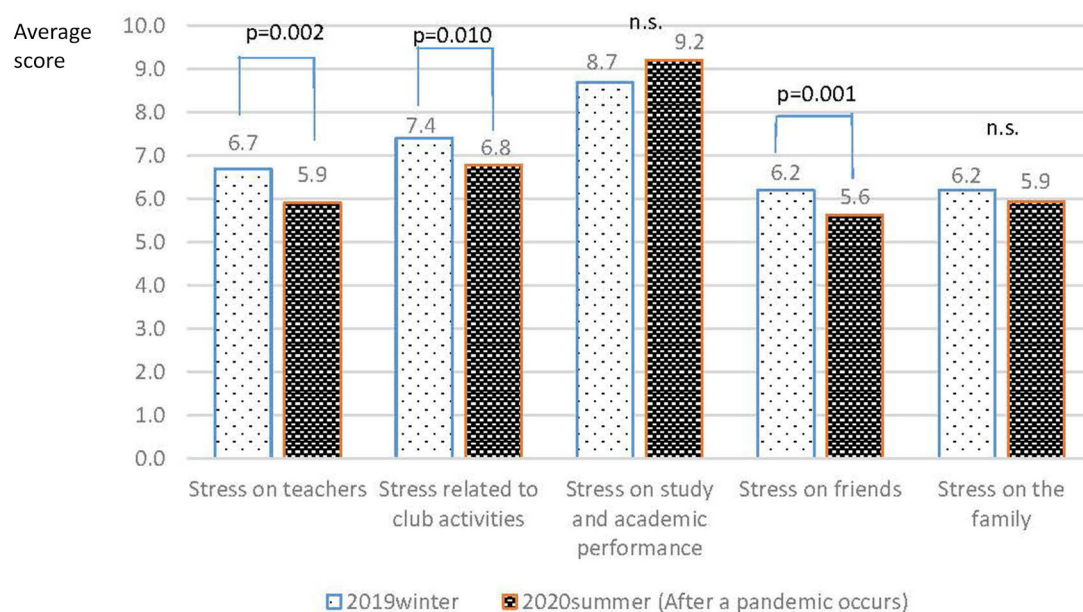


FIGURE 1 | Comparison of student's stress experiences before and after the onset of COVID-19 pandemic.

TABLE 3 | Comparison of mean scores of variables between two SOC groups of students and mothers before (2019 spring) and after the onset of the pandemic (2020 summer).

Variables	Group 1 <i>n</i> = 99	Group 2 <i>n</i> = 67	<i>p</i> -value
Student's Variables			
Sense of Coherence (range 13–65)			
2019 spring, $t_{(164)} = 3.093$	39.6	42.8	0.002
2020 summer, $t_{(164)} = -0.834$	46.2	37.7	<0.001
MHI (Mental Health Inventory) (range 5–25)			
2019 spring, $t_{(163)} = -0.413$	18.8	18.9	0.949
2020 summer, $t_{(164)} = -5.225$	20.2	17.3	<0.001
Physical symptoms (range 8–32)			
2019 spring, $t_{(163)} = -0.413$	24.7	24.3	0.680
2020 summer, $t_{(161)} = -2.237$	25.0	23.2	0.027
Mothers' Variables			
Baseline variables answered by mothers			
Family economic condition (the higher the score, the more money you can afford) (range 1–5)	3.3	3.2	0.817
Working condition			
Working in regular employment <i>n</i> (%)	18 (20.7%)	19 (33.9%)	0.078
Non-regular staff / not working <i>n</i> (%)	69 (79.3%)	37 (66.1%)	
Life events experienced by parents in summer of 2020 (after the onset of pandemic)			
"I got a new job", Yes <i>n</i> (%)	10 (10.3%)	13 (21.0%)	0.062
"I got a new job", No <i>n</i> (%)	87 (89.7%)	49 (79.0%)	

SOC, Sense of coherence. Group 1 = SOC increased/maintained group, Group 2 = SOC decreased group. A *t*-test was performed on continuous variables, and a χ -square test was performed on discontinuous variables.

Tables 4, 5 show the results of the *t*-test, which revealed the relationship between the two variables, and the generalized estimating equation-logistic model (GEE-L), which examined the differences between the two groups. In Table 4, the variables at baseline (spring of 2019) were entered as the explanatory variables to be examined. Consequently, no significant variables were found in the *t*-test or in the GEE-L.

In Table 5, the variables observed in the summer of 2020 (after the onset of the pandemic) were used as explanatory variables. *T*-test showed that the sense of belonging score was significantly lower in the decreased group ($p = 0.004$). In stress experience recognition, the stress experience perception in all the domains—Teachers ($p = 0.041$), club activities ($p < 0.001$), academic performance ($p = 0.008$), friends relationships ($p = 0.010$), and family relationships ($p < 0.018$)—was higher in the decreased group. In the GEE-L analysis, the decreasing group was set to 0 and the increasing/maintaining group was set to 1. The results showed that the sense of belongings was positively related ($\beta = 0.172$) and the odds ratio was 1.188 ($p = 0.017$). In terms of stress experience, club activities had a negative relationship ($\beta = -0.256$) and the odds ratio was 0.774 ($p = 0.004$).

As a result of examining the difference in the frequency of stress experience between Groups 1 and 2 for each specific item, in Table 6, five items related to club activities ($p < 0.001$ – 0.026), two items related to academics ($p = 0.020$), two items related to friends and gender relationships ($p = 0.020$, 0.040), and one

item related to family relationships ($p = 0.011$), showed high experience frequency recognition in Group 2.

DISCUSSION

Students' SOC Scores

The SOC scores of the junior high school students improved unexpectedly. Losing direct contact with non-family members and the sudden interruption of the normal “going to school” routine due to the nationwide lockdown may have reminded them of the happiness of being able to go to school. This is similar to when the residents of Japan experienced the shock of “suddenly changing their ordinary lives 1 day at a time” when an unprecedented earthquake called the Great East Japan Earthquake struck Japan in 2011. During that time, people also realized how dear everyday life was (34). In the current case, experiencing the pandemic, school closures, and resumption of school due to COVID-19 may have reaffirmed the joy of going to school every day among the students. Moreover, the reopening of schools (4), which is a sign of order, may have presented a hope for the future.

SOC is nurtured by family habits in which daily routines are habitually repeated, such as daily greetings and regular declarations such as “I’m leaving!” and “I’m home!” between family members (35). Previous studies have pointed out that stable habits provide good foreseeing and a sense of security,

TABLE 4 | Generalized estimating equation and logistic model with baseline measurement variables as explanatory variables ($n = 166$).

Valuables in 2019 spring (Baseline)	Bivariate analysis				GEE-L					
	Mean scores for each group		T-test p-value	Coefficient β	Standard error	Hypothesis testing		Odds ratio	95% CI	
	Group	Score				Wald χ^2	p-value			
Variables of students										
School membership scale										
Accepted by students (range 4–20)	Group 1 (1)	16.19	0.391	−0.077	0.095	0.656	0.418	1.080	−0.262	0.109
	Group 2 (0)	16.12								
Accepted by teachers (range 5–25)	Group 1 (1)	18.08	0.347	−0.042	0.063	0.436	0.509	0.959	−0.166	0.082
	Group 2 (0)	16.60								
Sense of belonging (range 4–20)	Group 1 (1)	16.64	0.944	0.036	0.088	0.173	0.678	0.964	−0.136	0.208
	Group 2 (0)	16.60								
Interpersonal hypersensitivity tendency										
Sensitivity to evaluation (range 9–45)	Group 1 (1)	28.52	0.465	−0.071	0.040	3.116	0.078	1.074	−0.151	0.008
	Group 2 (0)	27.67								
Excessive reaction to evaluation (range 5–25)	Group 1 (1)	15.88	0.134	0.143	0.066	4.764	0.069	1.154	−0.015	0.271
	Group 2 (0)	14.66								
Children's report on Parenting attitude										
Acceptance (range 6–30)	Group 1 (1)	24.15	0.879	−0.026	0.049	0.287	0.592	1.026	−0.123	0.070
	Group 2 (0)	24.28								
Psychological control (range 6–30)	Group 1 (1)	12.74	0.737	−0.021	0.040	0.266	0.606	1.021	−0.098	0.057
	Group 2 (0)	13.04								
Monitoring (range 3–15)	Group 1 (1)	12.37	0.940	0.089	0.112	0.638	0.424	1.093	−0.130	0.309
	Group 2 (0)	12.40								
Variables of mothers										
The parental attitude scale										
Acceptance/child-centered (range 10–50)	Group 1 (1)	40.61	0.429	0.055	0.045	1.512	0.219	1.057	−0.033	0.143
	Group 2 (0)	39.98								
Control (range 8–40)	Group 1 (1)	21.33	0.743	−0.002	0.037	0.002	0.963	1.002	−0.073	0.070
	Group 2 (0)	21.64								
Inconsistent indecisive discipline (range 7–35)	Group 1 (1)	14.17	0.269	0.030	0.053	0.320	0.571	1.030	−0.074	0.135
	Group 2 (0)	13.46								

Generalized Estimating Equations - Logistic Model (GEE-L). Group 1 = SOC increased/maintained group, Group 2 = SOC decreased group. In the dependent variable, Group 2 was set to 0 and Group 1 was set to 1. Student baseline variables were entered as explanatory variables.

while anxiety reduces SOC (9, 36). Face-to-face communication with peers and homeroom teachers in the same class at school gives students a sense of security and allows them to evaluate their future from regular timetables and fixed annual events. This was also reflected by the significantly higher comprehensibility scores in SOC than in the baseline. Even though the virus was previously unknown, it is now gradually becoming a known (comprehensible) phenomenon accompanied by the feeling that students can go back to school.

Antonovsky (11) also states that fostering manageability is a load-balanced experience that is neither overloaded nor underloaded. According to Feldt et al. (37), doing various tasks and homework required at school means gaining proper experience in balancing the load, and that successful experience leads to strengthening SOC. With the reopening of schools,

students may have regained an environment that fosters manageability through daily experiences such as completing daily homework and tasks at school. Alternatively, the fact that only the meaningfulness subscale scores did not increase may indicate that the COVID-19 pandemic has not reached a sense of significance and value in every student's life and daily living yet.

Overall, the frequency of the recognition of interpersonal stress experiences after the onset of the pandemic, especially regarding teachers, club activities, and friends, which are closely related to school, were significantly reduced. This may be because the pandemic has reduced physical and social interaction with people. Thus, for some adolescents that are sensitive to interpersonal relationships or having difficulty being in relationships, the pandemic may have worked in their favor.

TABLE 5 | Generalized estimating equation and logistic model with 2020 summer (after the onset of the pandemic) measurement variables as explanatory variables ($n = 166$).

Valuables in 2020 summer (After the onset of the pandemic)	Bivariate analysis					GEE-L				
	Mean scores for each group		T-test p-value	Coefficient β	Standard error	Hypothesis testing		Odds ratio	95%CI	
	Group	Score				Wald χ^2	p-value			
Variables of students										
School membership scale										
Accepted by students (range 4–20)	Group 1 (1)	16.74	0.098	−0.004	0.110	0.001	0.969	1.004	−0.219	0.211
	Group 2 (0)	15.97								
Accepted by teachers (range 5–25)	Group 1 (1)	19.36	0.306	−0.045	0.078	0.329	0.566	0.956	−0.198	0.108
	Group 2 (0)	18.73								
Sense of belonging (range 4–20)	Group 1 (1)	16.79	0.004	0.172	0.072	5.694	0.017	1.188	0.031	0.314
	Group 2 (0)	15.36								
Stress experience recognition										
Teachers (range 5–20)	Group 1 (1)	5.75	0.041	−0.021	0.123	0.030	0.862	0.979	−0.262	0.219
	Group 2 (0)	6.42								
Club activities (range 5–20)	Group 1 (1)	6.04	0.001	−0.256	0.090	8.174	0.004	0.774	−0.431	−0.080
	Group 2 (0)	7.71								
Academic performance (range 5–20)	Group 1 (1)	8.72	0.008	−0.031	0.059	0.268	0.604	0.969	−0.146	0.085
	Group 2 (0)	10.08								
Friends and opposite gender (range 5–20)	Group 1 (1)	5.34	0.010	−0.098	0.174	0.319	0.572	1.103	−0.438	0.242
	Group 2 (0)	6.11								
Family relationships (range 4–16)	Group 1 (1)	5.57	0.018	−0.041	0.077	0.282	0.595	1.042	−0.191	0.110
	Group 2 (0)	6.52								

Generalized Estimating Equations - Logistic Model (GEE-L). Group 1 = SOC increased/maintained group, Group 2 = SOC decreased group. In the dependent variable, Group 2 was set to 0 and Group 1 was set to 1. Student baseline variables were entered as explanatory variables.

Two-Group Comparison of Students' SOC Scores

The results of this study showed that 40.4% of students had below-baseline SOC scores and that they were unable to recover from their decreased SOC. A comparison between Groups 1 and 2 showed that there was almost no difference in the original family rearing attitude and personality traits of the child, whilst showing a difference in the experience at school after the onset of the pandemic. This indicates the impact of school life on adolescents. Adolescents live most of their days at school and gain much of their adolescent “life experiences” there (38). Therefore, school-related experiences may be a more crucial factor in the formation and development of SOC during adolescence than home or community experiences. Furthermore, the impact of school life may have become relatively large because of the pandemic, limiting social life. Schools and teachers need to assess student's time spent at school carefully, their facial expressions, behavior, and relationships with their peers. Particularly, Group 2 had more physical symptoms such as physical and mental disorders than Group 1. The frequency of going to the infirmary and participation status in physical education classes at school, as well as whether the child is sleeping well at home are considered

checkpoints, and it is possible to detect a reduced will to live in students and reduced vitality from complaints related to poor physical condition.

Characteristically, in Group 2, the sense of belonging remained low and did not improve on the school membership scale, showing that students find it more challenging to feel comfortable and attached to the school than to be recognized by teachers and other students (friends) (39). Although the school closure has been lifted, the shortened lessons continue and with this shortened time of being at school physically, some children may be still be unable to develop “feelings of having one's own place at school.” Even though there are restrictions, it is necessary to devise ways to enhance each student's sense of belonging during school events.

For households, there was no significant difference in baseline subjective economic conditions, but there were more full-time mothers in Group 2 and more mothers started new jobs after the outbreak of the pandemic. This may possibly be because families found themselves in economic situations that prompted mothers to seek full-time employment or new jobs to meet household financial needs and supplement the household budget. The pandemic has had a major impact on the global economic situation (40) and the aftermath extended to families

TABLE 6 | Comparison between two groups regarding the mean score of stress experience recognition.

Details of stress experience (question items)	Group 1 <i>n</i> = 99		Group 2 <i>n</i> = 67		Significant difference in two groups <i>p</i> -value
	Mean score	(SD)	Mean score	(SD)	
Club activities					
<i>I couldn't keep up with the practice of club activities:</i> <i>t</i> _(104.0) = 2.264	1.0	(0.33)	1.2	(0.49)	0.026
<i>The practice of club activities was tough:</i> <i>t</i> _(96.2) = 2.630	1.2	(0.50)	1.5	(0.83)	0.010
<i>It was difficult to balance club activities and study:</i> <i>t</i> _(97.3) = 3.622	1.4	(0.72)	2.0	(1.18)	<0.001
<i>I made a mistake in club activities and was scolded:</i> <i>t</i> _(86.2) = 2.454	1.1	(0.40)	1.4	(0.82)	0.016
<i>No matter how much I practice in club activities, I'm not good at it:</i> <i>t</i> _(112.2) = 3.017	1.2	(0.57)	1.6	(0.77)	0.003
Academic performance					
<i>I couldn't understand the content of the lesson or the teacher's explanation:</i> <i>t</i> _(102.1) = 3.039	1.4	(0.72)	1.9	(1.01)	0.020
<i>I couldn't answer the teacher's question during class:</i> <i>t</i> ₍₁₆₃₎ = 2.353	1.4	(0.76)	1.7	(0.86)	0.020
Relationship with friends and the different gender					
<i>I was made fun of regarding my face and body style:</i> <i>t</i> _(81.7) = 2.377	1.1	(0.37)	1.4	(0.82)	0.020
<i>I am disliked by the opposite gender:</i> <i>t</i> _(79.5) = 2.089	1.0	(0.26)	1.2	(0.63)	0.040
Family relationships					
<i>My parents told me to study more:</i> <i>t</i> _(112.0) = 2.575	1.5	(0.81)	1.9	(1.09)	0.011

Only the question items with significant differences are shown. Group 1 = SOC increased/maintained group, Group 2 = SOC decreased group. Mean score for each group was calculated with never experienced = 1, occasionally experienced = 2, experienced = 3 points, and frequently experienced 4 points.

with junior high school students, seemingly affecting their mental health.

When the two groups were compared on the items of stressful events, the results showed that Group 2 experienced more stress than Group 1, and the stress experience in club activities was the highest among the five items. Club activities in Japanese junior high schools are extracurricular programs that students spend a lot of time on after school and on weekends, and they vary from physical activities, such as baseball, soccer, and volleyball, to cultural activities, such as chemistry and theater. It is often obligatory for everyone to participate in one of the club activities according to their interests (41). Additionally, club activities are outside the curriculum and are composed of students who wish to actively participate in them beyond their grades and classes (42).

According to Finnish public health scholars, Konu and Rimpelä (43), psychosocial well-being in adolescents includes not only physical health but also successful coping with developmental tasks. They reported that it can be classified into four categories: school conditions (having), social relationships (loving), means for self-fulfillment (being), and health status. Club activities have been shown to contribute greatly to self-fulfillment (being). Self-fulfillment is a successful response to problems related to self-esteem, competence, and self-determination. Improving abilities through steady efforts in cultural and sports activities and achieving good results means increasing self-esteem and achieving self-fulfillment.

Sumiya and Muto (42) demonstrated that club activities increase satisfaction with school life for students with low-class satisfaction. Due to the influence of the pandemic, many

major events such as cultural festivals, athletic meets, and choral festivals were canceled in Japanese junior high schools. For students, self-fulfillment in school life other than school grades may have been the last bastion of club activities. Small setbacks, annoyances, and difficult experiences in club activities can impede school adaptation, sense of belonging, and SOC recovery. Schoolteachers need to understand that the reduction in school events during a pandemic means that each of the few barely viable school events, club activities, and classroom activities will have relatively greater significance to students. Teachers should pay close attention to the activities and reactions of students. It is important to talk to students to enhance their sense of belonging and devise a mechanism to obtain a small sense of accomplishment.

Limitations of This Study

First, the results of the study are limited to two junior high schools. Both were public schools; one was an integrated school (including both junior high and high school) with an entrance examination, and the other was a junior high school without an entrance examination. We chose different types of junior high schools to consider diversity as much as possible, but we analyzed only 166 students and mothers. It is possible that the number of Covid-19 PCR-positive patients in the region was different, or that the results differed between local cities and rural areas.

Care must be taken when generalizing the unexpected increase in SOC scores after the onset of the pandemic. According to Antonovsky (11), SOC in adulthood is said to increase slowly with age, but very few studies have investigated within-year or

multi-year variations in adolescents. In Japan, a longitudinal study of high school students (38) reported that SOC decreased in both males and females from the first to the second year and that it may be maintained or decreased from winter to spring and from spring to summer. Therefore, it may be difficult to believe that the rise in this report is age- or season-related. Diverse longitudinal studies in early adolescents are needed in the future to pursue the relationship between this rise and the pandemic. In addition, this study only reports data for 166 students and mothers from two schools. More diverse and more junior high school verifications are required.

Additionally, the situation may be more serious in households who did not agree to participate in the survey from the beginning. It is necessary to carefully observe and care for complaints of physical and mental disorders not only in the decreased SOC group but also in families and their children (students) who did not consent to the survey.

CONCLUSIONS

We analyzed 166 parent-child pairs for changes in the SOC of junior high school students and their mothers before and after the onset of the pandemic. Overall, the SOC scores of junior high school students after the onset of the pandemic were higher than those before the outbreak, but about 40% of the student's scores did not recover. When comparing the increased/maintained SOC group with the decreased SOC group, there was no significant difference in baseline data between the two groups. The decreased SOC group may have not recovered their sense of belonging to school after the onset of the pandemic and there may be a combination of troubles in friendships at school and negative experiences in club activities. Since the decreased SOC group often complained of physical difficulties, it is important for teachers and families to listen carefully to the complaints of students, clarify the cause of the upset, and take care of it. Additionally, even with the restrictions imposed by COVID-19, it is necessary to take measures such as holding school events to the extent possible and calling out to each student to create a place for students and expand their playing field. The COVID-19 pandemic is ongoing worldwide. As long-term effects of the pandemic are expected, attention and care for vulnerable adolescents are crucial. In the future, it will be necessary to verify the effects of the pandemic over the long term. Even if it does not seem to have any effect now, a prolonged pandemic may have a different effect. Moreover, there is a

possibility that the consequences of the effects will be completely different after 1 or 2 years; therefore, continued research is required. Additionally, students and mothers who declined to participate in the survey may be facing more serious problems, so it may be important to make provisions for support and care for these individuals.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because the data in this survey is a parent-child survey of adolescent junior high school students and is highly confidential, including information on personality trends and financial conditions associated with legal minors. Schools surveyed do not allow disclosure of raw data, even anonymously. Requests to access the datasets should be directed to Tomoko Omiya, toomiya-ky@umin.ac.jp.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the medical ethics review board of the University of Tsukuba. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

TO presented the structure, ideas of the research, and wrote the entire paper. YS provided advice on the composition and writing of the treatise. ND and YT coordinated the field and advised as an adolescent expert. YY supported the whole concept of SOC, solidified the theory, and advised the discussion. All authors contributed to the article and approved the submitted version.

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Depressive Symptoms Among Children and Adolescents in China During the Coronavirus Disease-19 Epidemic: A Systematic Review and Meta-Analysis

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Background: The Coronavirus Disease-19 (COVID-19) pandemic negatively impacts mental health. Some published studies have investigated the prevalence of depression among children and adolescents in China during the pandemic. However, the results vary widely. We aimed to systematically analyze and estimate the prevalence of depressive symptoms and attempted to reveal the reasons for prevalence variety in previous studies.

Methods: Published studies were searched in PubMed, Embase, Cochrane Central, the Chinese Scientific Journal Database (VIP Database), China National Knowledge database (CNKI), and the WanFang database from December 2019 to May 2021. The quality of all included studies was assessed by the Joanna Briggs Institute (JBI) checklist and the American Agency for Health Care Quality and Research's (AHRQ) cross-sectional study quality evaluation items. Meta-analysis was performed using random-effects modeling.

Results: Of the 1,708 references screened, 13 related reports that involve 41,729 participants were included. The results suggested that the pooled prevalence of depressive symptoms among Chinese children and adolescents during the COVID-19 epidemic was 28.6%. Subgroup analyses showed that the pooled prevalence was highest among the studies using the Patient Health Questionnaire (PHQ)-9 (46.8%) and lowest among these using Depression Self-Rating Scale for Children (DSRSC) (11.4%). All studies using PHQ-9 set the cutoff at 5 points instead of 10. The pooled prevalence of studies that include primary school students was lower (16.5%) than that of studies excluding primary school students (39.1%).

Conclusion: The meta-analysis suggests that depressive symptoms were relatively prevalent among Chinese children and adolescents during COVID-19, especially among the secondary school students. The suitable screening tools and cutoff should be carefully chosen in the survey.

Keywords: COVID-19, children and adolescent, China, depression, meta-analysis

INTRODUCTION

Depression severely impacts the mental health of children and adolescents. According to previous studies, depression in children and adolescents may have devastating consequences (1–3).

Early evidence highlighted that depression symptoms are very common among children and adolescents in China, the prevalence was estimated to be 22.2% (4), before the outbreak of Coronavirus Disease-2019 (COVID-19). Since the first case of COVID-19 was reported in Wuhan, Hubei, China (5), it had spread rapidly among provinces in China in a short time. At the same time, the COVID-19 was also reported around the world (6). The Chinese government implemented social distancing, home confinement, and school closure measures to control the spread of the infection. All Chinese children and adolescents were separated from society and schools from January to April 2020 (7). The prolonged home confinement is associated with a range of negative outcomes for children and adolescents, such as decreased social interactions with peers, reduced physical activity, increased conflicts with parents, and academic pressures due to sudden changes in traditional learning methods (8, 9). These might lead to a persistent impact on the mental health of children and adolescents and eventually contribute to the occurrence of depressive symptoms (10).

There have been some cross-sectional studies on the prevalence of depression among children and adolescents in China during the COVID-19 epidemic. However, the results vary widely, some studies found that it was as high as 52.4% (11), while others found that it was as low as 10.4% (12). Given the large disparity in previous cross-sectional studies since the beginning of the pandemic, the purpose of this review was to provide an estimate of the prevalence of depressive symptoms and to explore the reasons for prevalence variety in previous studies (e.g., differences in the application of screening scales). This is of great significance for further intervention and may also play a certain role in the design of the future studies on depression in children and adolescents who experience major public events.

METHODS

This study was conducted in accordance with the requirements and standards set forth in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (13). All data analyses were based on the original study, so no additional ethical approvals and consent forms of the participants were required.

Search Strategies

A systematic search was performed to identify published studies on the prevalence of depressive symptoms in Chinese children and adolescents during the COVID-19 outbreak. We searched 6 major digital databases. The English databases were PubMed, Embase, and Cochrane, and the Chinese databases were China National Knowledge Infrastructure (CNKI) database, WanFang database, and VIP database to find all of the articles that met the criteria. In the search strategy, medical keywords (Medical Subject Headings; MeSH) were used to find relevant research published at all times: “Depression*,” “Depressive Symptoms*,” “Depressive Disorder*,” “Mental Health*,” “COVID-19*,” “Adolescent*,” “Child*,” “Youth*,” “Teenager*,” “Student*,” “China*,” “Prevalence*,” “Ratio*.” Some entry terms with similar expressions are omitted here. Bibliographies and citations of the related articles and review studies were also screened for other potential articles.

Inclusion and Exclusion Criteria

All of the original studies were included if they met the inclusion criteria listed below: (1) cross-sectional study of depression symptoms among children and adolescents under the age of 20 and over the age of 6 in mainland China; (2) the prevalence statistics of depression were calculated based on related articles; (3) using standardized self-assessment scales; (4) the study subjects were limited to children and adolescent; and (5) cross-sectional study was conducted during the COVID-19 pandemic.

The following publications were excluded: (1) published reviews, meta-analysis, case reports, comments, protocols, letters, and editorials; (2) the subjects were patients with different medical conditions or comorbidities, such as schizophrenia, circulatory disorder, or bipolar disorder; and (3) the participants of the study included people infected with the new coronary virus. Any disagreement at each stage was resolved through consensus.

Data Extraction

Two reviewers (JC and YC) independently screened titles and/or abstracts, then searched the full text of studies and independently assessed them according to inclusion and exclusion criteria. Two reviewers independently collected critical data information using a standardized data extraction form. After one independent reviewer completed the review results, the other reviewer would conduct a thorough and rigorous review of the review results. If the two reviewers could not reach a consensus on the review results, then the third reviewer (YD) would conduct the final review and a consensus would be reached.

Quality Assessment

Each of the original studies was assessed by the JBI checklist (14) and American Agency for Health Care Quality and Research's (AHRQ) cross-sectional study quality evaluation items (15). JBI's quality evaluation tool for prevalence research includes 9 items, which evaluate the overall quality of prevalence research in terms of sampling methods, research objects, data collection, and analysis methods. The item is scored 1 point if the answer "yes," and scored 0 point if answer "no," "not clear," or "not applicable."

The AHRQ's cross-sectional study quality evaluation items were compiled by the AHRQ to assess the quality of cross-sectional research. It contains 11 items, the answer "yes" is scored 1 point, and "no" or "not clear" is scored 0 points. All included

studies were classified as having "low" (0–3 points), "medium" (4–7 points), or "high" (8–11 points) methodological quality. Discrepancies in the scores of included studies were resolved through discussion to reach a consensus.

Statistical Analyses

Stata version 16.0 (Stata Corp., College Station, TX, United States) was used for all statistical analyses. Prevalence estimates of depression were calculated by pooling the study-specific estimates using random-effects. The model could figure out an overall estimate weighted by sample size under the assumption of statistical heterogeneity between studies, which greatly reduced the impact of statistical heterogeneity (16). We

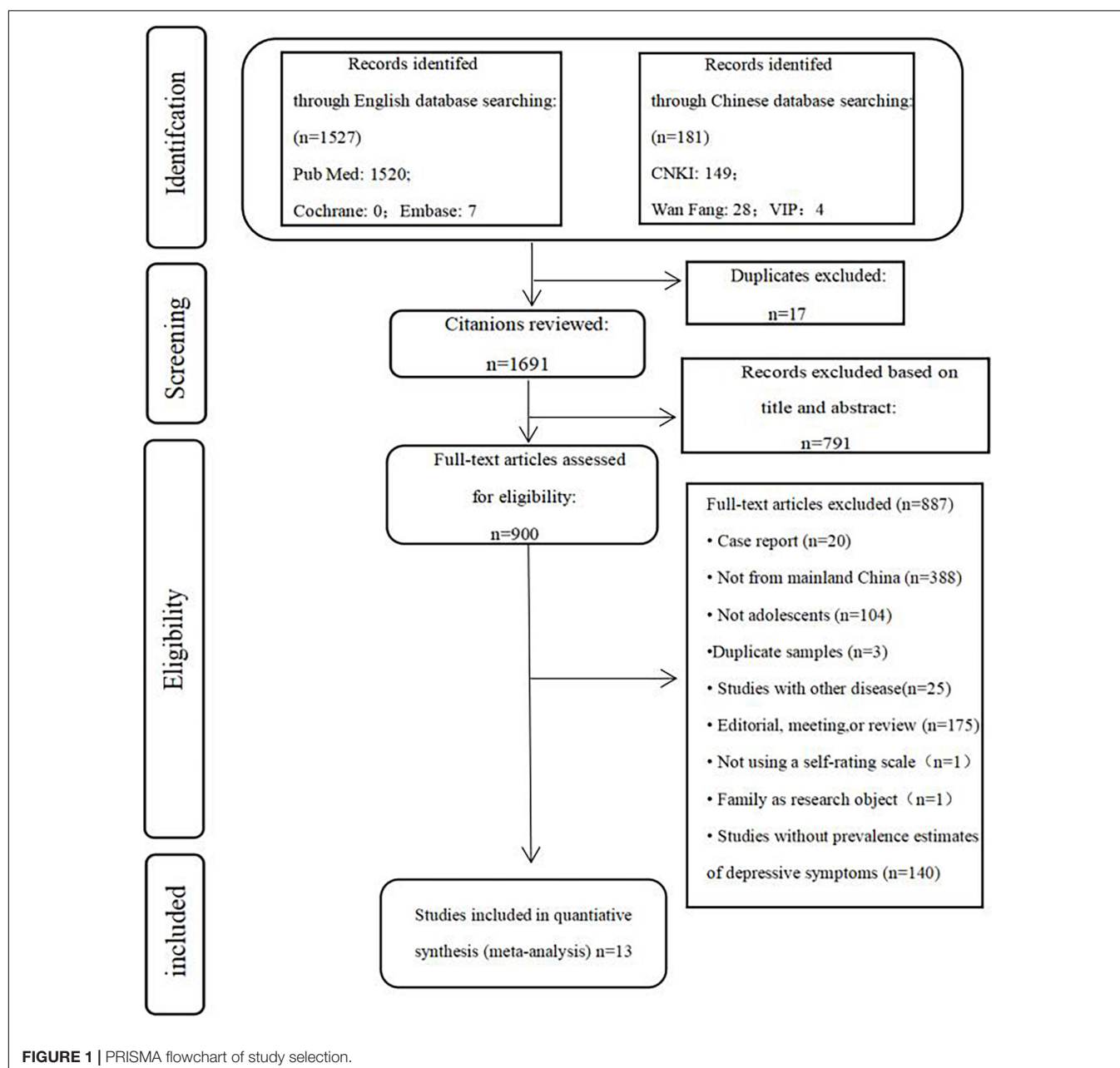


FIGURE 1 | PRISMA flowchart of study selection.

chose random-effects because the expectations of the study effects were unlikely to be identical and the variability across the studies was expected.

Assessment of Heterogeneity

The heterogeneity across the studies was assessed by determining the I^2 statistic to quantitatively measure the inconsistency across studies (17). Exploratory subgroup and meta-regression analyses were conducted to examine the possible sources of heterogeneity, and sensitivity analyses were performed to assess the robustness and stability of the results.

Assessment of Reporting Biases

Reporting biases were assessed by scrutinizing the protocols of the included studies (18). Potential publication bias was assessed by visually inspecting the funnel plots and quantified by Egger's and Begg's tests (19).

RESULTS

Study Characteristics

We initially identified 1,708 articles by searching 6 academic databases, of which 1,691 were evaluated after removing

duplicates. Of these, 900 articles were retained after the title and abstracts were screened. After reviewing the full text, 13 papers meeting the inclusion criteria were included in the analysis. Of the 887 articles excluded, 20 were case reports, 388 samples were not from China, 104 were not children and adolescents, 3 studies reported the same samples, 25 studies focused on other specific diseases, 175 were editorials or reviews, 1 did not use self-rating scale, 1 took the family as the research object, and 140 did not provide an assessment of the prevalence of depression. The flowchart of the selection process is shown in **Figure 1**. The characteristics of all included studies are summarized in **Table 1**. In these 13 studies (8, 11, 12, 20–29), a total of 41,729 children and adolescents had participated, with sample sizes ranging from 396 to 9,554. The publication year was between 2020 and 2021. The quality assessment shows that 6 articles were of high quality and 7 articles were of medium quality.

Prevalence of Depressive Symptoms Among Children and Adolescents in Mainland China During the Coronavirus Disease-19 Epidemic

The prevalence of depressive symptoms of all included studies was described, it ranged from 10.4 to 52.4% (**Table 1**).

TABLE 1 | Characteristics of the 13 studies of depressive symptoms in the meta-analysis.

References	The time of the investigation	Scale	Grades	Sample size	Case	Prevalence	AHRQ score	JB1 score
Zhou et al. (20) and Chan et al. (52)	From March 8th, 2020 to March 15th, 2020	PHQ-9	J,S	8,079	3,533	43.7%	9	8
Zhang et al. (11) and Duan et al. (25)	From May 1st, 2020 to May 7th, 2020	PHQ-9	S	1,018	533	52.4%	7	7
Chen et al. (21) and Deeks et al. (56)	From February 22th, 2020 to March 8th, 2020	PHQ-9	J,S	7,772	3,334	42.9%	9	8
Yang et al. (22) and Duan et al. (25)	From May 1st, 2020 to May 5th, 2020	PHQ-9	S	838	418	49.9%	8	7
Cui (7) and Xie et al. (23)	From February 28th, 2020 to March 5th, 2020	CDI	P	1,784	403	22.6%	7	8
Tang and Hongwei (24) and Clayborne et al. (37)	About 2 months after the outbreak of COVID-19	CDI	P,J	873	102	11.7%	6	6
Duan et al. (25) and Clayborne et al. (37)	N.A.	CDI	P,J,S	3,613	805	22.3%	6	8
Chen et al. (26) and Chan et al. (52)	From February 20th, 2020 to February 27th, 2020	CESD	J,S	9,554	3,498	36.6%	10	9
Tang and Hongwei (24) and Deeks et al. (56)	From March 13th, 2020 to March 23th, 2020	DASS-21	P,J,S	4,342	857	19.7%	10	7
Zhang et al. (27) and Deeks et al. (56)	From April 7th, 2020 to April 24th, 2020	DASS-21	J,S	1,025	226	22.0%	7	6
Xiao-rong et al. (28) and Deng et al. (42)	From January 26th, 2020 to January 28th, 2020	DASS-21	S	1,399	366	26.2%	6	7
Chen et al. (21, 29)	From April 16th, 2020 to April 23th, 2020	DSRSC	P,J	1,036	122	11.8%	6	7
Yue et al. (12) and Chan et al. (52)	From February 6th, 2020 to February 8th, 2020	DSRSC	P,J,S	396	41	10.4%	8	6

P, primary school; J, junior high school; S, senior high school; PHQ-9, the Patient Health Questionnaire; CDI, Children's Depression Inventory; CES-D, Center for Epidemiological Studies Depression; DASS-21, Twenty-one-item Depression Anxiety Stress Scale; DSRSC, Depression Self-Rating Scale for Children; JBI, Joanna Briggs Institute's critical appraisal checklist for studies reporting prevalence data.

The overall pooled prevalence of depressive symptoms in children and adolescents was 28.6% (95% CI: 21.7–35.5%, $I^2 = 99.6\%$, $p < 0.001$), showing significant heterogeneity among studies (Figure 2).

Heterogeneity Assessment and Subgroup Analysis

The heterogeneity across the studies was assessed by determining the I^2 statistic to quantitatively measure the inconsistency. We stratified the results by screening tool, and grades are summarized in Table 2. Significant differences were found in the prevalence of depressive symptoms based on different scales. Four studies used the Patient Health Questionnaire (PHQ-9) scale, the pooled prevalence was estimated as 46.8% (95% CI, 43.6–50.1%; $I^2 = 93.3\%$). Three studies used the Children's Depression Inventory (CDI) scale, it was estimated as 18.9% (95% CI, 12.5–25.3%; $I^2 = 97.4\%$). One study used the Center for Epidemiological Studies Depression (CESD) scale, which was estimated as 36.6% (95% CI, – 35.6 to 37.6%; $I^2 = 100\%$). Three studies used the Twenty-One-Item Depression Anxiety Stress Scale (DASS-21) scale, which was estimated as 22.6% (95% CI, 18.6–26.5%; $I^2 = 91.9\%$). Two studies used the Depression Self-Rating Scale for Children (DSRSC) scale, which was estimated as 11.4% (95% CI, 9.7–13.0%; $I^2 = 0.0\%$). The pooled prevalence of depressive symptoms was highest with the PHQ-9 (46.8%; $p < 0.001$) and lowest with the DSRSC (11.4%; $p > 0.05$).

Six studies included primary school students in the sample group, the pooled prevalence was estimated as 16.5% (95% CI, 12.4–20.6%; $I^2 = 96.9\%$). Seven studies did not include primary school students in the sample group, the pooled prevalence was estimated as 39.1% (95% CI, 33.4–44.7%; $I^2 = 98.9\%$).

Reporting Biases

No obvious bias was found on visual inspection of the funnel plot (Figure 3). Egger's and Begg's quantitative analyses showed that there was no publication bias in the data set ($p = 0.704 > 0.05$).

Sensitivity Analysis

Sensitivity analyses performed by consecutively omitting each study in each group showed that no single study significantly affected the initial results (Figure 4).

DISCUSSION

Prevalence of Depressive Symptoms Among Children and Adolescents

This systematic review and meta-analysis of 13 original studies involving 41,729 participants showed that 10.4–52.4% of children and adolescents were screened positive for depression during the COVID-19 epidemic, and the pooled prevalence was 28.6%. This prevalence was almost the same as that of the general Chinese population during the COVID-19 outbreak, which was 28% (30) (12 original studies involving 27,475 individuals were included). In a meta-analysis of 29 studies that include 80,879 children and adolescents worldwide, the pooled prevalence of

clinical depression was estimated as 25.2% (31). This result is similar to our study.

There are two possible reasons for the relative high prevalence of depressive symptoms among children and adolescents during the pandemic: First, the COVID-19 spreads *via* human-to-human transmission, children, and adolescents might worry about infections for themselves and their family members, especially when they had some common symptoms (such as a cough, runny nose, and headache) (32). Second, during the pandemic, home confinement also caused many adversely psychological impacts on children and adolescents, such as depression, anxiety and stress-related disorders (33). The online classes and e-learning could not provide the same environment as the live school (34) and social contact, security, and self-efficacy of students (35, 36). These might all contribute to the occurrence of depression in children and adolescents. While the experience of depression in adolescence is associated with a myriad of adult psychosocial outcomes, it may lead to the propagation of difficulties across the lifespan (37). We need to pay more attention to the mental health of children and adolescents during the pandemic.

In addition, before COVID-19, the prevalence of depression in children and adolescents worldwide was 12.9% (38), while in mainland China it was 22.2% (4) (62 original studies involving 232,586 children and adolescents). This suggests that the global prevalence of depression among children and adolescents during the COVID-19 pandemic has doubled when compared to pre-pandemic data (31), with only a slight increase in mainland China. The possible reasons for the slight increase in China are as follows: first, the pre-pandemic situation may contribute to this result. There was a high prevalence of depression in Chinese children and adolescents before COVID-19. As is known to all, the main purposes of education in Chinese schools are to obtain higher scores in the National College Entrance Examination with repeated exercises and examinations. School education stress is a serious social problem in China, many tests, exams, strict rules, and regulations in school, all could be stressors of depression (39–41). Second, the post-pandemic situation may deteriorate continually. A meta-analysis showed that the prevalence of depression symptoms among the general population was still increasing after the peak of COVID-19 in China (42). The possible reason is that the occurrence of depression requires a certain period of emotional accumulation and the occurrence of post-disaster depression has a certain delayed effect (43). While most studies included in this review were conducted in 2–3 months after COVID-19, the investigation time range was relatively narrow. The prevalence of depression may continue to increase during the continuing pandemic. As COVID-19 has continued for more than 2 years, the actual prevalence may be much higher than our result.

Prevalence of Depressive Symptoms in Different Grade Groups

In subgroup analysis, we found that the pooled prevalence of depression in the 6 studies that include primary school students was 16.5%, and the pooled prevalence of depression in 7 studies

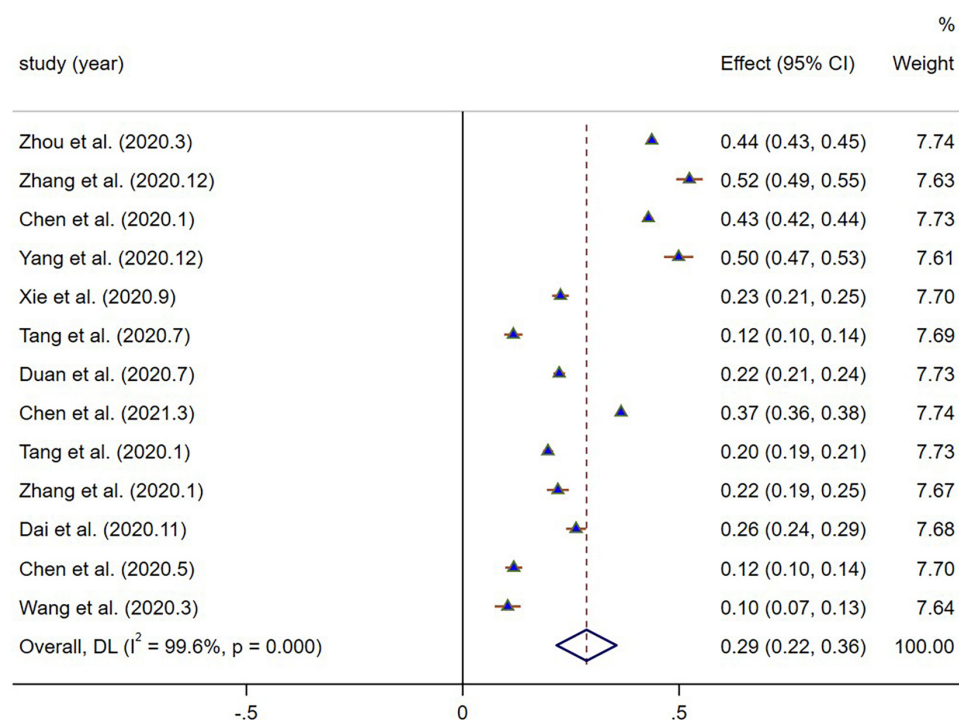


FIGURE 2 | The forest plot of the prevalence of depressive symptoms.

TABLE 2 | Subgroup analysis of the prevalence of depressive symptoms.

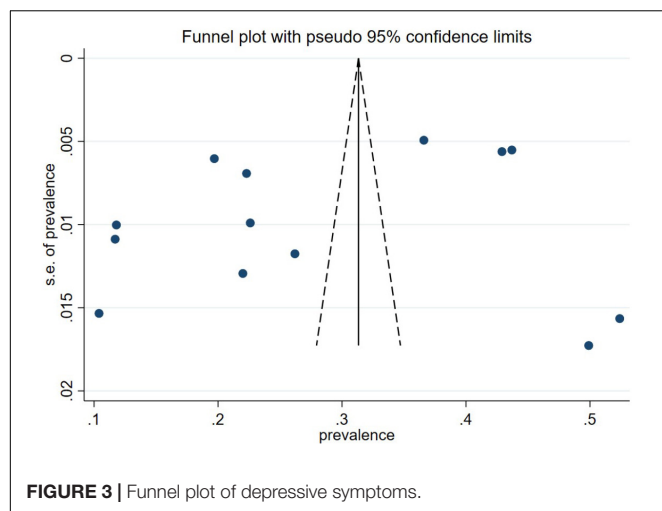
Subgroup	No. of Studies	No. of Participants	No. of Cases	Pooled prevalence of Depressive (95% CI)	(I^2)
Overall	13	41,729	14,238	0.286(0.217~0.355)	99.6%
Scale					
PHQ-9	4	17,707	7,818	0.468(0.436~0.501)	93.3%
CDI	3	6,270	1,310	0.189(0.125~0.253)	97.4%
CESD	1	9,554	3,498	0.366(0.356~0.376)	0.0%
DASS-21	3	6,766	1,449	0.226(0.186~0.265)	91.9%
DSRSC	2	1,432	163	0.114(0.097~0.130)	0.0%
Grade					
Included P	6	12,044	2,330	0.165(0.124~0.206)	96.9%
Not included P	7	29,685	11,908	0.391(0.334~0.447)	98.9%

P, primary school students.

that exclude primary school students was 39.1%. The result is consistent with previous studies. For instance, a previous meta-analysis demonstrated that the prevalence of depression among primary school students in China was 17.2% (27 studies that involve 42,374 subjects were included) (44), and the prevalence of depression among secondary school students was 24.3% (45) (51 original studies that involve 144,060 adolescents were included). We also found that in grade7 of secondary school, the prevalence was 24.5%, while in grade 10, the prevalence was increased to 40.1%.

The difference in the prevalence of depression between different grade groups may be related to biological changes, such as hormone changes during puberty (46). A meta-analysis

indicated that depressive symptoms are dynamic during puberty. Depressive symptoms tend to increase in early adolescence, reach their peak during mid-adolescence, and then begin to decrease in the late adolescence (during the transition to adulthood) (47). Additionally, in primary and secondary schools, the academic difficulty is different. Adolescents in higher grades may experience more adjustment difficulties, such as academic problems and social deficits, and are therefore more likely to have depressive symptoms. Senior students (especially these facing university entrance exams) suffered more from abruptly coronavirus-related new challenges, i.e., uncertainty of the exam time and the date of returning school.



Screening Scales for Evaluating Depression

In this study, we also found that a total of five different screening self-rating scales were used in cross-sectional studies that investigate the prevalence of depression among children and adolescents in China during the COVID-19 pandemic. Different depression screening scales have different clinical validity on the prevalence of depression (48).

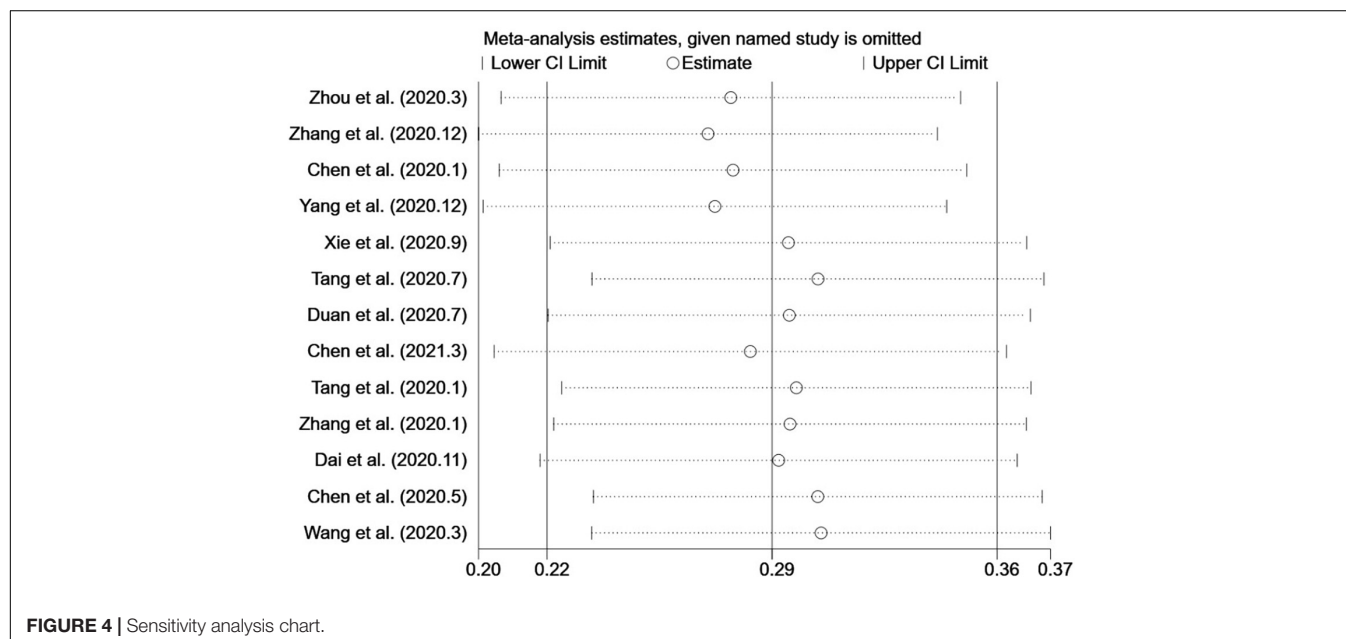
Some previous studies have explored the application of CDI in children and adolescents in mainland China, showing that the internal consistency coefficient of CDI was between 0.82 and 0.88, and the test-retest reliability was between 0.75 and 0.89, which means it has acceptable reliability and validity (49). The sensitivity of the DSRSC for diagnosing depression among children and adolescents in China was 86%, and the

specificity was 82% for the assessment (50). The DASS-21 has previously been used to assess children and adolescents who were aged 11–19 in China (51) and among these populations after the Sichuan earthquake (52). Previous studies also found that the CESD showed high reliability and stability in screening adolescents with depression (53). A large sample of Chinese children and adolescents completed the PHQ-9 in a cross-sectional survey ($N = 10,933$), the results indicated that the PHQ-9 is a reliable and valid scale and can be used in Chinese children and adolescents (54). The reliability and validity of the PHQ-9 scale in Chinese children and adolescents also have been tested, and it was found that the optimal cutoff of the PHQ-9 scale was 10 points, with a sensitivity of 93.33% and a specificity of 96.83% based on a receiver operator characteristic (ROC) curves (55).

In our analysis, the PHQ-9 was applied the most (4 studies that involved 17,707 participants), the pooled prevalence of depression assessed by the PHQ-9 scale was 46.8%, significantly higher than other scales (11.4% with DSRSC, 18.9% with CDI, 22.6% with DASS-21, and 36.6% with CESD). The PHQ-9 was applied by Zhou et al. (20), Zhang et al. (27), Chen et al. (29), and Yang et al. (22) in our study. They all adopted 5 points as the cutoff point for depression. This may be the reason for its higher detection rate of depression in the assessment of Chinese children and adolescents. To sum up, our results suggest that PHQ-9 may be a widely used self-assessing depression scale for children and adolescents in China, and 10 points may be an appropriate cutoff.

LIMITATIONS

First, this study is considered to have heterogeneity. Since clinical and methodological diversities always occur in a meta-analysis, statistical heterogeneity is relatively inevitable (17). We have



conducted subgroup analyses and performed a random-effects meta-analysis to avoid the effect of heterogeneity, as Cochrane recommends (56). During the COVID-19 pandemic, the severity of the epidemic and control measures varied among provinces in China, thus the prevalence of depression might vary in different provinces (57). Unfortunately, however, in our analysis, most of the studies did not provide accurate information about provinces, so we could not perform the analysis by province. We will continue to pay attention to this topic, there may be enough information to conduct the analysis by the province in the future. Second, due to the heterogeneity of screening scales, the evidence to support this estimated value of the depression prevalence is not strong enough. We will continue to update the data. If the data are sufficient, we will carry out a meta-analysis based on one scale, such as PHQ-9. The pooled prevalence rate will more truly reflect the situation.

CONCLUSION AND FUTURE DIRECTIONS

In summary, our findings show that depressive symptoms were frequently experienced by Chinese children and adolescents during the COVID-19 epidemic. Close attention should be paid to the mental status of children and adolescents, especially to the secondary school students. The strengthened psychoeducation, enhanced policy efforts, and effective medical services are needed. In the future, epidemiological studies on Chinese children and adolescents should focus on selecting scales that have good

reliability and validity in this population and adapt appropriate cutoff points. In addition, it is worth to consider that performing a two-stage prevalence estimation (58) after the COVID-19 epidemic is fully controlled and ends.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

JC and KY designed the study, conducted the statistical analysis, and wrote the manuscript. YC and JC conducted the double screening, coding, and assessed the quality of the reviewed studies. KY provided consultations for data analysis. MQ and NW critically reviewed and revised the manuscript. All authors provided critiques and approved the final manuscript.

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Maternal Anxiety Symptoms and Chinese Adolescents' Mental Health During the COVID-19 Pandemic: The Protective Role of Adolescents' Self-Compassion

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The COVID-19 outbreak triggered dramatic changes to family life. Parents, especially mothers, were found to experience more psychological distress during the pandemic, which may have had an impact on their children's mental health. The primary goal of this study was to examine the potential protective role of adolescents' self-compassion in the relationship between maternal anxiety and adolescents' mental health during the COVID-19 pandemic. Participants included 5,720 adolescents (48.9% girls; $M_{\text{age}} = 11.60$, $SD_{\text{age}} = 1.36$) and their mothers from Zhengzhou city, Henan province, in Mainland China. Adolescents reported their level of self-compassion, PTSD symptoms, and negative affect during the COVID-19 pandemic. Mothers reported their own anxiety symptoms and their children's depression and anxiety symptoms. Results indicated that older female adolescents reported higher levels of PTSD symptoms and negative affect and lower levels of self-compassion than their counterparts. Maternal anxiety during the COVID-19 pandemic was consistently positively associated with adolescents' psychological maladjustment. These associations were buffered by adolescents' self-compassion. Specifically, adolescents with higher levels of self-compassion were found to be less psychologically affected by their mothers' anxiety during the COVID-19 pandemic. Findings highlighted the possibility of improving adolescents' mental health through fostering their self-compassion during the COVID-19 pandemic.

Keywords: maternal anxiety, psychological maladjustment, self-compassion, COVID-19, Chinese adolescents

INTRODUCTION

The outbreak of the 2019 coronavirus disease (COVID-19) and its public health responses, such as stay-at-home policies and school closures, triggered "a complex worldwide stressor" (1). In China, empirical studies found that around 30–40% of adolescents were prone to depressive and anxiety symptoms (2), and around 15% of adolescents showed post-traumatic stress

disorder (PTSD) symptoms (3) after the COVID-19 outbreak. In the family environment, the pandemic outbreak brought more substantial changes in family routines, which would undoubtedly affect many aspects of family members' lives and may further exacerbate their mental health condition. As such, researchers have made urgent calls for paying more attention to mental health problems in both parents and children (4, 5). Studies found that mothers were likely to perceive more health risk (6) and experience more psychological distress, such as anxiety symptoms, due to the COVID-19 outbreak (7). The transactional process of psychological distress (i.e., anxiety) from parent to child has also been widely documented in previous studies (8–10). However, few empirical studies have explored such issues in the context of COVID-19 with limited research probing the possible protective factors that may buffer the effects of maternal anxiety on children's mental health. Thus, this study aimed to examine the link between maternal anxiety and adolescents' psychological maladjustment (i.e., PTSD symptoms, negative affect, depression, and anxiety) in the family environment as well as the potential protective role of adolescents' self-compassion that may buffer the impact of maternal anxiety during the COVID-19 pandemic.

Anxiety refers to an emotional response to an assessment of uncertainty and potential threat (11). The outbreak of the COVID-19 pandemic imposed a great deal of uncertainty and threat in the family environment, including fear of infection, challenges of homeschooling, disrupted family routines, and lack of social interaction with others (12). As adolescents naturally have an underdeveloped self-regulatory system (13) and as peer interactions are their primary source of social activity (14), it is possible that COVID-19-related stress would exacerbate the emotional challenges adolescents typically face, increasing the risk for poor mental health (15–17). Parents also experienced challenges during the COVID-19 pandemic, including financial stress, which may result in anxiety symptoms. For example, research in Canada found that 35.7% of parents reported being extremely or very anxious about COVID-19 (18). Another study in the United States found that the challenges of caregiving during the COVID-19 pandemic could lead parents to experience anxiety and depressive symptoms (19). In China, during the COVID-19 pandemic, the detection rate of mild anxiety symptoms in parents was 20.7% while that of moderate-to-severe anxiety symptoms was 4% in parents, where parents with school-aged children (ages 5–17) reported more anxiety symptoms (20).

According to the spillover hypothesis (21), affect and behavior from one environment or connection can transfer to another within the family system. Parental negative affect during the COVID-19 pandemic, such as anxiety symptoms, can be directly linked to children's negative emotional outcomes in the home. The literature on COVID-19 supports the spillover hypothesis. A longitudinal study conducted by Liang et al. (22) recently reported that, in Italy, higher levels of parental stress due to the COVID-19 pandemic predicted more severe anxiety and depression in their adolescent children. After the stay-at-home orders were implemented in the United States, a transactional association between parent and child took place,

where parents' reported anxiety and depressive symptoms predicted adolescents' reports of the same symptoms 1 month later (23). Moreover, previous studies demonstrate that the COVID-19 pandemic increased mothers' perceived vulnerability to the virus (6) and led to an increase in maternal anxiety and depression (24, 25), suggesting the need to pay more attention to the potential impact of maternal mental health problems on adolescents. According to previous epidemiological studies, PTSD symptoms, negative affect, anxiety, and depression are considered important indicators of youth mental health during the COVID-19 pandemic (2, 3). In the present study, we focused on the relationship between maternal anxiety during the COVID-19 pandemic and adolescents' psychological maladjustment (i.e., PTSD symptoms, negative affect, anxiety, and depressive symptoms) and anticipated spillover effects such that maternal anxiety would be associated with adolescents' mental health.

Self-compassion in adolescents may buffer the impact of maternal anxiety on adolescents' mental health during the COVID-19 pandemic. Self-compassion, as defined by Neff (26), entails three basic components: (1) self-kindness, an attitude for extending kindness and understanding to oneself rather than harsh judgment and self-criticism; (2) common humanity, seeing one's experiences as part of the larger human experience rather than separated and isolated; and (3) mindfulness, a capacity for holding one's painful thoughts and feelings in balanced awareness rather than over-identifying with them. A meta-analysis of 19 studies conducted with adolescents found a large effect size for a negative relationship between self-compassion and psychological distress (indexed by anxiety, depression, and stress) (27), which indicated a protective effect of self-compassion for adolescents when met with personal challenges or difficult life circumstances. Evidence from empirical studies also supports the protective role of self-compassion in adolescents (28, 29). For example, Latinen et al. (28) found that, among high school students, self-compassion could alleviate the relationship between academic difficulties and depressive symptoms. A longitudinal study found that self-compassion served as a protective factor in preventing the transition from suicidal ideation to suicide attempt in Chinese adolescents (29).

To our knowledge, few studies directly examine the protective role of self-compassion among adolescents in the context of COVID-19. There is some evidence of the protective role of self-compassion that appeared among adults during the COVID-19 pandemic (30, 31). For instance, Lau et al. (30) found that self-compassion could buffer the impact of COVID-19 on Hong Kong residents' psychological distress during the peak of the local outbreak of the virus. Additionally, a 14-day mobile self-compassion intervention was found to have the ability to reduce stress and help participants maintain healthy eating habits during the COVID-19 pandemic (31). Theoretically, self-compassion may protect adolescents from maternal COVID-19 anxiety through three mechanisms. First, preventing negative self-talk, and promoting self-kindness may make it easier for adolescents to maintain the balanced awareness of other's emotions (i.e., maternal anxiety) and their own emotions (32), thus preventing the negative emotional transaction from mother to child. Second, through common humanity, the feeling of connection (33)

allows adolescents to realize that they may not be the only ones facing at mother's anxiety during the COVID-19 pandemic. This realization may reduce their psychological maladjustment. Third, mindfulness may foster a broadened perspective toward stressful situations (i.e., maternal anxiety caused by COVID-19), allowing for psychological distance between these maternal negative emotions and adolescents themselves (29). Thus, mindfulness may also work to aid adolescents in their adjustment to changing environments due to maternal anxiety about the COVID-19 pandemic.

In summary, the aim of this study was to examine the impact of maternal anxiety symptoms on adolescents' mental health (i.e., PTSD symptoms, negative affect, anxiety, and depression symptoms) in the context of COVID-19 and explore the moderating role of adolescents' self-compassion on the relationship between maternal anxiety symptoms and adolescents' mental health. Two hypotheses were proposed:

Hypothesis 1. Maternal anxiety during the COVID-19 pandemic is expected to be positively associated with adolescents' psychological maladjustment.

Hypothesis 2. Self-compassion is expected to serve as a moderator in the relationship between maternal anxiety and adolescents' psychological maladjustment. Specifically, adolescents with higher levels of self-compassion would experience less of an impact of maternal anxiety on their mental health during the COVID-19 pandemic.

METHODS

Participants

Adolescents in this study were recruited from three public schools in Zhengzhou, Henan province. The city is located in central China with a population of approximately 10.35 million. After obtaining relevant informed consent, the final sample included 5,720 adolescents ($M_{\text{age}} = 11.60$, ranging from 10 to 17 years, $SD_{\text{age}} = 1.36$, 48.9% girls) and their mothers ($M_{\text{age}} = 39.75$, $SD_{\text{age}} = 4.21$). The majority of the adolescents came from families of lower-middle to middle socioeconomic status. This distribution was representative of the general population in Zhengzhou based on data from the Bureau of Statistics of Zhengzhou (34). **Table 1** presents demographic information reported by adolescents and their mothers in the current study.

Procedure

Data for the current study were collected in April 2020 when schools in Zhengzhou remained closed. Data on adolescents and their mothers were collected through a Chinese online platform (Wenjuanxing). Due to the COVID-19 school closure, our research assistants organized online information groups to communicate with participants after access was granted by teachers and principals in local schools. The online survey was designed as a closed survey, and the potential participants could only access the survey through the links offered by research assistants in the groups. The online consent forms were sent to parents in the groups with the invitation to mothers and adolescents to participate in the current study. 96% of

TABLE 1 | Demographic information of the sample ($N = 5720$).

Categories	<i>M (SD)%</i>
Adolescent characteristics	
Age (year)	11.60 (1.36)
Only child	24.0%
Gender	
Boys	51.1%
Girls	48.9%
Grade	
Primary school (grade 4–6, age range: 10–14 years)	82.3%
Middle school (grade 7–9, age range: 10–17 years)	17.7%
Living characteristics during COVID-19(mother report)	
Residence during the COVID-19 pandemic	
Low risk	60.3%
Middle risk	35.7%
High risk	4.0%
Knowledge of relatives or close friends infected by COVID-19	
Yes	0.9%
No	99.1%
Knowledge of someone infected by COVID-19 in the same community	
Yes	13.5%
No	86.5%
Family Characteristics	
Maternal Age (year)	
	39.75 (4.21)
Maternal education	
Middle school or below	18.0%
High school or technical secondary school	31.0%
Junior college or higher vocational college degree	26.2%
Bachelor's degree	21.7%
Master's degree or above	3.0%
Family Income (per year)	
¥30,000 or below (approx \$4,641 or below)	16.1%
¥30,000–50,000 (approx \$4,641–7,736)	19.0%
¥50,000–100,000 (approx \$7,736–15,472)	28.2%
¥100,000–150,000 (approx \$15,472–23,209)	16.9%
¥150,000–200,000 (approx \$23,209–30,945)	11.4%
¥200,000–400,000 (approx \$30,945–61,891)	6.1%
¥400,000 or above (approx \$61,891 or above)	2.2%

parents provided consent with the completed maternal survey, and 100% of adolescents with parental consent assented to participate and completed the online survey. Survey questions on demographic information were optional. All other survey items were mandatory with nonresponse options (e.g., “not applicable” or “rather not say”). The study's procedure was approved by the Research Ethics Review Board at East China Normal University.

Measures

Maternal Anxiety

Mothers self-rated symptoms of anxiety during the COVID-19 pandemic utilizing the 7-item Generalized Anxiety Disorder-7 (e.g., “not being able to stop or control worrying,” “becoming

easily annoyed or irritable") (35). All the items were rated on a 4-point Likert scale, ranging from *never* to *almost every day* pertaining to the previous 2 weeks. The mean score was used as the final indicator of the severity of anxiety symptoms. Previous studies show that this questionnaire has high reliability and validity in China (36). Internal consistency reliability was 0.93 in the current study.

Self-Compassion

The abbreviated version of the Neff self-compassion questionnaire (37), revised by Chinese scholars (38), was used to examine adolescents' self-compassion. The 12-item scale used in the current study contains three dimensions: self-tolerance (three items, e.g., "I can accept my own shortcomings and deficiencies"), universal humanity (four items, "When I fail in important things, I always feel isolated and helpless" reverse scored), and mindfulness (five items, e.g., "When things get worse, I can understand that frustration is part of the life experience"). All items were rated on a 5-point Likert scale, from *never* to *always*. The mean score was calculated with higher scores indicating higher levels of adolescents' self-compassion. Previous studies find great reliability and validity in this scale (38) for Chinese adolescents. The Cronbach's α in the current study was 0.73.

PTSD Symptoms

The 17-item PTSD Checklist [PCL; (39)] was used to assess the level of adolescents' PTSD symptoms during the COVID-19 stay-at-home period. Pertaining to the previous 7 days, adolescents rated items measuring symptoms of PTSD (e.g., "I have nightmares," "I am sad to think of what has happened"). These items were measured utilizing a 4-point Likert-scale, ranging from *no* to *always* in regards to their experience with the COVID-19 pandemic. The mean score was calculated with higher scores indicating a greater influence of the COVID-19 pandemic on the adolescents' psychological status. Previous research using the PCL revealed its strong internal consistency and good test-retest reliability (40). The Cronbach's α was 0.88 in the current study.

Negative Affect

Adolescents reported their feelings regarding the previous week using the revised Positive and Negative Affect Schedule for Children (PANAS-C). The original short-version scale is composed of two subscales, Positive Affect (PA) and Negative Affect (NA). Both subscales contain five items (41) evaluating the intensity of each type of emotion experienced by the respondent for a certain period of time. For this study, we simplified the questionnaire into six items in total with three items from each subscale. Those of the NA subscale include "I felt nervous," "I felt upset," and "I felt afraid." All items were rated on a 7-point Likert scale (from 1 = none to 7 = completely). The original scale has been validated in Chinese adolescent samples (42). The internal consistency reliability was 0.74 in this study.

Anxiety and Depression

Mothers reported adolescents' emotional status utilizing the subscale (i.e., Anxious/Depressed) of the Child Behavior

Checklist [CBCL; (43)]. Example items were "worry and anxiety" and "prone to crying." All items were rated on a 5-point Likert scale, ranging from *non-conformed* to *very conformed* with the mean score determining the emotional state of the adolescents over the previous 2 weeks. This measure has been validated in Chinese adolescent samples (44). Internal consistency reliability was 0.93 in the current study.

Statistical Analysis

The statistical analyses were conducted using SPSS version 23.0 and Mplus 8.3. Primary analyses included descriptive statistics, tests for gender and grade differences with MANOVAs, and correlation analyses.

Latent moderated structural equation models [LMS; (45)] were used to evaluate hypothesis 2. A maternal anxiety latent variable was created using the original seven items. A self-compassion latent variable was created using its three dimensions: self-tolerance, universal humanity, and mindfulness. Psychological maladjustment was indicated using adolescents' PTSD symptoms, negative affect, anxiety, and depression. Confirmatory factor analysis was first conducted to test the measurement models of three latent variables (maternal anxiety, self-compassion, and psychological maladjustment). Two steps of LMS were then used to test the moderating effect of self-compassion.

The first step estimated the structural model without the latent interaction term (Model 0). The second step estimated the structural model, including the latent interaction term (Model 1). It should be noted that the latent moderated model does not report fit indices (i.e., comparative fit index [CFI], Tucker-Lewis index [TLI], root mean square error of approximation [RMSEA]); however, the latent interaction term does not affect the fit of the measurement model (46). The log-likelihood ratio test was used to determine whether the more parsimonious Model 0 represents a significant loss in fit relative to the more complex Model 1 (46). The test equation was as follows:

$$D = -2[(\log - \text{likelihood} M0) - (\log - \text{likelihood} M1)]$$

The values of D are distributed approximately as χ^2 with df equal to the difference in free parameters between the two models. If Model 0 fits well and the log-likelihood ratio test is significant, then the researcher can conclude that Model 1 is also a well fitted model, and the moderated effect is supported.

Missing data were treated using full information maximum likelihood estimation in Mplus (47). As suggested by previous studies, all continuous variables were standardized in the model to avoid multicollinearity effects. The simple slope was applied for probing interactions with the ± 1 SD of the mean of self-compassion.

RESULTS

Primary Analysis

Mean values and standard deviations of all study variables are shown in Table 2. The exploratory multivariate analysis of variance (MANOVA) test revealed a significant main effect of

TABLE 2 | Descriptive statistics of and correlations among the study variables.

	<i>M(SD)</i>	1	2	3	4	5	6
1. Gender	NA						
2. Grade	NA	0.06**					
3. Maternal anxiety	1.64 (0.61)	−0.03*	−0.01				
4. Adolescent self-compassion	3.44 (0.59)	−0.02	−0.08**	−0.23**			
5. Adolescent PTSD symptoms	1.53 (0.43)	0.02	0.08**	0.25**	−0.34**		
6. Adolescent negative affect	2.36 (1.26)	0.04**	0.16**	0.21**	−0.31**	0.62**	
7. Adolescent anxiety and depression	1.79 (0.84)	−0.02	0.02	0.43**	−0.33**	0.31**	0.24**

Gender was dummy coded: 0 = boys, 1 = girls. Grade was dummy coded: 0 = primary school, 1 = middle school. * $p < 0.05$, ** $p < 0.01$.

gender (1 = boys, 2 = girls), Wilks' $\lambda = 0.99$, $F_{(5, 5705)} = 4.46$, $p < 0.01$, partial $\eta^2 = 0.004$, and grade (1 = primary school, 2 = middle school), Wilks' $\lambda = 0.97$, $F_{(5, 5705)} = 31.88$, $p < 0.01$, partial $\eta^2 = 0.03$, and interaction effects between gender and grade, Wilks' $\lambda = 0.997$, $F_{(5, 5705)} = 3.27$, $p < 0.01$, partial $\eta^2 = 0.003$.

For *gender* differences, the subsequent univariate analyses showed that, compared with boys, girls reported lower levels of self-compassion, higher levels of PTSD symptoms, and higher levels of negative affect. For *grade* differences, the univariate analyses indicated that, compared with primary school students, students in middle school reported lower levels of self-compassion, higher levels of PTSD symptoms, and higher levels of negative affect during the COVID-19 stay-at-home period. For the *gender* \times *grade* group interaction, results from simple-effect analyses indicated that girls reported lower levels of self-compassion than boys in middle school, whereas there was no significant gender difference in self-compassion in primary school. Furthermore, girls reported higher levels of PTSD symptoms and negative affect than boys in middle school, whereas such gender differences were not significant in primary school.

Intercorrelations between all study variables are presented in **Table 2**. In short, the pattern of associations between these variables is consistent with our hypotheses. Maternal anxiety during the COVID-19 pandemic was found to be negatively associated with adolescents' self-compassion and positively associated with each of the indices of adolescents' psychological maladjustments. Moreover, adolescents' self-compassion was negatively associated with every measurement of adolescents' psychological maladjustment.

Maternal Anxiety and Adolescents' Psychological Maladjustment: Self-Compassion as a Moderator

Results of the confirmatory factor analysis indicated that the measurement model evaluated in our primary analysis fit the data well, $\chi^2 = 1987.48$, $df = 61$, CFI = 0.93, TLI = 0.91, RMSEA = 0.07, SRMR = 0.06. Given the gender and grade differences found in the primary analyses, we explored the gender and grade differences in the relationship between maternal anxiety and adolescents' psychological maladjustment. The results indicate that there were no gender or grade differences

TABLE 3 | Model fit indices and regression coefficients for the latent moderated model.

	Model 0	Model 1
χ^2	2659.84	
df	121	
Log (L)	−88092.68	−88069.21
CFI	0.92	
TLI	0.90	
RMSEA	0.06	
SRMR	0.06	
Maternal anxiety \rightarrow Psychological maladjustment	0.56**	0.54**
Self-compassion \rightarrow Psychological maladjustment	−0.36**	−0.43**
Maternal anxiety \times Self-compassion \rightarrow Psychological maladjustment		−0.16**
Gender \rightarrow Psychological maladjustment	−0.002	−0.004
Grade \rightarrow Psychological maladjustment	0.08**	0.08**
Maternal educational level \rightarrow Psychological maladjustment	−0.04	−0.03
Family income \rightarrow Psychological maladjustment	−0.02	−0.02
Living in the COVID-19 risk area \rightarrow Psychological maladjustment	0.05**	0.05**

CFI, comparative fit index; TLI, Tucker-Lewis index; RMSEA, root mean square error of approximation; SRMR, Standardized Root Mean Square Residual. Estimates are standardized coefficients.

Covariates are gender, grade, maternal educational level, annual family income and COVID-19 related risk living area. Gender was dummy coded: 0 = boys, 1 = girls. Grade was dummy coded: 0 = primary school, 1 = middle school.

** $p < 0.01$.

found in these relationships. Thus, in the subsequent latent moderated structural equation model, adolescents' gender and grade combined with maternal educational level, annual family income, and COVID-19 related risk living area were included in the analyses as *covariates*.

The model fit indices for the latent moderated structural equation model are presented in **Table 3**. As evident in this table, the result indicated that Model 0 with the main effect of self-compassion fit the data well, $\chi^2 = 2,659.84$, $df = 121$, CFI = 0.92, TLI = 0.90, RMSEA = 0.06, SRMR = 0.06. As noted above, Model 1 included the latent interaction terms (maternal anxiety \times self-compassion) on the basis of Model 0. The log-likelihood ratio test found that the fit of Model 1 (likelihood value

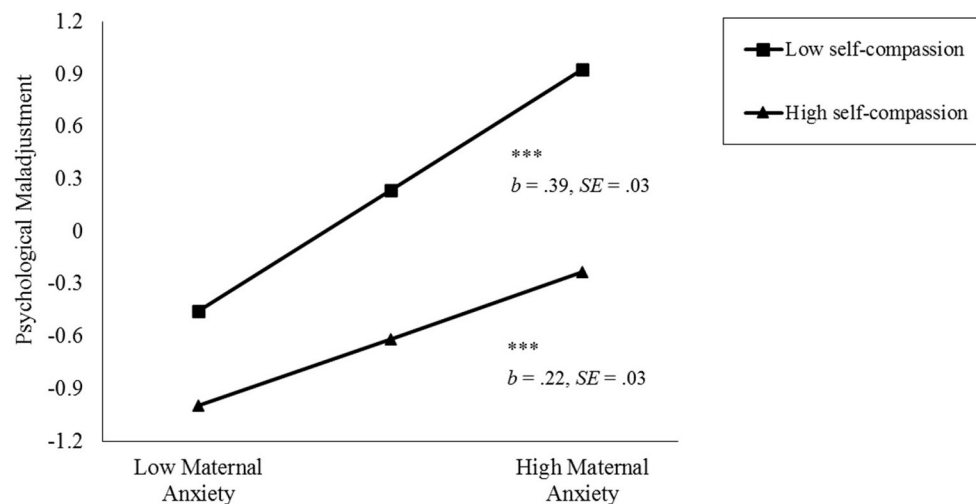


FIGURE 1 | Simple slopes of the relationship between maternal anxiety and adolescents' psychological maladjustment at different levels of adolescents' self-compassion.

$= -88,069.21$) was better than the fit of Model 0 (likelihood value $= -88,092.68$), $D (df = 1) = 46.94$, $p < 0.001$. These results indicate that the interactive effect of maternal anxiety and self-compassion on adolescents' psychological maladjustment was significant, $\beta = -0.16$, $p < 0.01$.

Furthermore, the simple slopes test indicates that, among adolescents with low self-compassion ($-1 SD$), maternal anxiety during the COVID-19 pandemic was significantly and positively associated with adolescents' psychological maladjustment ($b = 0.39$, $p < 0.001$). However, among adolescents with high self-compassion ($+1 SD$), the effect of maternal anxiety on adolescents' psychological maladjustment became weaker ($b = 0.22$, $p < 0.001$). Overall, adolescents with higher levels of self-compassion ($+1 SD$), regardless of their mothers' level of anxiety, reported fewer psychological maladjustments (i.e., below the mean level) during the COVID-19 pandemic (see **Figure 1**).

DISCUSSION

The present study investigates the potential protective factor in the transactional process of psychological distress from mothers to children in the COVID-19 pandemic context. As expected, when mothers reported more anxiety during the COVID-19 pandemic, adolescents also reported more psychological maladjustment (i.e., PTSD symptoms, negative affect, anxiety, and depression). This finding was consistent with previous research during the COVID-19 pandemic (22, 23) and provided more empirical evidence of this process in China. During the COVID-19 pandemic, parents were faced with many uncertainties and potential threats caused by the virus, such as a sudden lockdown and the possibility of infection. These concerns may raise psychological distress, such as anxiety. In addition, compared with other family members, mothers were found to face more challenges during the pandemic (19) and perceived more COVID-19 related health risks (6), which may further exacerbate their feelings of anxiety. The prolonged stay-at-home

period resulted in parents and children spending significantly more time interacting with each other. Such an environment would make the direct transactional process of psychological distress (i.e., anxiety) from parent to child more likely to occur as suggested by the spillover hypothesis (21). Adolescents may develop more psychological maladjustments when their mothers experience high anxiety during the COVID-19 pandemic.

Importantly, our study found that adolescents' self-compassion was an important protective factor that buffered the association between maternal anxiety and adolescents' psychological maladjustment during the COVID-19 pandemic. Adolescents with high levels of self-compassion not only experienced a weaker impact of maternal anxiety, but also reported less psychological maladjustment regardless of their mother's emotional status. Self-compassion is considered an adaptive self-regulatory skill, especially for adolescents (28). When exposed to maternal anxiety, adolescents with higher levels of self-compassion may show more understanding of the negative emotions they witnessed in their mothers (i.e., "mother is facing more stress during the COVID-19, so she is in a bad mood") and hold fewer harsh judgments and more self-kindness for themselves also. Mindfulness may increase the psychological distance between maternal anxiety and adolescents themselves, reducing the impact of this negative emotion on them. Besides this, prior studies find that the COVID-19 outbreak has altered adolescents' social patterns with families and friends evidenced by increased family conflict but strengthened and more selective peer relationships (48). Positive online communication with peers may increase common humanity allowing adolescents to maintain self-compassion (e.g., communicating online with friends about their mothers' anxiety and emotional state during the COVID-19 pandemic). As a result, the impact of maternal anxiety during the COVID-19 pandemic on children may be lessened.

Moreover, our findings suggest that *lower* levels of self-compassion may be a potential *risk* factor for adolescents'

mental health during the COVID-19 pandemic. As seen in **Figure 1**, when mothers reported higher levels of anxiety symptoms, adolescents with lower levels of self-compassion (-1 SD) exhibited the highest score of psychological maladjustment as compared with other situations. Lower levels of self-compassion may indicate that these adolescents process stressful events in a maladaptive way (e.g., self-judgment, isolation, and over-identifying with distress) and, thus, experience harsher negative consequences of maternal anxiety during the COVID-19 pandemic.

It is worth discussing how adolescents in families with highly anxious mothers maintained their self-compassion during the COVID-19 pandemic. Two possible explanations were raised. First, maternal anxiety during the COVID-19 may differ from mothers' real interactions with their children. As suggested by the research of Dollberg et al. (49), mothers' mentalization skills (i.e., the ability to recognize child's mental and emotional needs) (50) during the COVID-19 pandemic were unrelated to maternal anxiety symptoms. Additionally, children were found to have a decreased risk of behavioral problems if their mothers had stronger mentalization skills (49). In this regard, some anxious mothers may wish to provide a safe and secure family environment in the unpredictable COVID-19 period for their children. They may conceal or regulate their feelings when interacting with children, which may promote self-compassion in adolescents during the COVID-19 pandemic. A second possible explanation is that an external factor, such as the setting of online school curricula rather than the family environment, may have a positive effect on the development of adolescents' self-compassion during the COVID-19 pandemic. For instance, the *School's Out, But Class's On* project launched by the Chinese Ministry of Education considered students' mental health education as greatly important during the pandemic (51). Adolescents may have opportunities to learn how to promote self-kindness and mindfulness in dealing with their negative emotions during the COVID-19 school closure period.

Finally, gender and grade differences existed in adolescents' self-compassion and psychological maladjustment with middle school girls reporting lower levels of self-compassion and higher levels of psychological maladjustment (i.e., PTSD symptoms and negative affect) than primary school girls or boys of any grade during the COVID-19 pandemic. These findings of the current study were not only consistent with previous studies (52, 53) but built on them to consider the COVID-19 context. In line with previous studies prior to the COVID-19 pandemic, older female adolescents were found to be more vulnerable to adverse conditions such as family conflict (54), showed less self-compassion (52), and experienced more psychological distress, such as anxiety, depression, and stress (53) compared with their counterparts. Furthermore, studies during the COVID-19 pandemic also reveal that older children experienced more psychological distress due to COVID-19's daily impacts compared with younger children (55). As self-compassion was examined as the protective factor buffering the impact of stressors in the current and in previous studies (30), the present study's findings suggest that more attention is needed on older female adolescents' mental health during the COVID-19

pandemic. In addition, the need to investigate how to aid older female adolescents in developing more self-compassion during the pandemic is evident from the current study's findings.

Limitations and Future Directions

The present study offers evidence of the protective role of self-compassion in the relationship between maternal anxiety and adolescents' psychological maladjustment in the context of the COVID-19 pandemic. Several limitations should be noted in the current study along with suggestions for future research. First, the cross-sectional design precluded our ability to make causal inferences regarding the relationship between maternal anxiety and adolescents' mental health. Alternative explanations must be considered. For instance, bidirectional relationships between maternal anxiety and adolescents' mental health may be found in the family system during the COVID-19 pandemic. It is also possible that a genetic link exists between mothers and children (54), impacting the results of this study as pre-COVID-19 anxiety assessments were not given. Although adolescents' reported self-compassion was found to buffer the relationship between maternal anxiety and adolescents' psychological maladjustment, it is important to recognize these notable limitations.

Second, several measurement issues should be considered. Although the current study used a multiple-informant approach to improve the validity of adolescents' psychological maladjustment, mothers with especially high levels of anxiety symptoms may have been more likely to report anxiety and depression symptoms in their children. This may have exaggerated the results on the psychological effects of maternal anxiety on children. Moreover, the present study only investigated the negative aspects of mental health outcomes. Considering the dual-factor model of mental health (56), future studies should further explore the possible role of self-compassion on the positive aspects of mental health (e.g., life satisfaction) during the COVID-19 pandemic.

Third, it is also important to contextualize the current findings as our results may not be generalizable to other samples of individuals who were exposed to more stressful conditions. In more stressful settings, such as the "red zone" in Italy, mothers are more likely to be aware of the life-threatening risks of COVID-19 (25), and adolescents may fail to develop a certain level of self-compassion, a potential protective factor during a stressful event.

Finally, it is worthy for future studies to investigate the two possible explanations we raised to explain how adolescents developed self-compassion with their anxious mothers. Conducting qualitative studies or directly testing for the two hypothetical explanations proposed in the current study through quantitative research would provide valuable information on the possible mechanisms at play between maternal anxiety and adolescent mental health.

Implications

The present study highlighted the protective role of adolescents' self-compassion when faced with maternal anxiety during the COVID-19 pandemic. The findings have practical implications

for families, schools, and societies at large. For instance, parents should recognize their negative emotional state may have a transactional impact on their children in the family system. Thus, more emotional awareness and emotional regulation should be practiced by parents during the COVID-19 pandemic. Second, self-compassion and mindfulness training proved to be effective for adolescents before and during the COVID-19 pandemic (57, 58). School counselors and therapists could implement the self-compassion intervention to enhance adolescents' well being. Governments and institutions should also offer the public information and tools to develop adolescents' self-compassion during the pandemic to improve their mental health.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Research Ethics Review Board at East China Normal

University. The participants provided their informed consent via the online link to participate in this study.

AUTHOR CONTRIBUTIONS

TZ, XB, and JL conceptualized the study, developed methods, ethical documentation, and study materials. XB recruited participants and collected data. TZ drafted the manuscript, with KZ's help on the Method section and YL's help on the Results section. SZ, XB, HZ, JL, and JF conducted the proofreading. JL funded the current project and supervised the whole manuscript writing process. All authors contributed to the article and approved the submitted version.

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Factors Influencing Post-traumatic Stress Symptoms in Chinese Adolescents During the COVID-19 Pandemic

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To investigate the prevalence of post-traumatic stress symptoms (PTSSs) and analyze the influencing factors of PTSS among adolescents in a large sample study during the COVID-19 pandemic, we did a cross-sectional study by collecting demographic data and mental health measurements from a large group of 175,318 adolescents in 32 Chinese provinces and autonomous regions, using the Impact of Event Scale-Revised (IES-R) that was used to measure the PTSS of the participants. The results showed that the prevalence of PTSS was 35.7% in Chinese adolescents during the COVID-19 pandemic. Binary logistic regression analysis showed that, for the personal risk factors, the older age, female gender, the personality domains of extroversion, the irregular sleep schedule, the lack of aerobic exercise, and the lack of peer support were associated with the higher levels of PTSS. The family subjective and objective factors were associated with higher levels of PTSS. Our findings suggested that family factors are the most important factors that affect Chinese adolescents' PTSS due to the longtime home quarantine.

Keywords: COVID-19, adolescents, PTSS, family factors, home quarantine

INTRODUCTION

On 30 January 2020, the World Health Organization declared the 2019 novel coronavirus disease (COVID-19) as a public health emergency of international concern (1). COVID-19 has swept across 210 countries and territories with over 92 million cases and 479,133 deaths reported by 25 June 2020 (2). Most countries have implemented social isolation measures, such as school closures and some public places, to curb the spread of infection and minimize the impacts of the virus (3). According to United Nations Educational, Scientific, and Cultural Organization (UNESCO), by 8 April 2020, schools in 188 countries around the world have closed due to COVID-19 (4). To halt the spreading of COVID-19 in schools, China's ministry of education has asked for a postponement of the spring semester in 2020. This move has led to more than 220 million children and adolescents confined to their own homes in China (5).

Physical damages caused by public health emergencies have been pointed out that could be recovered in a short time, but the psychological impacts will last for a long time (6). Teenagers are in adolescence, with immature psychological mechanisms, which makes them more susceptible

to changes in the external environment and prone to psychological problems (7). Due to the incomplete cognitive development of adolescents, they have limited knowledge about the epidemic situation, which may lead to negative emotions, such as fear and anxiety. Adolescence is usually associated with increased risk-taking behaviors, increased needs for social connection and peer acceptance, and increased sensitivity to peer influence (8). During this period, young people grow in independence and begin to prioritize connections with peers over parents (9). Due to home quarantine, the need for adolescents to get along with their peers is difficult to be met and they have to spend more time with their parents. So, this means that the family environment plays an important role in the psychological development of adolescents and has a great impact on them during the outbreak (10). A good parent–child relationship and family atmosphere can positively promote the personality development and mental health of adolescents. In the face of COVID-19, support and care from parents can help adolescents to overcome negative emotions and protect their psychological resilience. However, many parents in China have “Chinese parental authority” in the way they communicate. Such excessive parental control or overprotection can backfire on a child who is in adolescent rebellion. Parent–adolescent conflict is regarded as the “major influence” in adolescent unacceptable behavior (11). In addition, as examinations are still covered during the pandemic, adolescents are likely to have concerns about their studies and future development. For these adolescents who may need mental health support, such suspensions at home mean that they do not have access to the resources normally available through schools and some social supports. Furthermore, changes in the study method, such as online learning and independent reading, could bring more challenges for young people (12). In conclusion, the interaction between lifestyle changes brought about by home confinement and the pandemic itself could further exacerbate the detrimental effects on adolescents’ mental health and may even lead to a vicious circle (13).

Adolescents face stresses, such as prolonged duration, fears of infection, lack of in-person contact with peers, and reduced personal space at home, may appear even more problematic and enduring symptoms (14). These symptoms manifest as the repeated experience of invasion, avoidance, and increased alertness, which are closely affiliated with post-traumatic stress disorder (PTSD) symptoms (15). When people face major stress events, such as interpersonal conflicts, deaths of family members, traffic accidents, natural disasters, and disease epidemics, there will be a series of post-traumatic stress symptoms (PTSSs) (16). PTSSs are the result of multiple factors, including stress, genetics, personality, coping style and social support, past trauma experience, past mental illness, and so on (17). Usually, this reaction may be temporary and controllable. Once they cannot solve it, serious psychological imbalances may occur, and some people will develop PTSD and related symptoms (18). However, if the individual is found in a timely manner and can receive appropriate post-traumatic psychological support, it is possible to avoid or reduce PTSD. There is an increasing number of evidence showing that the Impact of Event Scale—Revised (IES-R) is valid and reliable as “a low-cost measure to detect PTSD” (19). The

IES-R is a screening tool rather than a formal diagnostic test, but it correlates well with the diagnosis of PTSD (20). The IES-R is a self-report measure for capturing the level of symptomatic responses to specific traumatic stress in the past week (21). The IES-R can timely assess the individual’s PTSS level after the traumatic event, so as to effectively screen the PTSD (22).

This study represents the survey based on a large sample of adolescents in the mainland of China and aims to (1) describe the prevalence of PTSS among adolescents during the pandemic and explore whether the severity of the pandemic will affect the prevalence of PTSS and (2) investigate and analyze the influencing factors of adolescents’ PTSS during the COVID-19 pandemic, so as to provide a theoretical basis for reducing the prevalence of PTSD in adolescents worldwide.

METHODS

Study Design and Participants

Our online cross-sectional survey was conducted in the mainland of China from February 23 to March 8, 2020. The Chinese adolescents aged 16–26 years were invited to participate in the online survey through the Survey-Star platform, and the electronic questionnaire was distributed through the WeChat group and encouraged to pass it on to others. We carefully check the quality of each questionnaire to ensure that the returned questionnaire is filled in effectively. This web-based questionnaire was completely voluntary and non-commercial. A total of 175,318 adolescents covered all 32 provinces and autonomous regions have completed the questionnaires in this study during the COVID-19 pandemic. This study was approved by the Ethics Committee of Harbin Medical University (HMUIRB20200002). The attributes, benefits, uses, and disadvantage effects of the study were explained to all the participants. Each participant provided online informed consent to participate in the study.

Procedures

The adolescents completed the following scale. The Impact of Event Scale-Revised (IES-R) was used to measure the post-traumatic stress symptoms of the participants (23). The IES-R is a self-report questionnaire and consisted of 22 items, each item scored from 0 (no problems) to 4 (frequent problems). The total score is obtained by summing across all items, which ranges from 0 to 88. The cutoff score of IES-R is 20, and a score of ≥ 20 on the IES-R is used to estimate the prevalence of PTSS, with higher IES-R scores indicating more symptoms (24). The scale had 3 subscales: avoidance (8 questions), intrusion (8 questions), and hyperarousal (6 questions). IES-R has previously been shown to have good reliability and has been widely used among the Chinese population. In this study, the Cronbach’s α value for all 22 items was 0.964.

Sociodemographic data included the participant’s gender (male/female), age (16–20/21–26), residential areas (rural/urban), situation of COVID-19 epidemic in residence whether cumulative confirmed cases >500 (slight/severe), symptoms related to COVID-19 during past 14 days included fever, cough, and fatigue (no/yes), relatives or friends having

TABLE 1 | PTSS, scores, and dimensions in the adolescents who scored ≥ 20 ($N = 62,668$).

Variables	Range	Mean (SD)	Mean item score
Avoidance	0–32	12.53 (4.80)	1.56
Intrusion	0–32	11.61 (4.60)	1.45
Hyperarousal	0–24	8.65 (3.81)	1.44
IES total score	20–88	32.80 (11.69)	1.49

symptoms related to COVID-19 (no/yes), personality type (introvert/general/extrovert), sleep time (<5 h/5–7 h/8–10 h), peer support (no/yes), aerobic exercise >30 min per day during the epidemic (no/yes), having a separate room at home (no/yes), family economic status (poor/general/good), relationships with family (good/general/poor), parental education (senior high school and below/junior college and above), quarrel with parents >3 times during home quarantine (no/yes), overprotection from parents (no/yes), and activities with parents during home quarantine (no/yes).

Statistical Analysis

The Statistical Package for Social Science 22.0 (SPSS 22.0) program was used for all statistical analysis. Continuous data are shown as mean (standard deviation). To examine the differences in demographic, psychological, and COVID-19 epidemic-related variables, we conducted the chi-square tests, the *t*-tests, and the F-tests. Binary logistic regression analysis was used to identify the factors associated with PTSS, independent variables include age, gender, residential areas, situation of COVID-19 epidemic in residence, symptoms related to COVID-19 during the past 14 days, relatives or friends having symptoms related to COVID-19, personality type, exercise during the epidemic, peer support, family economic status, relationship with family, sleep time, separate room, quarrels with parents during home quarantine, parental education, overprotection from parents, and activities with parents. *p*-Values < 0.05 were regarded as significant for all tests (two-sided).

RESULTS

A total of 175,318 valid questionnaires had been collected, including 80,595 (46.0%) men and 94,723 (54.0%) women. The average age of the study population was 20.52 ± 1.69 years (mean \pm SD), ranged from 16 to 26 years. **Table 1** shows the means and standard deviations of the IES-R subscale scores, and the mean score for IES-R was 32.80 ± 11.69 . The results showed that 35.7% of the students had a total IES-R score ≥ 20 , that is to say, the prevalence of PTSS among Chinese adolescents was found to be 35.7%. Furthermore, **Table 1** presents the scores of each dimension among adolescents who experience PTSS. The dimensions with the highest means were avoidance, intrusion, and hyperarousal.

Additionally, **Table 2** displays the basic demographic data, IES-R scores, and the prevalence of PTSS (IES-R score ≥ 20) for each demographic group. The results showed that there

were significant differences in PTSS related to gender, age, residential areas, situation of COVID-19 epidemic in residence, symptoms related to COVID-19 during the past 14 days, relatives or friends having symptoms related to COVID-19, personality type, sleep time, peer support, exercises during the epidemic, having a separate room at home, family economic status, relationships with family, parental education, quarrels with parents, overprotection from parents, and activities with parents.

Figure 1 shows that the prevalence of PTSS was 35.0% in slight epidemic areas and 37.6% in severe areas. The prevalence of PTSS between slight and severe epidemic areas was small and almost identical. Therefore, the prevalence stratified by the situation of COVID-19 epidemic in residence could be considered as no differences.

Table 3 presents the binary logistic regression analysis results for the PTSS-dependent variables. Although the analysis indicated that all the independent variables were associated with PTSS, some independent variables' odds ratio values were approached to 1.00, including age [odds ratio (OR) = 1.011, 95% confidence interval (CI) = 1.005–1.017], residential areas (OR = 0.931, 95% CI = 0.912–0.915), situation of COVID-19 epidemic in residence (OR = 0.921, 95% CI = 0.900–0.941), exercise during the epidemic (OR = 1.060, 95% CI = 1.035–1.084), parental education (OR = 1.161, CI = 1.138–1.185), and family economic status. Those variables that OR value approached to 1.00 were weakly associated with PTSS; meanwhile, the other independent variables had a stronger impact on PTSS. The results identified that having symptoms related to COVID-19 during the past 14 days (OR = 2.302, 95% CI = 2.028–2.612), relatives or friends having symptoms related to COVID-19 (OR = 1.922, 95% CI = 1.735–2.128), overprotection from parents (OR = 1.689, 95% CI = 1.640–1.738), quarrels with parents during home quarantine (OR = 1.254, 95% CI = 1.229–1.280), gender (OR = 1.203, 95% CI = 1.179–1.228), good relationship with family (OR = 0.487, CI = 0.411–0.577), separate room (OR = 0.518, 95% CI = 0.501–0.535), peer support (OR = 0.798, 95% CI = 0.779–0.818), introvert personality type (OR = 0.846, 95% CI = 0.821–0.871), sleep 8–10 h (OR = 0.860, 95% CI = 0.833–0.888), and activities with parents (OR = 0.897, 95% CI = 0.879–0.916) were the significant predictors for PTSS in adolescents. Having symptoms related to COVID-19 during the past 14 days played the most important risk role in PTSS, and a good relationship with family played the most important protective role in PTSS.

DISCUSSION

This survey was conducted during the rapid rising period of the COVID-19 pandemic, and the adolescent population covered 32 provinces and autonomous in the mainland of China. The results illustrated that the prevalence of PTSS was 35.7% in Chinese adolescents during the COVID-19 pandemic, and avoidance symptoms were of the highest score among all the three symptoms in adolescents with PTSS. As the previous study reported, about 14.5–21.1% of children and adolescents were diagnosed with PTSS during the month after being exposed to traumatic events, such as earthquakes and

TABLE 2 | Socio-demographic factors for the sample of Chinese adolescents.

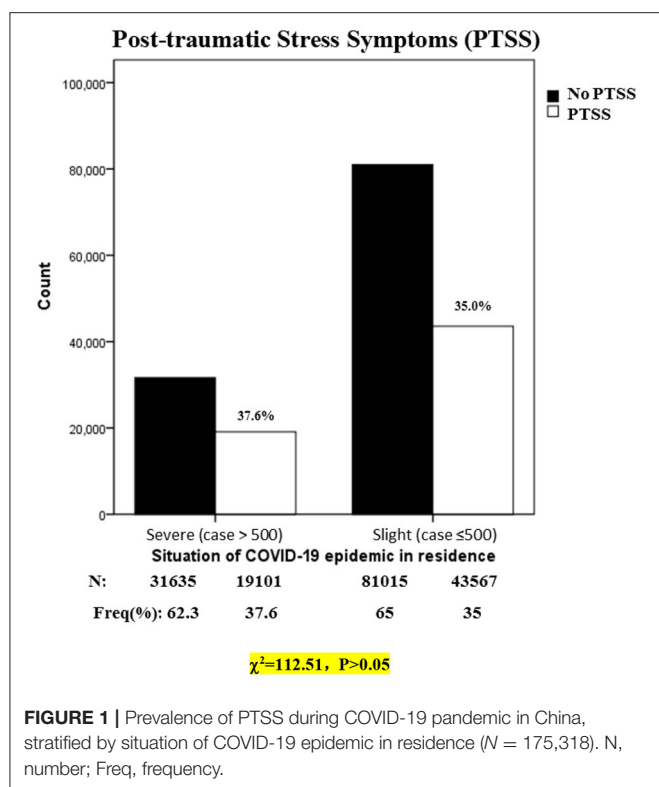
Variables	Group	N (%)	IES-R score	F/t	IES-R score ≥ 20 (%)
Gender	Male	80,595 (46.0)	14.33 (16.21)	-23.35**	34.0
	Female	94,723 (54.0)	16.07 (14.88)		37.3
Age	16–20	93,454 (53.3)	15.26 (15.48)	-0.39**	35.3
	21–26	81,864 (46.7)	15.29 (15.58)		36.2
Residential areas	City	70,254 (40.1)	15.61 (15.28)	7.59**	36.9
	Rural	105,064 (59.9)*	15.05 (15.68)		35.0
Situation of COVID-19 epidemic in residence	Severe	50,736 (28.9)	16.11 (16.01)	14.45**	37.6
	Slight	124,582 (71.1)	14.93 (15.31)		35.0
Having symptoms related to COVID-19	Yes	1,073 (0.6)	26.11 (20.66)	22.97**	60.2
	No	174,245 (99.4)*	15.20 (15.47)		35.6
Relative or friends having symptoms related to COVID-19	Yes	1,573 (0.9)	22.51 (18.93)	18.57**	53.5
	No	173,745 (99.1)*	15.21 (15.48)		35.6
Personality type	Extrovert	35,587 (20.3)	16.89 (16.21)	261.42**	39.5
	Ambivert	94,572 (53.9)	15.04 (15.22)		35.4
	Introvert	45,159 (25.8)	14.49 (15.52)		33.4
Exercise during the epidemic	Yes	127,735 (72.9)	15.30 (15.16)	1.105**	34.9
	No	47,583 (27.1)	15.20 (16.46)		36.1
Sleep time	<5 h	35,015 (20.0)	16.61 (17.00)	176.4**	39.0
	5–7 h	104,757 (59.8)	15.07 (14.78)		35.6
	8–10 h	35,546 (20.2)	14.56 (16.07)		33.0
Peer support	Yes	137,855 (78.6)	14.81 (14.92)	-23.72**	34.6
	No	37,463 (21.4)	16.96 (17.48)		40.0
Separate room	Yes	17,572 (10.0)	22.61 (18.43)	66.82**	52.5
	No	157,746 (90.0)	14.45 (14.95)		33.9
Family economic status	Good	29,802 (17.0)	15.42 (15.85)	5.89**	35.5
	Moderate	116,516 (66.5)	15.18 (15.32)		35.7
	Poor	29,000 (16.5)	15.48 (15.99)		36.2
Relationships with family	Good	167,431 (95.5)	14.91 (15.24)	1,191.34**	34.9
	Moderate	7,225 (4.1)	22.09 (18.27)		52.2
	Poor	662 (0.4)	33.04 (23.78)		67.2
Parental education	Senior high school and below	85,031 (48.5)	16.10 (15.82)	21.68**	38.1
	Junior college and above	90,287 (51.5)	14.49 (15.20)		33.6
Quarrels between parents during home quarantine	Yes	72,527 (41.4)	16.46 (16.04)	26.98**	39.0
	No	102,791 (58.6)	14.43 (15.09)		33.4
Overprotection from parents	Yes	24,054 (13.7)	21.02 (17.98)	62.76**	50.0
	No	151,264 (86.3)	14.36 (14.90)		33.5
Activities with parents	Yes	99,963 (57.0)	14.98 (15.03)	-9.14**	36.8
	No	75,355 (43.0)	15.66 (16.15)		34.9

* $P < 0.05$.** $P < 0.01$.

snowstorms (25). These unprecedented challenges have been reported to cause more than half of the participants (52.1%) feeling horrified and apprehensive (26), which may result in increased PTSS prevalence and high avoidance symptoms in our study. Therefore, to improve the adolescent's mental health status over the long term, there is a need to study how the pandemic itself prolonged and strict social distancing measures affect the PTSS of adolescents.

In our analysis, it is surprised to find that the family environment was the most important factor of the PTSS of

Chinese adolescents during the COVID-19 pandemic. Due to the home quarantine, adolescents will spend more time with families which will make the role of family factors become particularly important. Family environmental factors could be divided into objective factors and subjective factors. Family objective environmental factors basically are to point to family material condition environment (27), which include parental education and occupation, family structure, family economic status, etc. The family subjective factors include the relationship with families, parental relationship, parenting style,



communication with parents, etc. Subjective factors are mainly social environment within the family, which has been considered as an important factor regarding the PTSS of adolescents (28).

Among the family objective environmental factors, the strongest indicator of the PTSS was whether the adolescent has a separate room at home. We found that adolescents without separate rooms are associated with higher levels of PTSS. Anderson et al. illustrated that adolescents have more needs for privacy than younger children (29). During adolescence, the desire to seek personal independence and privacy protection increases (30). For adolescents without a separate room, it may be easier for parents or family members to take direct boundary invasion that includes interrogating, giving unsolicited advice, violating private space, and so forth. Due to COVID-19, adolescents spent more time at home with a lack of private time and space. In response, adolescents had to take defensive actions, such as evading or confronting, meanwhile, psychological pressure increases accordingly (31). This puts them at a much higher risk of developing PTSD. Although the independent room provides a certain “spatial distance” for adolescents and their parents, the generation of “spatial distance” also largely avoids the trivial collision and friction in daily life. It greatly improves the private family life and maintains the emotional exchange and support between the members of the extended family.

Compared with these objective factors, the subjective factors from the family in the study were found to be more important and controllable. The family subjective environmental factors

were a major factor in the prevalence of PTSS among Chinese adolescents. Poor relationship with family, overprotection from parents, parents arguing more, and no joint activities with parents were associated with higher levels of PTSS. It was found that adolescents with poor family relationships are more prone to PTSS. The evidence summarized in Klein’s paper indicated that the nature and quality of relationships with family members matter profoundly for all adolescents, and perhaps uniquely for adolescents who experience traumatic events (32). Keeshin and Strawn study also suggested that good parent–child relationships are beneficial for reducing PTSD in adolescents (33). These strongly support our conclusions. It is no doubt that adolescents who have a good relationship with their families tend to have more support from their families. Family support is crucial for adolescents who stay in isolation. Anna’s study proved that family support, such as love, care, and attention, is important and beneficial for all adolescent victims of disasters (33). However, low cohesion families usually were reluctant to offer help and support. Individuals from these families will increase the likelihood to suffer PTSD because they are more likely feeling completely alone when they face stress. Due to China’s unique one-child policy, the current structure of most adolescents’ families is composed of parents and only child. This allows parents to put more attention and expectation on the only child, which leads to excessive protection from parents. Moreover, parental overprotection is particularly important for the prevalence of PTSS in adolescents based on regression results. It has been reported that overprotection from parents in combination with higher levels of exposure to trauma was associated with the highest levels of PTSD symptoms among adolescent victims of disaster (34). Another study has also pointed out that defects in parenting, such as overprotection by parents, a lack of warmth, and effective response, can easily lead to adverse cognitive patterns in children (35). These conclusions are consistent with our views. Such excessive protection may make children believe that they cannot control the occurrence or outcome of everything, aggravate their psychological burden of the epidemic situation, and maintain it for a long time, thus resulting in PTSS. As Hobfoll’s (1988) COR theory suggested that declines in the perceptions of increases in interpersonal negativity in the family (e.g., greater frequency of family quarrels) are losses in the family resources that determine adolescents’ experience of stress and its deleterious consequences (36). In our study, parental quarrels increased during the period of staying at home, and the increased conflict would increase the degree of PTSS of adolescents. A previous study has confirmed that adolescents with high parental quarrels showed higher levels of PTSD symptoms 2 years after the traumatic event (34). This is consistent with our findings. As a result of the home quarantine, adolescents’ parents spent more time at home than before. Strains on household expenses, fears about the epidemic, household chores, and inconsistencies in children’s education all come to the fore at home and lead to arguments between couples. Quarrels between parents cannot only directly affect adolescents’ immediate emotional problems, such as depression, anxiety, and hostility (37), but also indirectly cause chronic stress responses in adolescents through their perception of hostility and

TABLE 3 | Binary logistic regression: the risk and protect factors of PTSS.

Variables	<i>B</i>	<i>S.E.</i>	<i>Exp (B)</i>	95% C.I.for <i>EXP (B)</i>		<i>Tol</i>	<i>VIF</i>
				Lower	Upper		
Age	0.011	0.003	1.011**	1.005	1.017	0.995	1.005
Gender	0.185	0.010	1.203**	1.179	1.228	0.967	1.034
Residential areas	−0.071	0.011	0.931**	0.912	0.951	0.977	1.024
Situation of COVID-19 epidemic in residence	−0.083	0.011	0.921**	0.900	0.941	0.994	1.006
Symptoms related to COVID-19 during past 14 days	0.834	0.065	2.302**	2.028	2.612	0.992	1.008
Relatives or friends having symptoms related to COVID-19	0.653	0.052	1.922**	1.735	2.128	0.991	1.013
Personality type						0.968	1.033
Ambivert	−0.102	0.013	0.903**	0.880	0.927		
Introvert	−0.168	0.015	0.846**	0.821	0.871		
Exercise during the epidemic	0.058	0.012	1.060**	1.035	1.084	0.990	1.010
Peer support	−0.226	0.013	0.798**	0.779	0.818	0.955	1.047
Family economic status						0.966	1.036
General	0.080	0.014	1.083**	1.054	1.113		
Poor	0.102	0.018	1.107**	1.069	1.146		
Relationship with family						0.931	1.074
General	−0.363	0.089	0.696**	0.584	0.829		
Poor	−0.719	0.087	0.487**	0.411	0.577		
Sleep time						0.950	1.053
5–7 h	−0.040	0.013	0.961**	0.936	0.986		
8–10 h	−0.151	0.016	0.860**	0.833	0.888		
Separate room	−0.658	0.017	0.518**	0.501	0.535	0.943	1.037
Quarrels between parents during home quarantine	0.226	0.010	1.254**	1.229	1.280	0.954	1.048
Parental education	0.150	0.010	1.161**	1.138	1.185	0.972	1.028
Overprotection from parents	0.524	0.015	1.689**	1.640	1.738	0.900	1.111
Activities with parents	−0.108	0.011	0.897**	0.879	0.916	0.919	1.088
Constant	1.123	0.115	3.074				

***P* < 0.01.

quarrels between parents. In addition, joint activities with parents during the epidemic are the protective factors for adolescents' PTSS. Family activities, such as eating with family, watching TV, and doing household chores, are very helpful to enhance the overall family atmosphere (38). The overall family environment and atmosphere can greatly help adolescents to resist external traumatic stress events. Thus, adolescents and their families are encouraged to carry out beneficial family activities during segregation at home. It is conducive to enhance the emotional communication between parents and children and strengthen the psychological resilience of adolescents.

Based on the above analysis, some suggestions have been provided. First, during the epidemic, parents should give more family support to adolescents and adopt proper parenting methods. Adolescents need to be given enough trust and space to develop. In addition, parents were suggested to stick to the principles when it comes to educating the children and not control everything in the name of "love." While creating space for adolescents, they try to help them overcome negative emotions and maintain emotional stability. Moreover, when there are quarrels and differences between couples, to communicate in a timely manner, they face together and create a comfortable and peaceful family atmosphere for children.

Furthermore, adolescents were encouraged to actively maintain good communication with parents, consciously improve their mental resilience, and maintain a good family relationship.

Study Limitations

It is important to recognize the limitations of this survey. First of all, this survey is a cross-sectional study, and future prospective studies are needed to determine correlation and causation. Second, although the survey conducted online is suitable for rapid assessment, there may be some bias in the sample that reduces the ability of the results to be generalized. Finally, PTSSs were assessed through self-report questionnaires only, which may not be as accurate as face-to-face interviews to allow a diagnosis of clinically relevant disorders.

CONCLUSION

To the best of our knowledge, our study established the largest Chinese adolescent cohort to investigate the impacts of the COVID-19 pandemic on PTSS. The findings showed that there was a high prevalence of PTSS in adolescents during the pandemic. One interesting and important phenomenon was that the extents of PTSS in the slight and severe areas were almost

the same. The influencing factor analysis indicated that it was not only the epidemic itself, but also the personal characteristics, health behavior, and peer support which were associated with PTSS. Among these factors, the family environment factors took the strongest influence on PTSS prevalence, which included the subjective environmental factors, such as the poor family relationship and overprotection from parents, and the objective environmental factors, such as lack of private space. The results highlight that the parents should enhance the interaction with adolescents and give adolescents more respect to comfort them in prolonged isolation, meeting their needs for private spaces to minimize the PTSS of the COVID-19 pandemic on adolescents. Above all, our study can help to have a better understanding of how the epidemic affects adolescent's mental health and offered valuable strategies to ameliorate the PTSS caused by viral pandemics in adolescents.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of Harbin Medical University

(HMUIRB20200002). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

YY, DC, and SK conceived, designed the study, and interpreted the data. XY, JZ, and LS supervised the analysis, interpreted the data, and wrote the preliminary manuscript. TB, HC, and YW supervised the data collection by JY, WaW, JL, and WeW. LZ, ZQ, and XQ compiled the data. All authors contributed to the writing and review of the manuscript and approved the final version.

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