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The acute and long-term impact of COVID-19 on mental health of children and adolescents, 2nd Edition

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The acute and long-term impact of COVID-19 on mental health of children and adolescents, 2nd Edition

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Editorial: The acute and long-term impact of COVID-19 on mental health of children and adolescents

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KEYWORDS

children, adolescents, COVID-19, mental health, long COVID, depression

Editorial on the Research Topic
The acute and long-term impact of COVID-19 on mental health of children and adolescents

The COVID-19 epidemic has dramatically paralyzed the world, which has also caused mental health problems among the public, especially vulnerable groups like children and adolescents. As a traumatic event, the outbreak of COVID-19 might increase the prevalence of a series of mental health problems in children and adolescents probably due to social distancing, school closures, as well as separation from parents and home quarantine (1). It is also noticed that COVID-19 patients may experience long-term post-acute COVID-19 symptoms, or long COVID, which describes a wide range of persistent neurological and neuropsychiatric symptoms developed during or following an infection, including cognitive impairments, depression, and anxiety (2).

In this regard, analyzing the impact of COVID-19 on mental health of children and adolescents from both the acute and long-term perspective is of great significance (3). On the one hand, children and youth are often politically neglected because they seem less likely to be infected early in the pandemic, leaving a less important burden of acute COVID-19; On the other hand, children and adolescents are in critical periods of neurodevelopment and once they develop mental health problems, the long-lasting negative influence might span across their lifetime.

The goal of this edition of Research Topic is mainly to highlight the mental health problem, substance use disorders, deviant behaviors and cognition impairment of children and adolescents during the COVID-19 pandemic, as well as related risk factors. Furthermore, we also aim to illustrate the persistent neurological, neuropsychiatric, and neurodevelopmental complication or sequelae among the pediatric COVID-19 survivors. Finally, we want to investigate effective and affordable interventions, especially online interventions, of mental health disorders of children and adolescents related to the COVID-19 outbreak.

These aims were addressed by a total of 18 studies, 3 of which reviewed life change and mental health problems caused by COVID-19 pandemic in children and adolescents. Guo et al. analyzed 5,594 relevant literatures, identifying mental health and life change as prominent themes. The findings provide valuable insights into trends and gaps, serving as a reference for future research, decision-making, and systematic reviews. Additionally, the study by Han et al. highlights the increased risk of gaming disorder during social isolation, emphasizing the need for mental health providers to educate children, adolescents, and parents about healthy stress relief alternatives and effective parental control measures.

Ng and Ng revealed that children from low socioeconomic status families, with parents having low educational attainment and living in small homes, are more vulnerable to mental health problems. Protective factors, including parents' resilience, positive parent-child relationships, and school connectedness, should be emphasized. By understanding and applying the findings and recommendations from these studies, policymakers, healthcare providers, educators, and parents can collaborate to develop effective interventions and support mechanisms to safeguard the mental wellbeing of children and adolescents during and beyond the COVID-19 pandemic.

Several research articles in our topic have shed light on the mental and psychological challenges encountered by children and adolescents. Shi et al. conducted a web-based survey and discovered that anxiety and sleep disturbances significantly improved after quarantine, while depression showed no alleviation. They also found bidirectional relationships between anxiety, depression, and sleep disturbance, with depression and sleep disturbances predicting post-quarantine mental health issues. In a cross-sectional online survey study, Nin et al. identified two clusters with varying stress levels, linked to differences in personality traits, quality of life, depression, and anxiety. Neuroticism was identified as a risk factor, while extraversion acted as a protective factor against pandemic-related stress. This study introduced a taxonomy of factors that influence stress sensitivity, providing indicators of psychological distress and quality of life during the pandemic.

Apart from cross-sectional study, longitudinal research by Martinsone et al. examined the impact of the pandemic on adolescents' mental health over time. They found that changes in social emotional skills were associated with changes in mental health outcomes, emphasizing the importance of addressing social emotional learning to enhance resilience and wellbeing. Additionally, Maouch et al. investigated the effects of disrupted activity systems on mental wellbeing. They discovered significant associations between activity system components and PTSD, reflective function, and schizotypal traits. The study highlighted how the disturbance of life narratives during the pandemic can significantly impact mental health. Collectively, these studies provide valuable insights into the mental and psychological problems encountered by children and adolescents.

Several studies have focused exclusively on depression symptoms precipitated by the pandemic in children and adolescents. A recent study has emphasized the perturbing rates of depression and its relationship with self-efficacy in Iranian children during the COVID-19 outbreak (Zakeri et al.). The research involved 321 children and utilized the Children's Depression Inventory (CDI) and Self-Efficacy Questionnaire for Children (SEQ-C). Interestingly, while no overall significant correlation was found between depression and self-efficacy, subscales of the CDI including negative mood, ineffectiveness, and negative self-esteem had a significant relationship with self-efficacy. Furthermore, family income, risk of coronavirus infection, effectiveness of preventive measures, and the source of information about the coronavirus disease were found to have a substantial association with depression rates.

Another study conducted among university students in Hong Kong highlighted the need for further investigation into the determinants and mitigating factors of depression within this demographic. The study, which utilized the Center for Epidemiologic Studies Depression Scale Revised (CESD-R) to assess depressive symptoms in 1,648 students, found a substantial 48.4% prevalence of "at-risk" scores for clinical depression (Shek et al.). Socio-demographic factors including age, gender, student status, and financial hardship were identified as significant correlates of depressive symptoms. Additionally, the study investigated the role of need satisfaction and positive youth development (PYD) attributes, such as resilience, emotional competence, and family functioning, in predicting depression rates. These factors were found to negatively predict depression, with all PYD attributes demonstrating a moderating effect on the predictive impact of need satisfaction on depression. The results above underline the importance of comprehensive intervention strategies and research efforts to mitigate and prevent depression among children, particularly in the context of global health crises.

It is noteworthy that the psychological distress of this era has been exacerbated by certain aspects of media engagement. A compelling investigation into media's influence on PTSD symptoms among college students revealed that the media content itself, rather than the source, significantly impacted the students' mental health (Zhu et al.). Positive media content correlated negatively with PTSD symptoms, emphasizing the role of constructive narratives in mental health resilience. Concurrently, students afflicted with PTSD symptoms displayed a reduced willingness to engage in efficient online learning, hinting at potential educational setbacks caused by the intersection of media exposure, information overload, and mental health disorders.

A natural experiment in Switzerland further expounded on this by illuminating the long-term consequences of increased screen time on adolescents' mental health during the lockdown (Marciano et al.). The study found that most mental health problems, including anxiety, depression, and inattention, escalated over time with a medium effect size. Interestingly, an increase in time spent on social media was significantly associated with deteriorating mental health, while more structured media activities, such as television viewing, was likely to mitigate levels of inattention and anxiety. These studies underscore the intricate and nuanced impact of media exposure on young minds, thereby prompting a pressing need for further studies on effective media practices during public health crises to safeguard the mental health of future generations.

Building upon the exploration of media exposure's effects on children and adolescents' mental health, it becomes imperative to delve into the grave subject of suicide among this population

during the COVID-19 pandemic. A nationwide survey in South Korea, utilizing nomogram techniques with a sample size of 54,948 adolescents, developed a model to identify cohorts vulnerable to suicidal ideation in the pandemic's aftermath (Byeon). The findings identified 8th graders with recent experiences of depression, heightened subjective stress, loneliness, decreased household economic status, and poor academic performance as particularly susceptible to suicidal ideation amid the COVID-19 crisis. The impressive precision of the prediction model, developed using logistic regression and Extreme Gradient Boosting (XGBoost), accentuates the urgency to acknowledge the severity of adolescent suicide and mental health in the wake of the pandemic. It further emphasizes the necessity for implementing customized support systems at community and school levels.

Another investigation resonated with these findings, demonstrating an escalation in the incidence of Slovene youth necessitating urgent psychiatric intervention due to suicidal ideation and attempts, specifically during the period of the COVID-19 pandemic (Kirič et al.). Upon analysis, the increase did not seem to align directly with periods of school closure, but instead exhibited a stronger correlation with the overall duration of the pandemic. The study stressed the importance for medical personnel to readily interpret these probabilities, thereby enabling the identification of children and adolescents at heightened risk. The results reiterate the paramount importance of a comprehensive support system, specifically advocating for characteristics that accommodate the unique needs of those individuals at an elevated risk of suicide amid the health crisis.

Finally, in the context of COVID-19, the critical role of anxiety as an intermediary between impulsivity and suicidal ideation among patients with major depressive disorder (MDD) is examined. Given the common co-occurrence of anxiety symptoms with depression, the exploration of its impact on suicidal ideation from the perspective of impulsivity becomes a priority. Findings from a study revealed that major depressive disorder (MDD) patients with high suicidal ideation exhibited more trait anxiety, albeit no discernible differences were found in state anxiety and impulsivity when compared to those with low suicidal ideation (Cheng et al.). Intriguingly, trait anxiety was found to mediate fully between impulsivity and suicidal ideation. This emphasizes the need for heightened attention toward MDD patients with anxiety symptoms, serving as a potent prevention and intervention measure against suicidality.

The COVID-19 pandemic has also caused long-term psychological effects on the youth. The study by Liao et al. provides evidence of the significant prolonged psychological burden among Chinese undergraduate medical students caused by the pandemic. They conducted a longitudinal survey, tracking the mental burden changes among 863 Chinese undergraduate medical students before, during, and after the outbreak. The findings revealed an increase in the prevalence of overall mental burden from 27.46 to 37.28% after the COVID-19 outbreak. Specifically, the prevalence of stress reaction symptoms decreased (from 10.90 to 3.60%), while the rates of psychological distress (from 28.06 to 37.95%) and insomnia symptoms (from 12.54 to 20.71%) increased. The study also identified several risk factors, such as obsessive-compulsive symptoms, somatic symptoms, internet addiction, childhood adversity, stressful life events, and neuroticism, which were associated with a higher risk of developing mental health problems. Conversely, healthy family function and extraversion were found to have a positive impact on mental burden.

Similarly, the study by Wei et al. highlights the ongoing impact on the mental health of first-year college students who encountered more challenges and suffer more mental health problems in the post-COVID-19 era. The research, based on the study demands-resources (SD-R) model, examined the effects of time pressure, perceived social support, emotional exhaustion, and student engagement on mental health. The findings revealed that time pressure and perceived social support were key factors influencing the mental health of first-year college students in the post-COVID-19 era. These findings emphasize the need for continued mental health care for students, even after the COVID-19 outbreak, particularly for those exhibiting persistent or worsening symptoms.

In the face of increasing psychological issues among children and adolescents especially the post-acute COVID-19 syndrome, it is crucial to develop effective strategies to help them overcome these challenges. A study conducted by Wu et al. examined the relationship between self-efficacy, self-disclosure, and coping strategies among 585 patients with moderate to severe depression, aged 11 to 24. The findings suggested that encouraging self-disclosure and sharing emotions and concerns significantly reduced their psychological stress. Additionally, fostering their self-efficacy, belief in their ability to cope with difficulties and challenges, facilitated their selection of proactive coping strategies. Furthermore, providing online physical activity programs, such as High-Intensity Interval Training (HIIT), proved to be an effective intervention in improving mental health and emotional wellbeing, as discussed in Philippot et al.'s study on the impact of an online HIIT program on clinical psychological symptoms among higher education students. The study revealed significant improvements in clinical stress and depressive symptoms among students who participated in a four-week online HIIT program during the COVID-19 pandemic. Therefore, by integrating these strategies, we can better assist children and adolescents in dealing with psychological issues and promoting their healthy neurodevelopment.

In conclusion, the COVID-19 pandemic has had both acute and long-term psychological impact on children and adolescents. They have experienced increased loneliness, anxiety, and depression due to prolonged social isolation and restrictions. Additionally, the disruption to their education and development may lead to learning difficulties and future mental health problems. Though the COVID-19 pandemic has presented unprecedented challenges, it has also opened up an opportunity to prioritize and enhance mental health support for young individuals. We hope our Research Topic could raise attention of the public on mental health problems of children and adolescents caused by the pandemic and provide continuous support and care to help them navigate through these challenging times.

Author contributions

KY: Conceptualization, Writing—original draft. YB: Writing—review and editing. YL: Conceptualization, Writing—review and editing. XL: Conceptualization, Writing—review and editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Suicidal Behavior in Emergency Child and Adolescent Psychiatric Service Users Before and During the 16 Months of the COVID-19 Pandemic

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Background: Slovenia is among the countries with the highest suicide rates in the world. The COVID-19 pandemic has had a significant impact on the mental health of children and adolescents. Our hypothesis is that the school closure during the pandemic with a gradual transfer to virtual schooling had an important impact on children's and adolescents' suicidal behavior. Therefore, we aimed to determine possible changes in the frequency of assessments as well as frequency and severity of suicidal behavior in the population of Slovene children and adolescents seeking emergency psychiatric help in correlation with the progression of the pandemic and online schooling.

Methods: We performed a retrospective observational analysis of medical records of all children and adolescents referred to the only 24-h emergency in- and outpatient child and adolescent psychiatry service in Slovenia from March 2019 through the end of July 2021. We extracted number of assessments, number of patients with suicidal ideation and with attempted suicide. A comparison between the same periods prior to the pandemic and during the pandemic was made. The months of school closure due to the COVID-19 restriction measures and the months without closures were also compared.

Results: During this period, 1966 children and adolescents were assessed. There was no statistically significant difference in the observed frequency of emergency visits when we compared all the months with to all the months without school closures, or when individual corresponding months with and without school closures were compared. However, there were statistically significantly more patients with suicidal ideation [$t(16) = -2.739$, $p = 0.015$; $W = 25.0$, $p = 0.016$] and patients who had attempted suicide [$t(16) = -3.412$, $p = 0.004$; $W = 14.5$, $p = 0.006$] during the pandemic as individually compared to the corresponding pre-pandemic months.

Conclusions: Our results show that the number of Slovene children and adolescents who required emergency psychiatric help with suicidality and attempted suicide increased during the COVID-19 pandemic. The increase was shown only after the first year of the pandemic. The observed increase did not appear to directly correspond to the school closures, but was more likely related to the duration of the pandemic.

Keywords: COVID-19, pandemic (COVID-19), suicidal thoughts and behavior (STB), attempted suicide, emergency psychiatric service, child and adolescent

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INTRODUCTION

The new coronavirus outbreak, declared as an epidemic by the World Health Organization on March 11, 2020, considerably changed the lives of the population (1). Many countries soon undertook measures to limit the spread of the disease, including recommendations for staying at home, closing schools, and social distancing, which significantly affected the mental health of children and adolescents (2).

A review, published in August 2020, examined the impact of the pandemic on the mental health of children and adolescents. Increased fear of infection and clinginess were found in younger children. Changes in routines, uncertainty and anxiety related to disruption in their education were seen in adolescents, as well as hoarding behavior, increased use of the internet, and limited ability to report violence and abuse. Children with special needs, neurodevelopmental difficulties or underprivileged youth were more vulnerable (3). On the other hand, a study by Penner et al. showed significant reduction in internalizing, attention, externalizing, and total mental health problems 1 month after school closures and start of virtual schooling in a predominantly racial and ethnic minority groups sample, who had had elevated levels of mental health problems before the pandemic. For some groups, this points to protective aspects of stay-at-home measures. Increased family time, decreased peer and academic stressors, community factors, more flexible routines at home, and the timeline of the conducted research were identified as possible protective factors (4). In October and November 2020, the Centers for Disease Control and Prevention (CDC) in the United States examined the differences in child and parent indicators of well-being according to the child's mode of schooling. Negative indicators were reported to a greater extent by parents of children receiving virtual or combined instruction than parents whose children received in-person instruction. Parents of the first group more frequently reported that their child's mental or emotional health worsened and that they spent less time outside, in-person with friends, or being physically active (5). A survey published in September 2021 found worse mental health outcomes in older children and children of low-income families that attended school remotely than those who attended school in person. Younger children who attended school remotely had comparable or slightly better mental health outcomes than those who attended school in person (6).

The COVID-19 pandemic affected child and adolescent psychiatry services as well. There was a decrease in the number of outpatient visits and hospital admissions reported in the longitudinal survey by European Society for Child and Adolescent Psychiatry (ESCAP) in 22 European countries at the beginning of the pandemic in March and April 2020. At that time, the overall perception of COVID-19 crisis was perceived as ≫medium≪. Almost a year later, in February and March 2021, the perceived impact increased to ≫strong≪ or ≫extreme≪, and there was also a substantial increase in referrals or requests for assessments. The impact on psychopathology appeared substantially more marked during the second phase of the study, particularly for anxiety disorders, major depressive episodes, eating disorders and suicidal crises (7). Similarly, a study by Fitzpatrick et al. reported high levels of perceived need for mental health services by children/adolescents and their caregivers. Raised levels of mental health symptoms in caregivers and children/adolescents with both internalizing and externalizing symptoms were observed (2).

So far, the reported data on suicidal behavior is showing mixed results. In Japan, suicide rates among children and adolescents (up to 20 years old) were not significantly affected during the first wave of the pandemic (8). In a French study, Mourouvaye et al. found a 50% decrease in the incidence of suicidal behavior in children and adolescents during the COVID-19 lockdown between March and May 2020. This was attributed to reduced help-seeking and a global decrease in hospital admission rates, as well as environmental and cognitive factors (9). On the other hand, Hill et al. found higher positive screen results for recent suicide attempts in a pediatric emergency department (ED) in February, March, April and July 2020, compared to the same months in the previous year. The results were not uniformly higher after the outbreak, which could be related to the time course of the pandemic and the generally reduced rate of ED visits, with elevated numbers of cases of suicidal ideation or attempts due to the increased overall severity of cases (10). A study of hospitalized adolescents, aged 11–18 years, found elevated rates of suicidal ideation and suicidal attempts during the pandemic as well, compared to the data from the same months in a year before (11). A large recent retrospective Swiss chart review study, reporting on emergency child and adolescent psychiatry assessments and hospitalizations, reported an initial drop of in-person assessments and hospitalizations during the first wave of the epidemic, only to observe a progressive rise from the end of the 2020 summer holidays until the end of June 2021 (the end of the study). Similar was observed for suicidal ideation and self-harm behaviors. They reported a slight drop in the number of outpatient assessments of patients with suicidal ideation and self-harm in March and April 2020 as compared to 2019, however they observed a twofold rise in the same 2 months in 2021 (12).

Slovenia is a country with traditionally high suicide rate. A 1999 study including 4706 Slovene high-school students reported, that by the age of 19 years 10% had had attempted suicide and 44% had experienced suicide ideation. When compared to the Dutch population, Slovene prevalences were more than three times higher for attempted suicide and twice as high for suicidal ideation (13). Similar prevalences of attempted suicide and suicidal ideation as in 1999 were subsequently reported on a smaller sample of Slovene high-school students in 2009 (14). However, these behaviors were only studied in the general population. Up to now, no study reported the prevalence of suicidal behaviors (ideation or attempts) in Slovene in- or outpatient emergency child and adolescent psychiatric service users.

Slovenia declared the COVID-19 epidemic on March 12, 2020 (15). The mode of school instruction in the remainder of the school year and during the subsequent school year varied from in-person to virtual schooling (as well as alternating both modes), depending on the epidemic progression, the restrictive measures issued, and the students' age group (16, 17). From the end of

2020 until the end of 2021 the Slovenian National Institute for Public Health conducted several surveys on adults that reported a decrease in perceived mental health, which was disproportionally severe for the younger population (aged 18–29 years) (18).

There was no research however, on the impact of the COVID-19 pandemic on the most endangering mental health symptoms in Slovene children and adolescents so far. The present study aimed to determine possible changes in the frequency of assessments and admissions and severity of suicidal behaviors in the population of Slovene children and adolescents seeking emergency psychiatric services.

METHODS

Sample

We performed a retrospective observational analysis of medical records of all the children and adolescents referred to the only 24-h emergency in- and outpatient child and adolescent psychiatry service in Slovenia from March 2019 to the end of July 2021.

Setting

Emergency child and adolescent psychiatric help in Slovenia is organized in three distinct centers in two separate geographic parts of the country. The first two centers offer assessments during working h (Monday-Friday, 8–15 h). The third, located in the University Psychiatric Clinic Ljubljana, offers emergency outpatient assessments in a clinic attached to the only Slovene Intensive Child and Adolescent Psychiatry Unit. As such it offers assessment and treatment by a child and adolescent psychiatrist 24/7 for the entire country and provides more than 50% of emergency outpatient and inpatient treatments (19). Children and adolescents aged 0–19 years are referred for assessment by their pediatrician or other emergency doctor, however, they can be examined by self or parents' referral as well.

All the data was extracted from the written and electronic medical records. The number of emergency outpatient assessments and admissions was recorded separately for each month from March 2019 until September 2021. For all the patients assessed or admitted from March 2019 until the end of July 2021 the medical history reports and mental state examinations were examined for age, gender, suicidal ideation at assessment, past and recent attempted suicide (as a reason for referral). Suicidal ideation, and current and past attempted suicides are routinely screened for in every psychiatric examination and recorded in the patients' medical history. Suicidal ideation was recorded as present when the patient reported he/she wished they were dead, thought or planned about killing themselves. A current attempted suicide was recorded when the patient was assessed after a recent self-inflicted action made with an intent of dying (regardless of the chosen method) or after something or somebody interrupted such an event. A past attempted suicide was recorded if a patient reported one or more attempts or interrupted attempts in the past.

The study was approved by the Ethical Review Board of the University Psychiatric Clinic Ljubljana in 2021.

The Schedule of Regular and Pandemic School Closures

A school closure with a gradual transfer to virtual schooling for children and adolescents began on March 16th and lasted until May 18th, 2020, when children aged 6–9 years and high school seniors (18 years old) returned to in-person schooling, or until May 25th when all other primary and secondary school children returned to school (16). In the subsequent school year, the schools were closed and provided online instructions from October 26th, 2020 until January 25th, 2021 for 6–9-year-olds and until February 15th, 2021 for the rest of the children and adolescents. Adolescents attending high school were schooled online from October 10th–February 15th, 2021, when seniors returned to in-person schooling, while others took bi-weekly turns (alternating between in-person and online schooling) until May 17th, 2021. For a brief period of time, between April 1–11th, 2021, all children and adolescents returned to online schooling (17).

The regular school holidays in Slovenia are as follows: October 26th–November 1st, December 25th–January 2nd, February (1 week, varies each year), April 27th–May 2nd and June 25th–September 1st (20).

Statistical Analysis

Analyses were performed in the statistical package IBM® SPSS® Statistics Version 28.0.0.0 (© IBM Corporation and its licensors 1989, 2021), and $\alpha = 0.05$ level of significance was used.

The descriptive comparisons between genders were made using independent samples *t*-test (continuous variables) and Pearson chi-square or Fisher's exact test predictor (categorical variables).

Two independent samples comparisons were conducted between the months where the schools were closed due to the COVID-19 restriction measures for at least 1 day and the months without closures.

The parametric independent samples *t*-test and the non-parametric Mann-Whitney U test were used. The comparisons were made for the total number of all emergency patients and separately for admitted patients, outpatients, patients who were suicidal at the assessment, and those who were assessed after attempting suicide.

The same months were also compared in pairs with the paired samples *t*-test and Wilcoxon signed-rank test: months during COVID-19 pandemic (from March 2020) vs. the same months before the COVID-19 epidemic (through February 2020). As the available data was from March 2019 up to July 2021 (for number of emergency admissions, outpatient assessments and combined emergencies, including September 2021), only exactly 1 year of COVID-19-free months was available. This means that both March 2020 and March 2021 were individually compared to the only March before COVID-19 (March 2019). School closure played no role in this last analysis.

RESULTS

During this period, 1966 children and adolescents were assessed; more than 99.9 % of the participants were white European. All

TABLE 1 | Descriptive statistics of all the consecutive patients assessed as outpatients and admitted to the hospital from March 1st 2019 until July 31st 2021.

	Female	Male	All	*p*
Number of patients	1362 (69.3)	604 (30.7)	1966	
Age (years ± SD)	16.30 ± 1.53	16.21 ± 2.10	16.28 ± 1.72 (min 6.9, max 25.2*)	0.391
Emergency outpatient	894 (68.7)	407 (31.3)	1301	0.450
Emergency inpatient	468 (70.4)	197 (29.6)	665	
Attempted suicide before assessment[a]	178 (13.1)	49 (8.1)	227 (11.7)	**0.003**
Suicidal at assessment[b]	834 (61.2)	237 (39.2)	1071 (54.5)	**<0.001**
Ever attempted suicide[c]	471 (35.2)	99 (16.6)	570 (29.5)	**<0.001**
Never attempted suicide[c]	866 (64.8)	498 (83.4)	1364 (70.5)	**<0.001**
Attempted suicide only in the past[a]	368 (27.0)	64 (10.6)	432 (22.0)	**<0.001**

*Data are presented as n (%) unless stated otherwise. The statistics used were χ^2 and Student's t-test; bold means the differences are statistically significant. Number of missing data, [a]31 cases; [b]29 cases; [c]32 cases. *The emergency out- and inpatient services provide for the patients up to the age of 19 years. In only one case (aged 25.2 years) an exception was made upon a decision of an extended medical board to arrange a specific type of emergency treatment in a secure child and adolescent psychiatric hospital department.*

the assessed suicidal behavior was statistically significantly more frequent in females than males (**Table 1**).

There were no statistically significant differences in any of the observed frequencies when months with and without school closures were compared, nor when comparing individual corresponding months with and without school closures (**Figure 1**).

However, there were statistically significantly more patients with suicidal ideation [$t(16) = -2.739$, $p = 0.015$; W = 25.0, $p = 0.016$] and attempted suicide [$t(16) = -3.412$, $p = 0.004$; W = 14.5, $p = 0.006$] during the pandemic as individually compared to the corresponding pre-pandemic months (**Figure 1**, **Tables 2**, **3**).

DISCUSSION

This is a retrospective chart review study aiming to determine possible changes in the frequency of emergency assessments, and frequency and severity of suicidal behavior in the population of Slovene children and adolescents seeking emergency psychiatric services during the COVID-19 pandemic.

Even though we weren't able to show (however perceived) an increase in all emergencies, our results show that the number of children and adolescents who required emergency psychiatric help for suicidality and attempted suicide in the only 24-h emergency child and adolescent psychiatric service in Slovenia significantly increased during the COVID-19 pandemic compared to the pre-pandemic months. After a small decline, the increase was shown only after the first year of the pandemic, which corresponds with the results of previous studies (21–23). Similar to other reports, the trend of increasing frequency of emergency visits due to suicidality persisted as the pandemic progressed (21). An initial decline during the first wave of the pandemic is a result similar to the reports from Japan, France and Switzerland (8, 9, 12, 24). To point out a recent study from Zurich, similar to our results, noted a brief decline in the emergency consultations in the initial 2 months of the first lockdown and a stable increase of consultations and frequency of patients with suicidality and self-harm from August 2020 onward (12). Thus, the increase in suicidality did not seem to directly correspond to the school closures but more likely to the duration of the pandemic. It is important to note, that the overall number of visits to their emergency child and adolescent psychiatry service increased as well, even though all the other child and adolescent mental health services were operating at least on-line after the first wave (7, 12).

Similar to other studies on adolescent suicidal behavior and psychiatric service use (12–14), our results confirmed that the observed behaviors were more frequent in females.

As the COVID-19 pandemic continued, potential social, economic and health stressors increased, thus contributing to psychological distress, and together increasing the risk factors for self-harm. Young females are a group that can be particularly affected due to social isolation, leading to a higher level of loneliness, anxiety and stress. Adolescents generally have a weaker ability to cope with stressful situations than adults and are prone to react impulsively and emotionally. As a result, pandemic-related distress can lead to increased suicidal behavior and a generally increased number of referrals for assessments in this age group (12). During the pandemic lockdowns, many adolescents spent even more time on social media platforms. Even though one is not allowed to share content depicting, promoting, normalizing or encouraging others to partake in dangerous activities that may lead to serious injury or death, these types of materials (e.g., comments, pictures, videos) are still posted, providing fodder for adolescent imitative behavior and influencing suicidal behavior (25).

During the first wave of the lockdowns, academic pressures might have been reduced due to virtual schooling and general expectations for a close end to the pandemic. Students were able to spend more time on schoolwork while simultaneously perceiving lower academic demands, including decreased numbers of officially required school assessments. Most parents were at home at least partially due to the general public lockdown and able to provide help, support, encouragement and structure. In the subsequent pandemic waves, the hybrid

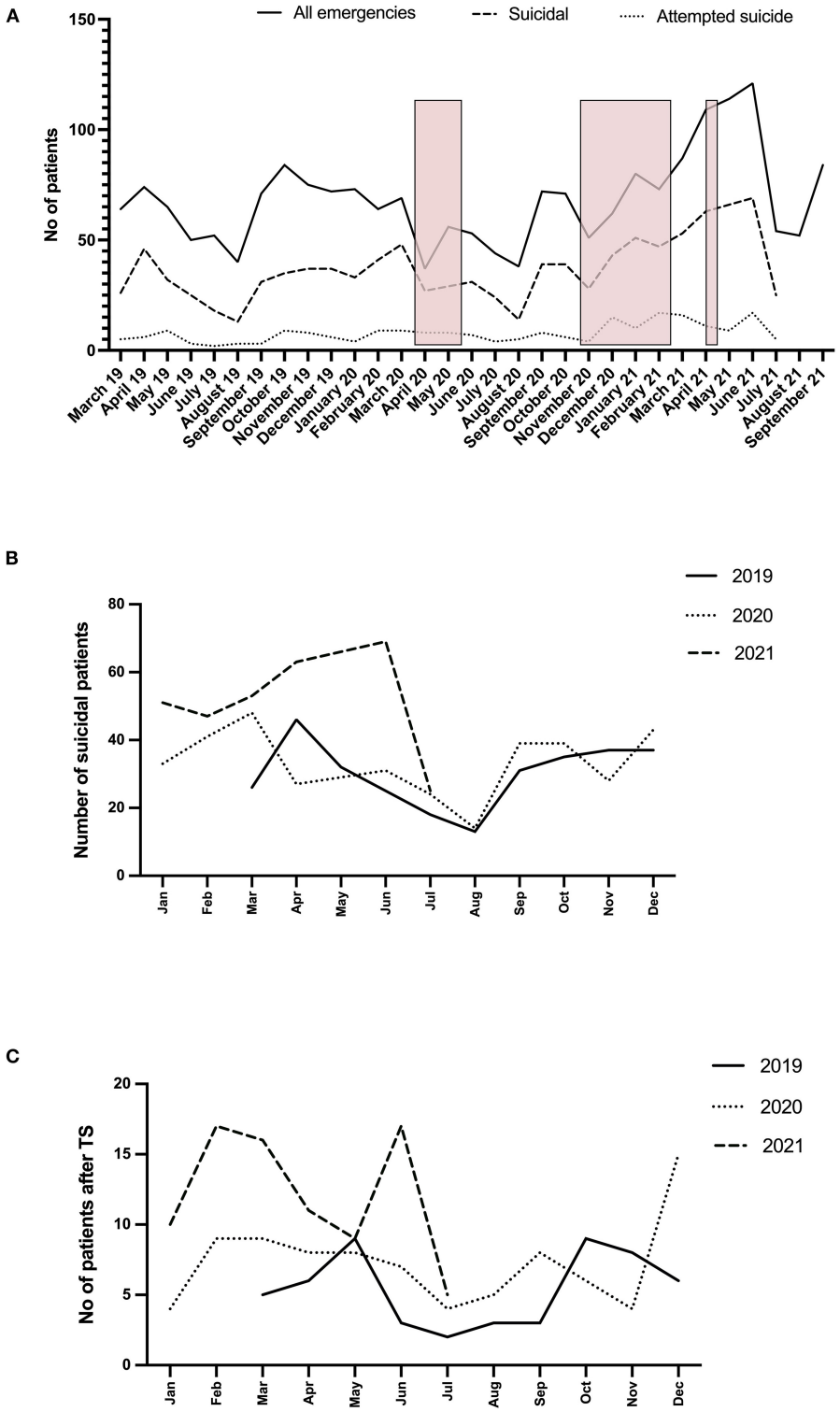

FIGURE 1 | Time course of monthly emergency service assessments (outpatient and inpatient) from the beginning of March 2019 until the end of July 2021. **(A)** The number of all the assessed patients (through the end of September 2021), suicidal patients (suicidal ideation + attempted suicide) and patients after attempted suicides for given months. The pink squares represent the months with school closures due to the pandemic restriction measures. **(B)** Comparison of the number of suicidal patients (suicidal ideation + attempted suicide) for the comparative months over three consecutive years – before and during the COVID-19 pandemic. **(C)** Comparison of the number of patients assessed after attempting suicide (TS) for the comparative months over three consecutive years – before and during the COVID-19 pandemic.

TABLE 2 | Comparison of the number of suicidal patients (with suicidal ideation or after attempting suicide) on individual corresponding months during the years 2019, 2020, and 2021.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2019			26	46	32	25	18	13	31	35	37	37
2020	33	41	48	27	29	31	24	14	39	39	28	43
2021	51	47	53	63	66	69	26					

The available data are from March 2019 until July 2021. Missing data for 29 cases out of 1966 of all the assessed patients in the observed period (suicidal and non-suicidal).

TABLE 3 | Comparison of the number of patients after attempted suicides on individual corresponding months during the years 2019, 2020 and 2021.

	Jan	Feb	Mar	Apr	Maj	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2019			5	6	9	3	2	3	3	9	8	6
2020	4	9	9	8	8	7	4	5	8	6	4	15
2021	10	17	16	11	9	17	6					

The available data are from March 2019 until July 2021. Missing data for 31 cases out of 1966 of all the assessed patients in the observed period (suicidal and non-suicidal).

model of schooling was established and the perceived school demands increased along with increased demands on their parents due to work and/or potential economic instability. Stress related to studies, grades, and difficulties in attending online classes due to inadequate technical or adult support is likely one of the important risk factors contributing to increased adolescent suicidal behavior during the COVID-19 pandemic (23). However, the present study was not able to test those assumptions.

Our study had several limitations. The data was collected in only one emergency child and adolescent psychiatry unit in the country. While the service itself covers the majority of the country's emergency assessments and admissions, the remaining two units were not included in the study. Therefore, caution is needed in generalizing from the presented data to other emergency child and adolescent psychiatry services or to the general population. As this was a retrospective observational analysis, we weren't able to assess and control for multiple factors influencing suicidal behavior in adolescents. This, however, was not the aim of the present study.

Our results show that the number of children and adolescents who required emergency psychiatric help for suicidal behaviors in the only 24-h emergency child and adolescent psychiatric service in Slovenia increased during the COVID-19 pandemic. The increase was shown only after a year of the pandemic and did not seem to directly correspond to the school closures. Longitudinal studies are needed to better understand the long-term consequences of the pandemic on adolescent suicidality and 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 Ethical Review Board of the University Psychiatric Clinic Ljubljana. 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

MDR designed and conceived the study, analyzed, presented and interpreted the data, had full access to all the data in the study, and takes responsibility for the integrity of the data and the accuracy of the data analysis. BK, LLN, PL, and MDR were involved in the acquisition and interpretation of data. The first draft of the paper was written by BK and MDR. All the authors contributed to and approved the final version of the manuscript.

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First-Year College Students' Mental Health in the Post-COVID-19 Era in Guangxi, China: A Study Demands-Resources Model Perspective

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The post-COVID-19 era means that the COVID-19 is basically under control; however, the risk of the pandemic still affects people's work, study, and life, physically and psychologically. In this era, due to the more challenges first-year college students face, more attention should be paid to their mental health. An emerging study demands-resources (SD-R) model can explain the influencing mechanism of college students' mental health. This model suggests that study demands increase the risk of student burnout, which results in mental health problems; meanwhile, study resources reduce student burnout and increase student engagement, thus improving mental health. Based on the SD-R model, this study explores the impacts of time pressure, emotional exhaustion, perceived social support, and student engagement on mental health and provides adequate measures to reduce the risk of mental health problems among first-year students. Time pressure, perceived social support, emotional exhaustion, student engagement, and mental health scales were used to investigate 537 first-year students at three universities in Guangxi, China, of whom 290 (54%) were female, and 247 (46%) were male, and the average age was 18.97 ± 1.01. Results indicated that: (1) Moderate scores on time pressure and emotional exhaustion and slightly-above-the-median scores on perceived social support, student engagement, and mental health were found among first-year students in the post-COVID-19 era. (2) Time pressure had a positive relationship with emotional exhaustion and a negative relationship with mental health. (3) Perceived social support was negatively correlated with emotional exhaustion but positively correlated with student engagement, and thus improved mental health. Results of this study with a sample of first-year college students in China support the hypotheses based on the SD-R model. These findings suggest that increasing perceived social support and student engagement while decreasing time pressure and emotional exhaustion may promote mental health among first-year college students.

Keywords: time pressure, perceived social support, emotional exhaustion, student engagement, mental health, first-year college students

INTRODUCTION

Since 19 April 2020, China has been in a post- COVID-19 era. The post- COVID-19 era means that the COVID-19 is basically under control; however, the risk of the pandemic still affects people's work, study, and life, physically and psychologically. COVID-19 is a crucial public health issue that may lead to considerable mental health problems (1), and COVID-19-related factors are associated with long-term mental health symptoms among the general public (2). Moreover, studies on college students' mental health have been mounting steadily during and since COVID-19. For example, it was revealed that college students were at high risk of developing mental health issues during the pandemic (3), and 6 months after the COVID-19 outbreak, the risk of mental health problems and suicidal thoughts among students was relatively high (4).

Studies show that first-year college students are expected to manage their study time on their own (5), build new relationships, and change their learning styles (6). They experience interpersonal difficulties (7), academic pressure (8, 9), and other practical problems. As a result, they may face more challenges and suffer more mental health issues (6). Dropping out often occurs in the first year (10) and first-year college students are more likely to suffer from academic burnout and psychological problems than other college students (11). In addition, many students start university with low mental health levels (12), and some mentally healthy students may slip into a crisis of significant mental health problems during their first academic year (13). More than one-third of first-year students reported mental health problems (14), which means that more attention should be focused on the mental health of first-year students [e.g., (12, 13)].

However, first-year college students with positive personal qualities, such as self-efficacy and resilience, can navigate college, showing higher academic achievement and fewer mental health problems (9, 15, 16). Those with good social support (8, 17) or support from family and peers (18) have better academic performance, and perceived social support is beneficial to students' mental health (19). Based on the prior studies, this study attempted to explore the mechanism of negative factors (such as time pressure and emotional exhaustion) and positive factors (such as perceived social support and student engagement) on mental health.

An emerging study model, the study demands-resources (SD-R) model, discusses the influencing mechanism from both positive and negative processes. Study demands increase the risk of student burnout, leading to adverse outcomes like mental health problems. In contrast, study resources alleviate student burnout and benefit mental health by improving student engagement (20). This study was intended to apply the SD-R model to explore the influencing mechanism of mental health among first-year college students in the post-COVID-19 era. It adopted a sample of first-year college students who entered college in September 2021 and had 2 months of college life in Guangxi, China. The aim is to explore the mechanism of factors, such as time pressure, emotional exhaustion, perceived social support, and student engagement on mental health, and provide adequate measures to reduce the risk of mental health problems among first-year students.

LITERATURE REVIEW

Study Demands-Resources Model and Current Research Framework

The study demands-resources (SD-R) model was proposed by Lesener et al. (20). Two causal and independent processes are combined in this model. One is the health impairment process; the increased risk of student burnout caused by study demands results in adverse outcomes such as mental health problems. The other is the motivational process; study resources alleviate student burnout and benefit mental health by improving student engagement. This study intended to apply the SD-R model to explore the influencing mechanism on mental health.

Lesener et al. (20) defined *study demands* as physical, psychological aspects that require sustainable physical or mental effort, such as development challenges, time pressure, and interpersonal problems. *Student burnout* means students are feeling exhausted and incompetent due to study demands, becoming cynical or detached in manner toward one's studies, and experiencing emotional exhaustion (21). *Study resources* are valuable parts of studying that promote positive outcomes, such as mental health and academic success. Those valuable parts may be psychological, physical, organizational, or social (20), such as perceived social support and self-efficacy. *Student engagement* refers to a positive and satisfactory state of mind, such as vigor, dedication, and absorption (21).

Lesener et al. (20) proposed a broad range of study demands and resources for future studies. It has been demonstrated that the explanatory power of time pressure for study demands is greater than other variables, such as challenging, physiological, and psychological demands (22–24). Therefore, this study also adopted time pressure as an indicator of study demands to test the relations between variables in the SD-R model. Similarly, emotional exhaustion is a crucial indicator with the most significant explanatory power for student burnout (25). In addition, perceived social support is one of the study resources which has been most widely studied (20, 26–28). Therefore, variables in this study included time pressure, emotional exhaustion, perceived social support, student engagement, and mental health.

Time pressure refers to stress caused by academic burdens and short-term emergencies, such as lack of leisure time, too many obligations or responsibilities, heavy demands from extracurricular activities, and lack of enough time for sleep (29). *Perceived social support* is the perception of support from family, a teacher, and a friend (30). *Emotional exhaustion* is a long-term state of psychosomatic depletion due to constant stress from excessive work and personal demands (31). In this study, the student's *emotional exhaustion* is a state of physical and mental exhaustion due to study demands, such as time pressure and academic burdens. *Student engagement* refers to a positive and satisfactory state of mind described as vigor, dedication, and absorption (21). *Mental health* refers to psychological well-being

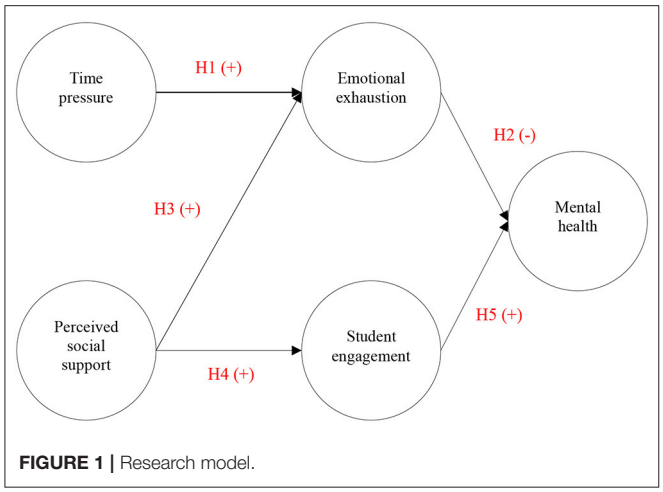

FIGURE 1 | Research model.

and distress in the general population (32). Psychological well-being is a positive mental health state (such as happy, calm, and peaceful), while psychological distress is a negative state (such as anxiety and depression).

Based on the SD-R model, this study was also intended to explore the influencing mechanism of mental health among first-year college students in the post-COVID-19 era through two processes. On the one hand, time pressure is positively related to emotional exhaustion, which impairs mental health; on the other hand, perceived social support is negatively related to emotional exhaustion and positively related to student engagement, which benefits mental health. The research framework of this study is shown in **Figure 1**.

Time Pressure and Emotional Exhaustion

The explanatory power of time pressure for study demands is greater than other variables, such as challenging, physiological, and psychological demands (22–24). Emotional exhaustion is a crucial indicator with the most significant explanatory power for student burnout (25). Most studies indicate that time pressure positively relates to student emotional exhaustion (33, 34). That is to say, students who encounter high time pressure may experience high levels of emotional exhaustion. For those students with part-time jobs, time pressure was positively related to emotional exhaustion (35). In addition, study demands have a longitudinal effect on school burnout a year later (36). Therefore, based on the studies above, hypothesis 1 was proposed as follows:

H1: Time pressure relates to emotional exhaustion positively.

Emotional Exhaustion and Mental Health

Studies show that emotional exhaustion is a negative indicator of mental health (37, 38). Greater emotional exhaustion is associated with poorer mental health (39). Students with higher levels of emotional exhaustion have more mental health problems (40, 41). Studies also found that emotional exhaustion harms mental health during the COVID-19 pandemic (42). Therefore, in line with the findings in prior studies, hypothesis 2 was proposed as follows:

H2: Emotional exhaustion negatively relates to mental health.

Perceived Social Support and Emotional Exhaustion

Studies show that perceived social support is significantly related to emotional exhaustion (43, 44). Social support from school or teachers, parents, and peers was negatively correlated with emotional exhaustion (27, 45–47). Meanwhile, social support helps reduce study burnout, including emotional exhaustion like dejection (48). Therefore, in line with these research findings, hypothesis 3 was proposed as follows:

H3: Perceived social support negatively relates to emotional exhaustion.

Perceived Social Support and Student Engagement

Studies indicate that perceived social support positively predicts student engagement (43, 49). The teacher-student relationship is an essential factor affecting student engagement (50–52). Support from teachers, peers, and family members positively impacts student engagement (53–55). Therefore, in line with the findings in the prior studies, hypothesis 4 was proposed as follows:

H4: Perceived social support positively relates to student engagement.

Student Engagement and Mental Health

Studies suggest that student engagement is positively correlated with mental health (56, 57). Students with higher engagement have better mental health (58, 59). Recently, some scholars pointed out that student engagement partially mediates perceived social support and mental health (49). Therefore, in line with these findings, hypothesis 5 was proposed as follows:

H5: Student engagement positively relates to mental health.

Student mental health is an essential issue in higher education. More and more students have to be confronted with mental health issues. The more challenges first-year college students face, the more attention should be paid to their mental health. This study took first-year college students as research subjects to explore the factors affecting their mental health. Thus, the findings may contribute to the study on first-year college students' mental health characteristics in China and help provide some practical suggestions to alleviate the risk of mental health issues.

Moreover, time pressure may impair mental health by increasing student emotional exhaustion. Simultaneously, perceived social support may benefit mental health by decreasing emotional exhaustion and increasing student engagement. Thus, the findings may enrich the empirical studies of the SD-R model and offer empirical evidence for promoting mental health.

RESEARCH DESIGN

Procedures

Adopting convenience sampling, this study was to investigate the relationship between time pressure, perceived social support, emotional exhaustion, student engagement, and mental health relating to first-year college students. The anonymous cross-sectional survey was conducted online from November 1–30, 2021 (nearly 2 months after entering college). First-year college

TABLE 1 | Description of demographics.

	Number or M ± SD	Percentage
Gender		
Male	247	46%
Female	290	54%
Age	18.97 ± 1.01	
Major		
Liberal arts	364	67.8%
Science	173	32.8%

students from nine classes at three universities (three classes per university) in Guangxi, China participated in this survey. Three mental health education teachers (one from per university) instructed the students to complete the questionnaire with informed consent in the introduction section.

Participants

Five hundred and eighty-eight questionnaires were received, 51 invalid questionnaires were excluded, and 537 valid samples (91.3%) were left for statistical analysis. Among them, 290 (54%) were females, and 247 (46%) were males; the average age of the respondents was 18.97 ± 1.01 years; 364 students (67.8%) were liberal arts majors, and 173 students (32.2%) were science majors, as shown in **Table 1**.

Questionnaire

The questionnaire contained scales measuring time pressure, perceived social support, emotional exhaustion, student engagement, and mental health. The items in the questionnaire were developed from relevant literature.

Three educational management experts and a doctor of psychology examined the accuracy and applicability of item translation to ensure content validity, and 10 students participated in a test to ensure face validity. The Likert scale employed in each scale in this study was the same as the original scales (see the introductions of the measurement tools below). The reliability and validity of items in the questionnaire were listed in **Tables 2**, **3**.

Time Pressure

This study employed a seven-item time pressure scale to measure students' study-related time pressure. It is a subscale of the Inventory of College Students' Recent Life Experiences (ICSRLE) (29). A sample item is "I always have many learning tasks to deal with." Two items were deleted because the factor loadings were lower than 0.50. The deleted items were "Not enough time for sleep" and "A lot of responsibilities." A four-point Likert scale was used (1 = *never* to 4 = *always*).

Perceived Social Support

Zimet et al. (60) developed the Multidimensional Scale of Perceived Social Support (MSPSS), which comprises 12 statements indicating three dimensions of perceived support (family, friends, and significant others), with four items for each dimension. The Chinese version of MSPSS, revised by Jiang (61), was used to measure students' perceived support from family members, peers, and teachers, with "significant others" replaced by "teachers" in this study. Items, for example, were "I can share my problems with friends" (perceived support from friends), "My family tries to help me" (perceived support from family), or "My teacher always offers emotional support to me" (perceived support from teachers). A five-point Likert scale was used (1 = *strongly disagree* to 5 = *strongly agree*).

Emotional Exhaustion

Ni et al. (62) revised the emotional exhaustion subscale from the Maslach Burnout Inventory—General Survey (MBI—GS) (63). The revised version comprises four items. In this study, the four-item subscale was employed to measure emotional exhaustion related to study among the first-year college students in Guangxi, China. A sample item is: "I feel exhausted at the end of a day at university." A seven-point Likert scale was used (1 = *never* to 7 = *always*).

Student Engagement

The nine-item Utrecht Work Engagement Scale-Student Form (UWES-9-SF) (21) consists of three subscales, including vigor, dedication, and absorption, with three items for each. The UWES-9-SF was used to measure student engagement among first-year college students. A sample item is as follows: "I feel happy when studying intensively." It was found in this study that the USES-9-SF is a unidimensional scale. Three items were deleted because the factor loadings were lower than 0.50. The deleted items were as follows: "At my study, I feel bursting with energy," "When I am learning, I feel that time flies," and "When I am learning, I forget everything else around me." A five-point Likert scale was used (1 = *strongly disagree* to 5 = *strongly agree*).

Mental Health

This study employed the Mental Health Inventory 5 (MHI-5) to measure the mental health of first-year college students. It was compiled by Berwick et al. (64), containing five items evaluating how long the following states were felt in the last month: Happy, calm, nervous, depressed, and so depressed that I cannot pull myself together. A sample item is: "During the last month, how much of the time have you been a very nervous person?" A four-point Likert scale was used (1 = never to 4 = always), assessing two positive items and three negative items on mental health, and the three negative items were scored in reverse.

RESULTS

Scores on the Study Variables

Scores for time pressure, emotional exhaustion, perceived social support, student engagement, and mental health are recorded in **Table 3**. Moderate levels of time pressure ($M = 2.57$, $SD = 0.60$, maximum was 4) and emotional exhaustion ($M = 3.86$, $SD = 1.47$, maximum was 7) were found, and slightly-above-the-median levels of perceived social support ($M = 3.84$, $SD = 1.01$, maximum was 5), student engagement ($M = 3.25$, $SD =$

TABLE 2 | Results of CFA Fit Indexes and Discriminant Validity of items.

Index	$\chi 2/df$	RMSEA	GFI	AGFI	*t*
Threshold	<5	<0.10	>0.80	>0.80	>3
Time pressure	3.01	0.06	0.99	0.97	6.09–14.46
Perceived social support	2.79	0.07	0.96	0.93	4.77–12.39
Emotional Exhaustion	1.69	0.04	0.99	0.98	36.62–41.52
Student engagement	4.46	0.07	0.97	0.95	21.93–31.37
Mental health	3.16	0.06	0.99	0.97	17.43–24.84

TABLE 3 | Reliability, Validity, Factor Loading (FL), and Scores of Each variable.

Variables	α	CR	AVE	FL	M ± SD	Maximum
Criteria	>0.70	>0.70	>0.50	>0.50	–	–
Time pressure	0.75	0.84	0.51	0.60–0.76	2.57 ± 0.60	4
Perceived social support	0.96	0.97	0.79	0.86–0.92	3.84 ± 1.01	5
Emotional Exhaustion	0.92	0.92	0.75	0.79–0.92	3.86 ± 1.47	7
Student engagement	0.92	0.92	0.65	0.70–0.90	3.25 ± 0.86	5
Mental health	0.80	0.81	0.52	0.50–0.85	2.80 ± 0.57	4

0.86, maximum was 5), and mental health ($M = 2.80$, $SD = 0.57$, maximum was 4) were found among the first-year students.

Measurement Model

In this study, SPSS 26.0 was used to calculate the Cronbach's α of each scale. Cronbach's α value of each component was between 0.75 and 0.96, indicating acceptable reliability. AMOS 23.0 was used for confirmatory factor analysis to examine the factor loadings, composite reliability (CR), and average variance extracted (AVE). This study employed the criteria of fit indexes in CFA suggested by Hair et al. (65). As shown in **Table 2**, all the χ^2/df values were <5, GFI and AGFI were higher than 0.80, and RMSEA were <0.10, indicating an acceptable model.

Convergent Validity

According to the convergence validity evaluation criteria (66), the acceptable factor loading value should be at least 0.50; composite reliability (CR) should be at least 0.7; and the average variance extracted (AVE) value should be at least 0.50. As shown in **Table 3**, the factor loading values of each dimension were between 0.77 and 0.87; The CR values were between 0.81 and 0.97, and the AVE values of the dimensions were between 0.59 and 0.77, indicating an acceptable convergent validity for each dimension.

Discriminant Validity

The square root of the AVE should be greater than the correlation coefficient between the two dimensions (67). As shown in **Table 4**, the square root of the AVE for each dimension was between 0.77 and 0.86, which was greater than the correlation coefficient between the dimensions, representing an acceptable discriminant validity for each dimension.

Structural Model

Model Fit Index

AMOS 23.0 statistical software was used to check the fitness of the research model. The model fit index standards recommended by Hair et al. (65) are RMSEA should be lower than 0.10, GFI, AGFI, NFI, and NNFI should be at least 0.90, CFI, IFI, and RFI should be at least 0.80, PNFI and PGFI should be at least 0.50. This study reported fit index values as follows: RMSEA = 0.07, GFI = 0.85, AGFI = 0.83, NFI = 0.90, NNFI = 0.92, CFI = 0.93, IFI = 0.93, RFI = 0.89, PNFI = 0.82, and PGFI = 0.72. Most of the fit indexes of the model in this study met the criteria, indicating it was an acceptable model.

Path Analysis

Data obtained through Path analysis can be seen in **Figure 2**. Findings revealed that the coefficient in each path was significant ($p < 0.001$). Time pressure had a positive association with emotional exhaustion ($\beta = 0.52$). Emotional exhaustion had a negative association with mental health ($\beta = -0.37$). Perceived social support had a negative association with emotional exhaustion ($\beta = -0.32$). Perceived social support had a positive association with student engagement ($\beta = 0.36$); student engagement had a positive association with mental health ($\beta = 0.30$).

The value of R^2 represents the compounding effects of the exogenous latent variables on the endogenous ones. R^2-values of 0.75, 0.50, or 0.25 indicate significant, moderate, or weak coefficients of determination, respectively (68). Time pressure and perceived social support accounted for 60% of emotional exhaustion; perceived social support accounted for 13% of student engagement. Emotional exhaustion and student engagement accounted for 28% of mental health.

Effect size f^2 is calculated by the formula $f^2 = R^2/(1–R^2)$. Effect sizes f^2 of 0.02, 0.15, and 0.35 indicate small, medium,

TABLE 4 | Discriminant validity analysis.

Construct	1	2	3	4	5
(1) Time pressure	**0.71**				
(2) Perceived social support	−0.60	**0.86**			
(3) Emotional Exhaustion	0.61	−0.67	**0.89**		
(4) Student engagement	−0.22	0.33	−0.32	**0.80**	
(5) Mental health	−0.34	0.44	−0.43	0.39	**0.72**

Note: The bold value indicates the square root of the AVE for each dimension.

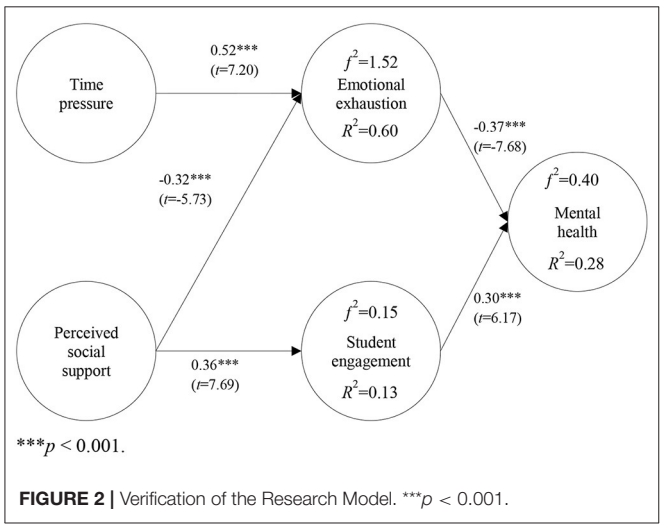

FIGURE 2 | Verification of the Research Model. ***$p < 0.001$.

and significant effects of exogenous latent variables, respectively (69). Time pressure and perceived social support accounted for emotional exhaustion with an effect size f^2 of 1.52, indicating significant effects of these two exogenous latent variables. Perceived social support accounted for student engagement with an effect size f^2 of 0.15, indicating a medium effect of this exogenous latent variable. Student burnout and student engagement accounted for mental health with an effect size f^2 of 0.40, indicating significant effects of these two exogenous latent variables.

DISCUSSION

Scores on the Study Variables

Studies show that COVID-19 has a moderate but sustained impact on the mental health of first-year students (70). Van Zyl et al. (71) found in a sample of university students in the Netherlands that the scores on study demands are slightly lower than the median, and the scores on mental health and perceived support from peers and teachers are higher than the median. This study revealed that the time pressure scores of the first-year college students in Guangxi are consistent with those of the Dutch sample. Namely, it is also slightly lower than the median. The difference is that the mental health and perceived social support scores were close to the median. In addition, studies show that college students have opposite scores on student burnout and study engagement. For example, Barratt and Duran (43) found that students score high on student engagement but low on student burnout in a UK sample of an online teaching project. A study from Poland also shows that scores on student engagement are opposite to student burnout scores (72). However, this study revealed that both emotional exhaustion (student burnout) and student engagement scored near the median, and they did not score oppositely. The results of this study enrich the studies on characteristics of mental health of first-year college students in Guangxi in the post-COVID-19 era.

Hypotheses Based on the Health Impairment Process

Lee and Ashforth (73) believed that compared with cynicism and inefficacy in job burnout, emotional exhaustion has a higher correlation with demands (including time pressure as an indicator) and resource variables. More recently, Kim et al. (33) found a positive correlation between study demands and emotional exhaustion in the school setting through a meta-analysis. Similar findings show a significant positive correlation between study demands and emotional exhaustion among high school students (34) and college students (20). This study also reported that the time pressure of first-year students in Guangxi colleges was positively correlated with emotional exhaustion, and therefore, hypothesis 1 of this study is supported.

Studies before the COVID-19 outbreak show that student burnout is negatively correlated with the mental health of college students. In other words, student burnout is positively related to mental health problems, including depression, anxiety (41), and psychopathological symptomatology (74). A COVID-19-related study on the correlation of emotional exhaustion with mental health revealed that, around the outbreak of COVID-19, the mental health of college students decreased with the increase of student burnout, especially emotional exhaustion (37, 75). A similar finding reported that student burnout is positively correlated with depression among medical students (76). This study also supports these findings; namely, the emotional exhaustion of first-year students in Guangxi colleges was negatively correlated with their mental health.

In the health impairment process in the SD-R model, time pressure, as an essential indicator of study demands, is positively related to emotional exhaustion (an indicator of student burnout), which is negatively correlated with mental health. As discussed above, the results of this study provide empirical evidence of the health impairment process of SD-R,

just as Gusy et al. (22) did in a longitudinal study of SD-R's health impairment process.

Hypotheses Based on the Motivation Process

Lee and Ashforth (73) claimed that resource variables are negatively related to emotional exhaustion. As one of the study resources, perceived social support has been widely discussed in a variety of studies (20, 26–28). Many studies show that social support is negatively correlated with student burnout (27, 33, 48). Social support from school or teachers, parents, and peers is negatively correlated with student burnout (27, 45–47); that is probably because social support has a promotive effect on reducing student emotional exhaustion (48). However, few studies have explored the relationship between social support and emotional exhaustion in the post-COVID-19 era. These studies mainly focus on occupational groups, such as medical professionals (77). The finding of the present study may fill this research gap. This study indicated that perceived social support was negatively related to emotional exhaustion among first-year college students in the post-COVID-19 era.

Many studies have focused on the correlation of perceived social support with job engagement in the context of COVID-19. For example, organizational support perceived by nurses during the COVID-19 pandemic was significantly correlated with job engagement (78, 79), and teachers' perceived organizational support had a positive impact on their job engagement (80). Similar results were also found in drivers (81), service workers (82), and technological workers (83). Studies have demonstrated that perceived social support positively relates to student engagement (43, 49); that is probably because social support plays a promotive role in increasing student engagement (53–55). However, few studies have explored the correlation of perceived social support with student engagement of college students in the context of COVID-19. Recent studies show that social support as a significant study resource positively impacts student engagement in colleges during the pandemic (84). The more support college students receive from their teachers, the higher their student engagement is (85). The finding of the present study may enrich studies on the correlation of perceived social support with student engagement of college students in the context of COVID-19.

Students with higher student engagement have better mental health (58, 59); that is to say, student engagement is positively correlated with mental health (56, 57). However, few studies explore the relationship between student engagement and mental health in terms of the environment in which students engage in their studies and cope with their psychological problems. This study was conducted under the background of COVID-19, adopting a sample of first-year students and exploring the factors which may influence their mental health. The results showed that student engagement of first-year students in Guangxi colleges after the pandemic was significantly correlated with their mental health.

In line with the motivation process of the SD-R model, the findings in this study revealed that perceived social support (study resources) was positively related to student engagement but negatively related to emotional exhaustion, and student engagement was positively related to mental health. These findings supported the motivation process of the SD-R model, just as the previous studies have shown (71, 86).

Based on the discussion above, the results in the current study offered empirical evidence to support the SD-R model in first-year college students in Guangxi, China, which may contribute to the application of the SD-R model in first-year college students, especially in the post-COVID-19 era.

In addition, this study revealed the impacts of time pressure, perceived social support, emotional exhaustion, and student engagement on mental health. The findings may contribute to the study on the characteristics of mental health among the first-year college students in China in the post-COVID-19 era and help explore some practical ways to alleviate the risk of mental health issues among them.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

In terms of scores on time pressure, perceived social support, and mental health, a medium level was found in this sample and samples of other college students; namely, the findings in this study are consistent with those of the prior studies. However, scores on emotional exhaustion and student engagement were close to the median in this sample. In contrast, opposite scores were found in other samples in the previous studies. This study provides new findings on the mental health characteristics of first-year college students through a sample study of first-year college students in Guangxi in the post-COVID-19 era.

Results in this study offer empirical support for the SD-R model; that is, all the SD-R model hypotheses were supported. Time pressure (study demands) had positive effects on emotional exhaustion (student burnout), which negatively affected mental health. This finding supports the health impairment process of the SD-R Model. In addition, perceived social support (study resources) increased student engagement and decreased the emotional exhaustion of first-year students, thus promoting their mental health, which supports the motivational process of the SD-R Model.

From the above findings revealed in this study, we conclude that time pressure and perceived social support are critical factors that influence the mental health of first-year college students in the post-COVID-19 era. Both indicators impact the mental health of first-year students, the former by increasing emotional exhaustion, the latter by increasing student engagement and decreasing emotional exhaustion.

Recommendations

Moderate levels of time pressure, emotional exhaustion, and a slightly above-average level of perceived social support, student engagement, and mental health were found among first-year students in the current study. We suggest that more attention should be paid to those students with low scores in mental health, which may indicate that they are suffering from mental

health problems. Furthermore, we suggest that measures should be taken to reduce time pressure, which affects mental health by increasing emotional exhaustion. As for reducing time pressure, interventions should be adopted by modifying study programs or structural settings at universities (22); simultaneously, time management training may help reduce time pressure for university students (87). In addition, support from teachers, good campus environment perceptions, excellent class (socio-affective, design, and organization), and motivating teaching behavior are considered to help foster student engagement (88), thus, enhancing student mental health.

Research Limitations and Future Study

First, one limitation of this study is that the sample was drawn from first-year college students in Guangxi, so the findings may not apply to all student groups. Future research should employ a stratified probability sample, investigating college students in different grades and regions.

Second, this cross-sectional study would not establish any causal relationship among the study variables. Longitudinal studies should be conducted in future research to examine the causal relationship among variables in the SD-R model.

Third, as one of the most crucial study demands, time pressure is a study demand that all students must face in most cases, but it is not representative enough to cover all indicators of study demands. Similarly, though perceived social support is a widely used study resource, it is unreasonable to employ it to stand for all study resources. That is to say, in future studies, other indicators concerning study demands (e.g., emotional demands, study load) and indicators related to study resources (e.g., self-efficacy, perceived classroom climate) should be taken into consideration.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

CW, YM, and J-HY: concept and design, drafting of the manuscript, acquisition of data, and statistical analysis. CW, J-HY, and LN: critical revision of the manuscript. All authors contributed to the article and approved the submitted version.

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Feasibility of Online High-Intensity Interval Training (HIIT) on Psychological Symptoms in Students in Lockdown During the COVID-19 Pandemic: A Randomized Controlled Trial

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Objective: We aimed to evaluate the feasibility of an online High-Intensity Interval Training (HIIT) program on clinical psychological symptoms in higher education students in the context of the COVID-19 pandemic lockdown.

Materials and Methods: During the lockdown, 30 students aged 18–25 years, who had been screened previously with a cut-off score ≥5 in the Generalized Anxiety Disorder-7 (GAD-7) questionnaire, were randomly assigned to either the 4-week HIIT program with three sessions per week conducted through online videos, or a no-intervention control group. The primary outcome was the feasibility assessment. The secondary outcome was a psychological self-report with the 21-items Depression, Anxiety, and Stress Scale (DASS-21). Assessment and intervention were performed in compliance with social distancing rules.

Results: Two participants in the HIIT were lost to follow-up, leaving 13 participants vs. 15 in the control group. We observed high adherence (87%) and complete safety for mental and physical status with the HIIT intervention delivered by online videos. The Mann-Whitney test demonstrated a significant (group × time, *P*-Value = 0.046) reduction of clinical stress symptoms and a trend (group × time, *P*-Value = 0.08) toward reduction of clinical depression symptoms, both favoring the HIIT group. No significant (group × time, *P*-Value = 0.118) interaction was found for anxiety symptoms.

Conclusion: The online HIIT program was found to be feasible and safe in a clinical sample of young adults, who were experiencing social and physical restrictions due to COVID-19. HIIT reduced stress and depressive symptoms and thus these preliminary results show promise for broader application among higher education students during the present lockdown necessitated by the global COVID-19 health crisis.

Keywords: anxiety, depression, stress, High-Intensity Interval Training, exercise, students, lockdown, COVID-19

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INTRODUCTION

The incidences of depression and anxiety symptoms doubled to 21% between 2018 and 2021 in the Belgian adult population, according to data collected during the lockdown necessitated by the COVID-19 pandemic (1). A recent meta-analysis and meta-regression including 226,638 individuals in 60 studies similarly showed a 24.0% global prevalence of depression and 21.3% for anxiety across the world during the COVID-19 pandemic (2); clinically significant symptoms were noted in association with risk factors such as female gender and youth (3, 4). Indeed, during the second lockdown in Belgium (March 2021), 38% of young people (18–29 years) suffered from depression, as evaluated by a Patient Health Questionnaire, and 34% suffered from anxiety, as evaluated by Generalized Anxiety Disorder-7 (GAD-7) (1), in accordance with surveys during COVID-19 waves in Western countries (5–8). Another recent meta-analysis for students in higher education in China (12 studies) and other countries (eight studies) revealed approximate doubling of the prevalences of depression (54%) or anxiety (37%) relative to corresponding results in surveys conducted prior to March, 2020 (4). Generally speaking, young people are apt to experience fears and uncertainties arising from their continued physical and social isolation during pursuit of a degree course. There is evidence for a causal association whereby anxiety precedes depression, such that many young people with depressive symptoms suffer from comorbid anxiety (9). The reduction of physical activity and sports due to constraints from the COVID-19 pandemic contributes to the stress experienced by students in higher education (10). Formerly active individuals who had been obliged to reduce their physical activity showed more symptoms of depression and loneliness, increased stress, and diminished ratings of positive mental health (11). On the other hand, individuals in the general population who managed to maintain their physical fitness in the face of the pandemic showed a 12–32% lower risk of experiencing anxiety and a 15–34% lower incidence of depression during the COVID-19 pandemic (12).

A recent meta-analysis compiling nine randomized control trials (RCTs), performed before the COVID-19 pandemic, showed a moderate improvement in state anxiety upon engaging in structured physical activity, as compared to no intervention or a minimal intervention control condition in groups of children and young people aged up to 25 years (13). However, there is a need for caution in interpretating such results, particularly with respect to establishing the dose-response relationship of different levels of intensity of exercise on anxiety symptoms in young people (13). Indeed, there is currently no consensus on the optimal frequency, intensity, type and duration of exercise to treat anxiety symptoms (13, 14). Moreover, High-Intensity Interval Training (HIIT) has gained increasing interest in recent years and has been ranked among the top fitness trends by the Association College of Sport Medicine (2022). In the adult population, HIIT has been shown to significantly improve cardiorespiratory fitness, cardiovascular function, anthropometric variables, exercise capacity, muscle structure and function (15). In addition, this type of training has been shown to reduce symptoms of anxiety and depression in non-clinical individuals (15) and depressed moods in people with severe mental illness (16) with better enhancements than moderate continuous fitness session (17).

In contrast, in young people, HIIT yielded mixed results in depression (18–20), anxiety and stress decreasing (18, 19, 21, 22). Despite the particular context of COVID-19, after restrictions in China, an encouraging RCT demonstrated depression reduction by running training supervised in person in a clinical sample in middle school (23). Concerning stress and anxiety, HIIT has raised questions about its impact on generating or reducing mechanisms (24). However, whereas the COVID-19 pandemic was a trigger for stress and anxiety in youth, home-based HIIT demonstrated a positive effect on symptoms of stress, anxiety in young people (21) and depression in adults (25), as well as showing a strong beneficial effect on moderate to severe anxiety symptoms pre-existing the pandemic (26). The inconsistency in results could be explained by the fact that the impact of HIIT has been overlooked on anxiety and stress disorders, as reported in a recent meta-analysis (16).

Therefore, given the deterioration of physical and psychological status observed in young people following the onset of the COVID-19 crisis, we sought to investigate the feasibility of an online HIIT intervention in a Belgian tertiary education student sample (aged 18–25 years) screened for clinical symptoms of anxiety during the lockdown arising from the COVID-19 pandemic. In addition, we also aimed to analyse preliminary findings on depression, anxiety, and stress symptoms after online HIIT. We hypothesized that the participants in the online HIIT would show better improvement in psychological symptoms compared to a passive control group.

MATERIALS AND METHODS

Trial Design

We conducted a RCT to evaluate the feasibility of online HIIT intervention on psychological symptoms compared to a passive control group in tertiary education. The HIIT intervention entailed three sessions of 10 min per week and lasted for 4 weeks. Baseline and post-psychological testings were carried out the week before and after the 4-weeks follow-up. We followed the Consolidated Standards of Reporting Trials (CONSORT) checklist.

Participants

Participants were recruited in a physical therapy higher education setting [Haute Ecole Bruxelles-Brabant (HE2B), Brussels, Belgium]. We offered them to participate in the study by contacting them through an email sent to all students in the month prior to the start of the study. We recorded descriptive characteristics and medication status of participants. Screening of general anxiety of participants was assessed with the GAD-7 (27). Written informed consent according to the Declaration of Helsinki and medical history was obtained from each participant.

Abbreviations: HIIT, High-Intensity Interval Training; GAD-7, Generalized Anxiety Disorder-7; DASS-21, Depression, Anxiety, and Stress Scale-21 Items.

The study was approved by the Bio-Ethical Committee for Research and Higher Education, Brussels (No. B200-2020-088).

COVID-19 Lockdown Conditions

Sciensano, the Belgian research center and national public health institute in charge of the pandemic statistics, reported that 21% of intensive care beds were occupied by COVID-19 patients in March 2021. The transmission rate was 1.02, and 288 of 100,000 Belgian citizens were infected on average per day in March 2021 (1). In response to the burgeoning caseload, Belgian government had decided to order closed the majority of non-essential shops, as well as sports clubs. The restrictive measures lasted between October 26, 2020 and June 9, 2021. A curfew was introduced from 10 p.m. to 6 a.m. in Brussels, the capital city.

Eligibility Criteria

The inclusion criteria for participants were being a student in higher education, age between 18 and 25 years, having a score ≥5 in GAD-7, and accepting the principle of randomization in the trial. The exclusion criteria were refusal to participate, neurological history such as illness or head trauma, present severe and unstable respiratory disease, history of heart defect or cardiovascular disease or any other medical conditions prohibiting high-intensity sport or physical activity, substance abuse, i.e., alcohol or drugs, and being a high-level athlete. A comprehensive self-questionnaire was provided to students to collect all medical conditions to inform potential exclusion criteria and ensure safe participation.

Randomization and Blinding

The week before and after the intervention, the students completed the DASS-21 questionnaire. Participants were anonymously assigned sequentially to one of two groups (HIIT and control group) using permuted block randomization with secret assignation. During the intervention sessions, therapists and participants were unaware of the individual scores used for randomization. The analysis was carried out in unlabelled group datasets.

High-Intensity Interval Training Group

The HIIT intervention was conducted with session videos produced by a physical therapist (PM), which were available on an online platform for the participants. **Table 1** displays two variants of sessions based on the main variables that can be manipulated to prescribe a HIIT session (28). Participants were free to decide when they wanted to perform their sessions during the week. We recommended having a rest day between sessions due to the high-intensity effort produced. The intervention consisted of 12 structured sessions of bodyweight intermittent aerobic and muscular strengthening exercises, designed to remedy a decline of aerobic fitness in lockdown (29). A block of three sessions to complete was sent to participants each week for 4 weeks, to a total of 12 sessions. Each session entailed alternating of High-Intensity Intervals (HIT) and active recovery intervals, each lasting 30 s to reach 10 min, see **Table 1**. The HIT comprised, for instance, jump squats, burpees, mountain climbers, jump forward lunge, jumping jack with a Rate of Perceived Exertion (RPE) of 6 or greater (1–10), following the modified Borg Analog Scale, which corresponded to a HRmax at least 80% (30). The active recovery intervals included plank, lateral plank, push-up, squat at a requested RPE of 4 or less. We encouraged to maintain the required intensity during each interval of the sessions. To promote motivation, each session was videotaped in different outdoor and indoor locations. All exercises employed own body weight for resistance, without use of special equipment. The HIIT sessions were carried out at the participants' home, thus in compliance with social contact regulations.

TABLE 1 | Bodyweight HIIT circuit.

Variant 1	
Bear walk Back and forth squat jump Plank Ice skater Squat pulse Burpees Squat hold Back and forth lunge (left side) Superman breaststroke Back and forth lunge (right side)	Alternating between High intensity exercises (30 s) ≥6 RPE and active recovery exercises (30 s) ≤4 RPE
Variant 2	
Lateral lunge Run on the spot Back lunges Jumping jack Spider plank Diagonal knee kick, right hand/ankle touch Squat Diagonal knee kick, left hand/ankle touch Squat hold Floor touch jump squat	Alternating between High intensity exercises (30 s) ≥6 RPE and active recovery exercises (30 s) ≤4 RPE

The 10-min session consisted circuit of 10 exercises (30 s each), repeated twice.

Participants recorded their participation in the sessions in weekly reports sent to the trainer, who regularly guaranteed the monitoring for safe participation. These reports included attendance at the three sessions per week, their rate of perceived exertion, and possible questions about recovery, movement execution, and other issues addressed. The global RPE was assessed by the modified Borg Analog Scale (0–10) at the end of each session, as is standard in clinical studies (31). Participants were given a descriptive document indicating the corresponding intensity for each level between 1 and 10 (32), assuring validity and good reliability (30). Participants were physical therapy students and underwent fitness training during their course of study, ensuring proper execution of movements and knowledge on HIIT principles before starting the study.

Control Group

Participants were requested to continue their usual activities without particular modification.

Feasibility Primary Outcome

We evaluated the feasibility of the online HIIT intervention compared to a passive control group in the specific context

of closure and distance measures imposed by the COVID-19 spread. We analyzed several outcomes: mean program adherence, individuals completed their sessions in a document sent each week to the supervisor; dropout rate per intervention; protocol monitoring with the collection of the mean RPE per session for each participant with the modified Borg scale (31); and safety concerning participants mental and physical progress with the psychological outcome and participant feedback.

Psychological Secondary Outcome

The Depression, Anxiety, and Stress scales-−21 Items (DASS-21) (33) is a set of three self-reports. For each scale, there are seven questions (rated 0, 1, 2, and 3) related to depression, anxiety, and stress, thus providing three scores, each ranging from 0 to 21. The depression scale assesses dysphoria, hopelessness, devaluation of one's life, self-deprecation, lack of interest/involvement, anhedonia, and inertia. The anxiety scale assesses autonomic arousal, skeletal muscle tension, situational anxiety, and the subjective experience of anxious affect. The stress scale is sensitive to levels of chronic non-specific arousal, assessing difficulty in relaxing, nervous arousal, and being easily upset/agitated, irritable/over-reactive, and impatient. Scores for the three dimensions were calculated by summation, and the final severity score was obtained by multiplying by two. The DASS-21 has shown excellent internal consistency and temporal stability in large clinical samples (34).

Sample Size

The sample size was calculated from a previous RCT, wherein we had evaluated Beck anxiety inventory scores after 2 weeks of physical exercise in tertiary education students suffering from clinical anxiety symptoms (35). To detect a decline in −8 points out of the maximum of 42 in the DASS-21 at the 5% significance level with a power of 85%, and assuming a standard deviation of seven points, we calculated a sample size of at least 15 participants per group.

Statistical Analysis

The Mann–Whitney test was performed to determine the difference between the two groups over time regarding the outcomes for psychological scores. All statistical procedures were performed using the SPSS software (IBM SPSS Statistics 27.0, Armonk, NY, United States). The group identity of the data was anonymized for the statistical analysis. Results were reported along with their 95% confidence intervals (95% CI). A *P*-Value <0.05 was considered significant. The Empirical Rule Effect Size (ERES), defined at one half SD from the baseline score, was used to define clinically significant effect sizes of the treatment (36). A Pearson correlation analysis was performed on psychological symptoms between the baseline and difference scores (T1–T2) in the HIIT group to observe whether the level of symptom severity could be related to change over time.

RESULTS

Study Sample

The experimental period ran from March 5, 2021 to April 2, 2021. Among the 30 students recruited at the baseline, two members of the HIIT were lost to follow-up (see Flow-chart, **Figure 1** for details). The statistical analysis of pre-and post-test measures was thus restricted to the remaining 28 participants. The control group consisted of 14 women and one man of mean age 20.93 years (SD 1.94), whereas the final HIIT groups contained 11 women and two men of mean age 20.69 years (SD 1.44). For details of the study population, see **Table 2**. We calculated The Metabolic Equivalent of Task (MET) per hour to measure their physical activities following the updated compendium (37) and classified them per week following the recommendations from WHO (2021).

TABLE 2 | Demographic characteristics of participants.

	HIIT ($n = 13$)	Control ($n = 15$)
Mean age (SD)	20.69 (1.44)	20.93 (1.94)
Gender		
Female	11	14
Male	2	1
Others	0	0
Mean BMI (SD)	22.67 (4.21)	21.35 (3.01)
Living environment (Family, cohabitating, alone)		
Alone	2	1
Cohabitating	6	7
Family	5	7
Daily physical activities (MET.hour per week)†		
(<7.5 MET)	6	8
(7.5–15 MET)	5	4
(>15 MET)	2	3
GAD severity		
GAD 5–10 (mild)	5	7
GAD 11–15 (moderate)	5	5
GAD 16–21 (severe)	3	3
SARS-2 infection‡	3	3
Co-morbidities		
ADHD	1	3
Eating behavior problems	1	0
Tobacco dependence	1	5
Physical disease	1	2
Antidepressant or anxiolytic medication	1	0
Family history of mental illness (1st and 2nd degree relatives)	6	4

SD, standard deviation.
† 7.5–15 Metabolic Equivalent of Task (MET) is recommended by the World Health Organization 2021.
‡ SARS-2 infection diagnosed before the study.

Feasibility Primary Outcome

In the HIIT group, the mean participation rate was 87%, and the dropout rate was assessed at 13.33%, with two participants lost because they refused to continue. The overall intensity set per session for each participant by the modified Borg scale (1–10) demonstrated a mean of 5.77 (SD 1.29), which is considered "hard" and a good execution of the intense effort provided by the participants. Regarding the safety assessment, the HIIT intervention did not reveal any increase in psychological levels,

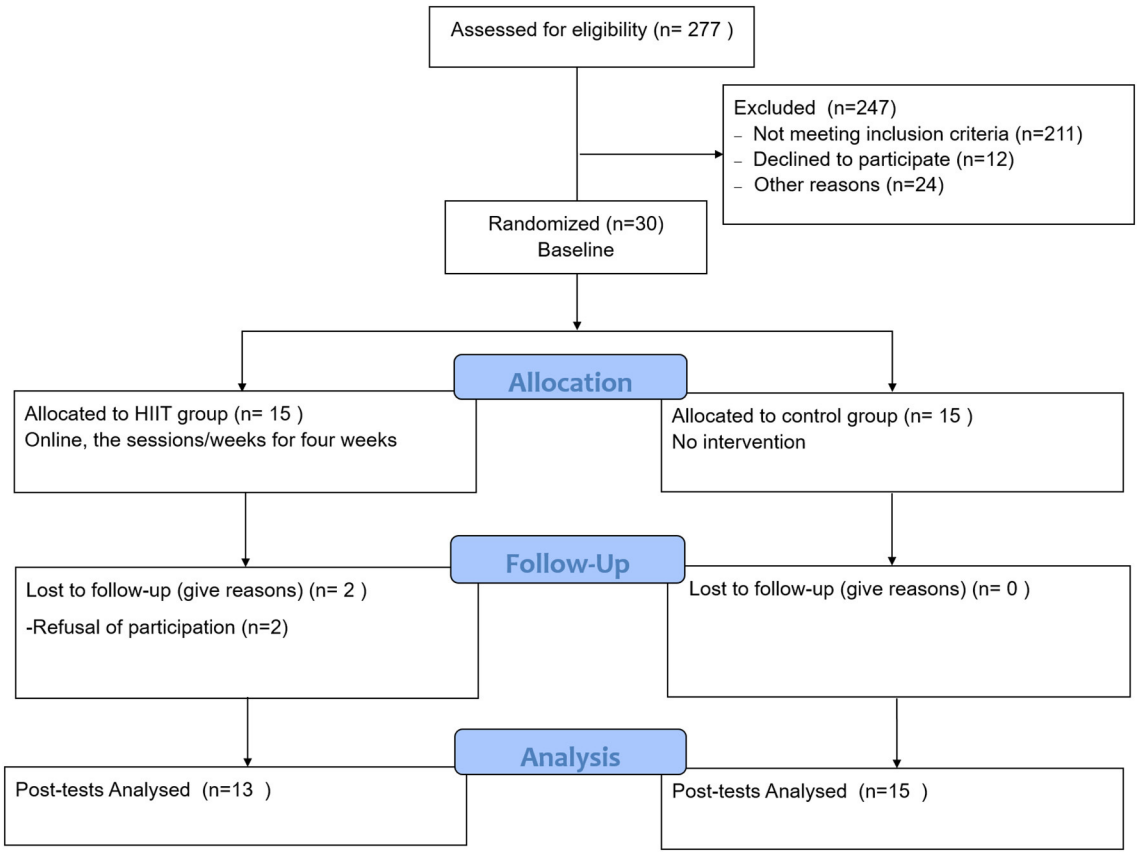

FIGURE 1 | Consort flow-chart.

with the exception of one participant with a higher anxiety score of 2, increasing from 2 to 4 on 42-point scale anxiety of DASS-21. The control group yielded higher scores for seven participants, including five for anxiety, six for stress, and three for depression scales in the DASS-21. The students reported no adverse physical events, except for stiffness due to the heavy exertion.

Psychological Secondary Outcome

Scores and the level of severity according to the pathological thresholds at baseline and after intervention are presented in **Table 3**. In the stress scale of DASS-21, the Mann-Whitney test revealed a significant (group × change from baseline) interaction ($P = 0.046$) in favor of the HIIT group (**Table 4** and **Figure 2**). After the intervention, students in the HIIT group had a mean decline (T1–T2) of 7.5 points on the 42-point scale [95% Confidence Interval (CI), 5.3–9.8] in their stress symptoms, progressing from a mean score indicating moderate stress symptoms, to a mean mild score. Students in the control group had a mean decline (T1–T2) of 2.5 points [95% (CI), −1.9 to 6.9] in their stress symptoms, this remaining on average at a moderate stress score. In the depression scale of DASS-21, Mann-Whitney test revealed a trend interaction ($P = 0.080$) in favor of the HIIT group (**Table 4** and **Figure 2**). After the intervention, students in the HIIT group had a mean decline of 9.5 points [95% (CI), 5.4–13.7] in their DASS depression symptoms, thus progressing from a mean score of moderate depression to a mean normal score. Students in the control group had a mean decline (T1–T2) of 3.7 [95% (CI), −1 to 8.4] in their depressive symptoms, thus progressing on average from a score of moderate depression to one indicating mild depression. In contrast, the Mann-Whitney test showed no significant interaction ($P = 0.118$) in T1–T2 anxiety score changes between groups **Table 4** and **Figure 2**).

A correlation analysis was performed to determine if a connection existed between the severity at the baseline and the reduction over time in psychological scores in the HIIT group. A significant and negative result was found for depression (P-Value $= 0.004$, $r = -0.734$, Pearson correlation), meaning that higher depression scores at baseline have a high potential to decrease. No significant result was shown for stress and anxiety (all P-values >0.05, Pearson correlation).

In the HIIT group, the mean score of improvement in symptoms of stress (7.5) exceeded the ERES score (4.4) and as did likewise the mean improvements in depression (9.5) compared to its corresponding ERES (4.8), demonstrating a clinically significant effect size of HIIT treatment. In the HIIT group, all 13 participants experienced a reduction in their stress scores, while only 8 of 15 (53%) of control participants experienced a

reduction, vs. 6 of 15 (40%) who experienced a worsening, and one of 15 (7%) with unchanged stress.

DISCUSSION

We undertook a RCT to test the feasibility of participating in a brief, online HIIT program that could decrease scores of clinical anxiety, stress, and depressive symptoms compared to a passive control group from sample of students undertaking higher education, while screening with the GAD-7 for symptoms of anxiety, during a government mandated lockdown context during the COVID-19 pandemic. The HIIT intervention was considered feasible with high adherence (87%), acceptable dropout rate (13%), and safe intervention for physical and mental health. As predicted, HIIT group enjoyed a significant decrease in stress symptoms and a trend for reduction of depressive symptoms as compared to the control group. Contrary to expectations, we did not find that the intervention reduced the extent of anxiety experienced by the participants.

The HIIT intervention exhibited high participation, limited participant dropout rates, and good tracking of the intensity of effort produced during the sessions. Online training with short 10-min sessions, freedom to decide when to practice, and weekly supervision appeared to work well. Previous studies with an online exercise intervention in youth have also demonstrated good adherence and a correct dropout rate in adults with HIIT during confinement imposed by COVID-19 with 77.78 and 22% (25) and a moderate aerobic program in college students with 92.08 and 3.33% (38). Another online HIIT during the COVID-19 pandemic in youth revealed no dropouts but did not inform adherence (21). In contrast, a face-to-face HIIT session with university students resulted in lower average participation of 66.7%, likely due partly to the chosen schedule (8:15 a.m.) (39). The online mode with the freedom to decide when you want to train, as we performed, could be interesting to continue to be explored. HIIT did not produce any adverse effects for physical and mental health safety in the present study. Only one participant slightly increased his anxiety score, but it could be negligible due to his weak score under the cut-off. Moreover, the difference is striking when compared to the control group, where seven participants observed a deterioration in one or several psychological symptoms. Being a student during the COVID-19 pandemic, accentuated by a state of confinement, may expose these youth to more negative emotions (3, 4). As previously suggested, exercise may have a protective effect on mental health (40, 41). Our HIIT intervention may have revealed this protective effect during a major social crisis compared to the control group. Finally, our results are consistent with those of the face-to-face HIIT intervention, with average adherence rates greater than 80% and no acute injuries throughout the population, according to a meta-analysis of 33 systematic reviews (15). Attendance is crucial to achieving effective exercise treatment in mental health (40, 41). Our online HIIT might be a feasible intervention strategy for the prevention and treatment in mental health. Despite this promising result, our sample size is small, and further work is needed to establish the viability of online HIIT in a clinical sample of youth.

The robust reduction of depressive symptoms in the HIIT intervention group was in line with a previous systematic review and meta-analysis (42), and also in accordance with our recent RCT on the effect of physical activity in young people (aged 12–25 years) experiencing a present diagnosis or threshold symptoms of depression (43). Following the high and negative correlation ($r = -0.734$) between the severity of depression and its reduction in the HIIT group, this intervention may be considered as an efficient antidepressant for clinical symptoms. The antidepressant effect of HIIT in this present study could be explained by biological and psycho-social mechanisms (41). In the brief course of our 4 week program, we suppose that clinical improvement might reflect neuroplasticity pathways involving such factors as improved brain-wide vasculature function, a well as neuronal effects mediated by neurotrophin release. Downstream effects on neuroendocrine response, neuro inflammation, and oxidative stress may also contribute to the improved depression scores in the HIIT group (44, 45). Regarding psycho-social mechanisms, exercising participants might experience improved physical and body image self-perceptions. While brief in duration, completing our HIIT program is a difficult task calling for a considerable expenditure of effort. Thus, it may suffice to improve participants' skill mastery and lower their barriers against self-efficacy. HIIT may also simultaneously enhance the quality of sleep and depression and thus could be a good complement to current therapeutic modalities (46). The reductions in depression and perceived stress favoring the present HIIT group also seem in accord with two systematic reviews concluding that initial first positive effects of HIIT on mental health are mediated by acute improvements in cardiorespiratory fitness. However, those studies were conducted in older subject groups with history of psychiatric illness (15, 17). Previous tests of an HIIT program in younger subjects did not indicate significant changes in depression symptoms (20). This difference might reflect differences in participant samples or HIIT design or their context preceding the onset of the COVID-19 pandemic and associated restrictive social measures.

Unexpectedly, we did not find any effect of the HIIT on the extent of anxiety experienced by our participants. Present results are thus at odds with a recent meta-analysis showing that physical activity could help to alleviate anxiety symptoms in young people (13). However, that study did not address the clinically relevant anxiety considered in our study, nor did it consider specific effects of the pandemic on anxiety. Furthermore, the changes in anxiety in the present study, although not significant, showed a moderate effect size (Cohen's $d = 0.8$). Hence, the *P*-Value ($P = 0.118$) for the interaction does not exclude the possibility that a larger sample might have yielded significant results; given the variances in anxiety scores, we can estimate that a population size of 20 per group might suffice to detect effects of the intervention. An additional consideration is that our participants had at recruitment elevated scores of trait anxiety on the GAD-7 score, such that their specific anxious symptoms might have been more resistant to the

TABLE 3 | DASS-21 assessment.

DASS-21	Baseline						Post-intervention					
Symptoms	**Depression**		**Anxiety**		**Stress**		**Depression**		**Anxiety**		**Stress**	
HIIT group ($n = 13$)												
mean (SD)	16.8	(9.6)	16.6	(7.2)	22.8	(8.7)	7.2	(6.6)	9.8	(7.5)	15.2	(8.3)
median (Min-Max)	16	[4-32]	18	[4-26]	22	[12-38]	4	(0–22)	8	[2-26]	14	[2-32]
Severity												
Normal	4		2		3		9		6		8	
Mild	2		0		3		2		1		2	
Moderate	1		3		1		1		3		1	
Severe	6		8		6		1		3		2	
Control group ($n = 15$)												
mean (SD)	16.9	(9.2)	14.7	(6.5)	22.9	(7.3)	13.2	(8.5)	13.3	(8.9)	20.4	(10.6)
median (min-max)	16	[4-32]	14	[6-26]	22	[10-34]	12	(0–26)	14	(0–34)	22	[6-42]
Severity												
Normal	4		1		3		5		4		5	
Mild	1		3		2		3		0		1	
Moderate	5		5		3		4		4		4	
Severe	7		6		7		3		7		5	

TABLE 4 | Results from the Mann–Whitney test on the difference (T1-T2) in intervention and control groups.

	HIIT group					Control group					Interaction
DASS-21	***n***	**Mean**	**(SEM)**	**[95%CI, lower to upper]**		***n***	**Mean**	**(SEM)**	**[95%CI, Lower to Upper]**		***P*-Value***
Depression Symptoms	13	9.5	(2.1)	5.4	13.7	15	3.7	(2.4)	−1	8.4	0.80
Anxiety symptoms	13	6.8	(1.7)	3.5	10.0	15	1.3	(2.7)	−3.9	6.6	0.118
Stress symptoms	13	7.5	(1.1)	5.3	9.8	15	2.5	(2.2)	−1.9	6.9	0.046

**Evaluated by Mann-Whitney test.*

intervention. Given the mixed results for RCTs against anxiety (19, 20, 25, 26, 38), we see a need for further investigation of the impact of HIIT on anxiety symptoms. A clinical sample screened for anxiety may show better improvements (21, 26). It seems that severity of anxiety, current fitness, exercise history, and exercise volume may be moderating factors for changes in cardiovascular and mental health after HIIT. Still, the mechanisms explaining their interactions are not clearly elucidated (14, 20).

The social isolation exacerbated by lockdown during the COVID-19 pandemic has detrimental psychological effects resembling those seen previously in diverse contexts such as space travel, polar or submarine expeditions, prison detention, certain military situations, or for patients in intensive care units (47). Therefore, we see prospects for a general utility of HIIT interventions in circumstances enforcing social isolation. The high adherence (87%) observed in our online HIIT intervention group indicates good tolerance, and may reflect its positive effects on wellbeing, notably with respect to reduction of depressive symptoms.

Strengths and Limitations

We demonstrated a feasible trial with high adherence (87%) with the HIIT intervention delivered by online videos. Safety was assured for participants mental and physical health who practiced HIIT, with even a potential protective effect in mental health during the current social crisis. This is the first RCT demonstrating a positive impact of HIIT on psychological symptoms in a clinical sample of adult students in higher education. Furthermore, we tested the effect of the intervention in the context of lockdown during the COVID-19 crisis, which is a distinct stressor and risk factor for this population.

However, we must exercise caution in the interpretation of the preliminary results in our feasibility trial, given the small sample ($n = 28$), which may have been insufficient to detect effects on anxiety scores. We see scope for testing dose-effects of the intervention, as well as the long-term effects of the intervention on psychological scores. Due to circumstances of the COVID-19 pandemic, the HIIT providers were not present face-to-face during the sessions, which might have reduced the quality of follow-up, although we did supervise participation online. The participants were physiotherapy students, which could contribute to their strong adherence to the program. The HIIT group received more attention than the passive control group, which may be involved to some extent in the improvement in psychological symptoms. For generalization of present results, we need to investigate a broader group of participants from the general population.

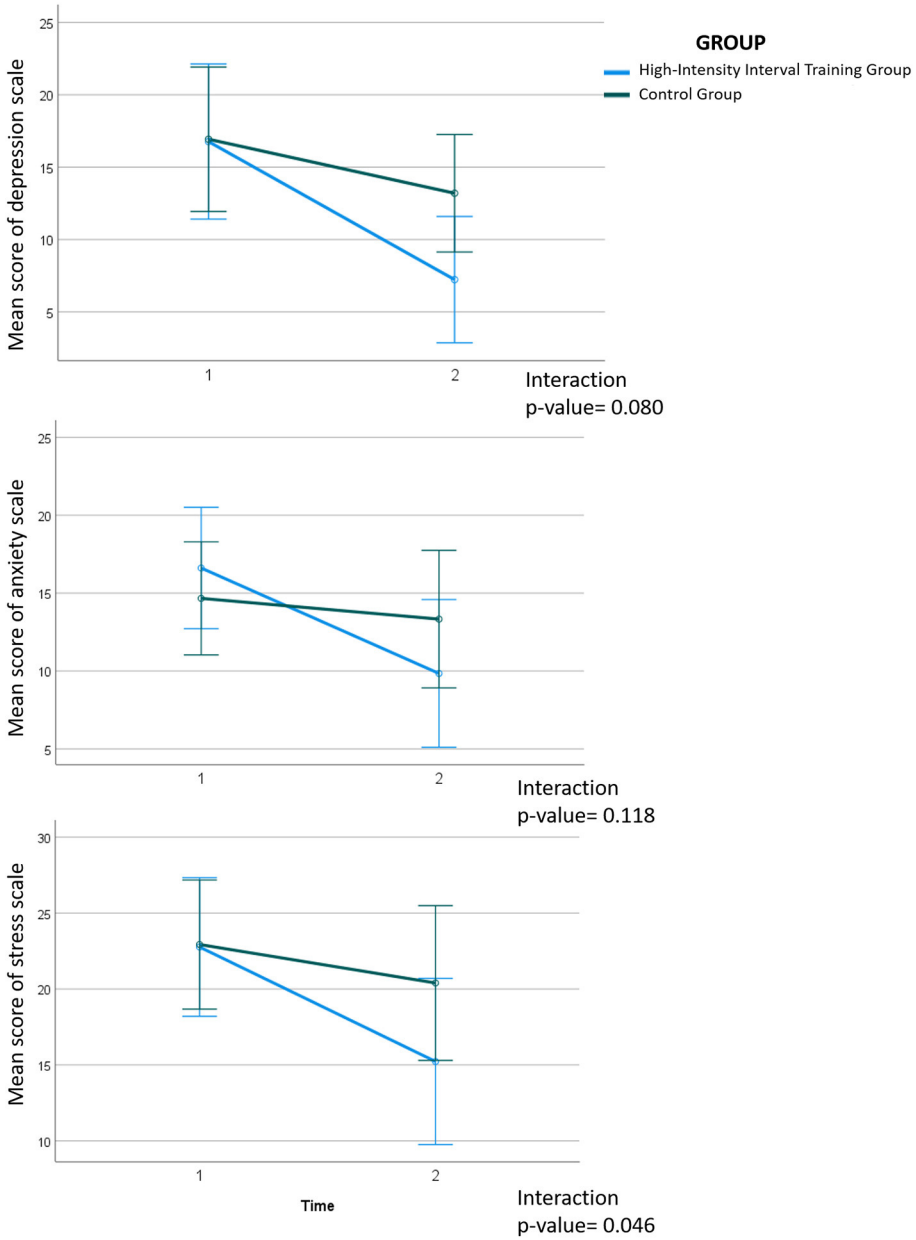

FIGURE 2 | Graphs of depression, anxiety, and stress scales from DASS-21.

Conclusions

Our study could be considered feasible and safe. The preliminary observations supported our hypothesis that the HIIT intervention could reduce stress and with a tendency depression symptoms in a clinical sample of adult students engaged in tertiary higher education during a challenging lockdown period of the COVID-19 pandemic. The analysis was unable to demonstrate a significant impact on anxiety. Further studies are recommended to confirm and extend these positive effects of the HIIT program on the mental health of young people, notably in a broader population and with consideration of possible dose-effects of a longer HIIT program. In addition, the neurobiological, psycho-social, and behavioral mechanisms induced by HIIT need to be explored to understand better its effect on mental health in a clinical sample of youth.

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 Bio-Ethical Committee for Research and Higher Education, Brussels (No. B200-2020-088). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

AP and PM contributed to the study design, were involved in the two arms of the trial at all steps, contributed to the statistical analysis, collected anamnestic data, and wrote the first draft of the manuscript. M-HC was involved in the two arms of the trial at all steps and in the collection of anamnestic data. AD, VD, PT, and CB gave comments and advice on interventions, study design, analysis, and draft manuscript. YB and KL conceptualized the project and oversaw its implementation, contributed to the study design, and wrote the manuscript. At the final step, all authors had access to the study data that support the publication. All authors contributed to the article and approved the submitted version.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Depression and Self-Efficacy Among Iranian Children During the Prevalence of COVID-19 Disease

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The coronavirus disease 2019 (COVID-19) outbreak has quickly endangered the physical and mental health of people in the community, particularly vulnerable people such as children. This study was carried out to investigate the depression and self-efficacy of Iranian children during the COVID-19 outbreak. This cross-sectional research was conducted on 321 students aged 8 to 17 in southeast Iran. A social media-based online questionnaire was used to collect data. The information was gathered using demographic and COVID-related items, the Children's Depression Inventory (CDI), and the Self-Efficacy Questionnaire for Children (SEQ-C). No significant correlation was observed between depression and self-efficacy of children ($P = 0.23$). However, in subscale of CDI, negative mood, ineffectiveness and negative self-esteem had a significant correlation with self-efficacy (<0.001). Depression had a significant correlation with family income ($p = 0.017$), being at risk of coronavirus infection ($p = 0.036$), effectiveness of preventive measures ($p = 0.015$) and how information about the coronavirus disease was obtained ($p = 0.018$). According to the results, the mean score of depression was higher than the midpoint of the questionnaire in Iranian children, therefore, it is needed to take the necessary measures and treatment plans to reduce the rate of depression in children. Further research is needed to assess and prevent childhood depression.

Keywords: COVID-19, coronavirus, depression, self-efficacy, children

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INTRODUCTION

Coronavirus is a type of virus that can cause respiratory infections. The virus can cause mild illnesses like colds or more severe illnesses like the severe acute respiratory syndrome (SARS) and the Middle East respiratory syndrome (MERS). The virus is now known as COVID-19 (1). The World Health Organization (WHO) has classified the disease as a major threat to physical and mental health because the outbreak of COVID-19 disease has altered families' daily and normal

lives, particularly their lifestyle (2). COVID-19 has also spread in Iran, threatening people's physical and mental health (3), as the disease prevalence has raised concerns about the possibility of death from viral infections and has caused psychological stress (4).

On the other hand, the spread of COVID-19 resulted in home lockdown and the closure of many recreational and educational facilities, which had a negative impact on people's mental health (5). School closures and home quarantine of students due to the spread of COVID-19 disease have a negative impact on children's physical and mental health (6). Reduced physical activity in children, the emergence of stressful stimuli at home, such as fear of getting sick, unpleasant thoughts, lack of communication with peers and friends, and lack of space for physical activity at home, as well as parental fear and anxiety, can all have long-term effects on children's mental health (7).

Children have to stay at home for a long period due to mandatory isolation and school closures during the COVID-19 outbreak, resulting in limited contact with peers, reduced physical activity, as well as more behavioral and emotional problems among them (8). Furthermore, home quarantine and its association with other factors such as parental mental illness and substance abuse, low socioeconomic status of the family, exposure to domestic violence, and a lack of opportunities for play and entertainment can have a significant impact on children's mental health during the COVID-19 epidemic (9). Children who witness the disease in others, on the other hand, are more likely to develop disorders like posttraumatic stress disorder and insomnia (10).

The limitations of COVID-19 disease can lead to adverse physical and mental health consequences. Children are among the most vulnerable groups who are at greater risk in such stressful situations.

In general, the prevalence of COVID-19 can cause feelings of insecurity, anxiety, fear, depression, insomnia, behavioral problems, irritability, posttraumatic stress disorder, and obsessive-compulsive disorder in children (11). Recent coronavirus research has found that anxiety caused by the coronavirus and family quarantine endanger family mental health and make children more susceptible to symptoms of psychological disorders (6, 12). Ghosh et al. (11) discovered that children were more likely to experience psychological problems during a crisis, particularly an epidemic. According to Wang et al. (13), children suffer more psychologically from an epidemic and experience a psychological crisis, which leads to a variety of psychological problems such as anxiety and depression. According to research, higher self-efficacy is associated with better practice (14) and lower psychological distress (15). The results of Zhou et al. (16) on the prevalence of coronavirus showed that people with higher general self-efficacy were more likely to have lower risk perceptions, fewer passive coping strategies, more active coping strategies, and subsequently fewer mental health problems. According to the results obtained from some research, fear of COVID-19 increases communication anxiety and decreases self-efficacy (17).

Self-efficacy is a person's belief in his or her ability to perform a specific task. This concept overshadows the person's effort and practice and refers to one's judgement of one's ability to perform an action, which can enable a person to adopt health-promoting behaviors and discontinue health-harming behaviors (18). Albert Bandura's cognitive-social theory is based on the concept of self-efficacy, which refers to people's beliefs in their capabilities to exercise control over their own functioning and over events that affect their lives. Bandura (19) believed that one of the most important factors in regulating human behavior was self-efficacy. Self-efficacy refers to an individual's belief in his or her ability and capacity to execute behaviors necessary to produce specific performance attainments. It means the belief a person has in their ability to attain results, to meet the challenges ahead of them, and to influence events that effect their own lives. Self-efficacy is predictive of future behavior, and it can serve as the inducer or inhibitor of appropriate actions (20). Hong et al. (21) acknowledged that the emotional climate of the classroom could have a significant impact on social self-efficacy, that social self-efficacy could significantly predict self-esteem and depression, and that self-esteem could significantly predict depression. Self-efficacy, a key element of social cognitive theory, appears to be an important variable because it affects students' motivation and learning. Several factors appeared to influence students' self-efficacy (22). High levels of self-efficacy decrease a person's possibility of experiencing stress and it can help control stress situations that one may encounter (23). Self-efficacy has been found to be positively correlated with posttraumatic growth (PTG) and to moderate the relationship between post-traumatic stress disorder (PTSD) and PTG in adolescents. An improve sense of self-efficacy in adolescents could promote positive psychological transformations (24). Psychological resources, such as self-efficacy, have been found to affect individual responses to traumatic events. A strong sense of self-efficacy strengthens a person's resilience to adversity (25).

Since mental health problems in children can have consequences and costs that affect not only the individual but also the family and society, understanding the psychological problems surrounding the COVID-19 outbreak can thus pave the way for more effective prevention, education, intervention, and treatment for families, professionals, and psychologists. Furthermore, because the effects of trauma and stress caused by social crises, particularly COVID-19 disease, on individuals, families, and communities persist, they may have an impact on a variety of psychological dimensions, including lifestyle, coping strategies, quality of life, and mental health.

Therefore, concerning the prevalence of COVID-19 in Iran and the need to investigate the effects of COVID-19 pandemic on the psychosocial status of Iranian children, the present study was conducted with the following specific objectives during the outbreak of COVID-19: (a) participants' level of depression based on the CDI; (a) participants' level of self-efficacy based on the SEQ-C; (b) the association of participants' demographic characteristics with depression; and (c) the association between depression and self-efficacy.

METHODS

Study Design and Setting

This cross-sectional study was conducted at Iranshahr University of Medical Sciences, Sistan and Baluchistan Province, Iran. A study was used to investigate the depression and self-efficacy of Iranian children and their determinant factors during the COVID-19 pandemic.

Sampling and Sample Size

The sampling was done by creating an online questionnaire and distributing it through social media (WhatsApp, Telegram, ETA, Soroush, and I-Gap). All children with 8 to 17 years living in both urban and rural areas in the province of Sistan and Baluchistan met the inclusion criteria. The study did not include questionnaires that were incomplete. The study population included school students at the time of data collection (n = 20,000). The sample size was estimated to be $n = 313$ using the Cochran formula ($\alpha = 0.05$, $d = 0.055$, $Z = 1.94$). Considering a 5% dropout probability, 329 students were selected.

$$N = \frac{N(Z_{a/2})^2 p_q}{(N-1)\,D^2 + PQ(Z_{a/2})^2} = \frac{20000 \times (1.96)^2 \times 0.25}{19999 \times (0.055)^2 + 0.25 \times (1.96)^2} = 313$$

Measurement

Data were collected using three questionnaires, including socio-demographic form, Children's Depression Inventory (CDI) and Self-Efficacy Questionnaire for Children (SEQ-C).

Socio-Demographic Form

(a) Participants' demographic information includes age, gender, education level, number of siblings, parents' level of education, job, and employment status, parents working in the healthcare system, and income of the family.

(b) Participants' COVID-19 disease information includes exposure to COVID-19 disease, precautions against the COVID-19 infection, concern about COVID-19 infection, illness in the family, having symptoms of the COVID-19 disease, and how information about COVID-19 disease was obtained.

Children's Depression Inventory

The CDI Questionnaire was developed by Kovacs and Beck (26) to measure depression in children and adolescents aged 7–17 years. The CDI scale consists of 27 items with five subscales of negative mood (6 items), interpersonal problems (4 items), ineffectiveness (4 items), anhedonia (8 items) and negative self-esteem (5 items). Each question of CDI consists of three sentences to measure depressive symptoms such as crying, suicidal ideation and the ability to focus on homework. Each item is assigned a score ranging from zero to two. The participants choose one of the three sentences that express his / her feelings and thoughts during the last 2 weeks. Questions are graded on a scale of 0 to 2. A score of zero indicates that there is no sign; a score of one indicates that there is a moderate sign, and a score of two indicates that there is an obvious sign. In Mokhtarnia et al. (27) study, Cronbach's alpha for this scale was reported to be 0.78 in Iranian children. In the present study, the Cronbach's alpha for CDI was 0.76.

Self-Efficacy Questionnaire for Children (SEQ-C)

To measure self-efficacy in children and adolescents, Muris used SEQ-C, a 23-item questionnaire, which included eight social questions, eight educational questions, seven emotional questions, and a general question. Five items (ranging from one to five) are used in each question of the SEQ-C to measure a person's level of self-efficacy. Cronbach's alpha coefficient is set to 0.86 in the original version (28). Habibi et al. investigated the psychometric properties of this scale in Iran (2014). The construct validity of this scale was confirmed by confirmatory factor analysis, and its convergent validity was confirmed by the Children Depression Inventory. In addition, Cronbach's alpha coefficients for social, educational, emotional factors and the whole scale were 0.73, 0.82, 0.76, and 0.85, respectively (29). In the present study, the Cronbach's alpha values for social, educational, emotional factors and the whole scale of CDI were 0.76, 0.89, 0.85, and 0.90, respectively.

Data Collection

Following the acquisition of the necessary permissions, the research team and computer experts created an online questionnaire based on the content of demographic information, COVID-related items, CDI, and SEQ-C. The research team controlled and tested the efficiency and responsiveness of this online questionnaire on 30 children. Data was collected from August to October 2020 in the third wave of coronavirus outbreaks. The questionnaire was distributed in coordination with schools in school social groups in urban and rural areas. The questionnaire was reported by 8–17-year-old children themselves and was completed by parents asking questions if the children had difficulty reading the questions (Only 7 questionnaires were completed by parents). Thirty-one hundred enO and sixty-seven questionnaires were studied, with 46 incomplete questionnaires removed (effective response rate: 87.46%). Data from 321 participants was used in the final analysis after the exclusion of incomplete questionnaires.

Data Analysis

SPSS 22 was then used to analyze the data. The data was described using descriptive statistics (frequency, percent, mean, and standard deviation). The correlation between the quantitative variables of the study was determined by the Pearson correlation coefficient. Independent t-test and ANOVA tests were used to determine SEQ-C based on the qualitative variables of the study. The SEQ-C determinants were identified using multivariate linear regression. The significance level of 0.05 was used.

Ethical Considerations

This research, with a code of ethics No. IR.IRSHUMS.REC.1399.008 was approved by Iranshahr University of Medical Sciences. The objectives and

methodology of the study were explained to the selected parents of a child. Consent form and questionnaires were sent to school social groups and it was mentioned that participating in the study is voluntary. After filling out the written consent form, the participants completed the first part of the online questionnaire anonymously. The written consent forms containing information on the objectives of the study, confidentiality, and exclusion from the study in the case of dissatisfaction were provided to all the participants. Participants agreed that their information would be used in research.

RESULTS

The mean age of children was 14.14 ± 1.91 (min = 8 to max = 17) years. The majority of the participants were middle school (62.6%) girls (75.7%) aged 13–17 years who had two siblings (26.8%) (**Table 1**). Other results of demographic characteristics of the participants are presented in **Table 1**. 8.4% of the participants were infected with the coronavirus ($n = 27$) and 57.6% of participants had relatives or friends who were infected with the coronavirus ($n = 185$). Furthermore, 38.6% of participants ($n = 124$) considered themselves to be at risk of the COVID-19 disease, and 75.1% of participants considered the effects of preventive measures in preventing the COVID-19 disease to be significant. More than 58% of participants ($n = 187$) said they always took precautions to avoid COVID-19 infection and practiced hand washing and disinfection ($n = 187$). The majority of the participants (41.1%) always advised others to take preventative measures. More than 35% of the participants ($n = 114$) were concerned about whether their families had been infected with COVID-19. In addition, 46.1% of the participants obtained the information about the COVID-19 disease from social networks ($n = 148$) (**Table 2**).

The mean score of depression was 25.29 ± 3.97, which was higher than the midpoint of the questionnaire (score = 13.5). Among the CDI subscales, the anhedonia had the highest score, while interpersonal problems had the lowest score. The mean score of self-efficacy was 79.84 ± 14.18, which was greater than the midpoint of the questionnaire (score = 57.5). Among self-efficacy subscales, the academic subscale had the highest score and emotional subscale had the lowest score (**Table 3**).

No significant correlation was observed between depression and self-efficacy of children ($P = 0.23$; $r = 0.06$). However, in subscale of CDI, negative mood ($r = 0.31$), ineffectiveness ($r = 0.-41$) and negative self-esteem ($r = 0.33$) had a significant correlation with self-efficacy ($p < 0.001$). None of self-efficacy subscales had a significant correlation with depression (**Table 4**).

The bivariate analysis showed a significant correlation between depression, income of family ($p = 0.017$), being at risk of coronavirus infection ($p = 0.036$), effectiveness of precautionary measures ($p = 0.015$) and how information about the coronavirus disease was obtained ($p = 0.018$) (**Tables 1**, **2**).

DISCUSSION

The purpose of this study was to look into depression and self-efficacy in Iranian children during the COVID-19 outbreak. The results of the current study revealed that the mean score of depression was higher than the midpoint of the questionnaire in children, indicating that children experienced depression during the COVID-19 epidemic. Anhedonia had the highest score in children among the depression subscales, while interpersonal problems had the lowest score. Bignardi et al. (30) emphasized that during the COVID-19 outbreak, symptoms of childhood depression were much higher during quarantine in the UK than before quarantine. These results support the current study's results. Kumar Panda et al. (31) identified anxiety, depression, irritability, impatience, inattention, and fear of COVID-19 as psychological problems in children during the COVID-19 outbreak. They also discovered that behavioral symptoms in children who already had behavioral problems, such as autism and attention-deficit/hyperactivity disorder were more likely to get worse (31). De Miranda et al. (32) discovered that children responded to stress in different ways depending on their developmental stage. As a result, high levels of anxiety, depression, and posttraumatic symptoms were found in children during the outbreak of COVID-19 (32). These results are consistent with the results of the current study. McKune et al. (33) found that the COVID-19 outbreak, followed by children quarantine, caused symptoms such as anxiety, depression, and obsessive-compulsive disorder. They admitted that these factors were more prevalent in younger children, girls, and low-income families. They also stated that school quarantine during the COVID-19 outbreak might have negative effects on children's mental health, so school principals should identify those at risk as soon as possible and take steps to reduce these risks (33). Yue et al. (34) considered anxiety, depression, and posttraumatic stress disorder as psychological problems for children and their parents during the COVID-19 outbreak. In this study, children living in areas with a lower prevalence of COVID-19 had fewer psychological consequences (34). Tang et al. (35) discovered three common psychological symptoms in children during the COVID-19 outbreak: anxiety, depression, and stress. They found that children who discussed COVID-19 with their parents experienced less anxiety, depression, and stress (35). Mangolian Shahrbabaki et al. (36) reported moderate-to-severe anxiety in female children who participated in their study. According to the findings of this study, 7–11-year-old girls suffered from fear and anxiety about COVID-19 because they misunderstood the news on social media and networks. On the other hand, parents could reduce their children's fear and anxiety by using simple words and explaining the disease to them (36).

According to the results of this study, the mean self-efficacy score was higher than the questionnaire's midpoint, indicating that the level of self-efficacy in the children who participated in this study was relatively acceptable. According to the articles in this field, no study examined self-efficacy in children during the coronavirus outbreak, so the studies that were most consistent with the current study were used to discuss and explain the results. As a result, Kermansaravi et al. (37) concluded that adolescents with type 1 diabetes had moderate self-efficacy. According to Behnam Vashani et al. (38), the self-efficacy of children with thalassemia major was moderate. Sheibani et al. (39), on the other hand, stated that the rate of self-efficacy in adolescents with thalassemia major was low. The results of

TABLE 1 | Demographic characteristics of the participants and their associations with depression ($n = 321$).

Variables	Frequency (Valid percent)	Depression score		Statistical test (p-value)
		Mean	SD	
Age				
8–12	47 (14.6)	24.68	4.02	$t = -1.14$ (0.25)
13–17	274 (85.4)	25.39	3.96	
Gender				
Boy	78 (24.3)	24.62	4.99	$t = -1.70$ (0.09)
Girl	243 (75.7)	25.50	3.57	
Level of education				
Primary	27 (8.4)	24.37	3.79	$F = 1.18$ (0.30)
Middle school	201 (62.6)	25.51	4.11	
Secondary school	93 (29.0)	25.07	3.71	
Sibling				
0	7 (2.2)	21.85	5.69	$F = 1.31$ (0.25)
1	40 (12.5)	25.80	3.00	
2	86 (26.8)	25.13	4.26	
3	79 (24.6)	25.29	4.35	
4	49 (15.3)	24.95	3.98	
5	39 (12.1)	25.64	3.09	
≥6	21 (6.5)	26.23	3.44	
Father's job				
Employed	115 (35.8)	25.11	4.06	$F = 1.24$ (0.29)
Self-employed	126 (39.3)	25.71	3.72	
Unemployed - retired	80 (24.9)	24.88	4.20	
Mother's job				
Employed	83 (25.9)	25.89	3.79	$F = 1.37$ (0.25)
Self-employed	42 (13.1)	25.33	4.83	
Housewife - unemployed - retired	196 (61.1)	25.03	3.84	
Income of family (Million Toman)[†]				
<1	75 (23.4)	24.58	3.86	$F = 3.43$ (0.017)
1–3	85 (26.5)	25.30	3.44	
3–5	78 (24.3)	24.78	4.69	
>5	83 (25.9)	26.39	3.65	
Father working in the health system				
Yes	49 (15.3)	25.40	3.93	$t = 0.22$ (0.82)
No	272 (84.7)	25.27	3.99	
Mother working in the health system				
Yes	27 (8.4)	25.33	2.93	$t = 0.05$ (0.95)
No	294 (91.6)	25.28	4.06	

SD, Standard Deviation; t, Independent t test; F, Analysis of variance; [†]*, One Dollar was 25000 Tomans.*

these studies may contradict to the results of the current study. Differences in results may be due to differences in target group age, target population, and data collection tools.

Self-efficacy beliefs determine how people feel, think, motivate themselves and behave (37). Self-efficacy, a key element of social cognitive theory, appears to be an important variable because it affects students' motivation and learning (38). A strong sense of efficacy enhances human accomplishment and personal wellbeing in many ways. Such an efficacious outlook produces personal accomplishments, reduces stress and lowers vulnerability to depression (39). Early stressful experiences may be related to the development of psychopathologies such as depression and social anxiety in adulthood (40). Various aspects of mental health are influenced by the sense of self-efficacy appraisal. As a result, low self-efficacy usually exacerbates some problems, such as emotional and social issues associated with mental health (41).

Depression, alcohol abuse, and suicidality each continue to threaten adolescent populations throughout the world. The comorbidity between these diseases has been found to

TABLE 2 | COVID-19 related variables and their associations with depression among children ($n = 321$).

Variables	Frequency (Valid percent)	Depression score		Statistical test (p-value)
		Mean	SD	
Infected with the coronavirus				
Yes	27 (8.4)	24.33	7.14	$t = -0.75$ (0.45)
No	294 (91.6)	25.38	3.55	
Relatives/ friends infected with the coronavirus				
Yes	185 (57.6)	25.20	4.61	$t = -0.49$ (0.62)
No	136 (42.4)	25.41	2.90	
Being at risk of coronavirus infection				
Yes	124 (38.6)	24.65	4.87	$t = -2.10$ (0.036)
No	197 (61.4)	25.69	3.24	
Effectiveness of precautionary measures				
Low	15 (4.7)	22.46	6.15	$F = 4.23$ (0.015)
Medium	65 (20.2)	25.16	4.77	
Much	241 (75.1)	25.50	3.50	
Taking precautions to prevent coronavirus infection				
Seldom / sometimes	36 (11.2)	24.02	6.14	$F = 2.20$ (0.11)
Most of the time	98 (30.5)	25.62	3.49	
Always	187 (58.3)	25.36	3.65	
Adherence to hand washing and disinfection				
Seldom / sometimes	40 (12.4)	25.07	6.59	$F = 1.21$ (0.29)
Most of the time	94 (29.3)	25.82	3.02	
Always	187 (58.3)	25.06	3.64	
Advising others to take preventative measures				
Seldom / sometimes	87 (27.1)	25.36	4.49	$F = 0.77$ (0.43)
Most of the time	102 (31.8)	25.62	3.90	
Always	132 (41.1)	24.98	3.66	
The most important concern about the coronavirus				
My family getting sick	114 (35.5)	25.22	3.63	$F = 0.02$ (0.97)
Death	89 (27.7)	25.33	4.16	
Others	118 (36.8)	25.32	4.18	
How information about the coronavirus disease was obtained				
Internet	78 (24.3)	24.12	4.90	$F = 3.38$ (0.018)
Medical staff	49 (15.3)	25.38	3.25	
Social networks	148 (46.1)	25.87	3.40	
Others	46 (14.3)	25.28	4.30	

SD, Standard Deviation; t, Independent t test; F, Analysis of variance.

be up to 73%, with consistent positive correlations between adolescent drinking, depression, and suicidality (40). Common risk factors for adolescent suicidality include depression and conduct problems (42). It is supposed that increasing the sense of self-efficacy helps manage such unpleasant emotions better and so decrease the probable harmful outcomes. Some research in this area has addressed the role of self-efficacy in the early-onset of depression. Children's perceived social and academic inefficacy contributed to concurrent and subsequent depression both directly and indirectly through their impact on academic achievement, prosociality, and problem behaviors (39). According to a study by Sawatzky et al. (43), identifying students with limited stress management self-efficacy and providing them with appropriate supportive services may help them to manage stress and prevent depression (44). By examining the determinants of depression and self-efficacy, a deeper understanding of children's conditions in crises such as the coronavirus can be achieved.

According to the results of this study, there is no significant correlation between children's depression and self-efficacy. In the CDI subscale, however, negative mood, inefficiency, and negative self-esteem were all significantly related to self-efficacy. However, none of the self-efficacy subscales had a significant correlation with depression. Hong et al. (21) demonstrated that the emotional climate of the classroom could have a significant impact on social self-efficacy and that social self-efficacy could predict self-esteem and depression. Marle et al. (41) also discussed the role of self-efficacy as a protective factor against

TABLE 3 | Description of the depression and self-efficacy and their dimensions' scores among children ($n = 321$).

Variable		Median	Mean	SD	Minimum	Maximum
Depression	Negative mood	7.00	6.43	1.72	1	10
	Interpersonal problems	2.00	2.62	1.17	0	7
	Ineffectiveness	3.00	3.42	1.54	0	7
	Anhedonia	7.00	6.60	1.85	0	15
	Negative self-esteem	7.00	6.19	1.66	1	9
	Total	26.00	25.29	3.97	4	41
Self-efficacy	Social	27.00	27.25	5.46	11	40
	Academic	31.00	30.38	6.07	10	40
	Emotional	22.00	22.20	5.88	7	35
	Total	81.00	79.84	14.18	35	114

SD, Standard Deviation.

TABLE 4 | Correlation between depression and self-efficacy and their dimensions' scores among children ($n = 321$).

Variable		Self-efficacy (Pearson's correlation coefficient)			
		Social	Academic	Emotional	Total
Depression	Negative mood	0.27*	0.21*	0.28*	0.31*
	Interpersonal problems	0.02	0.02	0.01	0.02
	Ineffectiveness	−0.29*	−0.36*	−0.34*	−0.41*
	Anhedonia	−0.12***	−0.03	−0.15**	−0.12***
	Negative self-esteem	0.26*	0.24*	0.31*	0.33*
	Total	0.06	0.04	0.05	0.06

*$p < 0.001$; ** $p < 0.01$, ***$p < 0.05$.

depression caused by COVID-19. Wen et al. (45) showed that increasing positive self-esteem, such as hope and self-efficacy, reduced students' stress during COVID-19. The findings of the previous studies contradict the findings of the current study. Differences in sample size, study population, research setting, and data collection tools may all be reasons for inconsistency. The type of psychological disorder in Wen et al.'s study was also different from that in the current study. According to Alemany-Arrebola et al. (42), a stressful situation (such as pandemic and quarantine) combined with a critical event (illness / death of a relative / friend due to COVID-19) increased students' anxiety and thus affected their academic self-efficacy. This study is also contradictory to the current study. It should be noted that in this study, students' anxiety was measured using self-efficacy, which could explain why the results of the two studies differed. Liu et al. (44) discovered a negative correlation between anxiety, depression, and self-efficacy in children with malignant tumors, and that increasing self-efficacy could reduce anxiety and depression. The findings of this study contradict the findings of the current study. Children with malignant tumors were examined in this study, which could explain why the results of the two studies differed. Furthermore, there were differences in sample size and data collection tools between the two studies.

Negative mood, interpersonal problems, ineffectiveness, lack of pleasure, and low self-esteem were all predictors of depression in the current study. Hong et al. (21) emphasized the current study's findings, demonstrating that self-esteem could significantly predict depression. However, due to a lack of additional research in this area, researchers must pay closer attention to the predictors of depression in children, particularly in crises such as COVID-19 disease.

The findings of this study revealed that the prevalence of COVID-19 and its associated factors, such as disturbances in daily routines and way of life, have produced concerns and problems among vulnerable populations, such as children. Consequently, the position of children and the trend of the COVID-19 outbreak in the region must be taken into account while managing vulnerable populations such as children. In the present study, bad mood, inefficiency, and low self-esteem were connected with self-efficacy in children, which should be taken into account in future research. There is a need for effective approaches to lessen childhood depression and prevent the long-term effects of COVID-19 outbreaks and worldwide crises. This study's findings can assist in identifying the levels of depression in children with COVID-19 as a worldwide crisis, as well as possible elements that contribute to the development of children's self-efficacy in professional guidance and crisis preparation involving COVID-19. Concerning future directions, we point to the existing position of children in crisis, which must be taken into account in order to combat the psychological consequences of epidemics and crises. Future research will focus on aspects associated with children's self-efficacy in

times of global catastrophe. In the future, understanding and advancing research on how to boost children's self-efficacy during times of global crisis or pandemic may be an essential field of study.

LIMITATIONS

The cross-sectional research design limits our understanding of the overall risk factors for depression and prevents us from determining the causal relationships between the variables studied. Longitudinal studies are required. As a result, longitudinal or interventional research should be conducted in the future. Second, self-report questionnaires were used, implying that future studies will require evaluations that are more specialized. Third, because of respondents' attitudes toward themselves, the use of self-report tools may result in biased answers to questions, which should be interpreted with caution. Our sampling was performed in the third wave of coronavirus outbreaks and was not related to all outbreaks of the disease, so the results may have been affected. Finally, because data were collected online without an independent assessment of respondents' health status, results should be generalized with caution.

One of the strengths of the present study is the attempt to better understand the factors affecting depression in children in the coronavirus crisis. Due to the special conditions and quarantine of children and the existence of various restrictions that make it difficult to have direct contact with children, the present study presents the challenges regarding the self-efficacy of children.

CONCLUSION

The current study found that the rate of depression and self-efficacy in children during the COVID-19 outbreak was higher than average, but self-efficacy did not play a significant role in predicting depression. Given that children are one of the most vulnerable groups in society, psychological trauma and problems can have a negative impact on them and society in the future. Furthermore, because pandemics such as COVID-19 will have a long-term impact on communities, appropriate and comprehensive planning is required to reduce psychological problems, particularly depression in children. Further studies in this area are needed since the children in this study had high self-efficacy and no correlation between self-efficacy and depression was found.

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 Iranshahr University of Medical Sciences No. IR.IRSHUMS.REC.1399.008. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

MZ, AD, and MD contributed to conception and design of the study. AD, AS, MA, and MK contributed to data collection. MZ and MD performed statistical analyses. MZ, MD, and FS wrote the first draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Trait Anxiety Mediates Impulsivity and Suicidal Ideation in Depression During COVID-19 Pandemic

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Suicidality in patients with major depressive disorder (MDD) has been an urgent affair during the COVID-19 pandemic. It is well-established that impulsivity and trait anxiety are two risk factors for suicidal ideation. However, literature is still insufficient on the relationships among impulsivity, (state/trait) anxiety and suicidal ideation in individuals with MDD. The present study aims to explore the relationships of these three variables in MDD patients during the COVID-19 pandemic through three scales, including Barrett Impulsivity Scale (BIS), State-Trait Anxiety Scale (STAI) and Self-rating Idea of Suicide Scale (SIOSS). Sixty-three MDD patients (low SIOSS group and high SIOSS group, which were split by the mean score of SIOSS) and twenty-seven well-matched healthy controls were analyzed. Our results showed that the high SIOSS group had higher trait anxiety ($p < 0.001$, 95% CI = [−19.29, −5.02]) but there was no difference in state anxiety ($p = 0.171$, 95% CI = [−10.60, 1.25]), compared with the low SIOSS group. And the correlation between impulsivity and suicidal ideation was significant in MDD patients ($r = 0.389$, $p = 0.002$), yet it was not significant in healthy controls ($r = 0.285$, $p = 0.167$). Further, mediation analysis showed that trait anxiety significantly mediate impulsivity and suicidal ideation in patients with depression (total effect: β = 0.304, $p = 0.002$, 95% CI = [0.120, 0.489]; direct effect: β = 0.154, $p = 0.076$, 95% CI = [−0.169, 0.325]), indicating impulsivity influenced suicidal ideation through trait anxiety in MDD patients. In conclusion, our results suggested that trait anxiety might mediate the association of impulsivity and suicidal ideation in MDD patients. Clinicians may use symptoms of trait anxiety and impulsivity for screening when actively evaluating suicidal ideation in MDD patients, especially in the setting of COVID-19 pandemic.

Keywords: suicidal ideation, major depressive disorder, impulsivity, anxiety, COVID-19 pandemic

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INTRODUCTION

Mental problems after COVID-19 outbreak arouse public concern (1–3). Latest statistics show that the rise of major depressive disorder (MDD) is 27.6% during the pandemic (4). Patients with MDD may experience worsening symptoms and their prevalence of suicidal ideation during the pandemic is 66.4% (5–8). Hence, suicidal ideation is a critical issue in patients with MDD during the pandemic. It is urgent to explore factors associated with suicidal ideation in MDD.

Impulsivity is a prominent factor of suicidality and may lead to an increased risk of suicidality (9–12). It refers to quick response and poor planning before considering consequences (13). Impulsive individuals may have a poor ability to get rid of suicidal thoughts or control their behaviors, thus causing tragedies. Wang et al. have found that MDD patients with higher impulsivity tend to have more suicidal ideation (14). Moreover, subcortical atrophy (e.g., globus pallidus) alterations have been revealed in patients with MDD and were severity of suicidal ideation and impulsivity dependent (15).

Although a majority of research has identified associations between impulsivity and suicidal ideation in individuals with MDD, the effect of anxiety is underestimated. Anxiety is a widely-explored risky predictor of suicidality (16–19). Recent research has demonstrated the correlation between anxiety symptoms and suicidality in MDD patients (20). This evidence displays the potential impact of anxiety on suicidal risk in MDD patients. Furthermore, anxiety symptoms commonly occur with MDD (21, 22) and would be intensified by COVID-19 pandemic (1, 5). Thereby, the influence of anxiety on suicidality should not be overlooked, especially during the pandemic. Patients with MDD are likely to have a higher level of anxiety, and subsequently, a higher risk of suicidality. Due to the negative impact, prevalence and severity of anxiety in the pandemic, great attention should be paid to anxiety in MDD patients.

The literature on the relationship of impulsivity, anxiety, and suicidal ideation is still lacking. A broad of evidence has verified the connection between impulsivity and anxiety, but their relationship has not reached a consensus yet (23–27). Notably, some studies have demonstrated the contribution of impulsivity to internalizing psychopathology [e.g., depression and anxiety; (28, 29)]. That impulsivity predicts anxiety severity has been found in both children (29) and adults (24) who are with internalizing or externalizing symptoms. Specifically, impulsivity would engage individuals in a highly emotional state in a stressful setting, causing anxiety symptoms (24). Hence, it could be inferred that impulsivity would lead to a higher level of anxiety during the pandemic. Trait anxiety is characterized as a general level of stress and anxiety, while state anxiety refers to a state of emotional stress and anxiety that responds to a fearful or dangerous situation (18, 30, 31). Previous research has suggested trait anxiety would amplify impulsivity, resulting in severer consequences (23). Extensive studies have indicated trait anxiety might be a more important predictor of suicide risk than state anxiety (18, 32). Based on the mentioned studies, trait anxiety may mediate the association between impulsivity and suicidal ideation.

Studies regarding the influence of impulsivity and trait anxiety on suicide ideation in MDD patients are still scarce. Our study aimed to investigate the relationship of impulsivity and anxiety on suicide ideation in an outpatient sample with MDD in the context of COVID-19 pandemic. We hypothesized that MDD individuals with higher suicidal ideation would exhibit increased impulsivity and trait anxiety. We also hypothesized that impulsivity was associated with suicidal ideation, which was mediated by trait anxiety in patients with MDD.

MATERIALS AND METHODS

Study Design and Sample Size

This study was designed as a case-control study, expecting to recruit a depressed group and a healthy control group. The sample sizes of patients and healthy subjects were calculated by using two independent proportions in PASS 15. Since the depressive group needed to be divided into two subgroups (groups with low and high suicidal ideation) for stratified comparison, the ratio of the sample size of healthy subjects to the sample size of patients should be 0.5. The exposure rates of patients (P1) and of healthy subjects (P2) were approximately estimated as 0.84 and 0.5 separately, according to a previous study related to suicidality and impulsivity (33). Power and alpha were set as 0.9 and 0.05, respectively. The results showed that the sample sizes of the depressive group should be 55 and the healthy group should be 28.

Subjects

We recruited 77 patients and 27 healthy subjects from April to September 2021, which was during the period of the COVID-19 pandemic. All patients should meet the criteria for depressive episodes according to the Mini-International Neuropsychiatric Interview (MINI) and the Hamilton Depression Scale (score $\geq$ 17). Exclusion criteria included the current or past history of psychotic disorders, bipolar disorder, history of alcohol/substance abuse, active medical or neurological problems, and other psychiatric diseases. After screening, 63 patients diagnosed with MDD (28.54 $\pm$ 6.75 years) and 27 well-matched healthy subjects (29.22 $\pm$ 10.87 years) were analyzed (see more details in **Figure 1B**). Part of the patients received or had been receiving drug treatment. This study was approved by the ethics committee of Shanghai Mental Health Center (ethics committee approval number: CRC2017YB01) and complied with the Declaration of Helsinki. The procedure of this study is shown in **Figure 1A**.

Questionnaires

The Hamilton Depression Scale (HAMD) (34) is a widely-used assessment for depressive severity (14, 35, 36), including 17 items on a 5-point scale (0 = "none", 4 = "extremely severe"). Higher scores represent severer depression symptoms. The scale is examined by a trained rater by conversation and observation.

The Hamilton Anxiety Scale (HAMA) (37) is a widely-used assessment for anxious severity (35, 36, 38), including 14 items on a 5-point scale (0 = "none", 4 = "extremely severe"). Higher scores represent severer anxiety symptoms. The scale is examined by a trained rater by conversation and observation.

The Barrett Impulsivity Scale (BIS) (39) is a self-rating scale used to evaluate impulsivity, containing 30 items on a 5-point scale (1 = "never", 5 = "always"). It consists of three dimensions: motor impulsivity, attentional impulsivity, and non-planning impulsivity, with a total score varying between 30 and 150. High scores represent hyperactivity, inattention, and lack of planning (i.e., higher impulsivity). Cronbach's alpha for BIS was 0.652 in the present study.

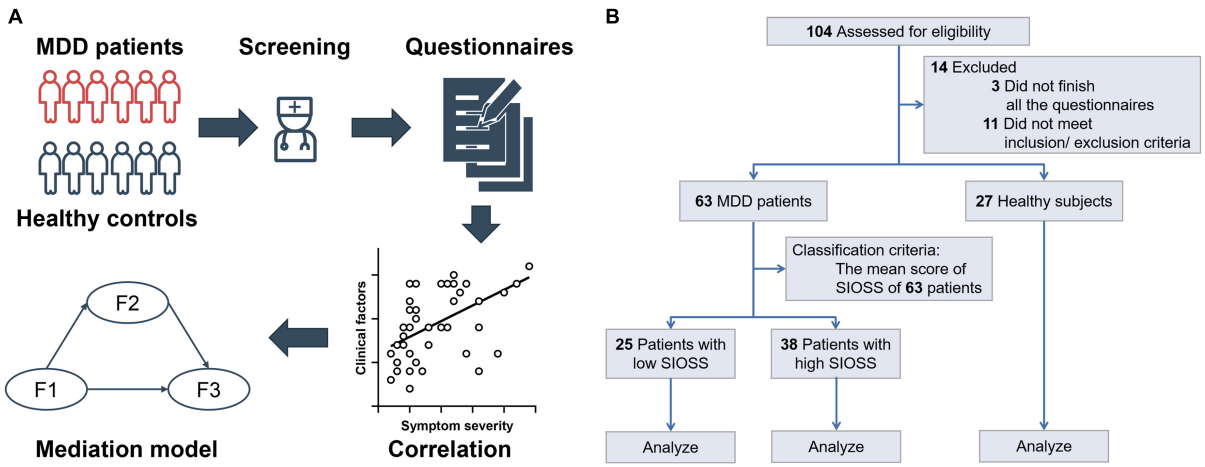

FIGURE 1 | The procedure of the study. **(A)** Study procedure; **(B)** The flow chart of sample size.

The 26-item Self-rating Idea of Suicide Scale (SIOSS) (40) is a self-rating scale used to evaluate suicidal ideation. The scale includes four factors: despair, sleep, optimism, and concealment. Participants should choose "yes" or "no" as the answer. If the concealment factor is ≥4, the result is invalid and should be excluded. High scores represent stronger suicidal ideation. Cronbach's alpha for SIOSS was 0.652 in the present study.

The 40-item State-Trait Anxiety Scale (STAI) (31) is a self-rating scale used to evaluate state and trait anxiety on a 4-point scale (1 = "not at all", 4 = "very much so"). The scale has two subscales: (1) State Anxiety Inventory (STAI-S) measures state anxiety, including items 1–20. State anxiety describes momentary and unpleasant emotions such as tension, fear, and worry. (2) Trait Anxiety Inventory (STAI-T) measures trait anxiety, including items 21–40. Trait anxiety describes a personality or a relatively stable tendency to feel anxious. Cronbach's alpha for STAI was 0.638 in the present study.

Statistical Analysis

Patients were divided into two subgroups (low/high SIOSS group) according to the mean of SIOSS of all patients, in order to distinguish the features of MDD patients with low and high suicidal ideation. One-way ANOVA analyses were used by IBM SPSS Statistics 24 (SPSS) on the demographic and clinical variables to compare the low SIOSS group, high SIOSS group, and healthy group. When significance was found in one-way ANOVA analysis, Bonferroni correction was then used in *post hoc* analysis. Pearson correlation analyses were performed by GraphPad Prism 8 to examine the relationships of clinical factors (suicidal ideation/impulsivity/trait anxiety) and symptom severity (HAMD/HAMA). To verify the relationships of suicidal ideation, impulsivity, and trait anxiety in depression, pairwise relationships of these three variables were first examined by Pearson correlation analyses. A mediation analysis was then performed by employing SPSS PROCESS Model 4. Similar analyses were also conducted in the healthy group. All statistical tests were two-tailed and the significance threshold was $p < 0.05$.

RESULTS

Demographic and Clinical Characteristics

Sixty-three MDD patients were divided into two subgroups by the mean score of SIOSS. Of all the patients, 25 (39.7%) were divided into the low SIOSS group (SIOSS < 15) and 38 (60.3%) were divided into the high SIOSS group (SIOSS ≥ 15). The two subgroups and healthy group did not differ on demographic characteristics, except sleep quality (see **Table 1**). Clinically, both subgroups showed more severe depression symptoms (low SIOSS group: $p < 0.001$, 95% CI = [17.60, 23.71]; high SIOSS group: $p < 0.001$, 95% CI = [19.61, 25.15]) and anxiety symptoms (low SIOSS group: $p < 0.001$, 95% CI = [16.64, 25.14]; high SIOSS group: $p < 0.001$, 95% CI = [19.33, 27.03]) t compared with healthy group, while two MDD subgroups showed no significant difference in depression severity ($p = 0.422$) and anxiety severity ($p = 0.479$).

Impulsivity

One-way ANOVAs were performed on impulsivity. Results showed that the low SIOSS group, high SIOSS group, and healthy group differed on the total score of BIS [$F(2, 87) = 22.56$, $p < 0.001$, $\eta^2 = 0.342$]. *Post hoc* analyses revealed that the two MDD subgroups showed no difference in the score of BIS ($p = 0.142$, 95% CI = [−5.44, 0.52]). However, the total scores of BIS of low SIOSS group ($p < 0.001$, 95% CI = [2.30, 8.72]) and high SIOSS group were both higher than the healthy group ($p < 0.001$, 95% CI = [5.05, 10.88]; **Figure 2A**). The results indicated that patients had higher impulsivity than healthy subjects, but impulsivity did not increase despite stronger suicidal ideation.

State and Trait Anxiety

The results of one-way ANOVAs revealed significant difference among three groups on trait anxiety [$F(2, 87) = 84.15$, $p < 0.001$, $\eta^2 = 0.566$] and state anxiety [$F(2, 87) = 61.66$, $p < 0.001$,

TABLE 1 | Demographic and clinical characteristics of patients with low suicidal ideation, patients with high suicidal ideation, and healthy subjects.

		Low SIOSS group			High SIOSS group			Healthy group			Adjusted *p*	η^2	*Post hoc*
		n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD			
Demographic information	Gender (Male: Female)		10:15			11:27			9:18		0.669	0.009	–
	Age	25	30.08	7.19	38	27.53	6.34	27	29.22	10.87	0.451	0.018	–
	Education (years)	25	16.20	3.49	38	14.89	2.57	27	15.89	2.04	0.138	0.044	–
	AUDIT	25	2.76	6.04	38	3.21	5.84	27	0.67	1.94	0.127	0.046	–
	FTND	25	0.56	1.56	38	0.37	1.40	27	0.00	0.00	0.246	0.032	–
	PSQI	25	10.00	4.07	38	10.89	3.19	27	4.48	2.16	<0.001	0.441	HC < LS, HS
Scales	HAMD	25	21.88	4.82	38	23.61	5.54	27	1.22	1.67	<0.001	0.835	HC < LS, HS
	HAMA	25	22.00	7.58	38	24.29	7.30	27	1.11	1.60	<0.001	0.734	HC < LS, HS
	BIS no plan	25	29.16	7.09	38	33.08	6.51	27	22.15	5.54	<0.001	0.346	HC < LS, HS
	BIS motor	25	26.44	6.40	38	29.34	5.59	27	21.37	6.07	<0.001	0.245	HC < LS, HS
	BIS attention	25	27.08	5.50	38	27.63	5.19	27	22.63	4.67	0.001	0.160	HC < LS, HS
	BIS total	25	27.56	4.98	38	30.02	4.75	27	22.05	4.50	<0.001	0.342	HC < LS, HS
	STAI-S	25	58.40	10.72	38	63.08	9.92	27	33.41	7.15	<0.001	0.659	HC < LS, HS
	STAI-T	25	56.40	13.41	38	68.55	9.51	27	36.85	11.67	<0.001	0.586	HC < LS < HS
	SIOSS despair	25	6.44	2.16	38	10.66	1.17	25	2.32	2.81	<0.001	0.751	HC < LS < HS
	SIOSS sleep	25	2.64	1.38	38	3.26	0.92	25	0.88	1.17	<0.001	0.444	HC < LS, HS
	SIOSS optimism	25	2.00	1.16	38	3.87	0.70	25	0.36	0.91	<0.001	0.730	HC < LS < HS
	SIOSS concealment	25	0.68	0.90	38	0.76	0.82	25	0.72	0.79	0.927	0.002	–
	SIOSS total	25	11.08	2.60	38	17.79	1.58	25	3.56	3.99	<0.001	0.828	HC < LS < HS

AUDIT, Alcohol Use Disorders Identification Test; FTND, Fagerstrom Test for nicotine dependence; PSQI, Pittsburgh Sleep Quality Index; HAMD, Hamilton Depression Scale; HAMA, Hamilton Anxiety Scale; BIS, Barrett Impulsivity Scale; STAI, State-Trait Anxiety Scale; SIOSS, Self-rating Idea of Suicide Scale; HC, healthy group; LS, low SIOSS group; HS, high SIOSS group.

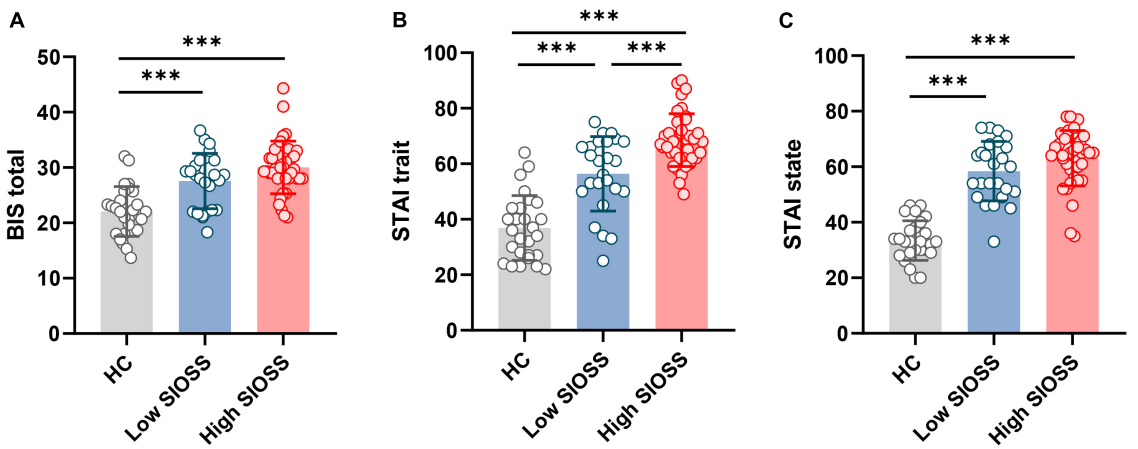

FIGURE 2 | Comparisons of healthy controls, patients with low suicidal ideation, and patients with high suicidal ideation on clinical factors. **(A)** Comparisons of impulsivity between three groups; **(B)** Comparisons of trait anxiety between three groups; **(C)** Comparisons of state anxiety between three groups. ***$p < 0.001$.

$\eta^2 = 0.659$]. *Post hoc* analysis revealed that both two MDD subgroups showed higher trait anxiety (low SIOSS group: $p < 0.001$, 95% CI = [11.86, 27.24]; high SIOSS group: $p < 0.001$, 95% CI = [24.73, 38.67]) and higher state anxiety (low SIOSS group: $p < 0.001$, 95% CI = [18.61, 31.38]; high SIOSS group: $p < 0.001$, 95% CI = [23.88, 35.46]) than healthy group (**Figures 2B,C**). However, low SIOSS group and high SIOSS group differed on trait anxiety ($p < 0.001$, 95% CI = [−19.29, −5.02]) but not on state anxiety ($p = 0.171$, 95% CI = [−10.60, 1.25]). These results suggested that severe state and trait anxiety were presented in MDD patients, and only trait anxiety was severer in MDD patients with higher suicidal ideation.

Correlations Between Clinical Indexes and Symptom Severity

We used Pearson correlation analyses to examine the relationships between symptom severity and clinical factors (see **Figures 3A–F**). The results showed that suicidal ideation was associated with HAMD ($r = 0.311$, $p = 0.013$) and

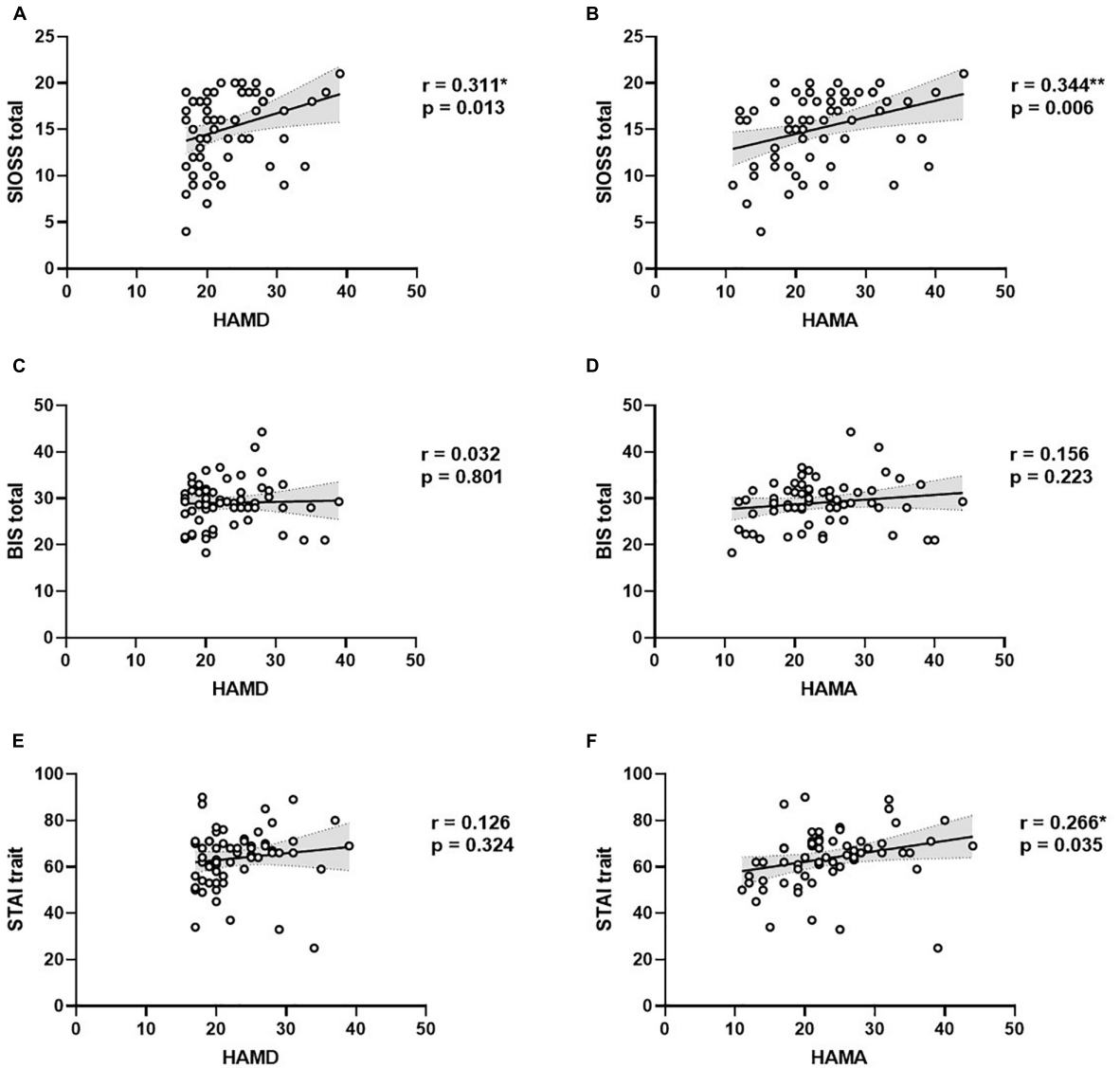

FIGURE 3 | Correlations between clinical indexes and symptom severity in MDD. **(A)** Correlation between suicidal ideation and depression severity; **(B)** Correlation between suicidal ideation and anxiety severity; **(C)** Correlation between impulsivity and depression severity; **(D)** Correlation between impulsivity and anxiety severity; **(E)** Correlation between trait anxiety and depression severity; **(F)** Correlation between trait anxiety and anxiety severity.

HAMA (r = 0.344, p = 0.006; **Figures 3A,B**). These results demonstrated that MDD patients with severer depression and anxiety symptoms tended to have stronger suicidal ideation. Additionally, trait anxiety was associated with HAMA (r = 0.266, p = 0.035; **Figure 3F**). Correlation analyses demonstrated that MDD patients with severer anxiety symptoms would have a higher level of trait anxiety.

Impulsivity Influences Suicidal Ideation Through Trait Anxiety

Pearson correlation analyses were performed to test the pairwise relationships among impulsivity, trait anxiety, and suicidal ideation in patients. The results showed that impulsivity was associated with suicidal ideation (r = 0.389, p = 0.002) and trait anxiety (r = 0.370, p = 0.003; **Figures 4A,B**). And trait anxiety was significantly correlated with suicidal ideation as well (r = 0.590, $p < 0.001$; **Figure 4C**). Additionally, the same analysis was also conducted on impulsivity and state anxiety and revealed no significant correlation (r = 0.134, p = 0.294). The results suggested that impulsivity only correlated with trait anxiety.

Given these pairwise relationships, a mediation analysis was performed to test whether trait anxiety mediated the relationship between impulsivity and suicidal ideation in MDD. The total effect of impulsivity on suicidal ideation was significant (β = 0.304, p = 0.002, 95% CI = [0.120, 0.489], **Figure 4D**). However, the direct effect of impulsivity on suicidal ideation was not significant (β = 0.154, p = 0.076, 95% CI = [−0.169, 0.325]).

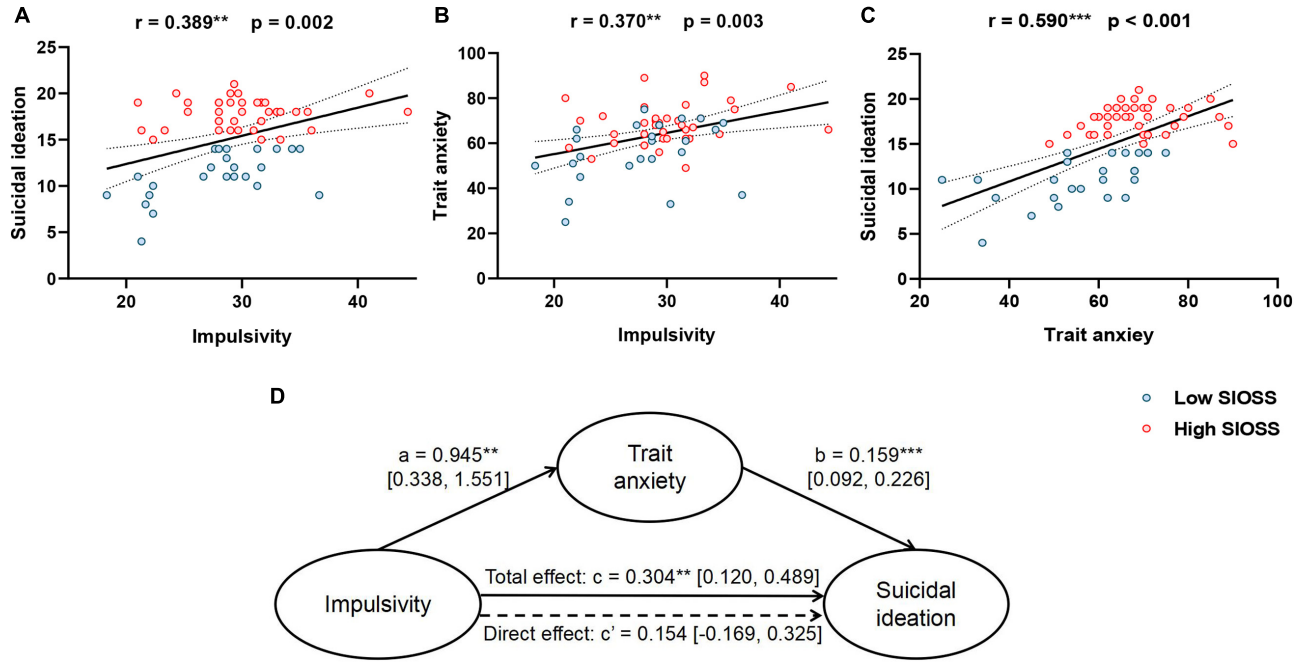

FIGURE 4 | Correlations and mediation model. **(A)** Correlation between impulsivity and suicidal ideation; **(B)** Correlation between impulsivity and trait anxiety; **(C)** Correlation between trait anxiety and suicidal ideation; **(D)** Mediation model. $^{**}p < 0.01$, $^{***}p < 0.001$.

These results suggested trait anxiety might play a fully mediating role between impulsivity and suicidal ideation in depression. The results supported that impulsivity might lead to suicidal ideation through trait anxiety instead of directly influencing suicidal ideation in MDD patients.

As for healthy subjects, same analyses were used to examine the relationship of impulsivity, trait anxiety and suicidal ideation. Pearson correlation analyses showed trait anxiety was positively correlated with suicidal ideation ($r = 0.442$, $p = 0.027$) while impulsivity have no correlation with trait anxiety ($r = 0.020$, $p = 0.921$) and suicidal ideation ($r = 0.285$, $p = 0.167$). These findings indicated that impulsivity has no correlation with trait anxiety and suicidal ideation in healthy subjects.

DISCUSSION

The results demonstrated that MDD patients with stronger suicidal ideation have higher impulsivity and trait anxiety, which was consistent with previous studies (20, 26, 41). Furthermore, the results showed trait anxiety played a fully mediating role between impulsivity and suicidal ideation in depression. The associations found among impulsivity, trait anxiety and suicidal ideation contribute to the current literature, and indicate that those individuals with MDD who have higher level of impulsivity and trait anxiety may be at risk for suicidal ideation.

The findings revealed that impulsivity had an impact on suicidal ideation through trait anxiety rather than state anxiety in MDD. The relationship of impulsivity and trait anxiety is consistent with the previous studies (24, 29). As extensive studies have revealed, impulsive individuals would have deficits in active coping (42) and emotion regulation (43, 44). Based on the data in the present study, it seems reasonable to assume that MDD patients with higher impulsivity would lack active coping to deal with the distress and negative emotions caused by COVID-19 pandemic, resulting in frequent, aggravated and long-lasting negative emotions [i.e., trait anxiety; (30, 45)]. Our findings also accord with previous studies and show that due to higher trait anxiety, individuals would then have stronger suicidal ideation (18, 32). Thereby, the mediating role of trait anxiety is observed in the association of impulsivity and suicidal ideation. However, these findings do not contradict accumulating evidence that impulsivity is an outcome or a moderator of anxiety (26, 27). Yu et al. reveal the impact of anxiety on impulsivity in college students (27), while Schaefer et al. demonstrate impulsivity moderates the association between anxiety and suicidal ideation in undergraduate students (26). Combined with the existing evidence, the relationship between impulsivity and anxiety may have its complexity. Future research could explore the influence of interactions between impulsivity and anxiety on suicidal risk in different situations or clinical populations.

Moreover, we found correlations between depression/anxiety severity and suicidal ideation, which are consistent with previous studies (14, 38). The results indicate that MDD patients with severe depression and anxiety symptoms are also at high risk of suicidality. Therefore, those patients with severe depression and anxiety symptoms need great concern. Additionally, the results showed that impulsivity was not correlated with depression severity (i.e., the score of HAMD) and anxiety severity (i.e., the

score of HAMA), which is contradictory to the finding of Johnson et al. (24). One possibility is the heterogeneity of measurements. Specifically, the Mood and Anxiety Symptoms Questionnaire (MASQ), used by Johnson et al., assesses core depression/anxiety symptoms from affectivity and somatic arousal (46). Yet, HAMA and HAMD measure some medication side effects or border symptoms (e.g., sleep, weight and sexual problems, and hypochondriasis) besides core symptoms (34, 37, 47). Our study corroborates the previous findings (24) by showing trait anxiety was correlated with impulsivity. The contradiction may indicate that impulsivity is mainly connected with the affective aspect of symptoms. It is essential for future studies further explore the relationship of impulsivity and negative effects or affective experiences. Alternatively, MASQ is a self-reported scale, while HAMA and HAMD are rated by trained raters. The way of rating may also cause inconsistent findings.

The findings suggest several clinical implications. Firstly, extra measurement tools (e.g., BIS and STAI) may assist the examination of suicidal risk in MDD patients. Furthermore, clinicians should put more emphasis on MDD patients with higher trait anxiety and impulsivity, and could consider interventions centered on anxiety and impulsivity to reduce suicidal risk. According to several clinical studies, Cognitive Anxiety Sensitivity Treatment (CAST) and Dialectical Behavior Therapy (DBT) target anxiety symptoms and suicidality, and have good efficacy in reducing suicidal ideation (48, 49). Besides, a brief online intervention is also proved to be efficient to reduce emotion-related impulsivity, which includes emotion recognization, self-calming techniques and pre-plan coping strategies (50). Retention and engagement of interventions would be challenging (51), especially considering the high level of impulsivity in MDD patients in our study. These impulsive individuals have difficulties in focusing on the task and long-term goals, and therefore, it is necessary to highlight the long-term goals and consequences of imprudent behaviors during the intervention (51).

Several limitations need to be mentioned in the present study. First, the relatively small sample and different sample sizes of each group (low SIOSS group/high SIOSS group/healthy group) may result in possible bias. If more subjects had been recruited, we may have demonstrated the difference in impulsivity between MDD patients with low suicidal ideation and with high suicidal ideation. Second, the self-report scale could also cause bias due to the honesty, education, and statement of individuals. Future work could recruit a larger sample of patients and adopt behavioral measurements to verify the relationships among impulsivity, trait anxiety, and suicidal ideation. Third, this study does not include the history of suicidal behaviors of MDD patients. Besides suicidal thoughts, suicidal behaviors are also an important part of suicidality in MDD patients, which is also necessary for exploration in the future.

In conclusion, impulsivity and trait anxiety may be the risk factors for suicidal ideation in depression. Besides, trait anxiety plays a fully mediating role between impulsivity and suicidal ideation. These findings indicate impulsivity has an impact on suicidal ideation through trait anxiety in MDD. Additionally, during COVID-19 pandemic, attention should be paid to MDD patients with high anxiety symptoms and impulsivity to prevent and intervene in the potential suicidal thoughts and behaviors.

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 Shanghai Mental Health Center. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

XC and YZ performed the study. XC, YZ, DZ, T-FY, and JQ designed the experiment, analyzed the results, wrote the manuscript, read, and approved the final version of the manuscript. All authors contributed to the article and approved the submitted version.

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Need Satisfaction and Depressive Symptoms Among University Students in Hong Kong During the COVID-19 Pandemic: Moderating Effects of Positive Youth Development Attributes

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As studies on the mental health status of university students during the COVID-19 pandemic are almost non-existent in Hong Kong, we examined four research questions in this paper: What is the prevalence of depressive symptoms in university students in Hong Kong? What are the socio-demographic correlates of depressive symptoms? Do need satisfaction and positive youth development (PYD) attributes, including beliefs about adversity, psychosocial competence (resilience and emotional competence) and family functioning predict depression? Do PYD attributes moderate the predictive effect of need satisfaction on depression? We examined the above research questions using the Centre for Epidemiologic Studies Depression Scale Revised (CESD-R) in 1,648 university students in Hong Kong. For PYD attributes, we utilized validated measures of Chinese beliefs about adversity, psychosocial competence (resilience and emotional competence), and family functioning. For need satisfaction, we used a measure derived from two focus group interviews involving university students. Results showed that 48.4% of the respondents (95% confidence interval = [45.9%, 51.1%]) scored 16 or above (i.e., "at-risk" for clinical depression). As predicted, age, gender, student status (local vs. international), and family financial hardship were significant socio-demographic correlates of depressive symptoms. Besides, need satisfaction and PYD attributes negatively predicted depression scores. Finally, multiple regression analyses controlling for gender, age, and student status as covariates showed that all PYD attributes moderated the impact of need satisfaction on depression. The findings reinforce the theoretical proposition that PYD attributes serve as important factors in protecting the mental health of university students during the pandemic.

Keywords: depression, positive youth development, beliefs about adversity, psychosocial competence, family functioning

INTRODUCTION

The mental health of university students is a growing concern in the global context (1). In particular, researchers have reported that depression is a common problem in university students. For example, Vázquez and Blanco (2) revealed that 33% of Spanish university students were at-risk of moderate and severe depression. In Ghana, Oppong Asante and Andoh-Arthur (3) found that 31.1% of university students showed mild to moderate depression and 8.1% showed severe depression. Similarly, Tao et al. (4) found that 6.1% of Chinese university students reported at least moderate depressive symptoms. In a prospective longitudinal study conducted in China, Song et al. (5) found that 42% of non-depressed Chinese first-year students developed depressive symptoms within 2 years of college study.

COVID-19 has adversely affected the mental health of students because the learning mode has substantially changed under the pandemic (6). Interestingly, while many researchers have conducted studies in different parts of the world to understand the mental health of university students under the pandemic, related studies are almost non-existent in the Hong Kong context. As the mental health of university students might be adversely affected during the "Social Event" taking place in 2019–2020 (7), there is an urgent need to understand the mental health of Hong Kong university students under the pandemic. In this study, we examined several issues based on a large sample of university students in Hong Kong. These issues included the prevalence and socio-demographic correlates of depressive symptoms in university students, predictive effects of need satisfaction, positive youth development (PYD) attributes and family functioning on depression in college students, and the moderating effect of PYD attributes on the influence of need satisfaction on depression.

LITERATURE REVIEW

Prevalence of Depression and Socio-Demographic Correlates of Depression Under COVID-19

According to Shek et al. (8), the COVID-19 pandemic has brought many challenges to university students, such as intrapersonal, interpersonal, academic, and financial adjustments that may lead to increased stress. Obviously, these adjustments within a short time would eventually impair the mental health of university students under the pandemic. There are studies suggesting mental health problems of university students under the pandemic are alarming. Yu et al. (9) showed that 56.8% of Chinese students had moderate or severe levels of depression; Luo et al. (10) showed that 26.0% of Chinese students were at-risk of depression; Truchot et al. (11) showed that 52% of the French female students and 49% of French male students displayed depressive symptoms.

Regarding socio-demographic correlates of depression in university students under COVID-19, researchers have identified several significant correlates. The first correlate is age. Theoretically, with more life experience and better coping abilities (12) as well as resilience (13), older students' mental health might be better than that of younger students. While many studies supported this hypothesis (14, 15), some studies showed the reverse pattern (16). The second significant demographic correlate is gender. While female college students showed poorer mental health than did male college students under the pandemic (17–19), male students showed more psychological symptoms than did female students (20). A recent meta-analysis also showed mixed findings (1).

The third factor is whether the student comes from abroad. Research generally showed that international students experienced many mental health problems during the pandemic (21) and their mental health was poorer than domestic students (22). Nevertheless, the picture may be different in Hong Kong. Cheung et al. (23) showed that some local students displayed high levels of depression while international students had the lowest level of depression. Furthermore, as the experience of social unrest preceding the pandemic may have already resulted in a deterioration in university students' mental health (7, 20), the COVID-19 pandemic might further impair the mental health of university students (20, 24).

Finally, college students' financial distress was significantly associated with anxiety, stress, depression, or post-traumatic stress symptoms [e.g., (25)]. As the pandemic creates a visible financial hardship for people, findings from different places (26, 27) showed that university students experiencing economic hardship had poorer mental health as compared to those without economic disadvantage.

Need Satisfaction and Positive Youth Development Attributes as Predictors of Depression

Self-determination theory maintains that satisfaction of one's needs in different aspects (e.g., personal development and social interactions) leads to better adjustment such that need satisfaction results in better mental health while need frustration leads to more mental health problems such as depression (28). There are studies showing need satisfaction was positively related to student mental health (29–31). During the pandemic, university students' need satisfaction may be threatened due to the interruption of a "normal life" resulting from social distancing measures and other sudden changes in life mode, which may in turn negatively affect their mental health. Hence, besides satisfaction with "basic psychological needs," we should examine how satisfaction of needs in different life domains would be related to the mental health of university students under the pandemic.

Besides need satisfaction, there are other psychosocial predictors of student mental health under the pandemic. According to the positive youth development (PYD) framework (32), developmental assets such as good family support (33) and attributes including resilience, emotional competence, and optimism (34) are commonly regarded as protective factors of mental health (32). In the present study, we focused on three PYD attributes, including beliefs about adversity, psychosocial

competence (resilience and emotional competence), and family functioning. These attributes represent students' internal as well as external assets that may help them to cope with stressful situations such as the pandemic.

The first PYD attribute is "belief about adversity" that reflects one's spiritual and positive beliefs about the future when experiencing hardship. Theoretically, holding positive meaning about adversity and positive life orientation can help one cope with stress arising from adversity, including the COVID-19 pandemic (9, 35). The second PYD attribute is "psychosocial competence," which is operationally defined by resilience and emotional competence in the present study. For resilience, it has been found to be negatively associated with university students' depression and anxiety during the COVID-19 pandemic (36). Emotional competence also showed a protective role in the context of the COVID-19 pandemic (37, 38). Besides "internal assets" indexed by resilience and psychosocial competence, "external asset" defined by family functioning also protects individual family members (39). There are research findings showing that family functioning was positively related to the mental health of young people under the pandemic (40–42).

Moderating Effect of Positive Youth Development Attributes

Besides the main effects of the above-mentioned PYD attributes on students' mental health, PYD attributes may also buffer the negative influence of risk factors (43), including the lack of need satisfaction considered in the present study. There are studies showing significant moderating effect of PYD attributes on the association between risk factors (e.g., stress) and depression (40, 44). Some studies also showed that positive beliefs, such as optimism and meaning-centered coping (e.g., maintenance of hope), mitigated the impacts of COVID-related stress on individuals' depressive symptoms (45, 46). Nevertheless, there are also studies showing insignificant findings (47, 48) or mixed findings on the moderating effect of PYD attributes on adolescent mental health (49). The inconclusive findings thus call for further exploration of this important issue.

The Present Study

We asked the following research questions in this study:

Research Question 1: What is the prevalence of depression amongst university students in Hong Kong?

Research Question 2: What are the socio-demographic correlates of depressive symptoms in university students?

- Based on the previous studies that older students showed better coping and resilience than did younger students, we proposed that there would be a negative relationship between age and the level of depressive symptoms (Hypothesis 1a).
- Regarding gender as a correlate, as the findings are inconclusive, we put forward two competing hypotheses: female university students would show a higher level of depression than male university students (Hypothesis 1b-x); male university students would show a higher level of depression than female university students (Hypothesis 1b-y).
- Regarding student status, because there are conflicting findings, we proposed two alternative hypotheses: international students would show a higher level of depression than local students (Hypothesis 1c-x); local students would show more depressive symptoms than international students (Hypothesis 1c-y).
- Based on the existing theoretical frameworks and previous studies, we hypothesized that students experiencing financial difficulty would have a higher level of depression compared to those without such experience (Hypothesis 1d).

Research Question 3: What is the relationship between need satisfaction and depressive symptoms among university students in Hong Kong? With reference to Shek et al. (8) we expected that there would be a negative relationship between these two domains (Hypothesis 2).

Research Question 4: Are PYD attributes related to depressive symptoms? Based on the general thesis that PYD attributes promote youth development, we expected that there would be negative relationships between PYD attributes (positive beliefs about adversity, psychosocial competence, and family functioning) and depressive symptoms (Hypotheses 3a, 3b, and 3c, respectively).

Research Question 5: Do the three PYD attributes moderate the impact of need satisfaction on depression? As PYD attributes are protective factors, we hypothesized that these three PYD attributes would moderate the negative relationship between need satisfaction and depressive symptoms (Hypotheses 4a, 4b, and 4c, respectively).

METHODS

To understand the mental health of university students under the pandemic, we conducted an online survey in the 2020/21 academic year using different measures of mental health (e.g., depression, anxiety, and post-traumatic stress disorder) to examine prevalence rates as well as related socio-demographic correlates. We also examined the risk factors (e.g., stressors in different domains) and protective factors (e.g., positive beliefs about adversity, resilience, emotional management, and family functioning) of student mental health. In this paper, we cover the prevalence of depressive symptoms as well as related socio-demographic correlates in university students in Hong Kong. Besides, we examined the main effect of need satisfaction and PYD attributes and the moderating effect of PYD attributes on the influence of need satisfaction on depressive symptoms.

Participants and Procedures

We collected data via an online student survey from January 2021 to the end of March 2021, during which the fourth pandemic of COVID-19 in Hong Kong took place. Undergraduate students from one university participated in the study. Although it is desirable to recruit students via random sampling strategies, we

were not able to do so in this study for two reasons. First, because of the "work from home" arrangement, it was not easy to get the complete student population list. Second, it was difficult to invite students to join this study via email because their email accounts were flooded with emails during the pandemic. Hence, we recruited participants via quota sampling using faculty and study year to form different categories. Actually, many studies used quota sampling in COVID-19 studies (50–52).

Because of the social distancing requirement, we conducted the online survey via Qualtrics XM. Online surveys have the advantage of flexibility, and they can also motivate participants to disclose information that would not be disclosed under other forms of survey (53, 54). In the online questionnaire, participants first read the information about the study as well as the confidentiality, anonymity, and participants' rights of the study. If a participant agreed to join after understanding the above information, he/she checked "Yes, I consent to participate in the captioned research." As an appreciation of their participation, students received a supermarket voucher for successful completion of the survey (HK$100 = roughly US$12.82).

A total of 2,050 students indicated their interest to join the study and 2,017 students met the inclusion criteria (e.g., being an undergraduate student) and gave their consent to join the study. As a measure of quality assurance, we inserted two "attention checking" questions in the questionnaire [e.g., (55, 56)]. In these two questions, we invited the respondents to choose a response option (e.g., "This is an attention check, please choose 'exactly true'"). Eventually, we excluded 369 cases showing careless responses, with 1,648 students in the final sample.

Instruments

Centre for Epidemiologic Studies Depression Scale Revised

The Centre for Epidemiologic Studies Depression Scale Revised (CESD-R) is a 20-item assessment tool measuring depressive symptoms based on Major Depressive Disorder listed in the DSM-V criteria (57). The original version was developed by Radloff (58). These symptoms include sadness (e.g., "I felt depressed"), anhedonia (e.g., "Nothing made me happy"), appetite problem (e.g., "My appetite was poor"), sleep problem (e.g., "I slept much more than usual"), concentration (e.g., "I could not focus on the important things"), and worthlessness (e.g., "I do not like myself"). There are also items assessing fatigue (e.g., "I was tired all the time"), agitation (e.g., I felt like I was moving too slowly"), and suicidal ideation (e.g., "I wished I were dead"). For each item, respondents were asked to rate their experience in the past week on a five-point scale ("0 = Not at all or less than 1 day in the last week; 1 = 1–2 days in the last week, 2 = 3–4 days in the last week, 3 = 5–7 days in the last week; 4 = nearly every day for the last 2 weeks"). We calculated and interpreted the scale scores according to the instructions on the official website.[1] There is support for the psychometric properties of the CES-D in the Chinese context (59, 60). The CESD-R was also validated in Chinese samples (61, 62). In the present study, the CESD-R was internally consistent (alpha = 0.96).

[1]http://cesd-r.com

Need Satisfaction During the Pandemic Scale

To understand the specific needs of university students in Hong Kong, we conducted two focus groups for 22 undergraduate students to facilitate the development of the online questionnaire. Based on the findings, needs in several areas emerged from the findings, including physical needs (e.g., keep physical fitness), psychological needs (e.g., keep good emotional health), social needs (e.g., go out with friends), familial needs (e.g., maintain harmony in family) and academic needs (e.g., have effective online learning strategy). Based on the qualitative data, we developed 15 items. In each item, we asked the respondents how well their needs were met in the past year on a six-point scale ("1 = Not met at all; 6 = Fully met"). Reliability analysis showed that the scale is internally consistent (alpha = 0.89).

Chinese Cultural Beliefs About Adversity Scale

We used the Chinese Cultural Beliefs about Adversity Scale designed by Shek et al. (63). There are nine items based on traditional Chinese cultural beliefs (e.g., "hardship increases stature"; "when there is a will, there is a way"). To avoid misunderstanding of the items, in addition to the English version, the original Chinese version was also given for reference. Respondents were required to indicate the degree of agreement on each item by using a 6-point Likert scale ("1 = Strongly disagree, 6 = Strongly agree"). Shek et al. (63) showed that the scale scores were related to measures of psychological well-being. In this study, we found that this scale was reliable (alpha = 0.73).

The Chinese Positive Youth Development Scale

We used two subscales in Chinese Positive Youth Development Scale (CPYDS) to assess psychosocial competence, including resilience and emotional competence (64). There are three items in the resilience subscale (e.g., "I would not give up easily even in face of difficulties") and three items in the emotional competence subscale (e.g., "I know how to ventilate my emotions appropriately in times of distress"). Respondents were required to indicate their level of agreement on the six items on a 6-point Likert scale ranging from "1" (Strongly disagree) to "6" (Strongly agree). The resilience and emotional competence subscales showed acceptable internal consistency (alpha = 0.78 and 0.81, respectively). We computed the mean score of these two subscales to indicate the construct of "psychosocial competence" (alpha = 0.86).

The Chinese Family Assessment Instrument

We used the 9-item Chinese Family Assessment Instrument (C-FAI) to assess family functioning in this study (65), including three items on family communication (e.g., "Parents often talk to their children"), three items on mutuality (e.g., "Family members love each other") and three items on conflict (e.g., "There is no mutual concern among family members"). We asked the respondents to indicate their level of agreement with each statement on a 5-point Likert scale ranging from "1" (Very unlike my family) to "5" (Very like my family). This 9-item measure shows good reliability in this study (alpha = 0.77).

RESULTS

The mean age of the final sample (N = 1,648) was 20.09 years, with 696 (42.23%) male students and 854 (51.82%) female students. The remaining 98 (5.95%) participants did not indicate their gender in the questionnaire. Most of the students (N = 1,613; 97.88%) were local students and 35 (2.12%) were international students, mainly from mainland China and Malaysia. Some students (N = 351; 21.3%) indicated that their families experienced financial hardship at the time they completed the survey. **Tables 1**, **2** show the demographic characteristics of the sample and the descriptive statistics of the variables of the study, respectively.

Among the 1,648 participants, 48.4% (95% CI = [45.9%, 51.1%]) scored 16 or higher in CESD-R (i.e., at-risk for clinical depression). Regarding the socio-demographic correlates of depressive symptoms (**Table 3**), younger participants (M = 19.82, SD = 15.36) scored higher depression scores than did older participants (M = 16.96, SD = 14.75; F = 13.30, $p < 0.001$, η^2_p = 0.01), providing support for Hypothesis 1a. For gender differences in depressive symptoms, male students (M = 20.79, SD = 15.82) displayed a higher level of depressive symptoms than did female students (M = 17.76, SD = 14.63; F = 15.26, $p < 0.001$, η^2_p = 0.01), lending support to Hypothesis 1b-y. For differences between international and local students, local Hong Kong students (M = 19.00, SD = 15.25) showed more depressive symptoms than did international students (M = 10.71, SD = 9.95; F = 10.23, $p < 0.01$, η^2_p = 0.01), giving support to Hypothesis 1c-y. Finally, supporting Hypothesis 1d, students experiencing financial hardship (M = 25.20, SD = 16.87) showed more depressive symptoms than did students without such an experience (M = 16.42, SD = 13.60; F = 98.15, $p < 0.001$, η^2_p = 0.06).

As predicted, need satisfaction, beliefs about adversity, psychosocial competence, and family functioning were negatively related to depression (see **Table 2**). To understand the predictive effect of these factors on depression, hierarchical multiple regression analyses were conducted with age, gender, student status, and financial difficulty as covariates. In Step 1, all covariates were entered as a block. Then we added each predictor separately in Model 2 to Model 5 (see **Table 4**). Results showed that these factors predicted depression in the expected direction (Hypothesis 2 and Hypotheses 3a to 3c).

To examine the main and moderating effects of PYD attributes, we conducted three multiple regression analyses (see **Table 5**). In each model, we examined the effects of need satisfaction and PYD attributes. Findings provided support for the significant main effects of need satisfaction (β = –0.23, $p < 0.001$, Cohen's f^2 = 0.06) and PYD attributes (β ranged between –0.34 and –0.23, $p < 0.001$, Cohen's f^2 ranged between 0.01 and 0.11). Results also showed significant interaction effects of need satisfaction and PYD attributes (β ranged between –0.91 and –0.70, $p < 0.001$, Cohen's f^2 = 0.01). The findings support Hypotheses 4a to 4c.

To understand the moderating effect of PYD attributes, we conducted simple slope analyses to check the predictive effect of need satisfaction on depression based on participants with high (scored one standard deviation above the mean score) or low (scored one standard deviation below the mean score) level on each PYD attribute. First, need satisfaction showed a significant negative predictive effect on depression among students with more positive beliefs about adversity (B = –4.46, SE = 0.69, $p < 0.001$, 95% confidence interval (CI) = [–5.82, –3.11]) but not among students with less positive beliefs about adversity (B = –0.76, SE = 0.68, p = 0.26, 95% CI = [–2.09, 0.56]). Second, need satisfaction only served as a negative predictor of depression among students with high psychosocial competence (B = –2.79, SE = 0.69, $p < 0.001$, 95% CI = [–4.15, –1.44]) but not among students with low psychological competence (B = 0.62, SE = 0.71, p = 0.38, 95% CI = [–0.78, 2.02]). Finally, need satisfaction demonstrated a stronger negative prediction on depression among students with better family functioning (B = –5.95, SE = 0.75, $p < 0.001$, 95% CI = [–7.42, –4.49]) than among those with poor family functioning (B = –2.03, SE = 0.68, $p < 0.01$, 95% CI = [–3.36, –0.69]). **Figures 1–3** depict the moderating effect of these three PYD attributes.

TABLE 1 | Demographic characteristics of the sample.

	Valid number	%
N (participants)	1,648	
Gender		
Male	696	42.23
Female	854	51.82
Missing value	98	5.95
Age (mean = 20.09 years)		
Below mean	1,074	65.17
Above mean	573	34.77
Missing value	1	0.06
Student status		
Local	1,613	97.88
International	35	2.12
Family financial difficulty		
Has financial difficulty	1,100	66.75
Without financial difficulty	351	21.30
Missing value	197	11.95

DISCUSSION

With reference to the limitations of the literature, this study has several advances. First, while studies on university students' mental health have been conducted in mainland China, there are relatively fewer studies in Hong Kong. Second, using the CESD-R, we obtained a picture of depression among university students during the COVID-19 pandemic, which has practical service implications. Third, we identified socio-demographic correlates of depressive symptoms in university students in Hong Kong. Fourth, instead of examining basic psychological need satisfaction, we examined need satisfaction in different life domains during the pandemic. Fifth, we recruited a large sample of students for this study. Sixth, we examined the relationships between PYD attributes and depression in

TABLE 2 | Statistics of mean, SD, reliability, and correlations.

	Variables	Mean (SD)	Cronbach's α (mean inter-item correlations)	1	2	3	4	5	6	7	8
1	Age	20.09 (1.37)	–								
2	Gender[a]	–	–	–0.02							
3	Student status[b]	–	–	0.13***	0.06*						
4	Family financial difficulty[c]	–	–	–0.003	0.02	–0.01					
5	Need satisfaction	3.78 (0.73)	0.89 (0.34)	–0.05	0.07*	0.09***	–0.15***				
6	Beliefs about adversity	3.89 (0.65)	0.73 (0.24)	0.03	0.20***	0.14***	–0.08**	0.37***			
7	Psychosocial competence	4.00 (0.78)	0.86 (0.51)	0.06*	0.11***	0.13***	–0.07*	0.50***	0.57***		
8	Family functioning	3.31 (0.58)	0.77 (0.27)	–0.04	0.08**	0.12***	–0.18***	0.36***	0.31***	0.32***	
9	Depression	18.82 (15.21)	0.96 (0.52)	–0.08**	–0.10***	–0.08**	0.25***	–0.26***	–0.34***	–0.38***	–0.22***

[a]*Male = 1, Female = 2.*
[b]*Local student = 1, International student = 2.*
[c]*Do not experience financial difficulty = 0, Experience financial difficulty = 1.*
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

university students, which are not systematically examined in the literature. Finally, the present findings highlighted the moderating role of PYD attributes on the impact of need satisfaction on depressive symptoms.

Regarding Research Question 1, the finding that 48.4% of the respondents were at-risk for clinical depression deserves attention. While the prevalence rate in the present study was similar to those reported in some Western studies during the pandemic [e.g., (66)], it is also lower or higher than the prevalence rates reported previously based on Chinese university students (9, 10). Of course, we should be cautious in interpreting the prevalence rates using the CES-D across different studies because different versions of CES-D, samples, languages, and timing during the pandemic were involved. Nevertheless, the present findings suggest that depression is a common risk amongst university students in Hong Kong during the pandemic that calls for intervention.

For Research Question 2, there are several interesting observations. Consistent with previous findings (67), younger students showed a higher level of depression than old students. This observation can possibly be explained in terms of higher coping abilities amongst the older students (12). Furthermore, young students may not be familiar with the university environment and related facilities, which would contribute to their relatively higher depression level. For gender differences in depression, in contrast to the common finding that female college students showed poorer mental health, we found that male students displayed more depressive symptoms than did female students. Several factors may contribute to this finding (68, 69). First, as Hong Kong is an achievement-oriented society, males experience greater stress than females because males are expected to be successful in the Chinese culture. Second, Chinese men used to suppress their negative emotions. Third, Chinese men also tended not to seek help when encountering problems. Actually, previous studies also showed that males

TABLE 3 | Results of UNIANOVA.

	N	Mean	SD	F	Partial eta squared
Age group					
Below mean	1,074	19.82	15.36	13.30***	0.01
Above mean	573	16.96	14.75		
Gender					
Male	696	20.79	15.82	15.26***	0.01
Female	854	17.76	14.63		
Student status					
Local student	1,613	19.00	15.25	10.23**	0.01
International student	35	10.71	9.95		
Family economic difficulty					
Do not have difficulty	1,100	16.42	13.60	98.15***	0.06
Have difficulty	351	25.20	16.87		

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

TABLE 4 | The predictive effects of need satisfaction and PYD attributes on depression.

Model	Predictors	β	t	Cohen's f^2	R^2 change	F change
1	Age	−0.08	−3.07**	0.01	0.08	30.70***
	Gender[a]	−0.01	−3.77***	0.01		
	Student status[b]	−0.06	−2.24*	0.004		
	Family financial difficulty[c]	0.25	9.58***	0.07		
2	Need satisfaction	−0.23	−8.70***	0.06	0.05	75.68***
3	Beliefs about adversity	−0.32	−12.82***	0.12	0.10	164.26***
4	Psychosocial competence	−0.37	−14.90***	0.16	0.13	221.91***
5	Family functioning	−0.18	−6.99***	0.04	0.03	48.90***

In Models 2–5, control variables (age, gender, student status, and family financial difficulty) were statistically controlled.
[a]*1 = male, 2 = female.*
[b]*1 = Local students, 2 = International students.*
[c]*0 = did not experience economic difficulties, 1 = experienced economic difficulties.*
*$p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

TABLE 5 | The predictive effects of need satisfaction on depression and the moderating effect of three PYD attributes.

Model	Predictors	Beliefs about adversity			Psychosocial competence			Family functioning		
		β	*t*	Cohen's f^2	*β*	*t*	Cohen's f^2	*β*	*t*	Cohen's f^2
Model 1	Age	−0.08	−3.07**	0.01	−0.08	−3.07**	0.01	−0.08	−3.07**	0.01
	Gender[a]	−0.10	−3.77***	0.01	−0.10	−3.77***	0.01	−0.10	−3.77***	0.01
	Student status[b]	−0.06	−2.24*	0.003	−0.06	−2.24*	0.003	−0.06	−2.24*	0.003
	Family financial difficulty[c]	0.25	9.58***	0.07	0.25	9.58***	0.07	0.25	9.58***	0.07
	R^2 change	0.08			0.08			0.08		
	F change	30.70***			30.70***			30.70***		
Model 2	Need satisfaction	−0.23	−8.70***	0.06	−0.23	−8.70***	0.06	−0.23	−8.70***	0.06
	R^2 change	0.05			0.05			0.05		
	F change	75.68***			75.68***			75.68***		
Model 3	PYD attributes	−0.28	−10.36***	0.08	−0.34	−11.96***	0.11	−0.12	−4.42***	0.01
	R^2 change	0.06			0.08			0.01		
	F change	107.33***			142.93***			19.52***		
Model 4	Need satisfaction × PYD attributes	−0.89	−4.44***	0.01	−0.70	−4.21***	0.01	−0.91	−4.37***	0.01
	R^2 change	0.01			0.01			0.01		
	F change	19.67***			17.73***			19.08***		

In Models 2–4, age, gender, student status, and family financial difficulty were statistically controlled. Based on Model 1, need satisfaction was added to Model 2. Based on Model 2, each PYD attribute was included separately in Model 3. Based on Model 3, the interaction of need satisfaction and the respective PYD attribute was further included in Models 4.

**p < 0.05; **p < 0.01; ***p < 0.001.*

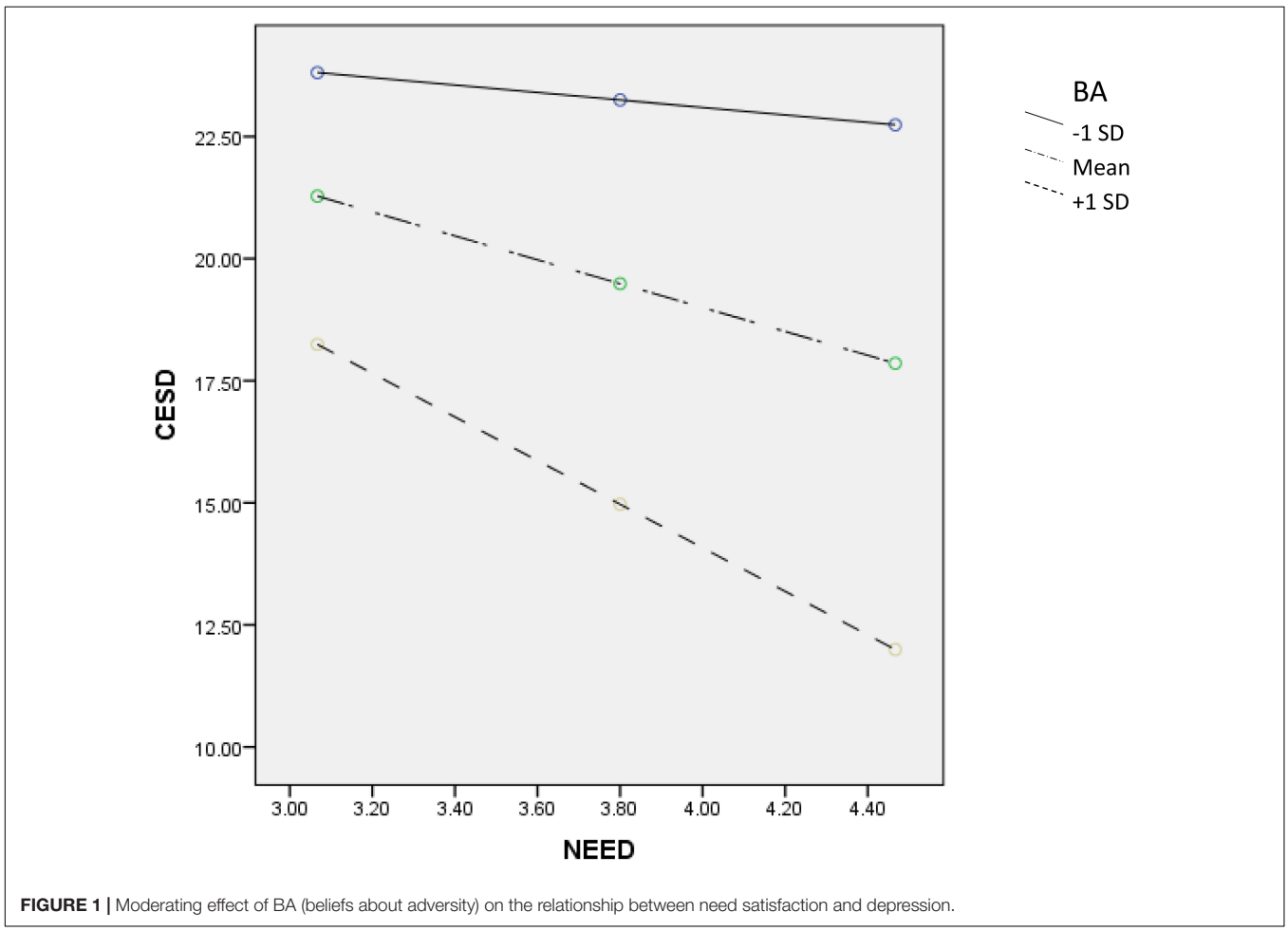

FIGURE 1 | Moderating effect of BA (beliefs about adversity) on the relationship between need satisfaction and depression.

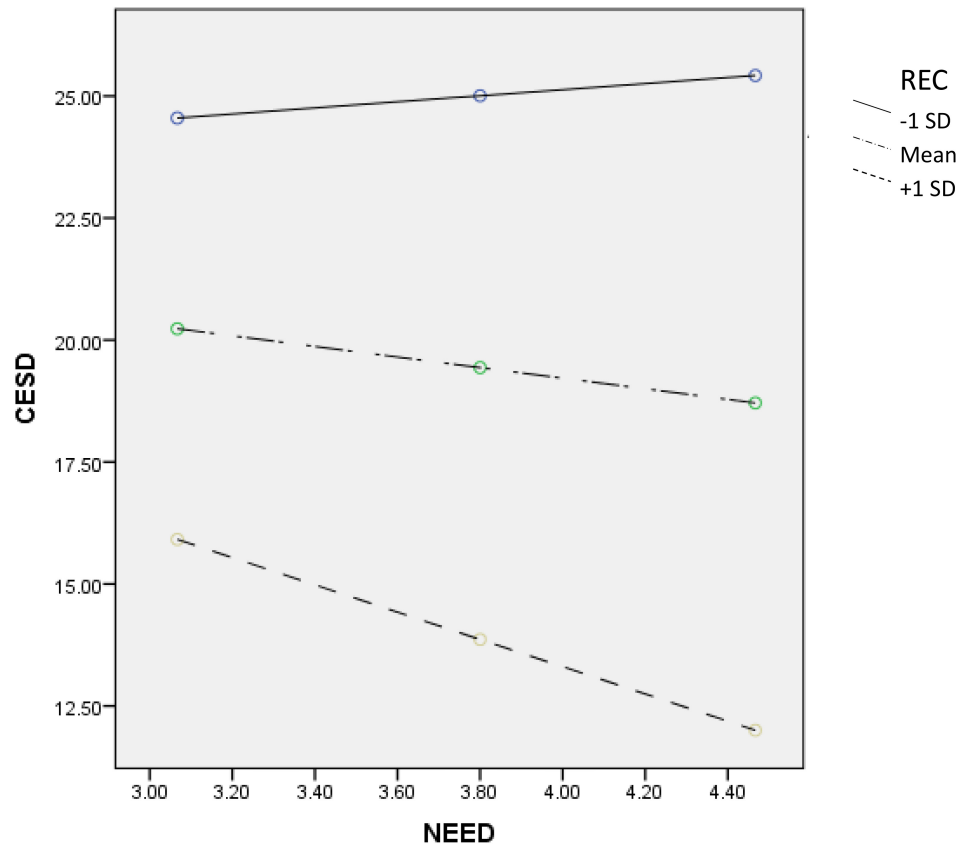

FIGURE 2 | Moderating effect of REC (psychosocial competence) on the relationship between need satisfaction and depression.

showed poorer mental health as compared to female students (20). Concerning student status, in contrast to the common belief that international students would experience more stress than local students, we found that Hong Kong students showed more depressive symptoms than did international students. There are three possible factors contributing to this observation. First, the mental health problems of university students in Hong Kong have been alarming historically (20). Second, because of social unrest and COVID-19, Hong Kong university students actually experience "cumulative stresses." Third, Hong Kong people are facing many stressors under COVID-19, such as having stressful online classes because of the tight living space in Hong Kong (8).

Consistent with the literature, financial difficulty is a risk factor for depression among university students. Theoretically, family economic burdens would adversely affect family processes (e.g., family functioning and parenting) which would eventually impair the mental health of children (70). Under COVID-19, because of city lockdown and social distancing measures, the economy is adversely affected. In Hong Kong, financial difficulty is particularly intense for three reasons. First, there is no unemployment benefit in Hong Kong. Hence, unemployment under COVID-19 is a big problem for families in Hong Kong, particularly grass-root families. Although the Government has launched employment protection schemes, only those who are employed are protected. Second, as university students commonly take up part-time jobs and such job opportunities drop under COVID-19, reduced income is a problem for university students. Third, as the cost of living in Hong Kong is very high, financial strain under COVID-19 is particularly painful.

With regard to Research Question 3, we found that need satisfaction was negatively related to depressive symptoms as predicted. As we have pointed out, while there are some studies examining the relationships between "general" or "basic" psychological needs and mental health, we found that satisfaction of "specific" needs was related to mental health in the present study. As the inability to satisfy needs can be regarded as "daily hassles," the present findings are consistent with the literature that daily hassles were positively related to mental health problems (71, 72). Theoretically, the present findings are in line with the theoretical proposition that satisfaction of basic psychological needs contributes to mental health (73). However, the present findings go beyond to show that need satisfaction with real-life challenges under COVID-19 is related to depression. Practically, university administrators and teachers have to figure out ways to meet the practical needs of the students.

Concerning Research Question 4, we found that PYD attributes indexed by the three measures were negatively related to depressive symptoms. Generally speaking, the findings are in line with the PYD literature demonstrating the protective effects

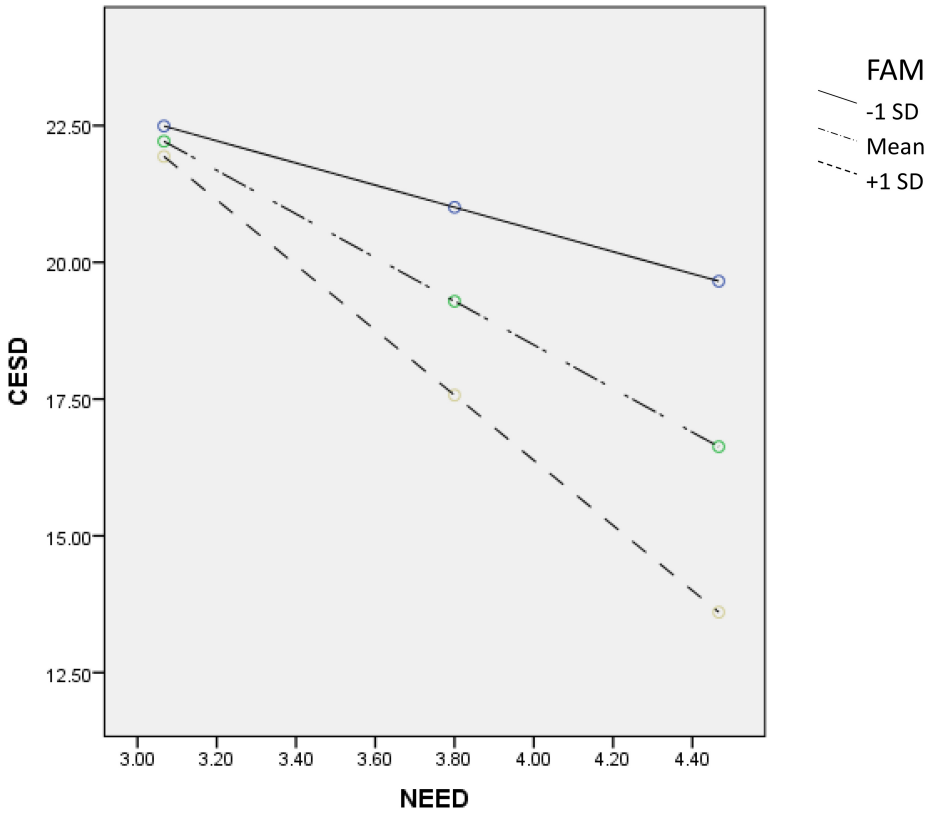

FIGURE 3 | Moderating effect of FAM (family functioning) on the relationship between need satisfaction and depression.

of PYD attributes, including belief about adversity, emotional competence, and family functioning, on adolescents' overall development (32) and mental health under the COVID-19 (41, 74). These findings are also consistent with the theoretical proposition that developmental assets such as PYD attributes promote holistic youth development such as positive mental health (75).

The first PYD attribute covered in this study is beliefs about adversity. The present finding provides support for the theoretical propositions that hope (76) or life meaning (77) are important factors helping people to adjust to life adversities. A special feature of this study is that we use indigenous Chinese beliefs about adversity that could strengthen the ecological validity of the measure. Obviously, how to remain hopeful and find out meaning in life under COVID-19 is important (78). In particular, the present findings echo the argument that cultural resources could help people to deal with adversity (79, 80).

We covered psychosocial competence as the second PYD attribute in this study. Theoretically, the importance of competence is highlighted in different PYD models (32). Empirically, there are studies showing that psychosocial competence contributes to positive development in young people. For example, in a meta-analysis, Durlak et al. (81) reported that compared to control participants, students joining social-emotional learning programs showed better developmental outcomes. With reference to Hong Kong, studies based on high school students showed that curricular-based PYD programs could promote the development of adolescents (82). In the university context, research findings also showed that credit-bearing subjects utilizing PYD principles were effective in promoting psychosocial competence in students (83, 84). Obviously, as there is much support for the effectiveness of social-emotional learning programs (85), there is a need to "inoculate" university students against the harmful effects of adversity by developing and implementing PYD programs.

Finally, in line with family functioning theories (86), family functioning was negatively associated with depressive symptoms. However, although family functioning is an important factor shaping adolescent development, systematic research work is not rich, particularly in the Chinese context. In fact, one can argue that although COIVD-19 may lead to a drop in "family financial capital," healthy family functioning can promote "family social capital" that can lead to the healthy development of young people. With particular reference to the Chinese culture, families are strongly emphasized as the core socialization base for children in a family. Nevertheless, there are three common problems within Chinese families. First, family communication is not open as Chinese people believe that "taboo" topics (e.g., parental problems) should not be openly discussed. Second, as Chinese culture emphasizes interpersonal harmony, expression of negative emotions is not commonly

encouraged. Third, there are inter-generational differences in viewing family responsibilities. Obviously, it is important to promote family functioning in university students. However, as university students are commonly regarded as "grown-up" individuals, there are very few related programs for them.

As for research question 5, the findings revealed significant moderating effects of PYD attributes in shaping the relationship between students' need satisfaction and their depression. For students with higher levels of PYD attributes, the negative relationship between need satisfaction and depressive symptoms was stronger than that for those with lower levels of PYD attributes. These findings echo the general theoretical prediction of PYD models that both internal assets (such as emotional competence, resilience, and beliefs about adversity) and external developmental assets (such as family functioning) protect adolescent mental health (32). Overall speaking, the present finding provides support that the theoretical view that a higher level of developmental assets is a protective factor for adolescent development [(87), p. 894].

The finding based on Chinese cultural belief about adversity broadens our understanding of the theoretical mechanisms involved in moderation. Of course, how to promote Chinese beliefs about adversity in Chinese young people when they do not endorse the Chinese culture (7) is an important point for reflection. For psychosocial competence, the present findings reinforce the notion that PYD attributes can be regarded as the "royal road" to optimal development in young people. In addition to resilience and emotional competence covered in this study, it would be exciting to understand how other PYD attributes, such as positive identity and cognitive competence, would contribute to thriving. Finally, the present study enriches the family ecological approach that family functioning is a key in promoting the wellbeing of young people. Obviously, good family functioning constitutes life meaning (e.g., maintaining a happy family and loving each other) and provides hope for an individual. Hence, how to promote family functioning is important during the COVID-19 pandemic, particularly when family members have to spend more time at home because of social distancing measures.

Despite the pioneering nature and the theoretical as well as practical implications of the study, there are several limitations of the study. First, although self-report measures are widely used, it has been criticized for low validity (88). However, Chan (89) argued that these limitations may have been exaggerated, claiming that "these errors may also apply to non-self-report measures" (p. 330), implying the importance of critically assessing the weaknesses (or strengths) of self-report data. Second, the present study is a cross-sectional study. However, cross-sectional studies are useful because they are relatively inexpensive, less time-consuming, and easy to perform (90, 91). Employing a cross-sectional design in this study can provide a "snapshot" of outcomes and features associated with COVID-19 related depressive symptoms and other mental health risk factors among university students at a particular point in time (90). Third, quota sampling instead of stratified random sampling was used in this study. Again, many studies, particularly during the COVID-19 pandemic, use quota sampling approach, with some researchers believing that this sampling method can generate representative samples. As commented by Sharma (92), using quota sampling has certain limitations (e.g., lack of random selection), but it is particularly useful when researchers are not able to get a probability sample but still want to generate a sample that's "mirrors" the population being researched. Despite these limitations, this study is a pioneering attempt to understand depression in university students and its related socio-demographic correlates, need satisfaction, and PYD attributes in university students in Hong Kong.

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 Institutional Review Board (or its Delegate) at the Hong Kong Polytechnic University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

DS contributed to all steps of the work. DD and XZ contributed to the project implementation, data interpretation, and revising the work. TW and LT helped draft part of the work. All authors approved the final version of the manuscript.

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Prediction of adolescent suicidal ideation after the COVID-19 pandemic: A nationwide survey of a representative sample of Korea

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Objective: This study developed a model to predict groups vulnerable to suicidal ideation after the declaration of the COVID-19 pandemic based on nomogram techniques targeting 54,948 adolescents who participated in a national survey in South Korea.

Methods: This study developed a model to predict suicidal ideation by using logistic regression analysis. The model aimed to understand the relationship between predictors associated with the suicidal ideation of South Korean adolescents by using the top seven variables with the highest feature importance confirmed in XGBoost (extreme gradient boosting). The regression model was developed using a nomogram so that medical workers could easily interpret the probability of suicidal ideation and identify groups vulnerable to suicidal ideation.

Results: This epidemiological study predicted that eighth graders who experienced depression in the past 12 months, had a lot of subjective stress, frequently felt lonely in the last 12 months, experienced much-worsened household economic status during the COVID-19 pandemic, and had poor academic performance were vulnerable to suicidal ideation. The results of 10-fold cross-validation revealed that the area under the curve (AUC) of the adolescent suicidal ideation prediction nomogram was 0.86, general accuracy was 0.89, precision was 0.87, recall was 0.89, and the F1-score was 0.88.

Conclusion: It is required to recognize the seriousness of adolescent suicide and mental health after the onset of the COVID-19 pandemic and prepare a customized support system that considers the characteristics of persons at risk of suicide at the school or community level.

KEYWORDS

suicidal ideation, COVID-19 pandemic, XGBoost, machine learning, subjective stress

Introduction

Since the WHO declared the COVID-19 pandemic in March 2020, the world has been experiencing a crisis of COVID-19 until now. The COVID-19 pandemic has affected all age groups. Especially, the youth have experienced indirect effects such as the unemployment of their parents and the separation from society or peers due to the school lockdown, as well as direct effects such as infection. In 2020, as COVID-19 spread in South Korea, the government extended the winter break of elementary, middle, and high schools nationwide three times, and schools started on April 6 instead of March 2. Moreover, as the social distance step was raised to the lockdown level, intensive COVID-19 response measures were implemented. For example, face-to-face classes were banned and they were replaced with online classes (1).

The UN (2020) was concerned that the crisis of the COVID-19 pandemic, an infectious disease, was rapidly increasing a crisis in children's health. Moreover, Choi (2) named the youth group suffering from the COVID-19 pandemic as the "COVID generation" and recommended showing more attention to their mental health because the COVID generation experienced interactions such as interpersonal relationships much less than the generations before the COVID-19 pandemic. People are highly concerned about its effect on suicidality after the outbreak of the COVID-19 pandemic. COVID-19 may increase the risk of developing suicidal behaviors by affecting numerous well-established suicide risk factors (3–5). Nevertheless, there are still not enough epidemiological studies using big data to identify groups vulnerable to mental health deterioration among adolescents after the COVID-19 pandemic.

In contrast, suicide refers to the act of taking own life with the intention of causing death (6). Adolescence is a stormy period, a transition period from childhood to adulthood, and adolescents may resolve the confusion about their identity and the uncertainty about their future by using extreme methods such as suicide without achieving psychological stability and balance (7). Many researchers (8, 9) have emphasized the importance of early detection of adolescent suicide while pointing out that adolescents with dangerous levels of suicidal ideation may not receive help early enough because suicidal ideation in adolescence is recognized by those around them as a universal psychological state that can appear during development. It was reported that the suicide rate of South Korea was the highest among OECD member countries as of 2020 (6). Especially, the suicide rate of teenagers skyrocketed by 9.4% compared to 2019 (10) before the COVID-19 pandemic. The result implied that youth suicide became a serious problem in South Korea after the outbreak of COVID-19.

Most previous studies (11–13) that identified predictors of suicidal ideation in adolescents mainly used logistic regression models. The logistic regression model is a stochastic model widely used to predict the likelihood of an event by linearly combining independent variables when the dependent variable is binomial. Although logistic regression analysis has the advantage of being able to identify the influence of individual variables on a dependent variable, it has a limitation in understanding the interaction between various explanatory variables used for the predictive model because it assumes independence that the effect of an explanatory variable does not depend on the level of other explanatory variables (14). As a way to overcome these limitations of regression analysis, many recent studies (15, 16) are widely using boosting-based machine learning models such as XGBoost (extreme gradient boosting).

Since the COVID-19 pandemic has not yet come to an end even after suffering from it for 2 years, it is necessary to conduct more studies based on scientific evidence to improve the mental health of the youth and prevent suicide. This study developed a model to predict groups vulnerable to suicidal ideation after the declaration of the COVID-19 pandemic based on nomogram techniques targeting 54,948 adolescents who participated in a national survey in South Korea.

Materials and methods

Data source

It was a secondary data analysis study using the 2020 Korea Youth Risk Behavior Survey (17). The Korea Youth Risk Behavior Survey is an anonymous self-reporting online survey targeting students between 7th-grade students and 12th-grade students to understand the health behaviors of South Korean adolescents. It was jointly conducted by the Ministry of Education, the Ministry of Health and Welfare, and the Korea Disease Control and Prevention Agency in South Korea. This study sampled subjects from the 2020 Korea Youth Risk Behavior Survey in the steps of population stratification, sample allocation, and sampling. In the sample allocation step, this study set the sample size to 400 middle schools and 400 high schools. Then, five middle schools and five high schools were first allocated to each of 17 cities and provinces. This study investigated 57,925 students who were selected as samples from 1 August 2020 to 30 November 2020. The participation rate was 94.9% (54,948 students). This study excluded students who were absent for more than 3 months, students with disabilities (e.g., intellectual disability), and students with dyslexia at the time of the investigation. The data collection method was an anonymous self-report online survey, if there were any unanswered items, it did not move on to the next item. Therefore, there was no missing value. All data were collected in a way that did not reveal personal identifiable information. This study analyzed the data of 54,948 subjects who responded that they had suicidal ideation among students between 7th grade and

12th grade who participated in the 2020 Korea Youth Risk Behavior Survey.

Measurement of variables

The presence of suicidal ideation, an outcome variable, was determined when a subject responded "yes" to the item, "Have you ever seriously considered committing suicide in the past 12 months?"

The input variables included grade (1 = 7th grade, 2 = 8th grade, 3 = 9th grade, 4 = 10th grade, 5 = 11th grade, or 6 = 12th grade), gender (1 = male or 2 = female), subjective economic status (1 = high, 2 = medium, or 3 = low), whether the economic status has changed during the COVID-19 pandemic (1 = strongly agree, 2 = agree, 3 = disagree, or 4 = strongly disagree), living with a family member (1 = yes or 2 = no), area of residence (1 = urban area or 2 = rural area), school type (1 = middle school, 2 = vocational high school, or 3 = general high school), academic performance (1 = high, 2 = medium-high, 3 = medium, 4 = medium-low, or 5 = low), drinking at least one glass or shot of beer, soju, or whiskey within the last 30 days (1 = no or 2 = yes), smoking at least one cigarette within the last 30 days (1 = no or 2 = yes), drug experience (e.g., hallucinogens and drugs such as methamphetamine) (1 = no or 2 = yes), conflict in relationship with friends or colleagues due to smartphone overdependence (1 = strongly disagree, 2 = disagree, 3 = agree, or 4 = strongly agree), days of conducting moderate- or higher-intensity exercise regularly (none, 1–2 times a week, or 3 or more times a week), subjective sleep satisfaction (1 = sufficient, 2 = moderate, or 3 = insufficient), subjective health recognition (1 = good, 2 = moderate, or 3 = bad), subjective stress recognition (1 = high, 2 = moderate, or 3 = none), subjective body type recognition (1 = underweight, 2 = moderate, or 3 = obesity), weight control efforts in the past 30 days (1 = no effort or 2 = effort), sexual relation (1 = no or 2 = yes), depression experience in the past 12 months (1 = no or 2 = yes), experience of loneliness in the past 12 months (1 = rarely, 2 = moderate, or 3 = frequent), and receiving treatment due to violence from an acquaintance (e.g., adult, senior, or friend) (1 = no or 2 = yes). Depression was defined as the case of answering "yes" to "Have you ever felt sad or hopeless enough to stop your daily activities for 2 weeks in the past 12 months?" that was a criterion for determining major depressive disorder. Smartphone overuse was defined as the experience of severe conflict in a friend, colleague, or social relation due to smartphone overuse in the past 30 days. Regular moderate- or higher-intensity exercise was defined as "the experience of conducting exercise (regardless of exercise type) at the intensity that increases heart rate than usual or makes you out of breath for 60 minutes or longer in total per day in the past seven days." Subjective sleep satisfaction was defined as the case in which the amount of sleep was sufficient to overcome fatigue in the last 7 days.

Variable selection

A nomogram generally identifies the predictive path of disease by using 5–7 variables because when a larger number of explanatory variables were entered into the nomogram, the number of cases for calculating the predictive probability for a disease increases as well (18). Therefore, when developing a nomogram, it is important to select explanatory variables to be used in the nomogram. This study used XGBoost to select variables, and the top seven variables with high-feature importance were selected as variables to be used in the nomogram. XGBoost is a boosting technique that has the advantages of fast speed and scalability (19). XGBoost is based on a decision tree-based algorithm that uses a boosting technique that lowers the error by coupling multiple classification and regression trees. XGBoost generates an optimized model in a way that controls the complexity of the tree to minimize training loss and prevent overfitting. The objective function of XGBoost (19) is presented in the following equation:

$$\text{obj}(\theta) = \sum_{i}^{n} l\left(y_i, \hat{y}_i\right) + \sum_{j}^{k} \Omega\left(f_k\right) \quad (1)$$

where K stands for the number of trees, and Ω refers to all situations that may affect the complexity of trees. Starting from a tree with a depth of 0, if a lot of new information is gained (Gain) when pruning, the tree continues to grow (greedy learning of the tree) (20). The gain function of XGBoost is presented in the following equation:

$$\text{Gain} = \frac{1}{2}\left[\frac{G_L^2}{H_L + \lambda} + \frac{G_R^2}{H_R + \lambda} - \frac{(G_L + G_R)^2}{H_L + H_R + \lambda}\right] - \gamma \quad (2)$$

Although XGBoost has been mainly used as a predictive model, it can also be used as an interpretable model for variable selection. This is because it is possible to understand the accuracy contribution score (gain) of each variable and the appearance frequency of the variable in the entire tree until the XGBoost model is formed by checking the feature importance (20). It can also confirm the split used for each pruning and the gain due to the split. It helps to understand the direction of the variable. This study set the hyperparameters of XGBoost as the number of trees = 100, learning rate = 0.3, regularization lambda = 1, and limit the depth of individual tree = 6.

Development and validation of the nomogram

This study developed a model to predict suicidal ideation by using logistic regression analysis. The model aimed to understand the relationship between predictors associated with the suicidal ideation of South Korean adolescents by using the top seven variables with the highest feature importance

confirmed in XGBoost. The regression model analyzed using multiple logistic regression with adjusted confounding factors. It presented an adjusted odds ratio (AOR) and 95% confidence interval (CI) to understand the independent relationship between predictive factors and adolescent suicidal ideation.

The regression model was developed using a nomogram so that medical workers could easily interpret the probability of suicidal ideation and identify groups vulnerable to suicidal ideation. The nomogram based on logistic regression is a two-dimensional diagram presenting the relationship between multiple risk factors to simply and efficiently calculate the predictive probability of disease (21). A logistic regression nomogram is generally composed of a point line, a risk factor line, a probability line, and a total point line (22). The point line is placed at the top of the nomogram to derive a score corresponding to the class of each risk factor (23, 24). Moreover, the number of risk factor line is equal to the number of risk factors for adolescent suicidal ideation. This study set the number of risk factor lines as seven for efficient interpretation of the nomogram. The total point line refers to the sum of the scores of individual risk factors. The probability line is the final risk probability value calculated based on the total point line and is placed at the bottom of the nomogram.

The predictive performance evaluation of the finally developed nomogram was analyzed using 10-fold cross-validation. The area under the curve (AUC), general accuracy, F1 score, and calibration plot were used as indicators for evaluating predictive performance. All analyses were conducted using Python version 3.10.4.[1]

Results

General characteristics of subjects by suicidal ideation experience after the COVID-19 pandemic

Table 1 shows the differences (Chi-square test results) in the general characteristics between adolescents who experienced suicidal ideation during the COVID-19 pandemic and those who did not experience suicidal ideation during the COVID-19 pandemic. Among 54,948 South Korean adolescents, 5,979 adolescents (10.9%) experienced suicidal ideation during the COVID-19 pandemic. The results of Chi-square test showed that adolescents who experienced suicidal ideation and those who did not experience suicidal ideation were significantly different in grade, gender, whether the economic status has changed during the COVID-19 pandemic, household economic status, living with a family member, school type, area of residence, academic performance, drinking within the last

TABLE 1 General characteristics of subjects according to suicidal ideation, *n* (%).

Variables	Suicidal ideation		*P*
	No (*n* = 48,969)	Yes (*n* = 5,979)	
Grade			<0.001
7th grade	9,108 (91.0)	897 (9.0)	
8th grade	8,501 (88.9)	1,063 (11.1)	
9th grade	8,339 (88.8)	1,053 (11.2)	
10th grade	7,981 (89.6)	926 (10.4)	
11th grade	7,822 (87.8)	1,085 (12.2)	
12th grade	7,218 (88.3)	955 (11.7)	
Gender			<0.001
Male	26,099 (92.1)	2,254 (7.9)	
Female	22,870 (86.0)	3,725 (14.0)	
Changes in economic status due to COVID-19			<0.001
Strongly agree	2,637 (81.0)	619 (19.0)	
Agree	11,817 (87.0)	1,766 (13.0)	
Disagree	19,641 (89.9)	2,200 (10.1)	
Strongly disagree	14,874 (91.4)	1,394 (8.6)	
Household economic status			<0.001
High	19,331 (90.6)	2,008 (9.4)	
Moderate	23,758 (90.0)	2,639 (10.0)	
Low	5,880 (81.5)	1,332 (18.5)	
Living with a family member			<0.001
Yes	46,738 (89.3)	5,594 (10.7)	
No	2,231 (85.3)	385 (14.7)	
School type			<0.001
Middle school	25,948 (89.6)	3,013 (10.4)	
Vocational high school	4,462 (89.7)	514 (10.3)	
General high school	18,559 (88.3)	2,452 (11.7)	
Area of residence			<0.001
Urban	21,181 (89.7)	2,440 (10.3)	
Rural	27,788 (88.7)	3,539 (11.3)	
Academic performance			<0.001
High	6,081 (90.3)	655 (9.7)	
Medium-high	12,123 (90.4)	1,278 (9.6)	
Medium	1,5034 (90.6)	1,551 (9.4)	
Medium-low	11,150 (87.9)	1,534 (12.1)	
Low	4,581 (82.8)	952 (17.2)	
Drinking within the last 30 days			<0.001
No	44,247 (90.2)	4,809 (9.8)	
Yes	4,722 (80.1)	1,170 (19.9)	
Smoking within the last 30 days			<0.001
No	47,311 (89.6)	5,499 (10.4)	
Yes	1,658 (77.5)	480 (22.5)	
Conflict in social relation due to smartphone overdependence			<0.001

(Continued)

1 https://www.python.org

TABLE 1 (Continued)

Variables	Suicidal ideation		*P*
	No (*n* = 48,969)	Yes (*n* = 5,979)	
Strongly disagree	33,257 (90.6)	3,454 (9.4)	
Disagree	14,065 (88.0)	1,924 (12.0)	
Agree	1,338 (75.1)	444 (24.9)	
Strongly agree	309 (66.3)	157 (33.7)	
Habitual drug use			<0.001
No	48,738 (89.4)	5,805 (10.6)	
Yes	231 (57.0)	174 (43.0)	
Regular physical activity			0.009
No	18,720 (88.7)	2,391 (11.3)	
1–2 times a week	14,376 (89.1)	1,754 (10.9)	
3 or more times a week	15,873 (89.6)	1,834 (10.4)	
Subjective sleep satisfaction			<0.001
Sufficient	15,850 (94.2)	974 (5.8)	
Moderate	16,868 (90.4)	1,788 (9.6)	
Insufficient	16,251 (83.5)	3,217 (16.5)	
Subjective health recognition			<0.001
Good	35,395 (92.1)	3,049 (7.9)	
Moderate	10,543 (85.4)	1,799 (14.6)	
Bad	3,031 (72.8)	1,131 (27.2)	
Subjective stress recognition			<0.001
High	14,208 (76.1)	4,454 (23.9)	
Moderate	23,055 (94.6)	1,324 (5.4)	
None	11,706 (98.3)	201 (1.7)	
Subjective body type recognition			<0.001
Underweight	11,934 (89.6)	1,390 (10.4)	
Moderate	18,024 (90.8)	1,825 (9.2)	
Obesity	19,011 (87.3)	2,764 (12.7)	
Weight control efforts in the past 30 days			<0.001
No effort	22,419 (90.5)	2,355 (9.5)	
Effort	26,550 (88.0)	3,624 (12.0)	
Sexual relation			<0.001
No	47,050 (89.7)	5,411 (10.3)	
Yes	1,919 (77.2)	568 (22.8)	
Depression experience in the past 12 months			<0.001
No	39,468 (96.0)	1,640 (4.0)	
Yes	9,501 (68.6)	4,339 (31.4)	
Receiving treatment due to violence from an acquaintance			<0.001
No	48,530 (89.5)	5,699 (10.5)	
Yes	439 (51.1)	280 (38.9)	
Experience of loneliness in the past 12 months			<0.001
Rarely	27,358 (96.8)	901 (3.2)	
Moderate	16,723 (88.4)	2,200 (11.6)	
Frequently	4,888 (62.9)	2,878 (37.1)	

30 days, smoking within the last 30 days, conflict in social relationships due to smartphone overdependence, habitual drug use, regular physical activity, subjective sleep satisfaction, subjective health recognition, subjective stress recognition, subjective body-type recognition, weight control efforts in the past 30 days, sexual relation, depression experience in the past 12 months, receiving treatment due to violence from an acquaintance, and experience of loneliness in the past 12 months ($p < 0.05$).

Predictive factors for suicidal ideation in South Korean adolescents

This study calculated the feature importance of factors associated with the suicidal ideation of South Korean adolescents by using XGBoost (Figure 1). The results showed that the top seven variables with high-feature importance were depression experience in the past 12 months, subjective stress recognition, experience of loneliness in the past 12 months, academic performance, grade, household economic status, and changes in economic status due to COVID-19.

Table 2 shows the results of logistic regression analysis for predicting the suicidal ideation of South Korean adolescents using the top seven variables with high-feature importance in XGBoost. The analysis results of adjusted model for predicting the suicidal ideation of South Korean adolescents showed that independent influencing factors were 7th grade (AOR = 1.15, 95% CI = 1.03–1.28), 12th grade (AOR = 0.89, 95% CI = 0.80–0.99), adolescents with very large economic changes due to COVID-19 (AOR = 1.25, 95% CI = 1.10–1.41), adolescents with poor household economic status (AOR = 1.26, 95% CI = 1.14–1.38), adolescents with moderate academic performance (AOR = 0.86, 95% CI = 0.77–0.96), adolescents who frequently experienced subjective stress (moderate: AOR = 1.88, high: AOR = 4.81), adolescents who experienced depression in the last 12 months (AOR = 4.85, 95% CI = 4.53–5.19), and adolescents who frequently experienced loneliness in the past 12 months (moderate: AOR = 1.93, frequently: AOR = 4.58) ($p < 0.05$).

Development and validation of a nomogram for high-risk groups for suicidal ideation in Korean adolescents

The nomogram for predicting the suicidal ideation of South Korean adolescents is presented in Figure 2. This nomogram derived that the predictive probability of suicidal ideation for eighth graders who responded that they experienced depression in the past 12 months, they had a lot of subjective stress, they frequently felt lonely in the last 12 months, their household economic status worsened a lot during the

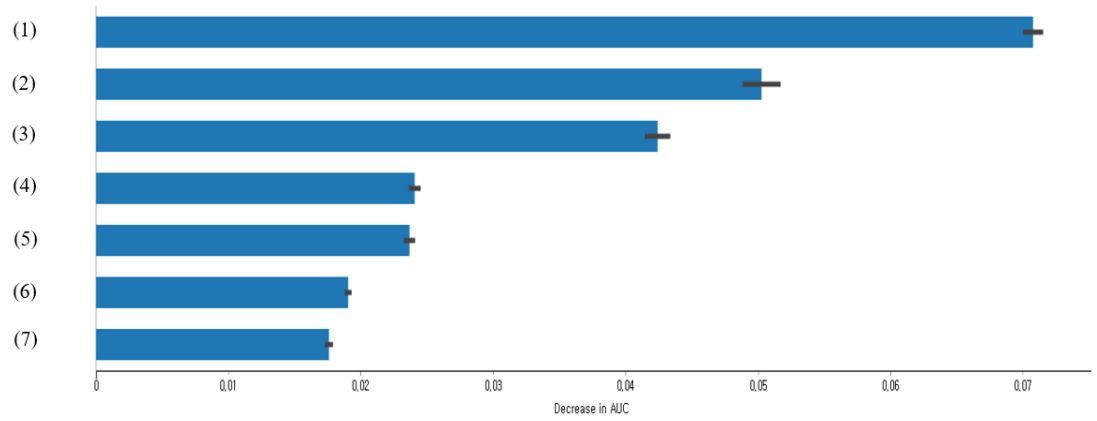

FIGURE 1
The features importance of factors related to the suicidal ideation of adolescents using XGBoost (only top seven factors are presented): (1) depression experience in the past 12 months; (2) subjective stress recognition; (3) experience of loneliness in the past 12 months; (4) academic performance; (5) grade; (6) household economic status; and (7) changes in economic status due to COVID-19.

COVID-19 pandemic, and their academic performance was very poor was 72%.

The predictive performance of the developed nomogram for predicting adolescent suicidal ideation was tested using AUC, general accuracy, F1, recall, precision, and calibration plot (**Figure 3**). The prediction probability and observation probability of the adolescent group that experienced suicidal ideation and those of the adolescent group that did not experience suicidal ideation were compared using calibration plot and Chi-square test (**Figure 3**). The results showed that prediction probability and observation probability were not significantly ($p < 0.05$) different. The results of 10-fold cross-validation revealed that the AUC of the adolescent suicidal ideation prediction nomogram was 0.86, the general accuracy was 0.89, the precision was 0.87, the recall 0.89, and the F1-score was 0.88.

Discussion

This study evaluated the factors associated with the suicidal ideation of adolescents using epidemiological data representing South Korean adolescents. The results showed that middle-school students had a higher risk of suicidal ideation than high-school students. Previous studies (25, 26) on South Korean adolescents reported that middle-school students had a 1.3-fold higher risk of suicide attempts than high-school students, which agreed with the results of this study. Brière et al. (26) showed that eighth and ninth graders had the most suicidal ideation and suicide attempts. Glenn et al. (25) also revealed that suicide ideation increased abruptly between 12- and 14-year-old adolescents. Suicidal ideation refers to a continuous interest, thoughts, and illusions about ending one's own life (27). Middle-school students who were adolescents could be more easily stuck in a psychologically maladjusted state (28) than high-school students when they experienced stress or negative life events. When this psychological maladjustment state persists, it is highly likely to develop mental health problems (29).

Dubé et al. (4) conducted a meta-analysis using 54 studies (308,596 subjects), which examined suicide behaviors during the COVID-19 pandemic, to find that event rates (e.g., 10.81% for suicidal ideation and 4.68% for suicide attempts) increased from studies conducted prior to the pandemic. Nevertheless, it is noteworthy that most of the studies targeted adults. Since only a few epidemiological studies analyzed the suicidal ideation of adolescents after the COVID-19 pandemic, additional epidemiological studies are needed to understand the difference between adolescent suicidal ideation before and after the pandemic.

Suicide has been a direct cause of death in South Korea and the top cause of death among South Korean adolescents for 10 consecutive years (30). Social efforts are required to maintain adolescent mental health because it has been reported that adolescents who experienced suicidal ideation have a high risk of suicide even if they do not choose to commit suicide during adolescence and may experience severe depression due to social maladjustment (26). Therefore, it is highly required to detect middle-school students highly vulnerable to suicide as soon as possible and intervene with them continuously to reduce the suicide rate of adolescents in the future based on the results of this study. It is also needed to develop a suicide prevention program tailored to the sociodemographic characteristics of middle-school students.

In this study, adolescents who experienced loneliness in the last 12 months had a higher risk of suicidal ideation. It seems that the result is related to emotional anxiety due to the absence of a person to seek help from. Choi et al. (31) examined the suicidal ideation of South Korean middle-school students

TABLE 2 Predictors for suicidal ideation in South Korean adolescents: AOR and 95% CI.

Variables	AOR	95% CI	*P*
Grade			
7th grade (reference)	1	1	
8th grade	1.15	1.03, 1.28	0.008
9th grade	1.04	0.93, 1.16	0.437
10th grade	0.91	0.81, 1.01	0.103
11th grade	1.01	0.90, 1.12	0.893
12th grade	0.89	0.80, 0.99	0.044
Changes in economic status due to COVID-19			
Strongly agree	1.25	1.10, 1.41	<0.001
Agree	1.09	0.99, 1.19	0.056
Disagree	1.03	0.95, 1.12	0.396
Strongly disagree (reference)	1	1	
Household economic status			
High (reference)	1	1	
Moderate	0.96	0.89, 1.03	0.310
Low	1.26	1.14, 1.38	<0.001
Academic performance			
High (reference)	1	1	
Medium-high	0.93	0.83, 1.04	0.226
Medium	0.86	0.77, 0.96	0.009
Medium-low	0.92	0.82, 1.03	0.187
Low	1.09	0.96, 1.24	0.156
Subjective stress recognition			
High	4.81	4.13, 5.60	<0.001
Moderate	1.88	1.60, 2.19	<0.001
None (reference)	1	1	
Depression experience in the past 12 months			
No (reference)	1	1	
Yes	4.85	4.53, 5.19	<0.001
Experience of loneliness in the past 12 months			
Rarely (reference)	1	1	
Moderate	1.93	1.77, 2.11	<0.001
Frequently	4.58	4.18, 5.02	<0.001

and reported that only 32.3% of South Korean adolescents had consulted with others or asked for help when they have difficulties. The results implied that two out of three middle-school students tried to solve problems on their own without the help of people around them when encountering difficulties. It is believed that middle-school students frequently feel lonely and give up asking for help from people around them. As a result, they feel helpless repeatedly, which ultimately leads to suicidal ideation.

The results of this study confirmed that the level of stress perceived by adolescents was significantly related to suicidal ideation. These results were similar to the results of previous studies (32, 33) showing that stress was a major risk factor for suicide in adolescence. Stress that is perceived as not controllable is highly likely to make people lose the meaning of their lives (32). Moreover, persistent stress is highly likely to intensify suicidal ideation (33). Therefore, medical personnel need to first understand the stress level perceived by the subject more than anything else to detect adolescents with a high risk of suicidal ideation.

Another finding of this study was that change in household economic status due to the COVID-19 pandemic was identified as a major risk factor for adolescent depression. As the lockdown caused by the COVID-19 pandemic continued, South Korean workers experienced income reduction and instability due to business regulations (34, 35). Moreover, many business owners had to close their businesses in extreme cases, in addition to income decrease (34, 35). The decrease in household income due to the extended COVID-19 pandemic threatened the survival of the family (35). This economic difficulty could become a bigger psychological problem for economically vulnerable groups such as older adults and adolescents than adults (36). For example, as the lockdown due to the COVID-19 pandemic continued, students could experience isolation due to school closures and the absence of psychological support providers (37). As they experienced a crisis in the household economy at the same time, their psychological and emotional problems could be further exacerbated. The results of this study showed that psychological problems such as the suicidal ideation of adolescents were significantly related to rapid changes in household economic status, such as unemployment or a decrease in income of workers due to the COVID-19 pandemic. These results implied that the government should respond to the unemployment and reduced income of workers due to the extended COVID-19 pandemic more sensitively. They also suggested that there would be a need to pay attention especially to the mental health of the children of households with sharply declining incomes continuously.

This study developed a logistic nomogram and identified multiple risk factors for adolescent suicidal ideation during the COVID-19 pandemic. This nomogram derived that the predictive probability of suicidal ideation for eighth graders who responded that they experienced depression in the past 12 months, they had a lot of subjective stress, they frequently felt lonely in the last 12 months, their household economic status worsened a lot during the COVID-19 pandemic, and their academic performance was very poor was 72%, which was high. In South Korea, the teenage suicide rate in 2020 increased by 9.4% from that in 2019 (10). As the prolonged COVID-19 pandemic has not ended as of May 2022, it may increase even further in the future. Therefore, it is necessary to screen depression for the high suicidal ideation risk group with all these multiple risk factors at the school or community level and to conduct community-centered monitoring continuously to prevent depression. It is also required to conduct additional studies on multiple risk factors for suicidal ideation among adolescents after the COVID-19 pandemic.

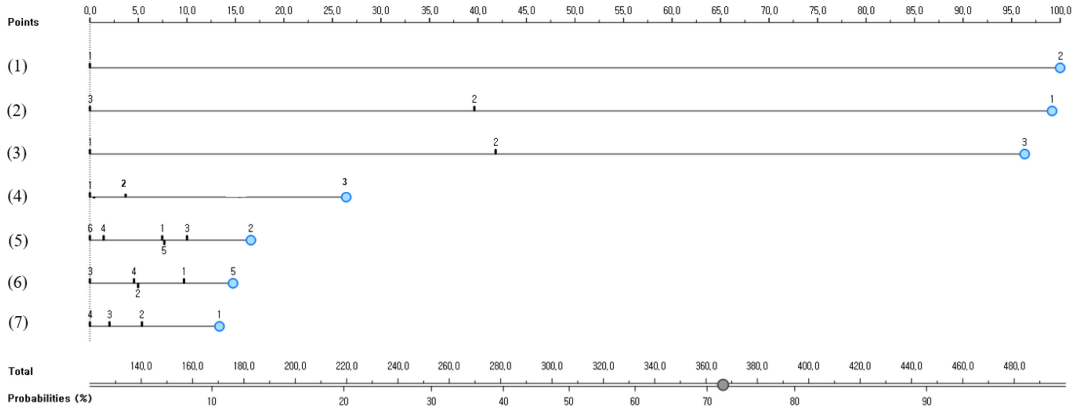

FIGURE 2
A nomogram predicting the South Korean adolescent group vulnerable to suicidal ideation: (1) depression experience in the past 12 months (1 = no or 2 = yes), (2) subjective stress recognition (1 = high, 2 = moderate, or 3 = none), (3) experience of loneliness in the last 12 months (1 = rarely, 2 = moderate, or 3 = frequent), (4) subjective economic status (1 = high, 2 = medium, or 3 = low), (5) grade (1 = 7th grade, 2 = 8th grade, 3 = 9th grade, 4 = 10th grade, 5 = 11th grade, or 6 = 12th grade), (6) academic performance (1 = high, 2 = medium-high, 3 = medium, 4 = medium-low, or 5 = low), and (7) changes in economic status during the COVID-19 pandemic (1 = strongly agree, 2 = agree, 3 = disagree, or 4 = strongly disagree).

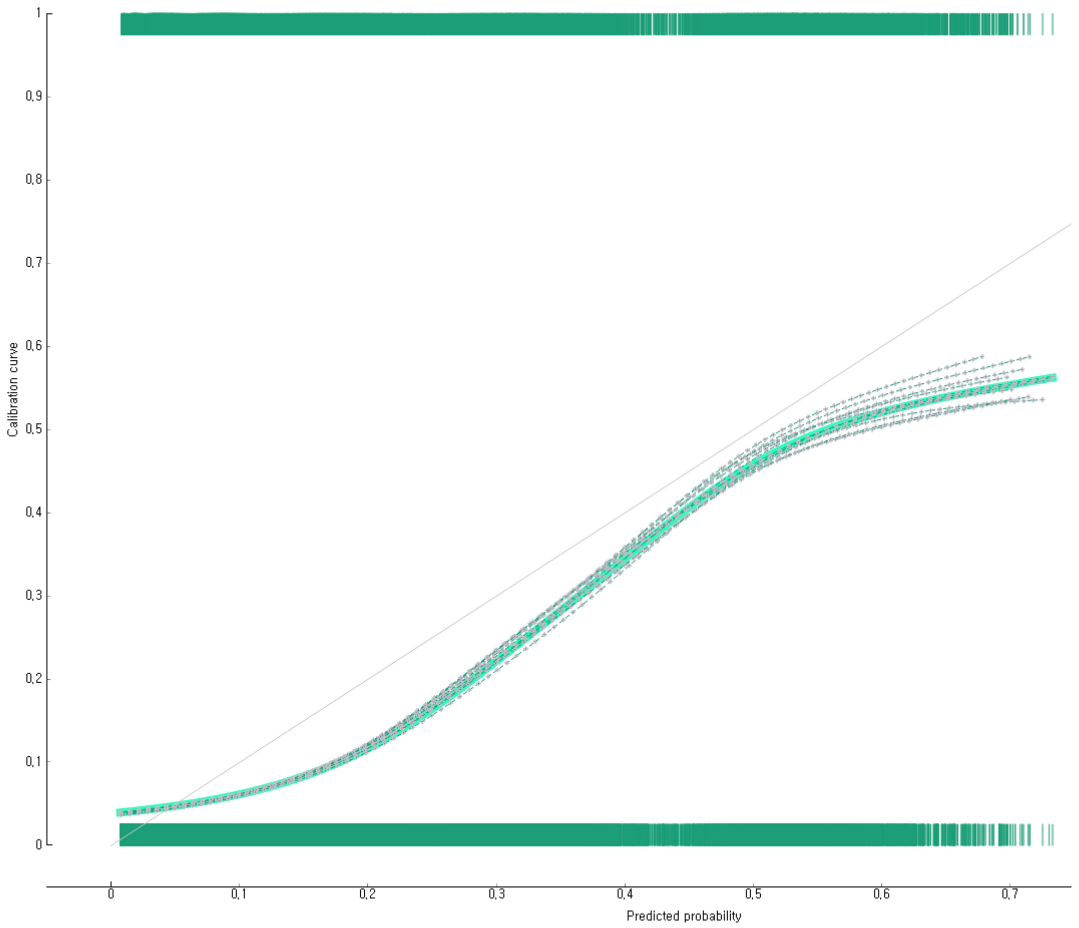

FIGURE 3
A calibration plot to identify the performance of the nomogram to predict the South Korean adolescent group vulnerable to suicidal ideation.

The strengths of this study were to identify the adolescent group vulnerable to depressive disorder based on multiple risk factors and present the basis for selecting the adolescent group vulnerable to suicide based on the results. This study had several limitations. First, this study did not investigate parental abuse or negligence. Second, the variables used in this epidemiological study were measurements based on self-report questionnaires. Future studies need to identify risk factors for adolescent suicidal ideation by integrating qualitative research methods such as in-depth interviews in addition to self-report questionnaires. Third, since the results of this study were based on a cross-sectional study, the results cannot be interpreted as a causal relationship. It is necessary to conduct longitudinal studies on adolescents vulnerable to suicidal ideation identified in this study.

Conclusion

This epidemiological study predicted that eighth graders who experienced depression in the past 12 months, had a lot of subjective stress, frequently felt lonely in the last 12 months, experienced much-worsened household economic status during the COVID-19 pandemic, and had poor academic performance were vulnerable to suicidal ideation (a high suicide risk group). Therefore, it is necessary to continuously intervene (e.g., early detection of adolescents vulnerable to suicidal ideation and mental health management) with adolescents to prevent adolescent suicide. It is also required to recognize the seriousness of adolescent suicide and mental health after the onset of the COVID-19 pandemic and prepare a customized support system that considers the characteristics of persons at risk of suicide at the school or community level.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://www.kdca.go.kr/yhs/.

Ethics statement

This study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of Korea Disease Control and Prevention Agency (protocol code 117075 and date: 01-07-2021). Written informed consent to participate in this study was provided by the participants or their legal guardian/next of kin.

Author contributions

HB was involved in study data interpretation, designed the manuscript, performed the statistical analysis, and assisted with writing the manuscript.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Adolescent social emotional skills, resilience and behavioral problems during the COVID-19 pandemic: A longitudinal study in three European countries

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Objectives: The consequences of long-lasting restrictions related to the COVID-19 pandemic have become a topical question in the latest research. The present study aims to analyze longitudinal changes in adolescents' social emotional skills, resilience, and behavioral problems. Moreover, the study addresses the impact of adolescents' social emotional learning on changes in their resilience and behavioral problems over the course of seven months of the pandemic.

Methods: The Time 1 (T1) and Time 2 (T2) measuring points were in October 2020 and May 2021, characterized by high mortality rates and strict restrictions in Europe. For all three countries combined, 512 questionnaires were answered by both adolescents (aged 11-13 and 14-16 years) and their parents. The SSIS-SEL and SDQ student self-report and parent forms were used to evaluate adolescents' social emotional skills and behavioral problems. The CD-RISC-10 scale was administered to adolescents to measure their self-reported resilience. Several multilevel models were fitted to investigate the changes in adolescents' social emotional skills, resilience, and behavioral problems, controlling for age and gender. Correlation analysis was carried out to investigate how changes in the adolescents' social emotional skills were associated with changes in their resilience and mental health adjustment.

Results: Comparing T1 and T2 evaluations, adolescents claim they have more behavioral problems, have less social emotional skills, and are less prosocial than perceived by their parents, and this result applies across all countries and age groups. Both informants agree that COVID-19 had a negative impact, reporting an increment in the mean internalizing and externalizing difficulties scores and reductions in social emotional skills, prosocial behavior, and resilience scores. However, these changes are not very conspicuous, and most of them are not significant. Correlation analysis shows that changes in adolescents' social emotional skills are negatively and significantly related to changes in internalized and externalized problems and positively and significantly related to changes in prosocial behavior and resilience. This implies that adolescents who experienced larger development in social emotional learning also experienced more increase in resilience and prosocial behavior and a decrease in difficulties.

Conclusion: Due to its longitudinal design, sample size, and multi-informant approach, this study adds to a deeper understanding of the pandemic's consequences on adolescents' mental health.

KEYWORDS

COVID-19, mental health, social emotional learning, behavioral problems, adolescents, multi-informant approach, longitudinal research

Introduction

In 2020 and 2021, the Coronavirus disease of 2019 (COVID-19) pandemic, whose causative agent is the SARS-CoV-2 virus, disrupted people's lives worldwide. Although SARS-CoV-2 infections among children and adolescents cause less severe illness and fewer deaths than in adults, direct and indirect consequences of preventive measures against the virus were nonetheless felt by these groups. The measures adopted by governments, such as forced social lockdowns and the closure of public facilities to prevent the spread of the virus, caused multiple restrictions on human activities and physical interactions and a growing recognition of the effects on children and adolescents' mental health (1–3).

Adolescence is a period of increased social and emotional development (4, 5). One of the major tasks in this period is the development of a cohesive personal identity. During the first years of adolescence, it is possible to see a significant self-understanding growth that sets the stage for critical elements of identity: self-awareness, the definition of own values, goals and future aspirations (6). Adolescence is also a crucial social expansion period, where the development of social cognitive skills is vital for healthy integration with others and in society (7). Relationships with social contexts show significant changes. Adolescents question parental authority and demand autonomy which can lead to conflicts (6). Parent-child conflicts during adolescence had been pointed out in the literature as normative. A meta-analysis on this scope also suggests that conflict and aggression in parent–child relationships negatively impact adolescent development (8). Nevertheless, Smetana and Rote (9) refer that these conflicts are temporary difficulties in parent-child relationships that help families redefine relationships from a more hierarchical to a more democratic dynamic. In this stage, adolescents' peers and friends' relationships also gain particular importance (8). The warmth, reciprocal understanding, and trustworthiness present in friendships are especially important for positive social and emotional development (6). Being with friends is one of adolescents' favourite leisure activities (10). Nowadays, being with friends happens also through digital channels. The HBSC international report of 2018 (11) report that one in seven adolescents prefer to communicate online with their friends to discuss intimate matters.

Over the last two years, adolescents have been heavily confronted with social isolation, online learning, and routine disruptions for extended periods (12). Since the pandemic's beginning, multiple studies regarding its impact on mental health have been published. Increased internalizing problems, such as anxiety and depression, and externalizing problems, such as anger, and reduced life satisfaction have been reported in school-aged children (1, 13–16). In addition, sleep problems, sadness, boredom, isolation, separation from peers, increased use of social media, reduced academic adjustment, and conflicts have been reported by other researchers (13, 15, 17–19). Systematic reviews have been consistent regarding adverse

effects on adolescents' well-being and mental health. These reviews also refer to a high prevalence of the COVID-19-related fear, fatigue, and distress in comparison with pre-pandemic estimates (20–23) and post-traumatic stress (22), with older adolescents and girls being more affected by these problems (2, 14, 16). Moreover, in a cross-cultural study with data from Italy, Spain and Portugal, including parents of 1,480 children from 3 to 18 years old, data showed an increased screen time and reduced physical activity (24).

Children and adolescents who experienced pre-pandemic vulnerabilities, namely lower socio-economic status, lower family support, and lower social emotional skills, experienced more significant mental health problems due to a reduction in the family income, problems with connectivity for online schooling, family conflicts, and neglect (16, 17, 20, 25, 26). Also, children and adolescents with neurodevelopmental and/or chronic physical conditions (3, 23) and youth living in rural areas were more likely to experience worsening mental health (27).

In the United Kingdom, the Co-SPACE Study (COVID-19: Supporting Parents, Adolescents and Children during Epidemics Study), which collected data monthly from over 9,000 parents/carers of 4-16-year-olds and over 1,300 adolescents (11-16-year-olds), found that participating children's mental health worsened during lockdowns and school closures and improved as restrictions eased (28). In this study, it was also found that primary school-aged children (4-10-year-olds) were more likely than secondary school-aged children (11-16-year-olds) to have persistently poorer or worsening behavioral and concentration symptoms (29).

Nevertheless, positive outcomes were also identified. For example, online schooling that allowed the continuation of the learning process was associated with less academic and social stress (17). However, it is important to highlight that internet access is not equal, and those with connectivity issues, mainly from the poorest and remote areas, had their learning process compromised (16). Another example of a positive outcome is the decreased exposure to some risks at school, such as bullying, since children became more protected with the imposed restrictions and online classes (16). Being able to spend time with family members and having more time for homework and personal development were other positive outcomes pointed out by students (18). Along with this, the increased use of social media to maintain social contacts with peers and family members once children and adolescents were removed from their social contexts, like school (16), with the lockdown could also function as a protective factor.

To add to the pandemic outcomes discussion, a critical aspect in this scope is the variability in the pandemic's effects (17, 30, 31). For example, Branje and Morris (17) report that despite its negative impact, many adolescents were able to face this adversity, and some even increased their social, emotional, or academic adjustment. In the same line, the study conducted by Salmela-Aro (31) found five different profiles of change in well-being, presenting the increasing well-being profiles as a growth in their intrapersonal social emotional competencies.

These results highlight the adolescents' and their proximal systems' ability to cope with this unexpected adversity. As Cefai et al. (32) mentioned, the pandemic presented an opportunity to obtain more insight into developing more resilient systems – in society, schools, and families – and find out which strategies contributed to their resilience and mental health and well-being using appropriate facilities, resources, and interventions (32). In this scope, previous evidence shows that social and emotional competencies are critical protective factors impacting the decrease in internalizing and externalizing problems and improvements in academic achievement (32).

During the pandemic, some studies reported that individual and family coping abilities and social support were significant predictors of positive mental health outcomes (33, 34). The available evidence identifies aspects of adolescents' resilience to COVID-19, protecting against the mental health problems caused by the pandemic (34, 35). Some studies on aspects of adolescent resilience during the pandemic found that variables such as cognitive appraisal and humor (36) or task-oriented and avoidance-oriented coping styles (35) seem to protect against the mental health problems caused by the COVID-19 pandemic. A study conducted in Italy (37) found a significant positive association between social emotional skills and resilience skills. In turn, social emotional skills explained externalizing problems and prosocial behavior, and resilience skills explained internalizing and externalizing problems. Also, Deng et al. (38) found that emotion regulation strategies were effective for positive outcomes during the pandemic, but primarily for youth with lower COVID-19 stress-related factors.

Although these relevant data were gathered during recent times, many authors warned that caution is needed when interpreting the results and the importance of not generalizing since each country's pandemic situation will influence how participants perceive themselves or others (13, 14, 39). Interestingly, transcultural and longitudinal data for Portugal, Spain, and Italy reported higher anxiety values in Spain and higher depression scores in Italy and Spain than in Portuguese children and adolescents (40). Another important aspect that further research needs to consider is the need to pay attention to the impact on different age groups since developmental timing is a critical variable in this context (41). The evidence in this scope presents other challenges since studies are mainly cross-sectional, retrospective, and longitudinal, comparing data collected before the pandemic (19, 31, 42, 43). Cross-sectional studies help to understand the immediate or short-term impact of the pandemic only at a particular time point, lacking insight into the long-term consequences (44). In addition, some longitudinal studies were carried out during the pandemic (40) but only for a

short period (45, 46). Given the rapidly evolving nature of the COVID-19 pandemic and the methodological challenges involved with identifying its impact, interdisciplinary and longitudinal research cohorts conducting repeated assessments of mental health (ideally with baseline measures) have been referred to as a key to understanding the long-term impacts of the pandemic (47).

As far as the conceptual and methodological issues affecting the mental health assessment of children and adolescents are concerned, previous studies have drawn several recommendations. These recommendations are based on the understanding, identification, evaluation, and treatment of youngsters recovering from disaster contexts, such as the need to use standardized batteries and to focus on the cultural sensitivity of measures (48), as well as the value of using multi-informant data.

Before this specific pandemic period, a widely cited meta-analytic review had already stated that the level of agreement across studies on internalizing and externalizing symptomatology as reported by children, parents, mental health workers, teachers, and peers should be considered (49). This need is based on the fact that correlations between similar types of informants (e.g., mother, father) are usually higher than correlations between different types of informants (e.g., parents, teachers) or self-other correlations and that all are commonly in a low-to-moderate range. Given the low level of agreement, several investigators have recommended using multisource and multimethod data to assess children and adolescents [e.g., (49–51)]. More recently, the importance of multisource information so that it is possible to minimize constrictions arising from a single self-report assessment has been underlined (52).

The challenge of determining whether the result is about the construct itself or the evaluation method that may condition the question has also been reported (53). Particularly at the level of self-report instruments, the authors reinforce the difficulty of discerning issues such as vulnerability to faking, responding in a socially more desirable way, or ecological validity.

Although research during the COVID-19 pandemic with adolescents relied mainly on online self-report data (44), studies including pre-adolescents focused mostly on parents' reports [for a meta-analysis, see (54)], with these reiterating the data obtained through self-reports. Regarding to self-report measures, namely the Strengths and Difficulties Questionnaire (SDQ), some authors state that caution is needed when assessing the mental health of children and adolescents. Although this measure shows validity and reliability (55, 56), it requires some caution as far as its suitability for cross-country comparisons is concerned due to the lack of a common acceptable model across countries, that is, its dimensional invariance (57).

As such, it seems that the need for identifying reliable data on changes in different adolescents' mental health variables during the pandemic and the latter's relationship with social emotional and resilience skills and behavioral problems is evident to provide evidence-based conclusions. Studies published on mental health indicators during the pandemic focus more on younger ages and more clinical perspectives, and evidence on the dynamic of resilience and the possible protective role of social emotional skills is very limited. Therefore, the present study aims to add to the existing evidence by addressing some of the gaps mentioned in the literature, namely the need for longitudinal studies with multi-informants, inclusion of older adolescents and addressing a positive perspective, namely resilience and social emotional skills.

Therefore, we posed two research questions for this study:

(1). What changes were there in adolescents' self-reported and parents' reported social emotional skills, resilience, and behavioral problems among age and gender groups in three European countries during the COVID-19 pandemic?

(2). Did social emotional learning relate to adolescents' resilience and behavioral problems during the COVID-19 pandemic?

Method

Research context

This research is part of the Erasmus + Key Action 3 funded international project "Promoting mental health at schools" (PROMEHS). The project's goal is to develop, implement, and evaluate an evidence-based universal curriculum focused on students' and teachers' mental health and propose recommendations for innovative educational policies. In total, seven European countries were involved in the project: Latvia, Italy, Portugal, Croatia, Romania, Greece, and Malta. The PROMEHS program included activities for students aged from 3 to 18 years to promote their social emotional learning and resilience, as well as to prevent social, emotional, and behavioral difficulties. To evaluate the efficacy of the program, a quasi-experimental study design was applied. Four age groups of students from preschool to high school (3-6, 8-10, 11-13, and 14-16 years) were selected and randomly divided into experimental and waiting-list control groups. Data were collected from three sources – students (with the exception of the preschool group), their parents, and teachers. The PROMEHS program was implemented and tested in the 2020/21 school year, which coincided with the time of the COVID-19 pandemic, affecting almost every aspect of life globally. It provided the opportunity to obtain longitudinal data from two measure points (T1 and T2) within the control group, which did not receive any intervention during the school year. Data from the control group of 11-16-year-old students and their respective parents from Latvia, Italy, and Portugal were used for the current study to test the dynamic of adolescents' social emotional learning, resilience, and behavioral problems during the pandemic.

A longitudinal research design was used, following 512 adolescents through the 2020/21 school year. The selected period was characterized by strict social distancing measures, including remote learning due to no vaccinations for this age group being available, allowing us to evaluate the dynamic of the mental health indicators among adolescents going through this very tense phase of the pandemic. This broadens evidence published so far, which is mainly based on cross-sectional or retrospective designs or where pre-test data were collected before the beginning of the pandemic.

Additionally, we used a multi-informant approach, including both students' and parents' self-reports, to evaluate broad indicators related to mental health – namely social emotional learning, resilience, and behavioral problems – in three European countries. This provides a more reliable and valid estimation considering internal and external difficulties and important resources for adolescents' healthy development and mental health.

National regulations due to the COVID-19 pandemic during the 2020/21 school year in the three countries

This study took place in one of the waves of the COVID-19 pandemic in Europe (see **Table 1**), specifically characterized by different types of restrictions (see **Table 2**) (e.g., remote learning, prohibited gatherings, or even lockdown), high mortality rates due to the high prevalence of infection, and increasing but insufficient vaccination coverage.

Latvia

The prevalence of COVID-19 infections rapidly increased between October and December 2020 and remained relatively stable until May 2021. Considering the low infection rates in the first wave of the pandemic, Latvia started with a relatively low number of cumulative confirmed COVID-19 deaths on 1 November 2020 (39.64 per million people), but there was a rapid increase, and 1,145.73 deaths per million were reached on 1 May. Vaccinations started on 28 December 2020, but on 1 May, only 15% of the population had received at least one dose, and only 3% were fully vaccinated. At the same time in Portugal, 25% had received at least one dose and 9% were fully vaccinated, while in Italy, these figures were 24 and 10%, respectively. There was no vaccination available for adolescents in Latvia (similar to Italy) until June 2021.

In Latvia, there was a state of emergency due to the COVID-19 pandemic from 9 November 2020 to 7 April 2021, and a distancing policy was in place. Children (aged 10 and younger) continued on-site learning until January 2021, whereas remote learning was introduced for older students (in December 2020 for students aged 11-13, and in October 2020 for students 14 and above). Remote learning continued mostly in all age groups until the end of the school year in May 2021. There was individual support available on-site for students who needed assistance from February 2021, and in some regions with lower infection prevalence, some of the older students were able to return to some activities at school on-site from April 2021. Overall, almost all the adolescents learned remotely. Classes were organized according to curricula; at least 30% of them ought to have been online interaction, and the remaining time was used for independent learning and individual tasks. Extracurricular activities were implemented remotely or individually on-site, and outdoor activities (e.g., sports training) were allowed in groups of up to 10 students.

Parents were encouraged to work from home whenever it was possible to carry out duties remotely, and employers were instructed by the government to actively encourage and support teleworking. Gatherings outside the household were prohibited, and a curfew during which individuals had to stay at their place of residence between 22:00 and 05:00 except for emergencies and work-related matters was introduced during the holidays (from 30 December 2020 to 4 January 2021) and weekends (from 8 January to 7 February 2021).

Italy

Italy was heavily hit by the pandemic from its beginning. Despite the strong health system, it was the hardest-hit European country for months, setting records in terms of cases and deaths (58). The Italian government declared a state of emergency from January 2020, then prolonged it until the end of March 2022. This challenging situation negatively affected both parents and students of every school grade (40) because the negative feelings (e.g., fear, helplessness, etc.) triggered by the pandemic were combined with nationwide lockdowns and the obligation of distance learning, which was protracted until the end of the 2019/20 school year.

In autumn 2020, contagions precipitously increased due to the COVID-19 variants. Thus, in October 2020, the government set curfews and strict rules concerning leisure and social activities, toughening rules on social distancing and home confinement. Based on contagion percentages, Italian regions were divided into red, orange, and yellow zones. Distance learning was required for all high schools, as well as second and third grades of middle schools located in red zones.

After a winter holiday break during which there were restrictions, in January 2021, middle and high secondary schools located in non-red zones gradually started to provide on-site learning, with between 50-75% of the students being present in the classroom and the remaining continuing distance learning. When on-site, masks and social distancing were compulsory. Nevertheless, single classrooms or whole schools often experienced forced closures due to students and/or

TABLE 1 Daily new confirmed COVID-19 cases per million people, 7-day rolling average/cumulative confirmed COVID-19 deaths per million people 2020/2021 in Italy, Latvia, and Portugal.

Time point	Italy	Latvia	Portugal
1 November 2020	434.37/643.16	111.57/39.64	360.45/250.20
1 January 2021	239.06/1,236.11	474.04/344.95	405.29/685.69
1 March 2021	282.81/1,622.48	356.96/868.27	96.69/1,608.10
1 May 2021	203.75/2,004.94	337.83/1,145.73	41.91/1,669.56

Data source: COVID-19 Data Repository by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University.

TABLE 2 Policy responses to COVID-19 (number of days with certain policy) and vaccination rates (% of population partly/fully vaccinated) between 1 November 2020 and 1 May 2021 in Italy, Latvia, and Portugal.

Policy/Time point	Italy	Latvia	Portugal
School policy (remote learning at home): partly/fully	131/50	181/0	35/57
Workplace policy (closing or work from home): partly/fully	66/115	130/51	127/54
Stay-at-home policy	181	0	152
Partly/Fully vaccinated (% of population)			
1 January 2021	0/0.33	0/0.05	0/0.13
1 March 2021	2.4/2.7	0.94/1.6	2.9/3.5
1 May 2021	10/14	3/12	9.3/17

Data source: Official data collated by Our World in Data; Oxford COVID-19 Government Response Tracker, Blavatnik School of Government, University of Oxford.
Notes.
School policy:
Partly - Policy requires on-site school closing only at some levels or categories, e.g., just high school.
Fully - Policy requires on-site school closing at all levels.
Workplace policy:
Partly - Policy requires closing or work from home for some sectors or categories of workers.
Fully - Policy requires closing or work from home all but essential workplaces (e.g., grocery stores, doctors).
Stay at home policy:
Policy requires not leaving house with exceptions for daily exercise, grocery shopping, and "essential" trips.

teachers testing positive for COVID-19. At a national level, movements across regions were prohibited, with the exception of those related to work and health reasons.

This situation continued until April 2021, when the government imposed a national lockdown on the occasion of the Easter holidays to limit the spread of the contagion. Access to schools depended on the seriousness of the contagion in the specific zone and the school's grade: in red zones, middle (with the exception of the first grade) and high schools kept on providing distance learning; in orange and yellow zones, middle schools provided on-site learning, while high schools adopted the 50-75% learning approach. Since then, control measures have been progressively loosened, in parallel with the successful vaccination campaign and a decrease in cases.

Portugal

The first COVID-19 case in Portugal was confirmed on 2 March 2020, and the first pediatric case on 7 March 2020 (59). The pandemic in Portugal forced two lockdowns, one in March 2020, when the World Health Organization declared a pandemic situation, and another in January 2021. Regarding health, a huge level of hospital demands were observed due to the increased number of cases with severe illness and required hospitalization caused by COVID-19 infections and increased stress on health services was observed. According to the Direção-Geral da Saúde (59), the highest rate of deaths due to a COVID-19 infection (200 per day) occurred in January 2021. Nonetheless, children and adolescents presented a lower risk of developing a severe form of the disease and required less hospital care (60).

These confinements caused significant changes in the functioning of schools. The majority were rapidly modernized for online learning provision, taking into account the moment's needs. Although there was a shortage of online education resources and a lack of a culture of autonomous work among the students, most teachers, students, and families organized themselves relatively efficiently to adapt to this period of mandatory physical distancing, social confinement, and school closure. However, Portuguese society's social and economic inequalities became an obstacle to education. Some children could not follow the classes, missing curricular objectives. However, an effort was made to equip students from lower social and economic groups with the necessary technology so as to cover a large part of this population during the confinement periods.

The creation of a support website, digital terrestrial television classes, the creation of five channels on YouTube, and distance learning online training in schools using the MOOC (Massive Open Online Course) format occurred between February and July 2021, and there was also the implementation of digital textbooks (PDT) and the production of digital educational resources (61).

Participants

The sample of 512 adolescents consisted of 245 boys with a mean age of 13.16 years and a standard deviation of 1.67 years and 267 girls with a mean age of 13.12 years and a standard deviation of 1.76 years. The mean age and standard deviations were calculated by taking their average age between T1 and T2. The participants were selected from Italy (n = 102, 19.9%), Latvia (n = 284, 55.5%), and Portugal (n = 126, 24.6%) and were stratified by gender and age group (11-13 and 14-16 years). The mean ages of Italian, Latvian, and Portuguese boys (13.27, 13.17, and 13.03 years, respectively) and girls (13.21, 13.03, and 13.12 years, respectively) varied marginally by country and gender.

TABLE 3 Characteristics of the sample.

		Country			Total
		Italy	Latvia	Portugal	
Gender	Boys	53(10.3%)	136 (26.6%)	56 (10.9%)	245 (47.8%)
	Girls	49 (9.6%)	148 (28.9%)	70 (13.7%)	267 (52.2%)
Age-Group	11-13 years	52 (10.2%)	148 (28.9%)	55 (10.7%)	255 (49.8%)
	14-16 years	50 (9.8%)	136 (26.6%)	71 (13.9%)	257 (50.2%)

TABLE 4 Reliability of SDQ, SSIS-SEL, and CD-RISC-10 scales (Cronbach's alpha).

Subscale	Informant	Country			Whole Group
		Italy	Latvia	Portugal	
Internalized difficulty	Child self-report	0.724	0.750	0.722	0.732
	Parent report	0.740	0.720	0.716	0.717
Externalized difficulty	Child self-report	0.702	0.701	0.751	0.712
	Parent report	0.745	0.781	0.784	0.777
Total difficulty	Child self-report	0.796	0.786	0.809	0.793
	Parent report	0.797	0.796	0.805	0.800
Prosocial behavior	Child self-report	0.607	0.668	0.664	0.656
	Parent report	0.675	0.663	0.649	0.672
Self-awareness	Child self-report	0.543	0.545	0.593	0.562
	Parent report	0.617	0.637	0.667	0.641
Self-management	Child self-report	0.586	0.585	0.648	0.619
	Parent report	0.693	0.705	0.686	0.702
Social awareness	Child self-report	0.743	0.710	0.721	0.733
	Parent report	0.785	0.819	0.771	0.804
Relationship skills	Child self-report	0.539	0.530	0.583	0.549
	Parent report	0.675	0.681	0.661	0.678
Responsible decision making	Child self-report	0.643	0.567	0.667	0.618
	Parent report	0.759	0.761	0.771	0.768
Social emotional learning	Child self-report	0.842	0.844	0.871	0.857
	Parent report	0.917	0.902	0.880	0.903
Resilience	Child self-report	0.840	0.839	0.845	0.843
	Parent report				

Table 3 represents the demographic characteristics of both the national samples and the whole sample of the study.

Procedure

The process of data collection took place twice: at the beginning and at the end of the 2020/21school year in October 2020 and May 2021, respectively. To ensure the participants' privacy and to match T1 and T2 data, every participant received a unique anonymized code to be used when filling in the survey. Parents were assigned the same code as their children to enable comparisons between the two time points. Only adolescents and their parents who completed their respective questionnaires in both phases were included in the study. Figure 1 displays the flowchart of enrollement of participants in each country. The initial sample of 1,059 adolescents and their parents was reduced to 512 either because one informant or both informants did not provide the requested information. Nevertheless, a sample of 512 participants still guaranteed a maximum margin of error of 4.3%, assuming a 95% confidence level. Moreover, when the responses of single informants were added to data set the changes in the mean pre- and mean post-test scores were insignificant. This indicates that dropouts occurred across the whole range of social emotional skills, behavioral problems and resilience scales and had no impact on the findings.

In Latvia, researchers organized informative campaigns in eight schools in the Sigulda region. This region is a

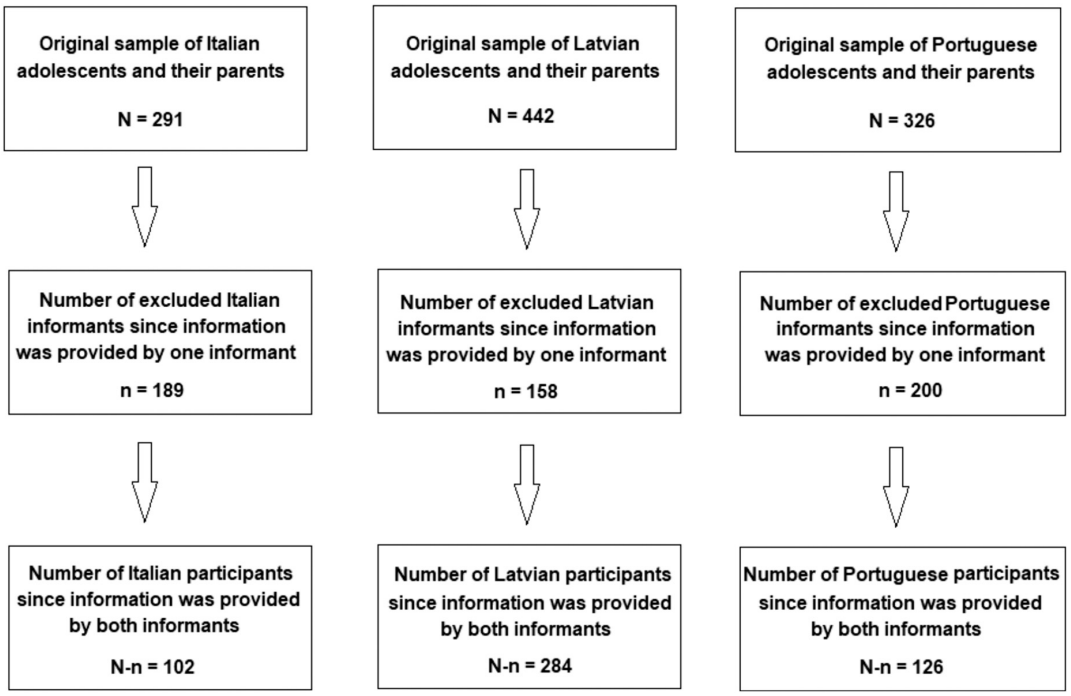

FIGURE 1
Flowchart of enrollment in each country.

project partner, so all schools in the region were invited to participate. Initially, agreements with school principals and teachers regarding participation in the project were reached. Then informative letters with an invitation to participate in the survey were sent to parents. Parent surveys with informed consent placed on the main page were put into envelopes, coded, and delivered to every school by researchers. The envelopes were distributed among parents by a class teacher. Parents were asked to sign the informed consent, fill in the survey, and return them in sealed envelopes to the class teacher. The sealed envelopes were collected by the researchers, who opened them and checked if the informed consent of the parent had been given. Then the researchers attended the school and invited those adolescents with signed parental informed consent to take part in the survey. Before students completed the survey, they also gave their own written informed consent to participate. Students filled in their self-report surveys in paper form at school, in the presence of the researcher, who answered questions and collected all completed surveys immediately. Finally, the researchers input all the answers into an electronic data file. Only surveys of students who had, together with their parents, given their informed consent were included in the research. The Ethics Committee for Humanities and Social Sciences Research Involving Human Participants of the University of Latvia granted permission for the research on 12 December 2019.

In Italy, researchers contacted schools located in northern Italy, namely in the Lombardy and Piedmont regions, explaining the objectives and methodology of the project. After exploring teachers' willingness to be involved in the research, school principals were asked to sign an agreement. All participants completed the survey online, with the exception of those parents who explicitly required it in a paper version. At the beginning of the survey, parents were required to provide their informed consent for themselves and their children. Before students completed the survey, they were also asked to give their informed consent to participate. The research was approved by the Ethical Committee of the University of Milano-Bicocca on 21 July 2020.

In Portugal, researchers organized meetings with local policymakers and wellness observatory organizations to present the project to them. Then those organizations contacted school principals who might be interested in participating in the project. Each school principal subsequently contacted and selected teachers interested in being part of the project. Meetings with principals, teachers, and school psychologists were held to present the project and the evaluation procedure. The researchers sent informed consent forms to the teachers, who then sent them on to the parents. After the teachers collected the parents' consent form, they sent them a link to the online survey or, in some cases, they sent a paper version. Students completed the self-report forms in class. However, some students did theirs at home due to the distancing restrictions. An assent form was also given to the students. Students gave their consent in the online survey or, in some cases, in the paper version. When

paper versions were used, they were sent by the teachers to the researchers, who input the data into the database. The Ethics Committee of the Environmental Health Institute at the University of Lisbon approved the research on 20 March 2020.

Measures

Both the adolescents and their parents participating in the study were asked to complete the Strengths and Difficulties Questionnaire (SDQ) and the Social Skills Improvement System Social-Emotional Learning Brief Scales (SSIS-SEL), while the adolescents were also asked to complete the Connor-Davidson Brief Resilience Scale (CD-RISC-10).

The SDQ (62, 63) is a widely used tool to measure the mental health of children and adolescents. It consists of 25 items (5 per scale), allowing the researcher to evaluate difficulties in four areas of difficulty (emotional, conduct, hyperactivity, and peer problems) and one strength (prosocial behavior). In this questionnaire, a 3-point Likert-type scale ranging from 0 (not true) to 2 (certainly true) is used, and higher scores indicate more social, emotional, and behavioral difficulties or a greater intention to help others, respectively. The model with a summed score for internalized and externalized difficulties, as well as for total difficulty and prosocial behavior, was used in the current study.

The SSIS-SEL (64, 65) evaluates students' social emotional learning. The measure consists of 20 items that allow one to estimate five domains of social emotional skills: self-awareness, self-management, social awareness, relationship skills, and responsible decision-making. Each item is measured on a 4-point Likert-type scale ranging from 0 (never) to 3 (almost always), and higher scores correspond to greater social emotional competence.

The CD-RISC-10 (66) is a self-report measure used to explore resilience among adolescents and adults. The short version of the scale (67) consists of 10 items on a 5-point Likert scale, from 0 (not true at all) to 4 (true nearly all the time), where higher scores indicate a greater ability to handle stress and to be more resilient.

The SDQ parent form was previously validated in the Latvian, Italian, and Portuguese languages. The Latvian SDQ self-report form and CD-RISC-10 were translated according to recommendations in the literature (68), namely translation, review, back-translation, review by experts, piloting in the target group, and final agreement among the experts' committee to reach appropriate cultural, semantic, and conceptual equivalence with the original measure. The same procedure was applied to the Brief SSIS-SEL scales for their Latvian, Italian, and Portuguese versions (see **Table 4**).

The Cronbach's alpha coefficient was computed to assess the internal consistency of the items measuring each scale, where values exceeding 0.7 indicate good internal consistency and values ranging from 0.5 to 0.7 indicate acceptable internal consistency. The SSIS-SEL summed score reached good internal consistency in both parent and child self-reports, and SDQ difficulty scales were characterized as good in terms of their reliability in both parent and child self-report forms. The reliability of the prosocial behavior scale was acceptable in both parent and child self-report forms. Similarly, four out of the five SSIS-SEL scales in the child self-report forms reached an acceptable level of consistency; only social awareness reached a good level of consistency. This was similar to the parent forms, where only social awareness and responsible decision-making could be characterized as having good reliability in all languages.

Data analysis

Descriptive statistics tables were generated to display the mean subscale scores for the SDQ, SSIS-SEL, and CD-RISC-10 questionnaires, where adolescents' and parents' evaluations were grouped by the adolescents' gender, age, and country of residence. The Wilcoxon signed-rank test was used to determine whether mean scores in behavioral problems, social emotional skills, and resilience varied significantly between October 2020 and May 2021. A limitation of the Wilcoxon signed-rank test is that it does not investigate the impact of other explanatory variables on behavioral problems, social emotional skills, and resilience. To address this limitation, several multilevel models were fitted, using both the adolescents' and parents' evaluations, to determine whether the changes in social emotional skills, resilience, and behavioral problems between October 2020 and May 2021 varied significantly between gender and age-groups. Multilevel models are hierarchical linear mixed models and were used to accommodate the nested structure of the data, where adolescents are nested in schools, which in turn are nested in countries. Besides identifying the significant explanatory variables, multilevel models also measure the variance at each level of nesting. Finally, correlation analysis was used to investigate the strength of the relationships between changes in SSIS-SEL and changes in SDQ and CD-RISC-10. These analyses were carried out for each country separately and for all countries combined.

Results

Changes in adolescents' social emotional skills, resilience, and behavioral problems during the COVID-19 pandemic

One way to measure changes in social emotional skills, behavioral problems and resilience scale scores is by computing the difference between the pre- and post-test scores and using this change score as the dependent variable. In this part of

analysis, pre- and post-test scores were used rather than change scores to compare the parents' perceptions with perceptions of adolescents on their social emotional skills, behavioral problems and prosocial behavior. Table 5 displays the mean scores of adolescents' self-reported evaluations in behavioral problems, social emotional skills, and resilience in October 2020 and May 2021. These scores were calculated by clustering the adolescents by age (11-13 years, 14-16 years), gender (boys, girls), and country (Italy, Latvia, Portugal).

The parents' reported changes in their adolescent children's behavioral problems, social emotional skills, and resilience in the two phases are in Table 6.

For each gender and age-group combination, adolescents report higher internalizing, externalizing, and total difficulties and lower prosocial behavior than perceived by their parents. Moreover, for each gender and age-group combination, adolescents report comparable levels of social emotional learning (self-awareness, self-management, social awareness, relationship skills, responsible decision-making) to those perceived by their parents (see Tables 5, 6). These trends are also visible across countries.

The Kolmogorov-Smirnov test was used to investigate the normality assumption of each scale's score distribution, and this was carried out separately for each gender, age group, and country. Non-parametric tests were used to analyze the data further, since all the scale distributions were skewed and violated the normality assumption.

For each participant, the changes in their social emotional skills, internalizing/externalizing difficulties, and prosocial scores were generated by subtracting the scores recorded in October 2020 from the scores recorded in May 2021. The Wilcoxon signed-rank test was also used to determine whether the scores differed significantly between the two phases. Table 7 displays the changes in the mean scores or change scores of these eleven scales for each country, gender, and age-group combination (significant changes are marked with an asterisk*).

Table 7 shows that some of the changes in the mean internalizing, externalizing, and total difficulty scores and in the mean social emotional learning, resilience, and prosocial behavior scores do not agree in their direction when comparing adolescents' and parents' evaluations. Moreover, most of these changes are not significant. This implies that there were few changes in adolescents' social emotional learning, difficulties, resilience, and prosocial behavior across the whole sample between October 2020 and May 2021. At the same time, several significant changes could be observed in certain age and gender groups when data were analyzed at the country level.

In Italy, adolescents' self-reports demonstrated a significant decrease in summed social emotional skills, more specifically in self-management and relationship skills among 11-13-year-old boys and responsible decision-making among all 14-16-year-old students and girls aged between 11 and 13. Regarding self-awareness, adolescents' self-report scores did not show any significant difference, whereas parents reported an increase in this skill in their 11-13-year-old boys and a decrease in 14-16-year-old girls. Contradicting results were also found regarding the social awareness of 14-16-year-old boys, which was self-evaluated as having increased but as having decreased in parents' reports. Parents also indicated a decreased level of social awareness among both age groups of girls. Parents observed increased total difficulties among girls of all ages, especially externalized difficulties; however, self-report data indicated that externalized difficulties increased among 11-13-year-old boys and internalized difficulties increased among 14-16-year-old boys. Both 11-13-year-old girls and 14-16-year-old boys reported decreased resilience. All students aged 14-16 reported a decrease in their prosocial behavior, which was also observed by parents of 11-13-year-old girls.

In Latvia, all significant changes observed were among girls. In their self-reports, 11-13-year-old girls evaluated a decrease in total social emotional learning, self-awareness, and prosocial behavior. Both 11-13-year-old and 13-16-year-old girls also reported a decrease in relationship skills. Parents observed a decrease in decision-making among 11-13-year-old girls and self-management among 14-16-year-old girls.

In Portugal, according to adolescents' self-reports, there was a decrease in prosocial behavior, self-management, and social awareness among 11-13-year-old boys and self-awareness among 11-13-year-old girls. Parents also reported decreased self-management among 11-13-year-old boys. Interestingly, parents observed that the dynamic of responsible decision-making was negative for boys and positive for girls in the 11-13-year-old age group. Parents and adolescents only simultaneously perceived a decrease in self-management among 11-13-year-old boys.

Several multilevel models were fitted to relate the difficulties, prosocial behavior, social emotional learning, and resilience scales to three predictors (age, gender, and phase). The aliased terms are age (14-16 years), gender (girl), and phase (October 2020). The model fits included three main effects and two pairwise interaction effects, and these were applied to both the adolescents' and parents' evaluations. Table 8 displays the regression coefficients, standard errors, and p-values of each model. We fitted appropriate models to investigate how these change scores vary between phase (2020, 2021), gender (boys, girls) and age (11-13, 14-16).

The main effect of age and gender reached statistical significance; however, inconsistent results were obtained from parents' and adolescents' reports. Adolescents, but not their parents, agree that, on average, boys score lower than girls and that adolescents aged 11-13 years score lower than their older counterparts on internalizing difficulties. At the same time, parents, but not adolescents themselves, evaluated boys' scores higher than girls and younger adolescents lower than older ones on externalizing difficulties.

TABLE 5 Mean SDQ, SSIS-SEL, and CD-RISC-10 scores as reported by adolescents (n = 512).

Subscale	Age	Gender	Italy				Latvia				Portugal				Whole Group			
			2020		2021		2020		2021		2020		2021		2020		2021	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Internalizing difficulty	11-13	Male	1.50	0.410	1.51	0.411	1.58	0.355	1.64	0.340	1.46	0.225	1.46	0.247	1.53	0.332	1.57	0.337
		Female	1.50	0.439	1.54	0.352	1.74	0.362	1.80	0.398	1.62	0.294	1.71	0.372	1.67	0.360	1.74	0.386
	14-16	Male	1.70	0.314	1.83	0.322	1.58	0.357	1.62	0.320	1.53	0.276	1.52	0.327	1.59	0.325	1.64	0.317
		Female	1.81	0.406	1.75	0.213	1.77	0.328	1.80	0.382	1.73	0.363	1.75	0.369	1.76	0.361	1.77	0.368
Externalizing difficulty	11-13	Male	1.47	0.267	1.60	0.310	1.68	0.307	1.63	0.326	1.55	0.345	1.63	0.326	1.60	0.315	1.62	0.319
		Female	1.47	0.340	1.39	0.276	1.60	0.267	1.68	0.321	1.56	0.377	1.57	0.410	1.57	0.316	1.61	0.348
	14-16	Male	1.65	0.201	1.63	0.396	1.64	0.245	1.69	0.298	1.62	0.296	1.66	0.406	1.64	0.278	1.67	0.332
		Female	1.58	0.232	1.55	0.262	1.55	0.271	1.62	0.297	1.67	0.360	1.61	0.373	1.59	0.345	1.60	0.335
Total difficulty	11-13	Male	1.48	0.301	1.55	0.309	1.63	0.274	1.64	0.289	1.51	0.218	1.54	0.245	1.57	0.270	1.60	0.281
		Female	1.48	0.302	1.46	0.272	1.67	0.268	1.74	0.314	1.59	0.306	1.64	0.332	1.62	0.291	1.67	0.324
	14-16	Male	1.67	0.172	1.73	0.265	1.61	0.237	1.66	0.242	1.57	0.254	1.59	0.342	1.61	0.253	1.65	0.280
		Female	1.69	0.308	1.65	0.209	1.66	0.256	1.71	0.301	1.70	0.286	1.68	0.315	1.68	0.291	1.69	0.295
Prosocial behavior	11-13	Male	2.52	0.237	2.43	0.327	2.42	0.343	2.41	0.388	2.64	0.286	2.52	0.352	2.49	0.354	2.44	0.386
		Female	2.57	0.352	2.61	0.329	2.55	0.317	2.42	0.356	2.65	0.307	2.69	0.274	2.57	0.322	2.51	0.365
	14-16	Male	2.55	0.314	2.30	0.283	2.27	0.435	2.33	0.404	2.57	0.371	2.53	0.288	2.39	0.371	2.37	0.386
		Female	2.59	0.346	2.39	0.241	2.52	0.275	2.54	0.311	2.62	0.393	2.64	0.377	2.56	0.361	2.54	0.367
Self-awareness	11-13	Male	2.80	0.432	2.69	0.520	2.95	0.436	3.00	0.426	3.22	0.465	3.15	0.419	2.97	0.482	2.96	0.481
		Female	2.85	0.566	2.84	0.571	3.12	0.462	3.01	0.519	3.26	0.586	3.12	0.543	3.10	0.520	3.00	0.519
	14-16	Male	2.66	0.529	2.68	0.243	2.82	0.407	2.83	0.523	3.06	0.426	3.04	0.369	2.85	0.447	2.85	0.455
		Female	2.79	0.528	2.73	0.420	2.99	0.459	2.91	0.444	2.95	0.394	2.95	0.455	2.94	0.433	2.89	0.461
Self-management	11-13	Male	2.62	0.489	2.33	0.532	2.89	0.478	2.82	0.485	3.06	0.545	2.87	0.551	2.86	0.525	2.71	0.516
		Female	2.61	0.530	2.77	0.460	3.00	0.509	2.90	0.512	2.91	0.662	2.95	0.584	2.91	0.579	2.89	0.534
	14-16	Male	2.60	0.608	2.49	0.332	2.81	0.450	2.84	0.464	2.88	0.568	2.79	0.381	2.78	0.512	2.76	0.505
		Female	2.56	0.420	2.75	0.207	2.91	0.500	2.94	0.410	2.88	0.406	2.81	0.557	2.83	0.504	2.87	0.538
Social awareness	11-13	Male	3.17	0.557	3.10	0.553	2.80	0.550	2.84	0.553	3.19	0.526	3.05	0.654	2.97	0.575	2.95	0.600
		Female	3.33	0.465	3.31	0.425	3.26	0.605	3.09	0.575	3.48	0.500	3.52	0.360	3.32	0.552	3.22	0.543
	14-16	Male	3.04	0.404	3.24	0.404	2.72	0.573	2.76	0.577	3.28	0.466	3.33	0.437	2.92	0.557	2.99	0.590
		Female	3.37	0.507	3.47	0.414	3.12	0.562	3.12	0.434	3.43	0.424	3.44	0.466	3.27	0.548	3.29	0.526
Relationship skills	11-13	Male	3.22	0.430	3.10	0.415	3.18	0.471	3.13	0.424	3.42	0.425	3.38	0.384	3.24	0.481	3.18	0.436
		Female	3.20	0.536	3.20	0.448	3.29	0.475	3.15	0.516	3.38	0.594	3.35	0.564	3.29	0.498	3.20	0.491
	14-16	Male	3.24	0.321	3.15	0.346	3.16	0.462	3.10	0.447	3.36	0.412	3.38	0.375	3.22	0.437	3.18	0.433
		Female	3.13	0.451	3.13	0.127	3.30	0.383	3.17	0.353	3.40	0.371	3.31	0.400	3.30	0.416	3.21	0.411
Responsible decision making	11-13	Male	2.87	0.404	2.91	0.600	3.09	0.505	3.09	0.470	3.18	0.545	3.14	0.521	3.06	0.504	3.06	0.528
		Female	3.09	0.482	2.88	0.610	3.23	0.467	3.23	0.457	3.42	0.519	3.39	0.543	3.25	0.480	3.20	0.539
	14-16	Male	2.97	0.671	2.76	0.707	3.00	0.440	3.01	0.491	3.34	0.422	3.28	0.405	3.08	0.510	3.03	0.522
		Female	3.24	0.502	3.05	0.351	3.18	0.357	3.21	0.338	3.44	0.386	3.40	0.401	3.27	0.434	3.24	0.454
Social emotional learning	11-13	Male	2.94	0.240	2.83	0.332	2.98	0.358	2.97	0.364	3.21	0.324	3.12	0.405	3.02	0.374	2.97	0.387
		Female	3.02	0.323	3.00	0.334	3.18	0.386	3.07	0.414	3.29	0.473	3.27	0.432	3.18	0.399	3.10	0.407
	14-16	Male	2.90	0.415	2.87	0.317	2.90	0.350	2.91	0.372	3.18	0.317	3.16	0.296	2.97	0.367	2.96	0.384
		Female	3.02	0.314	3.03	0.213	3.10	0.300	3.07	0.246	3.22	0.288	3.18	0.363	3.12	0.327	3.10	0.366
Resilience	11-13	Male	3.22	0.573	3.20	0.693	3.60	0.676	3.54	0.609	3.61	0.617	3.68	0.783	3.51	0.686	3.49	0.682
		Female	3.37	0.815	3.21	0.795	3.28	0.675	3.19	0.699	3.40	0.756	3.45	0.620	3.32	0.735	3.25	0.774
	14-16	Male	3.16	0.555	2.68	0.605	3.66	0.533	3.58	0.643	3.75	0.648	3.78	0.617	3.59	0.613	3.45	0.649
		Female	2.93	0.510	2.87	0.541	3.49	0.686	3.39	0.759	3.31	0.655	3.34	0.879	3.32	0.736	3.27	0.827

TABLE 6 Mean SDQ, SSIS-SEL, and CD-RISC-10 scores as reported by parents (n = 512).

Subscale	Age	Gender	Italy				Latvia				Portugal				Whole Group			
			2020		2021		2020		2021		2020		2021		2020		2021	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Internalizing difficulty	11-13	Male	1.37	0.291	1.43	0.327	1.45	0.296	1.45	0.335	1.34	0.234	1.34	0.197	1.40	0.284	1.42	0.309
		Female	1.25	0.463	1.43	0.286	1.48	0.294	1.50	0.358	1.56	0.379	1.53	0.364	1.46	0.360	1.49	0.345
	14-16	Male	1.63	0.309	1.53	0.292	1.47	0.341	1.53	0.354	1.35	0.271	1.34	0.254	1.48	0.332	1.49	0.327
		Female	1.36	0.311	1.47	0.250	1.51	0.322	1.48	0.313	1.44	0.335	1.49	0.302	1.46	0.301	1.48	0.322
Externalizing difficulty	11-13	Male	1.45	0.271	1.45	0.315	1.58	0.350	1.58	0.339	1.58	0.342	1.65	0.335	1.55	0.335	1.56	0.336
		Female	1.30	0.266	1.40	0.221	1.48	0.293	1.51	0.286	1.70	0.315	1.61	0.401	1.50	0.326	1.51	0.299
	14-16	Male	1.45	0.172	1.47	0.283	1.55	0.327	1.57	0.341	1.56	0.332	1.53	0.336	1.53	0.329	1.54	0.305
		Female	1.24	0.238	1.43	0.180	1.39	0.302	1.39	0.287	1.43	0.342	1.48	0.353	1.38	0.298	1.42	0.305
Total difficulty	11-13	Male	1.41	0.244	1.44	0.276	1.51	0.266	1.51	0.281	1.46	0.220	1.49	0.209	1.48	0.244	1.49	0.253
		Female	1.28	0.285	1.42	0.176	1.48	0.249	1.50	0.277	1.63	0.258	1.57	0.305	1.48	0.289	1.50	0.260
	14-16	Male	1.54	0.171	1.50	0.193	1.51	0.288	1.55	0.282	1.45	0.243	1.44	0.250	1.50	0.259	1.51	0.261
		Female	1.30	0.240	1.45	0.185	1.45	0.259	1.44	0.247	1.43	0.276	1.48	0.282	1.42	0.253	1.45	0.260
Prosocial behavior	11-13	Male	2.67	0.321	2.62	0.312	2.51	0.393	2.49	0.368	2.75	0.311	2.79	0.288	2.60	0.372	2.59	0.356
		Female	2.71	0.237	2.56	0.274	2.55	0.359	2.57	0.373	2.70	0.347	2.64	0.325	2.61	0.353	2.58	0.363
	14-16	Male	2.64	0.376	2.63	0.450	2.37	0.383	2.33	0.337	2.64	0.298	2.63	0.316	2.49	0.385	2.46	0.384
		Female	2.75	0.248	2.64	0.226	2.59	0.346	2.59	0.362	2.65	0.396	2.68	0.338	2.64	0.336	2.63	0.346
Self-awareness	11-13	Male	2.93	0.398	3.06	0.529	2.90	0.557	2.87	0.553	3.20	0.449	3.12	0.453	2.97	0.537	2.97	0.509
		Female	3.03	0.366	3.01	0.425	2.84	0.521	2.83	0.531	3.02	0.429	3.14	0.523	2.91	0.517	2.92	0.494
	14-16	Male	2.97	0.253	2.98	0.464	2.72	0.636	2.67	0.561	3.12	0.493	3.15	0.483	2.86	0.572	2.85	0.561
		Female	3.39	0.554	3.02	0.440	3.05	0.567	2.96	0.552	3.12	0.521	3.12	0.557	3.14	0.545	3.02	0.551
Self-management	11-13	Male	2.92	0.485	2.85	0.558	2.72	0.534	2.69	0.534	3.09	0.521	2.94	0.586	2.85	0.567	2.78	0.526
		Female	3.11	0.745	2.97	0.414	2.71	0.540	2.74	0.517	2.82	0.534	2.86	0.631	2.80	0.544	2.80	0.581
	14-16	Male	2.89	0.516	2.95	0.691	2.69	0.623	2.70	0.619	3.08	0.391	3.04	0.556	2.82	0.575	2.83	0.632
		Female	3.27	0.498	2.99	0.470	3.01	0.547	2.87	0.553	3.13	0.557	3.10	0.451	3.10	0.514	2.97	0.547
Social awareness	11-13	Male	3.21	0.399	3.25	0.450	2.95	0.631	2.89	0.644	3.47	0.518	3.43	0.511	3.13	0.610	3.09	0.602
		Female	3.39	0.411	3.17	0.368	3.05	0.558	3.06	0.590	3.45	0.395	3.49	0.380	3.19	0.547	3.17	0.529
	14-16	Male	3.32	0.613	3.13	0.616	2.68	0.626	2.66	0.635	3.41	0.392	3.36	0.387	2.98	0.667	2.92	0.654
		Female	3.31	0.489	2.96	0.467	3.11	0.650	3.07	0.638	3.40	0.601	3.38	0.519	3.24	0.584	3.15	0.625
Relationship skills	11-13	Male	3.36	0.532	3.38	0.477	3.07	0.635	3.02	0.567	3.42	0.520	3.36	0.436	3.21	0.541	3.18	0.609
		Female	3.24	0.515	3.24	0.479	2.94	0.570	2.93	0.533	3.06	0.560	3.22	0.531	3.02	0.531	3.05	0.573
	14-16	Male	3.42	0.605	3.28	0.623	2.85	0.564	2.85	0.511	3.36	0.300	3.26	0.438	3.08	0.583	3.03	0.555
		Female	3.32	0.394	3.10	0.563	3.06	0.600	2.99	0.613	3.13	0.499	3.19	0.560	3.13	0.592	3.07	0.539
Responsible decision making	11-13	Male	3.27	0.476	3.34	0.525	3.24	0.498	3.16	0.573	3.43	0.530	3.31	0.526	3.29	0.553	3.24	0.503
		Female	3.43	0.480	3.38	0.410	3.20	0.620	3.08	0.553	3.29	0.416	3.45	0.540	3.26	0.532	3.21	0.581
	14-16	Male	3.33	0.535	3.32	0.550	3.04	0.621	3.09	0.639	3.46	0.439	3.40	0.448	3.20	0.592	3.21	0.594
		Female	3.31	0.448	3.29	0.223	3.37	0.555	3.30	0.598	3.45	0.519	3.47	0.511	3.38	0.518	3.35	0.527
Social emotional learning	11-13	Male	3.14	0.343	3.18	0.397	2.98	0.463	2.93	0.468	3.32	0.368	3.23	0.392	3.09	0.455	3.05	0.437
		Female	3.24	0.345	3.15	0.221	2.95	0.449	2.93	0.429	3.13	0.303	3.23	0.433	3.04	0.416	3.03	0.425
	14-16	Male	3.18	0.307	3.13	0.436	2.80	0.490	2.79	0.491	3.29	0.296	3.24	0.338	2.99	0.472	2.97	0.489
		Female	3.32	0.366	3.07	0.351	3.12	0.474	3.04	0.493	3.25	0.423	3.25	0.400	3.20	0.445	3.11	0.447

TABLE 7 Adolescent and parent-reported changes in mean SDQ and SSIS-SEL scores and adolescent self-reported CD-RISC-10 scores (n = 512), October 2020 (T1) – May 2021 (T2).

Subscale	Age	Gender	Italy		Latvia		Portugal		Whole Group	
			Child	Parent	Child	Parent	Child	Parent	Child	Parent
Internalizing difficulty	11-13	Male	0.01	0.06	0.06	0.00	0.00	0.00	0.04	0.02
		Female	0.04	0.18	0.06	0.02	0.09	−0.03	0.07	0.03
	14-16	Male	0.13*	−0.10	0.04	0.06	−0.01	−0.01	0.05	0.01
		Female	−0.06	0.11	0.03	−0.03	0.02	0.05	0.01	0.02
Externalizing difficulty	11-13	Male	0.13*	0.00	−0.05	0.00	0.08	0.07	0.02	0.01
		Female	−0.08	0.10	0.08	0.03	0.01	−0.09	0.04	0.01
	14-16	Male	−0.02	0.02	0.05	0.02	0.04	−0.03	0.03	0.01
		Female	−0.03	0.19*	0.07	0.00	−0.06	0.05	0.01	0.04
Total difficulty	11-13	Male	0.07	0.03	0.01	0.00	0.03	0.03	0.03	0.01
		Female	−0.02	0.14*	0.07	0.02	0.05	−0.06	0.05	0.02
	14-16	Male	0.06	−0.04	0.05	0.04	0.02	−0.01	0.04	0.01
		Female	−0.04	0.15*	0.05	−0.01	−0.02	0.05	0.01	0.03
Prosocial behavior	11-13	Male	−0.09	−0.05	−0.01	−0.02	−0.12*	0.04	−0.05	−0.01
		Female	0.04	−0.15*	−0.13*	0.02	0.04	−0.06	−0.06	−0.03
	14-16	Male	−0.25*	−0.01	0.06	−0.04	−0.04	−0.01	−0.02	−0.03
		Female	−0.20*	−0.11	0.02	0.00	0.02	0.03	−0.02	−0.01
Self-awareness	11-13	Male	−0.11	0.13*	0.05	−0.03	−0.07	−0.08	−0.01	0.00
		Female	−0.01	−0.02	−0.11	−0.01	−0.14*	0.12	−0.10	0.01
	14-16	Male	0.02	0.01	0.01	-0.05	-0.02	0.03	0.00	-0.01
		Female	−0.06	−0.37*	−0.08	−0.09	0.00	0.00	-0.05	-0.12
Self-management	11-13	Male	−0.29*	−0.07	−0.07	−0.03	−0.19*	−0.15*	−0.15*	−0.07
		Female	0.16*	−0.14	−0.10	0.03	0.04	0.04	−0.02	0.00
	14-16	Male	−0.11	0.06	0.03	0.01	−0.09	−0.04	−0.02	0.01
		Female	0.19*	−0.28*	0.03	−0.14*	−0.07	−0.03	0.04	−0.13*
Social awareness	11-13	Male	−0.07	0.04	0.04	−0.06	−0.14*	−0.04	−0.02	-0.04
		Female	-0.02	-0.22*	-0.17*	0.01	0.04	0.04	−0.10	−0.02
	14-16	Male	0.20*	−0.19*	0.04	−0.02	0.05	−0.05	0.07	−0.06
		Female	0.10	−0.35*	0.00	−0.04	0.01	−0.02	0.02	−0.09
Relationship skills	11-13	Male	−0.12*	0.02	−0.05	−0.05	−0.04	−0.06	−0.06	−0.03
		Female	0.00	0.00	−0.14*	−0.01	−0.03	0.16*	−0.09	0.03
	14-16	Male	−0.09	−0.14*	-0.06	0.00	0.02	−0.10	−0.04	−0.05
		Female	0.00	−0.22*	−0.13*	−0.07	−0.09	0.06	−0.09	−0.06
Responsible decision-making	11-13	Male	0.04	0.07	0.00	−0.08	−0.04	−0.12*	0.00	−0.05
		Female	−0.21*	−0.05	0.00	−0.12*	−0.03	0.16*	−0.05	−0.05
	14-16	Male	−0.21*	−0.01	0.01	0.05	−0.06	−0.06	−0.05	0.01
		Female	−0.19*	−0.02	0.03	−0.07	−0.04	0.02	−0.03	−0.03
Social emotional learning	11-13	Male	−0.11*	0.04	−0.01	−0.05	−0.09	−0.09	−0.05	−0.04
		Female	−0.02	−0.09	−0.11*	−0.02	−0.02	0.10	−0.08	−0.01
	14-16	Male	−0.03	−0.05	0.01	−0.01	-0.02	−0.05	−0.01	−0.02
		Female	0.01	−0.25*	−0.03	−0.08	−0.04	0.00	−0.02	−0.09
Resilience	11-13	Male	−0.02		−0.06		0.07		−0.02	
		Female	−0.16*		−0.09		0.05		−0.07	
	14-16	Male	−0.48*		−0.08		0.03		−0.14*	
		Female	−0.06		−0.10		0.03		−0.05	

*$p < 0.05$.

Both sets of informants agreed that adolescent boys score lower than girls on prosocial behavior and social emotional learning. Boys demonstrated higher resilience scores compared to girls.

The main effect of the phase was not significant, demonstrating that, on average, changes between October 2020 and May 2021 were not significant when individual factors (age and gender) were controlled.

No pairwise interaction effects were significant either, indicating that no particular age or gender groups were identified in the sample as a whole as being more affected by the pandemic experience.

Multilevel models are hierarchical linear mixed models that facilitate the analysis of hierarchical data particularly when observations are nested within higher levels of classification. These models are extensions of regression models and

TABLE 8 Regression coefficients, standard errors, and p-values of the models for SSIS-SEL, SDQ, and CD-RISC-10 with age, gender, and phase as predictors.

	Adolescents			Parents		
	B	**SE**	***P*-value**	**B**	**SE**	***P*-value**
Internalizing difficulty						
Age (11-13 years)	−0.075	0.032	0.018	−0.035	0.029	0.223
Gender (Boy)	−0.155	0.032	< 0.001	−0.018	0.029	0.540
Phase (May 2021)	0.025	0.038	0.512	0.009	0.036	0.804
Gender (Boy) * Phase (May 2021)	0.004	0.045	0.930	0.018	0.040	0.656
Age (11-13 years) * Phase (May 2021)	0.024	0.045	0.585	0.007	0.040	0.862
Externalizing difficulty						
Age (11-13 years)	−0.028	0.028	0.319	−0.073	0.028	0.010
Gender (Boy)	0.040	0.028	0.155	0.101	0.028	< 0.001
Phase (May 2021)	0.021	0.034	0.523	0.007	0.034	0.839
Gender (Boy) * Phase (May 2021)	0.001	0.040	0.985	0.016	0.040	0.688
Age (11-13 years) * Phase (May 2021)	0.008	0.040	0.849	0.016	0.040	0.687
Total difficulty						
Age (11-13 years)	−0.051	0.025	0.039	−0.014	0.023	0.532
Gender (Boy)	0.058	0.025	0.021	0.025	0.023	0.284
Phase (May 2021)	0.023	0.030	0.437	0.033	0.027	0.230
Gender (Boy) * Phase (May 2021)	0.002	0.035	0.947	0.017	0.033	0.603
Age (11-13 years) * Phase (May 2021)	0.016	0.035	0.650	0.004	0.033	0.891
Prosocial behavior						
Age (11-13 years)	0.052	0.031	0.097	0.041	0.032	0.207
Gender (Boy)	−0.125	0.031	< 0.001	−0.082	0.032	0.011
Phase (May 2021)	−0.019	0.039	0.634	−0.015	0.040	0.705
Gender (Boy) * Phase (May 2021)	0.004	0.044	0.922	0.003	0.045	0.946
Age (11-13 years) * Phase (May 2021)	−0.036	0.044	0.409	−0.003	0.045	0.951
Social emotional learning						
Age (11-13 years)	0.054	0.032	0.094	0.035	0.040	0.384
Gender (Boy)	−0.152	0.032	< 0.001	−0.078	0.040	0.052
Phase (May 2021)	−0.006	0.041	0.881	−0.015	0.049	0.765
Gender (Boy) * Phase (May 2021)	0.019	0.046	0.684	0.015	0.056	0.793
Age (11-13 years) * Phase (May 2021)	0.047	0.046	0.304	0.034	0.056	0.543
Resilience						
Age (11-13 years)	0.039	0.062	0.534			
Gender (Boy)	0.228	0.062	< 0.001			
Phase (May 2021)	−0.034	0.076	0.654			
Gender (Boy) * Phase (May 2021)	−0.019	0.088	0.831			
Age (11-13 years) * Phase (May 2021)	0.046	0.088	0.602			

*refers to the interaction of two explanatory variables.

accommodate well the levels of our clustered data set in which individuals (adolescents or parents) are nested within school levels (lower and higher secondary) and schools are nested within countries (Italy, Latvia, and Portugal). **Tables 9**, **10** display the variances and intraclass correlations at each level of nesting for the multilevel models fitted to the difficulty, prosocial, resilience and SEL subscale scores. The STATA GLLAMM routine was used to fit these multilevel models.

For the parent and student evaluations, the intra cluster correlations at individual level ranged from 0.8674 to 0.9767; the intra cluster correlations at school level ranged from 0.0113 to 0.0511; while the intra cluster correlations at country level ranged from 0.0120 to 0.0900.

Relationship of social emotional learning to adolescents' resilience and behavioral problems during the COVID-19 pandemic

Using the adolescents' evaluations, the Spearman correlation test using change scores between T1 and T2 was used to measure the strength of the relationships between changes in social emotional learning scores and changes in difficulty, prosocial behavior, and resilience scores. **Table 11** shows that for each country, gender, and age-group combination, changes in social emotional learning scores are negatively related to changes in difficulty scores but positively related to changes in prosocial behavior and resilience scores. Moreover, most of these relationships are significant at the 0.05 level of significance. This implies that the adolescents who had the largest reductions in their social emotional learning scores between October 2020 and May 2021 had the largest reductions in their prosocial behavior and resilience scores and had the largest increments in their internalizing and externalizing scores. On the other hand, adolescents who experienced a greater development of their social emotional learning skills also experienced a larger increase in resilience and prosocial behavior and a decrease in difficulties.

Discussion

Changes in social emotional skills, resilience, and difficulties among adolescents during the pandemic

The first aim of the current study was to explore the changes in social emotional skills, resilience, and behavioral problems among different age and gender groups of adolescents in three European countries during the COVID-19 pandemic using data from both adolescents' self-reports and their parents' reports.

Addressing changes in adolescents' *social emotional skills*, most of them did not increase, and some of them even demonstrated a decrease. It is to be expected that social emotional skills should increase following normative developmental trajectories [e.g., (4, 5)]. However, a significant decrease in adolescents' self-management skills was reported by 11-13-year-old boys and 14-16-year-old girls' parents. This finding demonstrate that the pandemic experience has raised significant obstacles to the healthy development of the adolescents, given that social emotional learning is a crucial component of their social maturity.

This can be explained by the fact that educational practices during the pandemic were affected to a large extent in many countries. It was estimated that the school routine changed rapidly, starting from the beginning of the pandemic, and did not provide the necessary support for social emotional learning. Remote learning was used as an alternative to traditional education practice but was implemented with great variety and encountered several obstacles and challenges. First, the necessity to switch to remote learning was demanding for all involved in the education process – students, teachers, and parents [e.g., (37, 69)]. Remote learning was a challenge for the self-management skills of early adolescents. At the same time, it can be assumed that certain social emotional skills received more attention (e.g., self-management and responsible decision-making) because they became salient, especially during self-guided or independent learning, and parents had more opportunities to observe them because both adolescents and parents spent more time at home. Second, during this stage of the pandemic, schools were not a supportive environment for social emotional learning. Even before the pandemic, social emotional learning was often not perceived as a routine in the education curricula, and therefore it was not perceived as a priority within other fields (e.g., mathematics) in situations when teachers were faced with increased demands and stress. Third, restrictions related to social distancing decreased interaction possibilities both at school and in extra-curricular activities, limiting necessary space for practicing relationship skills. The aforementioned could be perceived as challenging for a normative development during adolescence [e.g., (6–9)]. Even those adolescents with no previous vulnerabilities were faced with situation, when optimal course of development of their identity, healthy separation from families and skills of social communication was jeopardized. From the one side, the COVID-19 pandemic requested more strong social emotional skills to overcome challenges, but from the other side, it worked as a mitigating force against the social emotional learning.

Addressing changes in adolescents' *resilience*, no positive dynamic was observed. This can be explained by the necessity to grow through difficulties to develop resilience. By T2, there had probably not yet been sufficient time for the growth of the experience of the pandemic to reach its potential. On the contrary, resilience decreased among 14-16-year-old boys, and the decrease was more notably expressed in the Italian sample. Comparing these results with other resilience measures obtained to date, it is known that social emotional skills are

positively related to resilience [e.g., (37)]. If social emotional skills decreased between the first and second measure points of this research, then it is plausible that resilience also decreased. The decrease in adolescent boys' resilience observed in the Italy sample provides insights that negative dynamics can be observed, and research on resilience changes during pandemics should be continued.

Addressing *social, emotional, and behavioral difficulties*, it was found that both internalized and externalized difficulties showed a tendency to increase and prosocial behavior to decrease; however, none of them across the whole sample reached a level of statistical significance.

This finding does not replicate results from previous studies [e.g., (15)] but is in line with results from one previous study (31). Studies demonstrating the pandemic's effect on adolescents have mostly used clinical indicators such as depression and anxiety. It can be assumed that the SDQ measures used in this study, albeit useful for screening purposes, were not sensitive enough to estimate potential threats to the mental health of adolescents during the pandemic. For example, Bignardi and colleagues (45) found weak, non-significant changes in the SDQ emotional difficulties scale but a medium to large increase in depression (measured with the Revised Child Anxiety and Depression Scale). Another explanation could be linked to the longitudinal design and timing of the current study. Significant changes can be observed when baseline rates are compared with those observed after the short period of pandemic exposure. At the same time, the mental health indicators can be observed to fluctuate in longitudinal studies with several repeated measures over a longer period. For example, in their 12-month study, Shum and colleagues (28) observed an increase in mental health issue symptoms when restrictions were at their highest as well as a decrease when restrictions eased. In light of this finding, we can speculate that even if there was a fluctuation between T1 and T2 with the peak rates around the time of the strongest restrictions, it was followed by a decrease related to loosened restrictions in spring 2021 at the time of the T2 measure. This allows us to assume that the pandemic influenced

TABLE 9 Variances and Intraclass correlations at levels 1, 2 and 3 (Adolescent Evaluations).

Dependent Variable	Individual Level 1		School Level 2		Country Level 3	
	Variance	Intraclass correlation	Variance	Intraclass correlation	Variance	Intraclass correlation
Internalizing Difficulty	0.2562	0.9599	0.0075	0.0281	0.0032	0.0120
Externalizing Difficulty	0.2308	0.8674	0.0136	0.0511	0.0217	0.0815
Total Difficulty	0.2220	0.9254	0.0064	0.0267	0.0115	0.0479
Prosocial	0.2448	0.9241	0.0093	0.0351	0.0108	0.0408
Resilience	0.4121	0.9324	0.0153	0.0346	0.0146	0.0330
Self-Awareness	0.2968	0.9416	0.0064	0.0203	0.0120	0.0381
Self-Management	0.3393	0.9089	0.0084	0.0225	0.0256	0.0686
Social Awareness	0.4031	0.9126	0.0097	0.0220	0.0289	0.0654
Relationship Skills	0.3113	0.8894	0.0072	0.0206	0.0315	0.0900
Responsible Decision Making	0.3415	0.9232	0.0088	0.0238	0.0196	0.0530
Social Emotional Learning	0.3005	0.9530	0.0046	0.0146	0.0102	0.0324

TABLE 10 Variances and Intraclass correlations at levels 1, 2 and 3 (Parent Evaluations).

Dependent Variable	Individual Level 1		School Level 2		Country Level 3	
	Variance	Intraclass correlation	Variance	Intraclass correlation	Variance	Intraclass correlation
Internalizing Difficulty	0.2521	0.9553	0.0063	0.0239	0.0055	0.0208
Externalizing Difficulty	0.2597	0.9654	0.0042	0.0156	0.0051	0.0190
Total Difficulty	0.2487	0.9580	0.0033	0.0127	0.0076	0.0293
Prosocial	0.2349	0.9767	0.0014	0.0058	0.0042	0.0175
Self-Awareness	0.3593	0.9721	0.0024	0.0065	0.0079	0.0214
Self-Management	0.4085	0.9582	0.0052	0.0122	0.0126	0.0296
Social Awareness	0.4163	0.9581	0.0049	0.0113	0.0133	0.0306
Relationship Skills	0.3671	0.9567	0.0049	0.0128	0.0117	0.0305
Responsible Decision Making	0.3885	0.9597	0.0065	0.0161	0.0098	0.0242
Social Emotional Learning	0.2721	0.9511	0.0074	0.0258	0.0066	0.0231

TABLE 11 Correlation between changes from T1 to T2 in SSIS-SEL and changes in SDQ and CD-RISC-10.

Subscale	Age	Gender	Italy	Latvia	Portugal	Whole Group
Internalizing difficulty	11-13	Male	−0.315*	−0.147	−0.158	−0.186
		Female	−0.185	−0.271*	−0.339*	−0.273*
	14-16	Male	−0.126	−0.129	−0.130	−0.117
		Female	−0.138	−0.188	−0.355*	−0.232*
Externalizing difficulty	11-13	Male	−0.133	−0.227*	−0.287*	−0.222*
		Female	−0.196	−0.348*	−0.358*	−0.330*
	14-16	Male	−0.223	−0.518*	−0.285*	−0.344*
		Female	−0.428*	−0.285*	−0.167	−0.252*
Total difficulty	11-13	Male	−0.232*	−0.159	−0.273*	−0.207*
		Female	−0.189	−0.369*	−0.390*	−0.353*
	14-16	Male	−0.192	−0.351*	−0.267*	−0.293*
		Female	−0.364*	−0.249*	−0.318*	−0.289*
Prosocial behavior	11-13	Male	0.320*	0.407*	0.631*	0.482*
		Female	0.523*	0.554*	0.380*	0.476*
	14-16	Male	0.430*	0.320*	0.259*	0.278*
		Female	0.303*	0.377*	0.294*	0.318*
Resilience	11-13	Male	0.386*	0.270*	0.611*	0.464*
		Female	0.463*	0.273*	0.306*	0.372*
	14-16	Male	0.442*	0.228*	0.293*	0.342*
		Female	0.466*	0.239*	0.396*	0.374*

*$p < 0.05$.

certain vulnerable groups who experienced rapid damage to their mental health (also observed by an increased need for psychiatric care) and had an immediate effect on them, but there is also the issue of adaptation.

The multilevel models demonstrate that the individual level-1 variance explains more than 90% of the total variation in the data, which implies that changes in adolescents' social emotional learning, prosocial behavior, difficulties and resilience varied more between individuals than between schools and countries. No age or gender group was more affected than the others when considering changes during the pandemic in social emotional learning, resilience, and internalized and externalized difficulties. However, average non-significant changes over the whole sample and contradictory findings within different age and gender groups cover huge individual differences and variety, assuming that specific groups could be considered as more vulnerable when facing pandemic-related difficulties. At the same time, several significant changes were observed in certain age and gender groups when data were analyzed at a country level, and most of the significant changes were observed in the Italian sample. This highlights the necessity to analyze environmental factors to explain the country-level differences, considering that the epidemiological situation was different in Italy, Latvia, and Portugal during this period of the pandemic, as were the restriction policies and adaptation of the learning environment.

Italy

Italy was characterized by the most intense pandemic experience compared to Portugal and Latvia. It was exposed to the pandemic intensively from the beginning of 2020 and entered this study with higher prevalence and cumulative death rates, characterizing prolonged exposure to the stress of the global pandemic.

There were more significant changes in Italy compared with other countries considering social emotional learning, resilience, and behavioral difficulties and more diverse results. For instance, resilience was only reported as having decreased by adolescents. However, if we consider the total Italian scores for social emotional skills and prosocial behavior in both informant reports, the scores have mostly the same trend, which is a decrease; emotional and behavioral difficulties tended, instead, to increase, as found in previous studies (1, 13, 15, 40). It could be explained that because social emotional learning decreased, resilience decreased as well due to their strong and positive association [e.g., (37)], and total difficulties increased in turn. Students were exposed to prolonged social isolation and intense negative feelings and experiences, which may explain lower scores in social emotional learning and resilience at T2. The result that prosocial behaviors decreased emphasizes the actual situation during the pandemic when adolescents did not have many opportunities to demonstrate their prosocial skills. Indeed, students in the 11-16-year-old age range were heavily penalized during the pandemic as

restrictions were strict for them across the whole school year. Italian adolescents used to go out with friends, do group sports activities, and have many social opportunities to be with peers. Prolonged distance learning, social distancing, and the closure of many leisure/sports centers represented a loss of opportunities to meet peers, which may have been detrimental to the development and practice of both social emotional skills and prosocial behavior.

Latvia

There were low prevalence and cumulative death rates in Latvia at the beginning of this study in October 2020. However, there had been a rapid increase in both prevalence and mortality rates by May 2021, demonstrating growing and consistently high exposure to the stress of the pandemic and epidemiological measures. During the current study, most participants experienced a period of remote learning (from 4 to 7 months). Remote learning was characterized by an increased proportion of independent tasks, a decreased number of topics, and a great variety of interaction opportunities, and it was evaluated by parents in Latvia as a significant source of stress (69, 70).

Differences found in the Latvian sample were gender asymmetric, and all significant changes observed were exclusively among girls. This is in line with findings from other studies (2, 14, 16) indicating that girls are more affected by the adverse experience of the pandemic. An explanation for this could be related to environmental factors. There is evidence that the educational environment in Latvia was more supportive for girls than boys, including important gender disparities in terms of the level of attainment up to tertiary education (71). It can be assumed that rapid changes in educational routine probably affected girls to a larger extent than boys. Another possible explanation is related to available resources. Extracurricular activities have been recognized as a significant resource for the development and well-being of adolescents (72); however, the observed effect is stronger for boys. During the period of restrictions during the pandemic, outdoor group sports activities were allowed in Latvia, but art, dance, and music classes (taking place indoors) were eliminated. Traditionally, more boys are involved in sports activities than girls, resulting in gender asymmetry in available resources for successful coping mechanisms and healthy development (communications, support, and physical activity). This could be assumed as one possible explanation for gender differences in changes observed during the pandemic in the Latvian sample. Nevertheless, the protective role of extra-curricular activities especially for boys would be as a direction for further research.

A significant protective factor that could be assumed in the Latvian sample is related to the availability of outdoor space, as most of the adolescents involved in the study live in small towns or in the countryside where there is a low population density. Outdoor leisure activities such as cycling, walking, hiking, and gardening were available to them, providing a valuable resource for maintaining physical and mental well-being (73). However, these activities are more characteristic for boys than girls.

Portugal

Portugal was characterized by a moderately high exposure to the pandemic at the beginning of the study in October 2020 and by a rapid increase and then a significant decrease in its prevalence, albeit with high death rates.

As far as the results obtained in the Portuguese sample are concerned, it can be assumed that most adolescents were able to maintain their social and emotional competencies through the pandemic, as mentioned in other studies (2, 74). Such results may also be related to protective factors related to the various school measures adopted in Portugal, which allowed more flexible and less distracting learning arrangements and self-paced and independent learning models, enabling the development of individual agency, self-advocacy, and time-management skills (75).

Despite this, the results show a worsening of social emotional learning among younger boys, which can be explained by an increased vulnerability of boys that is related to the later development of such competencies in boys compared with girls (76).

In sum, these results are in line with previous findings. A systematic review (2) reported that 93% of children could cope with lockdown measures. However, it also highlighted the need to recognize protective factors and resources.

The protective role of social emotional learning

The second aim of our study was to explore the relationship between social emotional learning and adolescents' resilience and behavioral problems during the COVID-19 pandemic.

Results both across the whole sample and at a country level demonstrate a clear pattern – changes in social emotional learning were related to changes in internalized and externalized difficulties. That means that those adolescents who experienced a larger increase in social emotional learning were better protected from the possible adverse effects of pandemic-related stress and vice versa – those students who had not succeeded in acquiring social emotional skills were faced with larger threats to their mental health and resilience development. Correlation coefficients ranged from weak to moderate, demonstrating that such skills as self-management, self-awareness, empathy, relationship skills, and responsible decision-making play a protective role when facing a global source of stress at an adolescent age.

This finding contributes to previous evidence supporting the protective and resource role of social emotional learning on the resilience of adolescents (37) and academic outcomes, even at a preschool level (77).

Our findings are in line with those observed in a study in Finland (31), where it was found that the majority of adolescents demonstrated no changes in social emotional skills; however, those who experienced growth also reported more stable or even increased academic well-being (in terms of engagement and chance of burnout).

The current study demonstrates the necessity to pay special attention to social emotional learning in the context of the global stress of the pandemic, as it has a protective role against emotional and behavioral difficulties and a promotional effect on resilience development. The "Promoting mental health at schools" (PROMEHS) program, including a ready-to-use activity plans for children and adolescents, fostering their social emotional learning and resilience, and mitigating development of behavioral problems, was designed to be provided in existing contexts without a pandemic. However, it proved to be a protective factor for both students and their teachers during the time of the COVID-19 pandemic (78, 79), thus contributing to the protection of mental health during this extreme situation.

Conclusions and Implications

It can be concluded that, in the general sample, we observed minor changes in adolescents' social emotional learning and resilience and no significant changes in their internalized and externalized difficulties. At the same time, it can be concluded that, in specific age and gender groups, there are significant differences, demonstrating the large variability of the pandemic's effect and the need for an individualized perspective emphasizing age and gender differences. This study provides evidence that prolonged intensive exposure to the pandemic can have a more significant effect on adolescents' mental health than in case of a less prolonged or intensive experience of the pandemic. Our findings confirm the protective role of social emotional learning, even in the context of the global stress related to the COVID-19 pandemic. Some contradictory results demonstrate the huge individual differences and diversity involved when adapting to pandemic-related stress and restrictions.

The practical implications emphasize the necessity to recognize individuals and groups for whom social emotional learning is difficult and to make an effort to strengthen them through training and support. Another practical implication is related to schools – social emotional learning should be prioritized during times of adversity and when considering limitations of resources.

Strengths and limitations

This study emphasizes the significance of longitudinal, multi-informant, cross-country research on the dynamic of adolescent social emotional learning, resilience, and behavioral problems during the COVID-19 pandemic. The three countries involved in the study experienced different dynamics during the pandemic and different epidemiological situations at the beginning of the study. However, the situation was comparable in terms of the restrictions and learning routines implemented in each country, providing solid ground for cross-country comparisons.

The limitations of the study are related to the reliability of the self-report form of SDQ and SSIS-SEL. However, reliability estimates in the current study are comparable with those obtained in previous research. Another limitation may be associated with the selection of the sample, which was based on convenience sampling; however, the recruitment strategy was population-based, although the initial response rate was high (e.g., 95% in Latvia), the rate of excluded cases, where only one informant (either the adolescent or the parent) answered the questionnaire, was considerable in all participant countries.

In this study, variables such as presence of a family conflict or availability of social support, known as having impact on emotional development and behavioral difficulties of adolescents were not measured. These aspect must be considered when drawing conclusions about consequences of the pandemic on adolescents' 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 the Ethics Committee for Humanities and Social Sciences Research Involving Human Participants of the University of Latvia. The Ethics Committee of the Environmental Health Institute at the University of Lisbon. The Ethical Committee of the University of Milano-Bicocca. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

BM: lead writer, arranging the research in Latvia, and collecting data. ISt: contributing to writing. ID and IS: arranging the research in Latvia and collecting data. CS: arranging the research in Portugal and contributing to writing. EC: a key

contribution in arranging the research in Italy, collecting data, and writing and revising the manuscript. VC: contributing to designing the research, arranging the research in Italy, and collecting data. AA and SG: arranging the research in Italy and collecting data. IG and VO: a key contribution to designing the research and revising the manuscript. LC: data analyses, contributing to writing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Activity system, schizotypal personality, and mentalization: A study between halted activity and COVID-19 conducted in Henan, China

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The pandemic-related lifestyle has potentially imposed crucial disturbances on daily and long-term activities, which, in turn, were associated with thought disturbance. This study investigates how the characteristics of the activity system during pandemic-related restrictions are associated with other psychomental aspects. By focusing on PTSD, mentalization, and schizotypal personality, and by inquiring about the main components of the activity system of 852 college students (Zhengzhou, Henan, China)- including the goals orienting their activity, goals' terms and types, the motivation levels and sources, the activity type and engagement time, the flow of the activity, and how due to pandemic lifestyle-results revealed that the activity system's components have significant associations with PTSD, reflective function, and schizotypal traits. Additionally, some of the activity system's elements have a significant predictive role regarding schizotypal traits. The study considered that the life narrative during the pandemic has been disturbed; hence, this may have a crucial effect on mind coherence. Additionally, the outcomes from the pandemic context will support mental health interventions in other similar contexts where the life narrative is severely affected.

KEYWORDS

COVID-19, pandemic lifestyle, schizotypy, mentalization, stress, activity system, life narrative disturbance

Introduction

Although statistics are not accurate due to low social engagement in surveys, reportedly only 40% of the member states in the World Health Organization (WHO) have compiled mental health data in their general health statistics. Of this percentage, approximately 800 million people are living with mental health disorders, which showed an increase of up to 250% between 1990 and 2017. Schizophrenia affects approximately 20 million people worldwide, with an increase of 166% from 12 million in 1990 (1–6). Furthermore, as in any emergency and other infectious diseases outbreaks, COVID-19

as a global pandemic imposed crucial changes on our lifestyle, including fears, worry, experiencing loss of own and other lives, separation from beloved relatives, being isolated and quarantined, loss of employment and income, haltering daily activity, social stigma, discrimination of infected individuals, and uncertainty about the future; hence, reducing mental health stability, and leading to stress, depression, anxiety, distress, coping strategies, and insomnia (7–11).

As in previous outbreaks (e.g., 2003-SARS), and along with the economic crisis outcomes since 2008 (e.g., unemployment, social, and political disturbances), several studies have investigated influencing factors such as demographic information, living area, having relatives or acquaintances diagnosed with COVID-19, the amount of exposure and the access to accurate COVID-19 information from media and other resources, social support, prior mental health problem, educational status. It is found that people in quarantine might face anger, loneliness, boredom, and various psychiatric morbidities, including psychomotor excitement, panic attacks, delirium, psychotic symptoms, and suicidality [see, e.g., (7, 10, 12–17)].

Furthermore, investigating the severe forms of the pandemic's outcomes is crucial for developing suitable intervention tools, by promoting and implementing mental health and psychological assessment, counseling, support, and treatment through multidisciplinary mental health policies, e.g., psychiatric teams, clinical psychologists, hotlines, and online platforms, especially that till now, countries like China are still experiencing COVID-19-related lifestyle, including restrictions, social distancing, testing, and reporting to designated authorities, is ongoing for around 3 years (7, 10).

The causal origins of schizophrenia as a severe outcome are still under ongoing debate. For mainstream currents, it is the interaction among genetics-environmental factors (5). Also, the different explanations of schizophrenia do not reflect a continuum in the research context, and parallelism is noticed (12). Some focus on biochemical factors such as the genetic level and the disturbance of the brain's chemistry and liaison, and support pharmacology and antipsychotics (18, 19), despite "less definite" genetic components proved (20), and the indefinite or negative effect of antipsychotics on the quality of life (21–23). Although they do not have consistent effects on overall social functioning and pervasive positive and negative symptoms, others focus on familial intervention, psychoanalysis, cognitive remediation, and cognitive-behavioral therapy (22, 24). However, social intervention through social integration and employment, and reducing discrimination and stigma, showed significant results (24–26). Overall, addressing the causal explanation of psychosis and schizophrenia is still problematic, related more to the after-diagnosis, and is only partly dedicated to preventive purposes.

Therefore, early detection is required. Developing schizophrenia is considered to be harbored in a latent personality organization conceptualized through the term "Schizotypy" as a construct reflected in a sub-clinical mental and behavioral state, manifesting itself through several phenotypic levels, such as the liability of schizotypal personality (27, 28). Although Schizotypy is still lacking a unified definition in literature, it helps to link a broad continuum of clinical and non-clinical manifestations to form a predictive factor of the probability of converging into psychosis (29–34).

Schizotypal personality disorder (SPD) involves cognitive, perceptual, and social affective processing distortions and impairment, and neural abnormalities and includes three dimensions: positive (e.g., delusions, hallucinations, paranoia, and magical beliefs), negative (anhedonia, alogia, affective flattening, avolition, and social withdrawal), and disorganization dimensions (eccentric behavior and odd thoughts) (33, 35–38). The three dimensions show stability across cultures (39).

Schizotypy, as well as psychopathy, psychosis, and borderline personality disorder, are associated with other factors, such as impaired mentalization [the reflective function (RF)] (40–44). "The mentalizing difficulties may constitute an important clinical assessment and early prevention treatment targets in adolescents who demonstrate schizotypal features" (45).

Additionally, mental impairment, emotional and behavioral changes, and a higher rate of chronic disease are associated with the traumatic life event and post-traumatic stress disorder (PTSD) (46–49). Regarding the COVID-19 outbreak, as a traumatic life event, including the long-home stay and quarantine, numerous severe disorders are reported like the fear of death (self and beloved), stigma, isolation, anxiety, insomnia, feelings of helplessness, the severe alteration of lifestyle and daily activity such as the absence of physical exercise and limitation or no recreational and occupational activities (14, 50–61). People who worked from home reported positive feelings (50, 62). People (including patients) able to work and perform occupational, productive, and structured activities in general (e.g., household chores, recreational activities, and physical exercise), especially during quarantine, are associated with lowering the levels of anxiety, depression, stress, and other disorders (14–16, 26, 63–69). The "activity level in individuals at risk of schizophrenia is extremely important from a preventive point of view" (69). Therefore, the goal-directed structured activity and motivation, in interaction with culture and personality, are crucial for executive function, self-regulation, and quality of life, all of which are factors that face impairment and deterioration in schizophrenia (70–75). In general terms, it is hypothesized that adolescents' mental health maybe is linked to the changes in the patterns of time usage in the last 20 years (76).

Furthermore, Cultural-historical activity theory (CHAT) "emphasizes the constant flow of activity as the source of mind and self" [(77), p. 484]. The activity is a *molar,* and its internalization forms the Dynamic

System of Meaning (DSM) as a structure of the mind, where experience is synthesized, including action, desires, needs, goals, sensory inputs, and emotions. DSM mediates the interaction with the environment—from straightforward motor action to higher mental functions (71, 72, 78).

Thus, investigating the activity system, including goals, motivation, and the actual activity, is essential for this study.

Materials and methods

Following China's COVID-19 Zero-Tolerance policy (the Zero-cases policy in China about COVID-19), which includes a range of measures, from partial to complete lockdown, including house/residence and medical centers quarantines, the study was conducted between the 10th of November 2021 and the 29th of March, 2022. During that period, Zhengzhou, the capital city of Henan province, where our study was conducted, was coming out from the flood that hit the city in July 2021. Due to the flood, more than 376 thousand people were relocated, and the daily life of millions was directly affected after the flood in terms of transportation, residency, workplaces, and food and water safety. In addition to the flood, Zhengzhou witnessed another COVID-19 outbreak resulting in a lockdown between July and August. Furthermore, in the course of data collection, the city (including Henan province) faced another outbreak in January 2022, leading to an increase in lockdown and medical testing conditions, imposing further travel bans and restrictions on citizens' movement and travelers' quarantine. Within the same period (January and February), China celebrated the Lunar new year (Spring Festival holidays), which is a time in which most students (who form the target of the current study) moved back to their hometowns in the province, further increasing public anxiety (7).

This study investigates the relationships between schizotypal traits, mentalization, stress, and the activity system (including goals and motivation) during the pandemic-related lifestyle.

It is hypothesized that mentalization, PTSD, the activity system's components, and schizotypy are associated. Individuals with an optimal level of mentalization, the existence of activities goals, and higher motivation will present a lower range of schizotypal traits, regardless of the level of post-traumatic stress.

Following this reasoning and, to grasp the complexity of the variables, a mixed-method is used, including open-ended questions to inquire about some of the activity system variables (e.g., activity flow, goals) and questionnaires regarding other variables (Schizotypal personality, mentalization, stress, and motivation). Moreover, focusing on a specific group of participants would be suitable for generating an in-depth understanding of the phenomenon (see the section below).

Participants

Our participants are college students currently enrolled in Zhengzhou Normal University (ZZNU), Henan, China. Previous studies have noted that college students showed considerable mental health impact during the pandemic. For instance, a study by Ma et al. (54) on a large sample of college students (746,217 participants) from 180 Chinese colleges revealed that about 45% of the participants had mental health problems, including acute stress, depression, and anxiety symptoms. Another longitudinal study by Wang et al. (16) showed that the respondents in the age group from 12 to 21 years old in the second survey had a higher psychological impact than in the first survey due to prolonged lockdown because this group is comprised of students "who were affected by prolonged school closure, requiring online education support, and uncertainty about examinations and matriculation arrangements" and young students were identified as a target group "prone for the psychological impact of the current COVID-19 outbreak" [(16), p. 47]. Additionally, Wang et al. (15) noted that being a student is significantly associated with higher levels of depression, anxiety, stress, and psychological impact due to the outbreak. Other studies also noted that the psychological consequences of the COVID-19 epidemic on Chinese college students could be severe, including PTSD, stress, anxiety, and depression (79–81). Overall, adolescents may experience increased psychiatric disorders resulting from the COVID-19 pandemic, and they may be less tolerant to lockdowns (53, 82).

By targeting college students, this study goes along with the National and Henan province multiple policies to address mental health and develop a monitoring system for adolescents. This study is part of the "Ministry of Science and Technology of the People's Republic of China, National Foreign Expert Program 'One Belt One Road' Innovative Talent Team regarding the development and application of intelligent monitoring and early warning system for adolescents psychological crisis."

A total of 909 college students participated in the study. All the students were invited to voluntarily participate in the survey through the platform named *Wenjuanxing via Wechat* (the Chinese communication application) and using internet browsers. Participants were asked to read the instructions about the purpose and methods to fill out the questionnaire carefully. Participants were also informed that the survey was anonymous. Twenty-three students (2.5%) refused to participate in the study. Another 34 (3.7%) were excluded due to missing data or completing the questionnaires in a short time of fewer than 3 min (taking into consideration that the mean of total time spent on the

questionnaires was 10 min), leaving 852 (93.7%) included in the analysis.

The sample size was derived, on one hand, following the feasibility in time limitation and accessibility in collecting the data that fulfill the measurement of the study's variables (related to the effect of quarantine and pandemic life conditions). In order not to take a long time to measure the variables after the outbreaks' period (the first one was in July–August 2021, and the second outbreak was in January 2022), and to stay within the period of winter vacation when the "allocation" of students-related conditions (traveling chance and requirements) take place between the University and their home-towns, the collection of data needed to be completed (in late March) so that the whole sample belong relatively to the same context.

On the other hand, from a statistical position, our sample size exceeds the required minimum sample size for three types of tests we are going to conduct in this study (Pearson correlation, One-way Anova, and multiple linear regression). Using the G*Power program (Version 3.1.9.6), for multiple linear regression, the required minimum sample size is 226, with a low effect size (0.15), confidence level [error probability (α)] is equal to 0.5, the power is equal to 0.80, and for 20 predictors. Also, for One-way Anova, the required minimum sample size is 266 with an effect size equal to 0.2294 (determined by G*Power) and confidence level is 0.05 and the power is equal to 0.80 when comparing 7 groups (that is the highest number of groups for one of our variables, i.e., the "Marital status" variable). In addition, for Pearson's correlation test, the required minimum sample size is 82, for medium effect size (0.3), the confidence level [error probability (α)] is equal to 0.05, and the power of 0.80.

Furthermore, our sample exceeds the sample size that satisfies the rule of thumb of 10 samples per every measurement variable suggested by Hair et al. (83). Since we have 21 main variables to be investigated, we need at least 210 participants (our samples exceeded that number). Furthermore, the population of ZZNU is around 16,500 students, and following the *Simple and random sampling scheme*, our sample exceeds the statistical *ideal* sample size, in this case, is around 376 participants for a confidence level of 95% and confidence interval (±) 5% (84). Also, our sample size exceeds the desired sample size for correlational (82 participants) and causal (64 participants) designs, as well as for interview-based studies averaged of 104 participants (raging from 2–720 interviewees) (85, 86).

In addition, in line with existing research, our sample size exceeds previous studies' sample sizes. For instance, the sample size in a study by Lincoln et al. (87) to measure the MMS in a non-clinical sample was 76 participants, and 575 participants from workers and students of one university in a study by Kemp et al. (88). Also, our study's sample exceeds the sample size (105 participants) in a study by Salaminios et al. (45) investigating the association between schizotypal personality features and mentalization and exceeds the sample size of another study (89) investigating psychological wellbeing of hospital medical staff (668 participants).

Tools

Schizoptypal personality

Measuring the Schizotypal symptoms in non-clinical samples can be done through several psychometric tools, using self-report surveys/questionnaires as the most common in the field, such as the Schizotypal Traits Questionnaire (STQ), Wisconsin Schizotypy Scales (WSS), Schizotypal Traits Scale (STA), Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE), Schizotypal Personality Questionnaire (SPQ), and Schizotypal Ambivalence Scale (SAS), among others (90). However, this study will employ the Multidimensional Schizotypy Scale-Brief (MSS-B) (91) as a brief version of MSS that measures the three directions (sub-scales) of Schizotypy: Positive, Negative, and Disorganized (92). The brief version (MSS-B) adopts 38 items from the 77 items forming the original scale. MSS-B showed valid psychometric properties, and the three analogous subscales of the MSS and MSS-B tap comparable constructs demonstrated by Kemp et al. (93), with high concordance across separate testings. In addition, MSS-B has a good construct of validity (94). Furthermore, studies revealed that MSS is valid in the Chinese context (Positive Schizotypy dimension's Cronbach's $\alpha = 0.892$, Negative Schizotypy dimension's Cronbach's $\alpha = 0.778$, and Disorganized Schizotypy dimension's Cronbach's $\alpha = 0.896$) [e.g., see (34, 38)].

For this study, the Chinese version was obtained from Professor Kwapil after personal communication *via* email.

Mentalization

Although there are several instruments for assessing mentalizing (95), few instruments have been developed with the goal of employment in quantitative large-scale studies (96). This study will adopt the Reflective Function Questionnaire (RFQ). RFQ is a 46-item self-report measure (41), that has been adapted to measure the reflective function of adolescents and young through the Reflective Function Questionnaire for Youth (RFQY) (44). Moreover, both RFQ and RFQY's Chinese versions showed good reliability and validity in the Chinese context (Cronbach's $\alpha = 0.747$) (97, 98).

Stress

Post-Traumatic Stress will be measured by the Impact Event Scale-Revised (IES-R) (99). IES-R was originally developed by Horowitz et al. (100) and further developed by Weiss (101) to assess intrusive experience and avoidant behavior as an aspect of post-traumatic stress disorder. IES-R is comprised of 22 items forming three subscales: intrusion (8 items), Avoidance

(8 items), and Hyperarousal (6 items). IES-R has convergent validity with diagnosed PTSD (102) and sound psychometric properties (101). Also, the Chinese version of IES-R (CIES-R) has shown valid and satisfactory psychometric properties in the Chinese context [Intrusion (Cronbach's $\alpha = 0.89$), Avoidance (Cronbach's $\alpha = 0.85$), and Hyperarousal (Cronbach's $\alpha = 0.83$)] (103, 104). Furthermore, IES-R has been used in numerous studies to measure the psychological impact of COVID-19-related experiences [e.g., (15, 16, 54, 59, 60, 68, 105, 106)].

Activity systems components

As noted earlier, the activity system highly depends on the goal of the activity, the motivation, and the flow of the activity. Personal activities, goals, and motivation are measured through self-report questions (structured, open, and close-ended).

Activity type

The questions regarding the type of activity in which the participants engaged were based on the Time Use Survey (TUS) regarding the time use and activities (107)—a Shortened version of TUS employed in Hodgekins et al. (65)—and the Quarantine activity checklist (68). Participants were asked to define what activities they are into and the daily scale in which they practiced each activity (hours per day).

Furthermore, separate questions were introduced to inquire about participants' engagement in the jobs. It is another factor to define how much an individual is engaged in social life and attached to a structured activity. The questions ask whether the participants are working during their study, the type of work (a full/part-time job), their position (self-employed or salaried employee), and the last time they worked.

Activity flow

As described earlier in the introduction, the activity flow is considered crucial for mental consistency. Therefore, participants had to describe how the COVID-19 situation affected their activities.

Goals and motivation

Regarding *goals*, the participants were asked whether they have any goals that direct their life and the type of these goals. The goals were described in answers to open questions. Later in the analysis of the answers (see Table 1), we will observe different categories of goals, including short term, long term, tangible and abstract goals. Regarding *motivation*, the participants were asked to state the motivation level (8 levels ranging from *None* to *High*) and describe the type of motivation through four states (intrinsic, identified regulation, extrinsic, and amotivated). Four themes are used to represent these four states: to *have fun* and *feel comfortable* (intrinsic). To have *great interest to me* (for identified regulation). *I have no choice* (for extrinsic), and *No motivation and no good reason to pursue it* (for amotivated) (see Table 1). The questions about motivation were formulated following the Situational Motivation Scale (SIMS) (108).

TABLE 1 Goal existence, type, and term.

Variable	**($n = 852$)**	**%**
Goal exists		
Yes	573	67.3
No	279	32.7
Goal term	**($n = 564$)**	**%**
Short	6	1.06
Medium	292	51.77
Long	266	47.16
Goal type	**($n = 564$)**	**%**
Abstract	124	21.99
Tangible	440	78.01
Motivation level	**(n=573)**	**%**
1	1	0.17
2	6	1.04
3	40	6.98
4	102	17.71
5	190	33.16
6	104	18.15
7	130	22.69
Motivation source	**($n = 573$)**	**%**
Intrinsic (It's fun and makes me feel comfortable)	173	30.19
Identified regulation (It can be of great benefit to me)	354	61.78
Extrinsic (I have no choice; this is what I should do)	33	5.76
Amotivated (Although I have this purpose in life, I have no motivation and see no good reason to pursue it)	13	2.27

Statistical analysis

Types of collected data (quantitative/qualitative)

Two types of data were collected: Quantitative data and qualitative data, collected through demographic questions (gender, age, whether the participant is the only child in the family, education, home town, marital status, having children, number of children) MMS-B, RFQY, IES-R, the questions about motivation level and source, activities that the participants are

part in, time spent on activities, the existence of goals, is the activity affected by the pandemic, are the participants working or not, the type/position of their job, and the time since they left their job (how many years), are all quantitative. Regarding the activities the participants are part of, eleven activities were included in the survey. In addition, the participants were required to answer about their engagement in these activities. The eleven activities are (1) Research, (2) Sports, (3) Online gaming, (4) Taking care of family and/or children, (5) Volunteering, (6) Reading, and (7) Music and art events, (8) Shopping, (9) Housework, (10) Handicraft, and (11) Other.

However, the data obtained from the questions regarding how the pandemic affected the activities, and the types of goals are qualitative.

Interpreting and analyzing qualitative data

Regarding the quantification of qualitative answers, the answers were organized under general themes and then coded for data manipulation.

Regarding the question about *how the pandemic affected the activity*, the participants' answers were organized under nine general themes (coded from 1 to 9): (1) shopping (when the participants explicitly declare that their shopping habits are affected either by the decrease of the outdoor shopping or the increase of the online shopping), (2) the activity in general decreased, (3) causing the participants to feel upset (when the participants expressed a feeling and a position toward the changes in their activity such as the loss of motivation, the influence on life, a bad mood, the inconveniency of the situation and the feeling of decrease in freedom), (4) the inability to go out and travel, (5) doing sports is affected, (6) the total halt of activity, (7) the education is affected, (8) more time spent on some aspects like playing online games, reading, and listening to music, (9) and the final theme is the effect on financial status (since part-time jobs were stopped).

Regarding the quantification of goals type (abstract and tangible), the answers that hold the aspects of social contributions and moral values (e.g., becoming a good/excellent teacher, taking care, and supporting their own family and friends), self-development (e.g., when participants declare that the graduation has a great impact on him/her; the goal to increase knowledge; to live a happy life; changing lifestyle), and other goals related to art, music, and becoming a writer/novelist, are considered as *abstract goals*. However, the goals directed toward direct desires such as educational (e.g., pass the exam, which formed the majority of the answers; learn English), financial (earn more money), career (find a job; to note here that we differentiated between the desire to have a job and the desire to become a good teacher since the first does not hold an explicit moral aspect), ownership and consumption (buying fancy cars and houses), and fitness-related (lose weight and perform the physical activity).

For the goal term, as noted earlier, we came to classify the answers according to three themes and coded them as such [(1) short, (2) medium, and (3) long terms]. The short-term goals were mainly based on answers such as: to study, or to study well, and to attend the classes, which refer to an ongoing process with a lack of futuristic tendency. However, taking into consideration them being college students, the participants' goals to graduate/pass the exam and other studies-related are classified as medium-term, while the goals to find a job or to reach certain achievements (publish a novel, contribute to teaching carrier, support the family, earning considerable money, and buying houses and cars, to move to other cities) are considered as long-term goals.

Regarding the *credibility* and *reliability* of the collected data, since the data were collected online, the responses are the participants' own words, so neither a moderator nor the researchers themselves engaged in recording or writing the responses. The collected answers are in the voice of the participants, so the researchers' *bias* is not affecting the obtained data and their *neutrality* is supported. In addition, two sorts of triangulations are used. First, is it data triangulation in terms of time is used to ensure multiple sources of data. The data were collected in two phases, the first was between the first of November and December 2021, and the second was March 2022. The second is the investigators' triangulation. For the coding and categorization of answers, multiple researchers have triangulated their classifications of answer themes.

To support the coding of the answers, previous resources are followed. For instance, regarding the classification of goals types (tangible/concrete and abstract) and range (short, medium, long), in the framework of control theory, Emmons (109) investigated the level of generality of personal goals in relation to mental illness and wellbeing, and they proposed two extremes. First are the broad goals. Here a person is called high-level strivers (their projects are more meaningful), and the implication/purpose of the goal is important, e.g., trying to make others happy, increase my knowledge, and be fun (in our case, we obtained answers such as *to improve myself*; see Table 2). The second extreme is the superficial one. Here a person is called *a low-level striver* (their project is molecular), and the way the actions are carried out is more important, e.g., looking physically fit, and buying new luggage (in our case, we obtained answers such as *buying houses/cars*; see Table 2). The collected data are represented in tables and analyzed with statistical tests, being as comprehensive and inclusive with quantitative aspects, as another factor of the study's *reliability*.

As another factor in evaluating *credibility*, *familiarity* with the context is ensured because some of this study researchers are natives and belong to the setting where the study was conducted while others (who are not natives) had been living in China, and in the city of Zhengzhou for several years. Therefore, they are familiar with the conditions and cultural tendencies surrounding the study, as well as the changes in these conditions

TABLE 2 Goals type and range examples.

Goal' type and range	Participants' answers
1. Tangible (Short-term)	Study
2. Tangible (Short-term)	To attend the classes
3. Tangible (Medium-term)	Postgraduate entrance examination
4. Tangible (Medium-term)	To find a job
5. Tangible (Medium-term)	To graduate
6. Tangible (Medium-term)	To pass English language tests (IELTS)
7. Tangible (Medium-term)	Lose weight
8. Tangible (long-term)	Travel
9. Tangible (long term)	Make Money
10. Tangible (long term)	To settle in a big city
11. Tangible (long term)	Buy a house
12. Tangible (long term)	Buy a fancy car
13. Abstract (Medium-term)	Read a few books to improve yourself
14. Abstract (Long-term)	Enrich my self
15. Abstract (Long-term)	To share responsibilities with the family
16. Abstract (Long-term)	Become a person with developed morality and intelligence
17. Abstract (Long-term)	To engage in music
18. Abstract (Long-term)	To be an excellent teacher
19. Abstract (Long-term)	Improve my life quality
20. Abstract (Long-term)	To reach financial independence
21. Abstract (Long-term)	To write my own novel

in the recent period. Being grounded in the set brings the researchers closer to the study's setting, hence, it reduces the level of preconceptions and misassumptions and increases their reflexivity. Therefore, *reflexivity*, in addition to the description of the context (regarding the *transferability* of the study) in the introduction of this section (*Materials and tools*) and reporting the sampling method, along with *credibility*, are other factors of *validity* and trustworthiness of the study [e.g., see, (110, 111)].

Types of variables (numerical/categorical)

Regarding the studies' variables, the MMS-B (for measuring Schizotypal personality) (higher score on each subscale means a higher level of Schizotypy), RFQY (for measuring mentalization, when a higher score means higher mentalization level), and IES-R (for measuring stress, where a higher score means higher PTSD, with the cutoff is equal to 24 so the participant's PTSD level is a clinical concern), provide a total score, so when conducting tests they all represent numerical data. Also, the age, whether the participant is the only child in the family, marital status, number of children, the duration of leaving work (in years), time spent on each activity (hours per day), and the level of motivation (ranges from 0 to 7) both represent the numerical type of data.

However, some demographic data (gender, education, whether the participant is the only child in the family, home town, marital status, having children) the existence of goals (yes/no), goal types (abstract/tangible; and short, medium, or long term), motivation source (intrinsic, identified regulation, extrinsic, amotivated), whether the activity is affected by the pandemic-related life conditions (yes/no), whether the participant worked or working (yes/no), the type of their job (full- time or part-time) and their job position (self-employed or salaried employee), are all categorical data. All categorical data will be coded numerically to be investigated.

Statistical tests

Using SPSS-IBM (22.0), correlation and regression tests were conducted to investigate the relationships among variables.

Pearson correlation (Two-tailed) is used to investigate the associations between continuous variables (e.g., PTSD, mentalization, Schizotypy, activities' total time, Motivation level), while the One-Way ANOVA test (with Tukey's *post-hoc* test and a significance level of 0.05) is used to investigate the differences among numerical and categorical variables, and two, among categorical variables. The dependent variables are the Schizotypal dimensions, PTSD, and reflective function, and the independent variables are the demographic variables, and the activity system's variables (goals, motivation, activity time, and activity type).

Moreover, Multiple linear regression (with a 95% confidence percentage) was used to investigate predictive relationships among variables. The dependent variables are Positive Schizotypy, Negative Schizotypy, and Disorganized Schizotypy, while the independent variables (predictors) for each one of the dependent variables is: the demographic variables (e.g., gender, age, being the only child in the family, education level), PTSD, reflective function level, and activity system-related variables (e.g., goals, motivation, activity time, and activity type).

Results

Descriptive statistics

Demographic

Demographic characteristics of the sample were: Mage = 20.06 years, SD = 1.45, range 18–28 years. The participants' age satisfies the conditions of RFQY and MMS. RFQY targets both adolescents and young (44), and MMS-B targets a sample between 18 and 60 years old (91). Ninety-one percent (91%) were female.

Regarding the gender imbalance in the sample, commonly, the majority of the Normal Universities students in China are females. In our case, the male/female ratio in the population of ZZNU is 1:8 (87.5% are females), which is nearly similar to the percentage in our sample. Therefore, the original skewness

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TABLE 3 Demographic characteristics of participants.

	Mean	%	SD	Range
Age	20.06		1.45	18–28
	N		**%**	
Gender				
Female	775	91	91	
Male	77	9	9	
Marital Status				
Single	639		75	
Married	1		0.1	
Widow	1		0.1	
In a relationship	196		23	
Other	15		1.8	
Number of children				
One	125		14.7	
More	727		85.3	
Hometown	***N***		**SD**	
City	202		23.7	
Town	154		18.4	
Countryside	496		58.2	
Education				
Bellow Junior college	2		0.2	
Junior college	123		14.4	
Undergraduate	724		85	
Master's	2		0.2	
Ph.D.	1		0.1	

is in the population. In the case of an imbalanced sample, it is important to check whether the sample is representative, and what is more important is to compute the power of interaction [e.g., see, (112)]. Therefore, by conducting a *post-hoc* test, with G*Power, to calculate the power of gender interaction (with other variables) for ANOVA (our sample size represented power of 0.7 when the effect size is 0.252, the level of confidence is 0.05, and the number of groups is 835 (the number of groups is the multiplication of the number of levels forming the independent variables that gender may interact with, e.g. the one *child* variable has 2 levels, *education* has 5 levels, *the home town* has 2, *goal range* has 2, *goal type* has 3, *motivation source* has 4) and the numerator is 35 [this is the result of multiplying each variable's number of levels minus one, i.e., (variable **one**' number of levels-−1)* (variable **two**' number of levels-−1)* variable **three**' number of levels-−1….]; which means that even if gender is interacting with other independent variables at the same time, this study's sample size supports strong power. There is a 70% chance of correctly rejecting the null hypothesis of no difference with a total of 852 participants.

For other demographic data about being the only child, education, hometown, marital status, and having children or not, please see Table 3.

TABLE 4 Activity type and working job.

	(*n* = 852)	%
Activity type		
Research	30	3.5
Sports	353	41.4
Online games	378	44.4
Take care of children and family members	134	15.7
Volunteer work	175	20.5
Reading	522	61.3
Music and art events	424	49.8
Shopping	596	70.00
Housework	370	43.4
Handicraft	226	26.5
Other	216	25.4
Activity time (Hour per day)	**Mean**	**SD**
	9.96	9.42
Working job experience	**(n = 852)**	**%**
Working now		
Yes	69	8.1
No	783	91.9
	(*n* = 69)	**%**
Working time		
Full-Time	3	4.35
Part-Time	66	95.65
Job type		
Self-employed	5	7.25
Salaried employees	64	92.75
	(*n* = 852)	**%**
Worked before		
Yes	180	21.1
No	652	76.5
No answer	20	2.3
Year of stopping work	**(*n* = 180)**	**%**
2012	1	0.56
2017	1	0.56
2018	4	2.22
2019	9	5
2020	23	12.78
2021	95	52.78
2022	25	13.9
No answer	22	12.2
Job type		
Self employed	15	8.3
Salaried employees	165	91.7

Activity related variables

Overall, the activities engagement time (hour/day) Mean = 9.96 (SD= 9.41) (see Table 4 for more about activity and working history). About 42% considered that their activities were affected by pandemic-related conditions. By analyzing participants'

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TABLE 5 How the activity is affected by the pandemic.

Main categories	*N* = 352	%
Activity is reduced	119	33.81
Unable to go out/travel	78	22.16
Shopping affected	55	15.63
Activity is stopped	44	12.5
Sports is affected	23	6.53
Mood is affected	14	3.98
More time for certain activities (reading, online games, staying with family…)	10	2.84
Education is affected	6	1.7
Financial related	3	0.85

TABLE 6 Examples of how participants' activities are affected.

How activity affected	Participants' answers
1	My activity is reduced
2	Can't realize my plans
3	Stop going to the gym
4	Unable to go out
5	Can't travel
6	Can't shop, only online shopping
7	Can't buy the materials you want
8	Inconvenient situation
9	Learning more online games and shopping is reduced
10	Increase online and indoor activity
11	Lost motivation
12	Can't be with relatives and friends
13	The mood is affected
14	Very uncomfortable
15	School's schedule is compressed and learning tasks are tense
16	More time for reading
17	More time for handicraft
18	More time with family
19	More time for online games

answers, we finally identified nine general categories. About 33.81% of them stated that pandemic-related conditions reduced their activity time, 22.16% stated that they were not able to go out and travel, and 15.63% considered that their shopping habits were affected or stopped. In addition, 12.5% considered that their activity is stopped. The answers of 3.53% were related to sports activities. A total of 3.98% expressed that their mood was affected. However, 2.84% considered that, during closure time, they had more time for certain activities such as reading, online games, and staying with the family. And only 1.7% answered educational-related effects (see Table 5). Examples of how the pandemic affected the participants' activities are included in Table 6.

Furthermore, 67.3% reported that they have plans and goals directing their activities. Regarding activities type, goals type and range, motivations type and source, and working status, see Table 1. Examples of goals types are presented in Table 2.

IES-R, RFQY, and MMS-B

The sample showed a Mean of 22.2 (SD = 14.9) on IES-R (stress level) which is considered lower than the limit where PTSD becomes a clinical concern (54% of participants expressed a low level below 24). A total of 22.2% belonged to the level where PTSD is a clinical concern, 5.8% of participants had a probable diagnosis of PTSD, while 18% expressed high PTSD. For IES-R subscales, Hyperarousal's Mean is equal to 0.88 (SD = 0.72); Avoidance's Mean is equal to 1.08 (SD = 0.75), and Intrusion's Mean is equal to 1.11 (SD = 0.71). The mean reflective function score as determined by the RFQY was 5.71 (SD = 0.43) with a minimum of 3.39 and a maximum of 6.48.

Around 46% of the participants had stress levels above the cut-off (score = 24 on IES-R), with a Mean score = 22.9 (SD = 14.9) (see Table 7), which goes with previous studies that also used IES-R to measure stress levels in the Chinese context during the pandemic. For Chen et al. (106) and Ting et al. (113) the considerable stress percentage was 44.5% for sample's $N = 9{,}225$ (Median is provided = 16.0) and 45.2% (Mean score = 26.61; SD = 17.95), respectively. However, our sample's PTSD mean was lower than that of studies conducted in 2020 [e.g., see, (15)], which may consistent with a longitudinal study by Wang et al. (16) that showed that the PTSD Mean score decreased over time [from 32.98 (SD = 15.42) to 30.76 (SD = 15.42)]. Also, along with previous studies, our results did not show any difference in age, marital status, and employment record on the PTSD score (15, 113). However, regarding gender difference in PTSD score, our study showed that males reported significantly higher levels than females, which contrasts with previous studies (15, 16, 54) (see Table 8). Also, unlike Ma's et al. (54) outcomes, different educational levels did not show any significant difference in PTSD levels.

For schizotypal personality as measured by MMS-B, the Negative Schizotypy's Means is equal to 3.99 (SD = 2.52), Positive Schizotypy's Mean is 2.41 (SD = 2.84), and the Disorganized Schizotypy's Mean is 1.87 (SD = 2.64) (see Table 7). Regarding schizotypal traits, our results showed lower levels on all the MSS subscales comparing previous studies in the Chinese context and higher than other studies in other contexts. Our scores were 3.99, 2.41, and 1.87, showing lower levels compared to 6.73, 3.54, and 3.63 in Wang et al. (38), and showing higher levels compared to 1.55, 2.03, and 1.81 in Gross et al. (91) (among college students in the U.S.), and compared to 0.93, 1.10, and 1.15 in Lincoln et al. (87) (among university students in the U.S.), and compared to 1.73, 1.30, and 1.56

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TABLE 7 IES-R, RFQY, and MMS-B descriptive results.

IES-R		(*n* = 852)	Minimum	Maximum
Variable				
IES-R total	*M*	22.9	0.00	88.00
	SD	14.9		
	n	**%**		
IES-R (>24)	460	54		
IES-R (≥24)	189	22.2		
IES-R (≥33)	49	5.8		
IES-R (≥37)	154	18		
IES-R subscale		**(*n* = 852)**		
Avoidance	*M*	1.08		
	SD	0.75		
Intrusion	*M*	1.11		
	SD	0.71		
Hyperarousal	*M*	0.88		
	SD	0.72		
RFQY				
RFQY total	*M*	5.71	3.39	6.48
	SD	0.43		
MMS-B subscales				
Negative schizotypy	*M*	3.99	0.00	13.00
	SD	2.52		
Positive schizotypy	*M*	2.41	0.00	13.00
	SD	2.84		
Disorganized schizotypy	*M*	1.87	0.00	12.00
	SD	2.64		

in Kemp et al. (88), on Negative, Positive, and Disorganized subscales, respectively.

Means difference, correlation, and linear regression

Using SPSS-IBM (22.0) results partially supported previous studies' results as well as showed the association between activity system and Schizotypal traits.

Comparing means by performing one-way ANOVA revealed a statistically significant difference between the participants who reported the effect of the pandemic on their activity in terms of Positive Schizotypy and PTSD levels [$F_{(1,850)} = (5.871)$, $p = 0.016$; $F_{(1,850)} = (13.082)$, $p < 0.001$, respectively]. Participants who reported that their activities were affected showed higher levels of Positive Schizotypy and PTSD (see Tables 8, 9).

Also, results revealed a statistically significant difference between the participants who reported the existence of goals in terms of Disorganized Schizotypy level [$F_{(1,850)} = (12.410)$, $p < 0.001$] and reflective function [$F_{(1,850)} = (12.001)$, $p = 0.001$].

TABLE 8 Means of significant variables in ANOVA.

Variables	*N*	*Mean*	*SD*
Pandemic Effect*Positive schizotypy			
Yes	358	2.6872	3.01
No	494	2.2105	2.67
Pandemic Effect*PTSD			
Yes	358	25.0503	15.621
No	494	21.3239	14.253
Goals existence*Pandemic Effect			
Yes	357	0.73	0.443
No	494	0.63	0.483
Goals existence*Disorganized Schizotypy			
Yes	573	1.644	2.393
No	279	2.319	3.047
Goals existence*Reflective function			
Yes	573	5.747	0.377
No	279	5.640	0.503
Goals' range*Negative schizotypy			
Short-Term	6	7.333	4.320
Medium-Term	292	4.007	2.204
Long-Term	266	3.748	2.360
Goals' range*Disorganized schizotypy			
Short-Term	6	4.500	4.324
Medium-Term	292	1.527	2.111
Long-Term	266	1.748	2.615
Goals' range*Reflective function			
Short-Term	6	5.367	0.787
Medium-Term	292	5.753	0.327
Long-Term	266	5.747	0.413
Goals' type*Negative schizotypy			
Tangible	440	4.082	2.383
Abstract	124	3.347	2.052
Goals' type* Disorganized schizotypy			
Tangible	440	1.693	2.395
Abstract	124	1.557	2.451
Goals' type*Reflective function			
Tangible	440	5.743	0.352
Abstract	124	5.757	0.457
Gender*Negative schizotypy			
Female	775	3.903	2.424
Male	77	4.844	3.257
Gender*Positive schizotypy			
Female	775	2.294	2.721
Male	77	3.584	3.676
Gender*Disorganized schizotypy			
Female	775	1.743	2.512
Male	77	3.091	3.499
Gender*PTSD			
Female	775	22.361	14.377

(Continued)

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TABLE 8 Continued

Variables	*N*	*Mean*	*SD*
Male	77	28.208	19.117
Gender*Reflective function			
Female	775	5.723	0.414
Male	77	5.596	0.515
Education*Negative schizotypy			
Bellow junior college	2	5.500	0.707
Junior college	123	3.431	2.875
Undergraduate	724	4.087	2.445
Master	2	0.00	0.00
PhD	1	6.00	0.00
Children number*Positive schizotypy			
One	125	3.200	3.429
More	727	2.275	2.708
Gender*Shopping			
Male	77	0.42	0.496
Female	775	0.73	0.445
Gender*Children number			
Male	77	1.73	0.448
Female	775	1.87	0.341
Gender*Online games			
Male	77	0.82	0.388
Female	775	0.41	0.491

Participants with goals directing their activity reported lower Disorganized Schizotypy and higher reflective function (see Tables 8, 9). Also, having different goals' range was statistically significant in terms of Negative and Disorganized Schizotypy [$F_{(3,848)} = (4.652)$, $p = 0.003$; $F_{(3,848)} = (6.005)$, $p < 0.001$; respectively], and reflective function [$F_{(3,848)} = (5.373)$, $p = 0.001$]. Participants with medium-term goals reported the lowest Disorganized Schizotypy and the highest level of reflective function (the difference in Disorganized Schizotypy and reflective function levels between medium and long-term goals groups is small; see Tables 8, 9). Additionally, participants with long-term goals reported the lowest Negative Schizotypy. However, participants with short-term goals reported the highest Negative and Disorganized Schizotypy and lowest reflective function. Regarding the goals' type, there was statistically significant difference between participants with tangible and abstract on Negative and Disorganized Schizotypy [$F_{(2,849)} = (4.755)$, $p = 0.009$; $F_{(2,849)} = (5.048)$, $p = 0.007$, respectively], as well as on reflective function [$F_{(2,849)} = (5.651)$, $p = 0.004$]. Participants with abstract goals reported higher reflective function and lower levels of Negative and Disorganized Schizotypy (see Tables 8, 9). Examples of participants' answers regarding their goals are introduced in Table 2.

TABLE 9 One-way ANOVA.

Variables	*df*	*F*	*p*
Pandemic effect*Positive schizotypy			
Source			
Between groups	1	5.871	0.016
Within groups	850		
Total	851		
Pandemic Effect*PTSD			
Source			
Between groups	1	13.082	0.000
Within groups	850		
Total	851		
Goals existence*Pandemic effect			
Yes	357	10.358	0.001
No	494		
Goals existence*Disorganized schizotypy			
Source			
Between groups	1	12.410	0.000
Within groups	850		
Total	851		
Goals existence*Reflective function			
Source			
Between groups	1	12.001	0.001
Within groups	850		
Total	851		
Goals' range*Negative schizotypy			
Source			
Between groups	3	4.652	0.003
Within groups	848		
Total	851		
Goals' range*Disorganized schizotypy			
Source			
Between groups	3	6.005	0.000
Within groups	848		
Total	851		
Goals' range*Reflective function			
Source			
Between groups	3	5.373	0.001
Within groups	848		
Total	851		
Goals' type*Negative schizotypy			
Source			
Between groups	2	4.755	0.009
Within groups	849		
Total	851		
Goals' type*Disorganized schizotypy			
Source			
Between groups	2	5.048	0.007
Within groups	849		

(Continued)

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TABLE 9 Continued

Variables	*df*	*F*	*p*
Total	851		
Goals' type*Reflective function			
Source			
Between groups	2	5.651	0.004
Within groups	849		
Total	851		
Gender*Negative schizotypy			
Source			
Between groups	1	9.845	0.002
Within groups	850		
Total	851		
Gender*Positive schizotypy			
Source			
Between groups	1	14.666	0.000
Within groups	850		
Total	851		
Gender*Disorganized schizotypy			
Source			
Between groups	1	18.597	0.000
Within groups	850		
Total	851		
Gender*PTSD			
Source			
Between groups	1	10.838	0.001
Within groups	850		
Total	851		
Gender*Reflective function			
Source			
Between groups	1	6.327	0.012
Within groups	850		
Total	851		
Education*Negative schizotypy			
Source			
Between groups	4	3.405	0.009
Within groups	847		
Total	851		
Children number*Positive schizotypy			
Source			
Between groups	1	11.434	0.001
Within groups	850		
Total	851		
Gender*Shopping			
Source			
Between groups	1	33.678	0.000
Within groups	850		
Total	851		
Gender*Children number			
Source			
Between groups	1	10.849	0.001
Within groups	850		
Total	851		
Gender*Online games			
Source			
Between groups	1	50.864	0.000
Within groups	850		
Total	851		

(Continued)

Results showed no significant difference among participants with different types of motivation sources.

After conducting the Pearson correlation test, results showed that the activities' total time (for all activities combined) was not correlated with Schizotypy, but was negatively correlated with reflective function and positively correlated with PTSD. However, research and volunteering were positively correlated with Positive Schizotypy, Disorganized Schizotypy, and PTSD, but negatively correlated with reflective function. Sports and shopping were negatively correlated with Negative Schizotypy and reflective function. While online games activity was positively correlated with Disorganized Schizotypy and PTSD. Moreover, music/art and handicraft activities are not correlated with any type of Schizotypy, but both were negatively correlated with reflective function, and music/art activity was positively correlated with PTSD. The reflective function was negatively correlated with both Positive and Disorganized Schizotypy, while PTSD (measured by IES-R) was positively correlated with three subscales of Schizotypy. Moreover, the three IES-R subscales (Intrusion, Hyperarousal, and Avoidance) were positively correlated with the three types of Schizotypy. However, the Motivation level was negatively correlated with Disorganized Schizotypy and positively correlated with reflective function (see Table 10).

Regarding demographic characteristics, comparing means by performing one-way ANOVA revealed a statistically significant difference between males and females regarding the three types of Schizotypy [$F_{(1,850)} = (9.845)$, $p = 0.002$, for Negative Schizotypy; $F_{(1,850)} = (14.666)$, $p < 0.001$, for Positive Schizotypy; and $F_{(1,850)} = (18.597)$, $p < 0.001$, for Disorganized Schizotypy]. Males has higher levels than females in the three types of Schizotypy. Also, there was a statistically significant difference between males and females regarding PTSD [$F_{(1,850)} = (10.838)$, $p = 0.001$] and reflective function [$F_{(1,850)} = (6.327)$, $p = 0.012$]. Males reported higher PTSD but lower reflective function. Moreover, males and females showed a significant difference in online games, shopping, and being the only-child in the family. Males had significantly higher scores on online game activity than females [$F_{(1,850)} = (50.864)$, $p <$

TABLE 10 Correlations results.

Variables	Negative MMS	Positive MMS	Disorganized MMS	RFQ-Y	PTSD
1. Activity time	−0.054	0.033	0.032	−0.106**	0.086*
2. Act1 (Research activity)	0.026	0.088*	0.053	0.022	0.079*
3. Act2 (Sports)	−0.103**	−0.017	0.000	−0.077*	0.032
4. Act3 (Online games)	0.041	0.058	0.085*	−0.038	0.088*
5. Act5 (Volunteer)	0.035	0.076*	0.074*	−0.112**	0.107**
6. Act7 (Music/Art)	−0.029	0.038	0.020	−0.102*	0.071*
7. Act8 (Shopping)	−0.076*	−0.040	−0.034	−0.072*	0.033
8. Act10 (Handicraft)	−0.019	0.014	−0.012	−0.100*	−0.013
9. Act11 (Other)	−0.024	−0.071*	0.016	−0.008	−0.013
10. Motivation level	−0.050	−0.001	−0.114**	0.088*	−0.019
11. RFQY	−0.053	−0.117**	−0.215**	–	0.040
12. IES-R	0.283**	0.431**	0.410**	0.040	–
13. IES-Avoidance	0.259**	0.384**	0.360**	0.043	–
14. IES-Intrusion	0.254**	0.420**	0.379**	0.038	–
15. IES-Hyperarousal	0.286**	0.409**	0.424**	0.029	–

*$p < 0.05$, **$p < 0.01$.

0.001], they belong to a one-child family more than females [$F_{(1,850)} = (10.849)$, $p = 0.001$], and they were less engaged in shopping activity than females [$F_{(1,850)} = (33.678)$, $p < 0.001$] (Tables 8, 9).

Regarding education, there was a statistically significant difference between educational levels regarding Negative Schizotypy [$F_{(4,847)} = (3.405)$, $p = 0.009$]. Even by excluding the Ph.D., Master, and Bellow Junior College participants because the Ph.D. level includes only one participant, while the Master's and Bellow Junior College level include only two participants, both Junior college and undergraduate students had significantly different Negative Schizotypy [$F_{(1,845)} = (7.176)$, $p = 0.008$]. Undergraduate students reported higher levels than students in Junior College. Also, there was a statistically significant difference between participants regarding the number of children in their family for Positive Schizotypy [$F_{(1,850)} = (11.434)$, $p = 0.001$] as well as for Disorganized Schizotypy [$F_{(1,850)} = (5.860)$, $p = 0.016$]. Being the only child in the family is associated with high Positive and Disorganized Schizotypy levels (see Tables 8, 9).

Other demographic variables (age, hometown, marital status, job engagement, and job history) did not show any significant difference among participants on reflective function, PTSD, and Schizotypy.

Moreover, to investigate variables predicting Schizotypy, multiple linear regression was used to test whether the activity system's variables (goal's type and range, motivation's level, and source, activity total time, if activity is affected by the pandemic), other correlated demographic variables (gender, the only child in the family), as well as reflective function and PTSD.

For Positive Schizotypy, the fitted regression model was: Positive Schizotypy = 7.849 −0.623*(gender)−0.645*(Only child)−0.110*(Activity affected by pandemic) + 0.080*(PTSD Level) −0.826*(Reflective function level). The overall regression was statistically significant [$R^2 = 0.216$, $F_{(5,846)} = 46.571$, $p \leq 0.001$]. About 21.6% of data can be explained by the model which is moderate level. It was found that gender, only child, PTSD, and reflective function significantly predicted Positive Schizotypy (β = −0.063, $p = 0.042$; β = −0.080, $p = 0.009$; β = 0.423, $p \leq 0.001$; β = −0.124, $p \leq 0.001$; respectively) (see Table 11). The pandemic effect on activity was not found to be a significant predictor for Positive Schizotypy.

For Negative Schizotypy, the model above was found to be less predictive. The fitted regression model was= 2.900–0.745*(gender) + 0.512*(Education) + 0.046*(PTSD). The overall regression was statistically significant [$R^2 = 0.091$, $F_{(3,848)} = 28.434$, $p \leq 0.001$]. It is only 9.1% of data can be explained by the model which is relatively low level. It was found that gender, education, and PTSD significantly predicted Negative Schizotypy (β = −0.085, $p = 0.011$; β = 0.076, $p = 0.021$; β = 0.272, $p \leq 0.001$, respectively) (see Table 12).

Finally, for Disorganized Schizotypy, the model above was found to be predictive (relatively less than Positive Schizotypy and higher than Negative Schizotypy). The fitted regression model was = 9.539–0.714*(gender) −0.429*(Goal existence) + 0.072*(PTSD) −1.343*(Reflective Function Level).

The overall regression was statistically significant [$R^2 = 0.234$, $F_{(4,847)} = 64.756$, $p \leq 0.001$]. A total of 23.4% of data can be explained by the model which is a moderate level. It was found that gender, the existence of goals, PTSD, and reflective function significantly predicted Disorganized Schizotypy (β = −0.078, $p = 0.011$; β = −0.076, $p = 0.012$; β = 0.408, $p \leq 0.001$; β = −0.216, $p \leq 0.001$, respectively) (see Table 13).

TABLE 11 Linear regression summary for positive schizotypy.

	B	β	t	*p*	F	df	Sig.	R^2
(Constant)	7.849		5.879	0.000	46.571	5, 846	≤0.000	0.216
Gender	−0.623	−0.063	−2.033	0.042				
Only child	−0.645	−0.080	−2.216	0.009				
The effect of pandemic	−0.110	−0.019	−0.620	0.535				
PTSD	0.080	0.423	13.672	0.000				
Reflective function	−0.826	−0.124	−4.031	0.000				

TABLE 12 Linear regression summary for negative schizotypy.

	B	β	t	*p*	F	df	Sig.	R^2
(Constant)	2.900		2.909	0.004	28.434	3, 848	≤0.000	0.091
Gender	−0.745	−0.085	−2.557	0.011				
Education	0.512	0.076	2.306	0.021				
PTSD	0.046	0.272	8.239	0.000				

TABLE 13 Linear regression summary for disorganized schizotypy.

	B	β	t	*p*	F	df	Sig.	R^2
(Constant)	9.539		8.189	0.00	64.756	4, 847	≤0.000	0.234
Gender	−0.713	−0.078	−2.548	0.011				
The existence of goals	−0.429	−0.076	−2.514	0.012				
PTSD	0.072	0.408	13.445	0.000				
Reflective function	−1.343	−0.216	−7.101	0.000				

Discussion

Results revealed that the main elements of the activity system (goal existence, goal type and terms, motivation, the activity flow in terms of being affected by the pandemic-related lifestyle), in addition to reflective function, are associated with schizotypal traits, regardless the level of PTSD.

Our results were similar to the previous studies about the association of three subscales of schizotypal traits with psychological trauma, affective symptoms, and stress [e.g., see (48, 88, 114–116)]. Furthermore, our results showed an association between reflective function and schizotypal traits (Positive and Disorganized schizotypy) in alignment with previous studies (40–45) (see Table 9). Also, as some studies in the Chinese context showed [e.g., see (117)], the male participants scored higher than females on schizotypal traits.

In addition, by considering the weight of social variables and social isolation as noted in previous studies [e.g., see (54, 113)], being not the only child in the family (more social connections and social support) is associated with a lower level of Positive Schizotypy. Also, being an undergraduate student is associated with high Negative Schizotypy (although both groups did not show any significant difference in terms of PTSD and reflective function) which goes partly with some previous studies where the higher the educational level we have, the higher some of the psychopathological aspects are (Depression, Stress, and Anxiety) [e.g., (16, 54, 68, 105, 118)].

Along with the goal-oriented aspect of the activity, and since goals play a crucial role in structuring and organizing both the mental and practical activities, our results showed that the existence of personal goals is associated with a lower level of Disorganized Schizotypy. The existence of a goal was one of the predictors of the regression model regarding the Disorganized Schizotypy (see Table 13). In addition, higher motivational levels appeared to be associated with lower levels of Disorganized Schizotypy. Also, our results showed the association of the goal's existence with a higher reflective function. And having abstract goals appeared to be associated with lower levels of Negative and Disorganized Schizotypy, and with higher reflective function.

For goal range, having Medium-term goals appeared to be associated with the lowest Disorganized Schizotypy and highest reflective function. Therefore, one may say that in the context where daily life is disturbed, the existence of goals, and having long-term and abstract goals, with a higher level

of motivation is associated with less withdrawal represented by Negative schizotypal traits. Savla et al. (119) argued that "better abstraction was associated with… shorter illness duration, and functional capacity" [(119), p. 1]. It seems also that during this disturbed flow period, having Medium-term goals appeared to be more associated with keeping the mind structured and higher reflective function (compared to short and long-term goals). Overall, it seems that the existence of goals is associated with less Schizotypy, but the type and range of the goals are differently associated. Neither being *drawn* to the current moment nor *dreaming* about the future may be healthier since having a higher risk to be linked with a disorganized mind (although the difference between medium and long-term goals is not high in terms of Disorganized Schizotypy) (see Table 8).

Furthermore, in addition to goals and motivation, the real flow of the activity is also associated with schizotypal traits. The participants who reported that their activity was affected by the pandemic-related conditions scored higher on Positive Schizotypy. It seems that in the conditions where the activity is halted, the personality tends to mentally compensate for the halted desired goals and activities through the inflation of certain traits. Here, the schizotypal traits appear to be a reaction to the disturbance of the activity system (120). Being governed by a dynamic system of meanings, the mind seeks balance among the components of that system. In our case, the withdrawal from social life requires compensation which appears through the inflation of mind activities represented by Positive Schizotypal traits (e.g., delusions, hallucinations, paranoia, and magical beliefs). This is supported by the fact that the Hyperarousal subscale (of PTSD) which is characterized mainly by irritability, hypervigilance, difficulty concentrating, and heightened startle, had the highest correlation with Negative and Disorganized Schizotypy and the second-highest on Positive Schizotypy (slightly lower than the Intrusion subscale) (see Table 10). Hyperarousal is another sign of the mind's hyperactivity and being on alert, representing the relationship between attention deficit, hyperarousal, and Schizophrenic traits [e.g., see (121)].

The relationship between mental processes and personality traits was noted by Luria (122). Regarding how the imbalance in mental aspects may shape personality traits and behavior.

In addition to being dynamic, the system of meanings is also contradictory. One needs to grasp its internal contradictions to explain contrasting outcomes following the law of contradiction in psychomental development (78, 123–129)]. For instance, Positive Schizotypy exists alongside or is nourished by Negative Schizotypy. This becomes clear by noticing that Negative Schizotypy is higher, which may indicate that social withdrawal during the pandemic is associated with mental withdrawal (representing the internal dynamic of Negative Schizotypy), allowing the mind to trigger its defense mechanism to cope through the development of Positive Schizotypal traits [for the contradicted tendencies in schizophrenia one can see Vygotsky (120) as a classical reference]. In fact, by checking the answers of participants regarding how the pandemic affected their activities one can deduce that the majority reported that their activity was halted. Halting the activity means that the reported goals cannot be realized. Among participants who considered that the pandemic affected their activities, 45% reported that going out, shopping, and engaging in sports activities were affected, while another 46% considered that the activity, in general, is reduced or stopped (see Table 5). Also, by investigating the type of the goals, around 78% of participants reported that their goals had tangible aspects. This may be another factor that explains why when the activity was halted and disturbed, individuals tended to withdraw from social life, and hence tended to develop Negative Schizotypy. Indeed, there is a correlation between tangible goals and a higher level of Negative Schizotypy (see Table 12). Furthermore, results revealed a significant difference between participants who reported the existence of goals and those who did not in terms of the effect of the pandemic on activity. The existence of goals directing the activity revealed an association with the existence of the effect of the pandemic on the activity which means that individuals respond differently depending on how their activity system is structured (see Tables 8, 9). Going back to the weight of activity flow on Schizotypy, the effect of the pandemic contributed to the regression model regarding Positive Schizotypy but was not a predictor (see Table 11).

On other hand, different activities seem to have different associations with schizotypal traits, stress, and reflective function. For instance, engaging in sports and shopping is associated with lower Negative schizotypy. This may imply, in contrast to social withdrawal tendency, an association of socialization and attachment to the direct context with the low Negative Schizotypy. Also, both sport and shopping are associated with lower reflective function, which may imply that not reflecting on the context may decrease the ability to perceive the detachment from social context during the pandemic when the context is severely altered and being "vacuumed" from daily details. Indeed, both sports and shopping are negatively correlated with reflective function. The data revealed that high activity time is associated with lower reflective function. Also, it seems easier to compensate for shopping with online shopping and sports with the indoor sport as explained by participants. Our conclusion agrees with previous studies that more concrete goals are associated with less negative affect and distress, compared to abstract goals (109).

The above argument is supported by examining other sorts of activities. For instance, unlike tangible activities (e.g, sports and shopping), abstract activities are associated with a higher level of Positive and Disorganized schizotypy and high reflective function. This is the case of *doing research* (associated with Positive Schizotypy) and *volunteering* (associated with both Positive and Disorganized Schizotypy) since these two types of activities hold general socially-directed meanings and cannot be relatively compensated the same way as sports and shopping.

Therefore, they will be mentally compensated through the inflation of certain schizotypal traits.

It seems that individuals who are not directed toward abstract meanings activities report low Reflective Function and low Negative Schizotypy (the case of *shopping* and *sports*), while individuals who are directed toward relatively abstract meanings tend to respond by developing Positive and Disorganized traits (the case of *doing research* and *volunteering*). Being engaged in *volunteering* activity may be associated with Disorganized Schizotypy by considering that *volunteering* structures the mind on a higher level than other sorts of tangible activity. Therefore, when volunteering is disturbed, the mind's structure will be disturbed as well by having higher Disorganized traits, and at the same time, it seems that the personality compensates for the loss of social engagement during volunteering events by the Positive Schizotypal traits. Also, the activity that transfers individuals into an *unreal* context is associated with Disorganized Schizotypy (in the case of *online games*). This is because the "narrative" that online games provide is not a part of the real-life narrative unlike other sorts of activities that have a connection with the ongoing life narrative.

These conclusions partially support the difference between genders by aiding to decrease the effect of gender imbalance in the sample size. For instance, males have significantly higher scores on online game activity, they belong to a one-child family more than females, and they are less engaged in shopping activities. Being a predictor of Positive Schizotypy, the one-child variable, in addition to that the males may have the potential feeling of being a *minority* among a majority of females in such Normal University types, supports the result that males scored higher on Positive Schizotypy. Being a minority (including sexual identity and gender minority) has a higher risk of developing Schizophrenic tendencies [e.g., see (130–133)]. Also, online games, in which males are engaged in higher than females are correlated positively with higher Disorganized Schizotypy (supporting the higher scores on disorganized schizotypy for male participants), and shopping is correlated negatively with Negative Shizotypy (males scored lower than females).

By reviewing CHAT's legacy including the functional method, compensation is a tendency of both the mind and brain, which is especially clear in the context of defectology [e.g., see (134)]. Also, compensation is mentioned in the writings of Oliver Sacks who is influenced by Luria [e.g., see (135–137)].

During lockdown and quarantine, the "life-term" goals became out of reach. So, due to the dynamic aspect of the meanings system, the pressure derived from the long period of halted activity may shift the goals implicitly and reconstruct the activity system. Therefore, to overcome the current unpleasant situation, the new goals related to pandemic-related lifestyle will gain more weight compared to the implicit reported goals that direct individuals' life. Therefore, even though 48% of participants reported having long-term goals, and 51% reported having medium-term aspects (2–3 years range), they are stained to more latent goals derived from social withdrawal. And one may argue that what is left is the mental compensation of the desired goals through schizotypal traits as discussed earlier.

In brief, due to the dynamic aspect of the meaning system forming the mind's structure, the organization of goals is not stable. Also, the personality and psychomental aspects will follow the continuous disruption in the activity flow, although individuals cannot explicitly grasp such re-organization of their system of meanings. This is the case when the reflective function is confronted with a disturbing context and faces the pressure of a current contextual impasse resulting from the disrupted life narrative. This may explain why high PTSD level was associated with all other variables regardless the difference in goals existence, goals type and term, motivation level, type of activity, and activity's time. The disturbance of life narrative was considered crucial in schizophrenia studies [e.g., see (138–141)].

Although it had a lower prediction value compared to other variables, PTSD was a predictor for three schizotypal traits' regression models. Also, the three subscales of PTSD (Intrusion, Avoidance, and Hyperarousal) were associated with the three schizotypy (see Tables 10–13) which goes with previous studies about the relationship between intrusion, avoidance, and hyperarousal on one hand, and schizophrenia on the other [e.g., see (121, 142–144)]. The association between high PTSD and high reflective function may reflect that people who consciously evaluate the disturbance of life's general narrative have more stress. Therefore, we may say that having a high level of reflective function is not always an element of lower psychopathological aspects. It depends on the meanings and the content being reflected. The linear regression model revealed that, in addition to the social relationship factor (the number of children in the family), the reflective function was found to be the strongest predictor of Positive and Disorganized Schizotypy.

Overall, the same context may have numerous reflected meanings, which may be contrary for the same individual and may create contradictions in reading the outcomes. For a general representation of the associations among variables please see Figure 1.

Conclusion

Overall, investigating the activity system and how it is changing (the internal conflicts according to the context) through time revealed a significant association with an extreme mind-state such as schizotypy (as a latent state of schizophrenia), especially in a social context where the life narrative is severely disrupted and is "on the edges." So, the context of the study falls directly under the topic of thought disorder (TD) [e.g., see (145)]. To grasp how different individuals may experience the pandemic-related context (including restrictions and lockdown), some psychomental factors such as stress, anxiety, and depression, and other variables (such as media

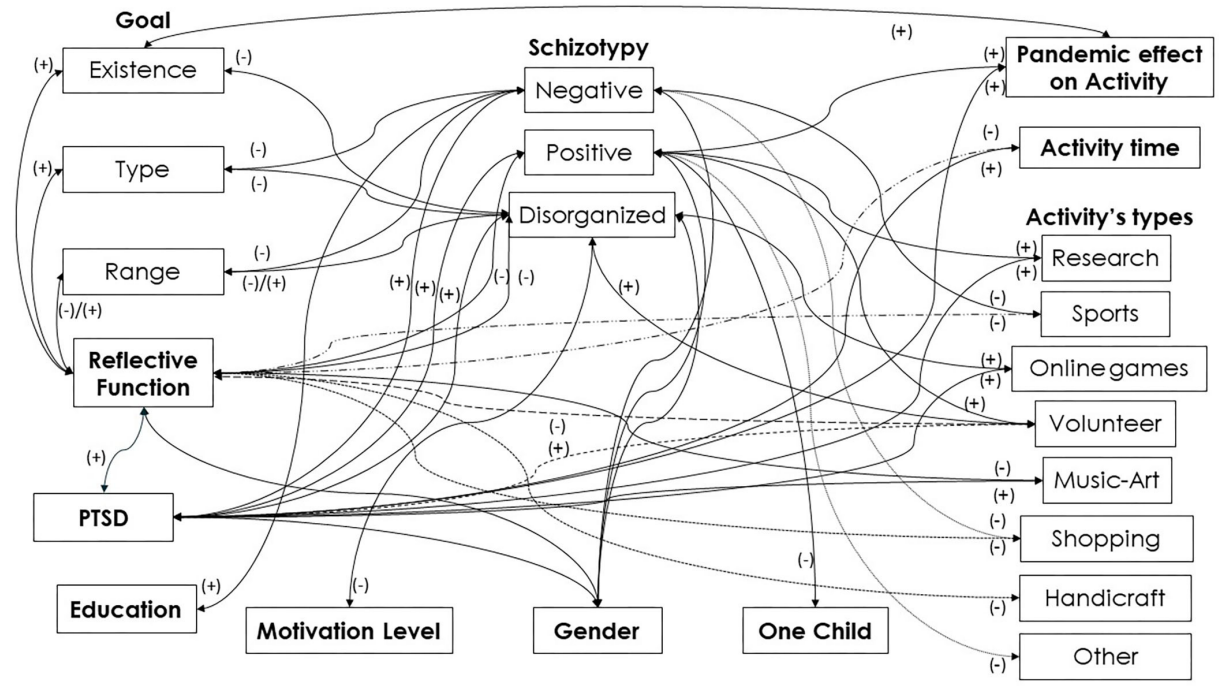

FIGURE 1
Variables' associations.

exposure, precautions, and knowledge about the pandemic) are required to be investigated. It is crucial to analyze the disturbance and the changes in the dynamic system of meanings and the flow of thought both in space and time. Being able to draw a dynamic view about how the system of meanings and thoughts may change in the pandemic context (and any other similar situation when the reality is being sharply disrupted) according to the general change of activity system, one can increase individuals' ability to cope and to gain the required psychomental tools in facing critical psychomental health problems. Building on Vygotsky's guidelines, some studies noted that cognitive flexibility is negatively correlated with psychopathology which we think is required in a critical fast-changing context like the one during a pandemic. Cognitive flexibility is required, especially regarding goal formulations and planning under the label of executive function [e.g., see, (119)].

Furthermore, according to the study results, future work needs to be performed regarding the elaboration of an intervention protocol not only for pandemic-related lifestyles but also for other "living on the edges" contexts. The protocol's role is to provide a *space-time* structure, such as the introduction of dynamic planning of activities according to individuals' interests and goals along with the continuous changes in the context. In addition, the protocol should include the development of mental skills such as mentalization and reflection in line with the content of the conceptualization and themes investigated in this study. In other words, in addition to the design and proposal of activity structure in general, the protocol should provide the participants the ability to develop self-reflective skills using the *narrative*, *goals description*, *activity changes and context, motivation sources, etc.* as tools to control and plan their own behavior in line with the dynamic and continuous changes in the situation.

Future studies need to be conducted for in-depth investigations about how the life narrative is disrupted. Additionally, they need to investigate how different individuals reflect on the disruption. This is necessary when the current disturbance in the world view, especially during the last decade, goes beyond the context of the pandemic, and when the "modern" lifestyle and life narrative are being altered around the world due to the socio-economic and cultural crisis.

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 Committee of Academic Ethics of Zhengzhou

Normal University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

ME: conceptualization, analysis, and writing. ME and YW: data interpretation. YW: revising intellectual content. ME and ZJ: methodology. KZ and TT: data collection. KZ: translation. ME and TT: encoding. YL: editing. YW: providing financial support that are necessary for this study. All authors contributed to the manuscript final form. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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A systematic review of the impact of COVID-19 on the game addiction of children and adolescents

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Background: During the COVID-19 pandemic, it is reported that children and adolescents who are socially isolated experience high levels of stress and various mental health problems. At present, little research has been done to collect previous studies that focused on game addiction in children and adolescents during the COVID-19 pandemic. In this research, we aimed to investigate the prevalence of gaming disorder during COVID-19 in children and adolescents and the various factors experienced by children and adolescents that affected gaming disorder.

Methods: We searched PubMed, Embase, PsycINFO, and Cochrane on 5 May 2021 to identify relevant literature. We extracted the prevalence estimates of game addiction from the studies to measure the global prevalence of game addiction. Then, we found the answers to the questions raised and synthesized them into several themes.

Results: We identified 2,609 articles. Among them, studies that were not related to the topic, duplicated, and that did not meet the selection criteria were excluded, and 18 studies were selected. We rated most of the studies as moderate, and a few were low, and high. A majority of studies found an increase in game usage time and game addiction score during the COVID-19 pandemic. Some children and adolescents in emotional pain play games to communicate with their peers. Regarding parenting, violent parenting and the absence of parental supervision increase levels of game addiction in children. Gaming disorder was caused by the impact of COVID-19 in a vulnerable group with predisposing factors such as depression, anxiety, and attention-deficit/hyperactivity disorder. Adolescents and males scored higher on a game addiction scale, although we could not find any quantitative correlations due to the heterogeneous scales used for gaming addiction.

Conclusions: During the COVID-19 pandemic, isolated children and adolescents reported increased gaming hours as a result of coping with their

psychological pain and avoiding social isolation. Their parents, who should provide proper supervision, also failed to provide appropriate support due to the stress caused by the pandemic. Mental health providers should educate children, adolescents, and their guardians on alternative ways to relieve stress and help parents effectively control their children's usage of games.

KEYWORDS

children, adolescent, game addiction, internet gaming disorder, COVID-19

Introduction

In 2019, an acute respiratory disease called COVID-19 was discovered in Wuhan, China, and spread rapidly across 20 countries worldwide. In January 2020, the World Health Organization (WHO) declared a public health emergency and later declared a pandemic in March 2020 (1). The characteristic of this virus is that it can be transmitted through human contact. Multiple prevention strategies were instated including, social distancing, quarantine, and school closures, and as a result, people became isolated (2). Moreover, people's work and lifestyles changed from offline to online, resulting in social gatherings taking place through video chat and online education becoming a larger part of education (3). During this period, there have been steady reports of increased game use (4–7).

During COVID-19, people who become socially isolated and inactive experience high levels of stress and various mental health problems (8, 9). Additionally, previous studies found that individuals with higher levels of depression, anxiety, and stress were more likely to develop an internet game disorder (10–14). As previously existing ways to relieve stress were impeded due to COVID-19, an increasing number of individuals began to relieve stress through online games and disconnect from reality. Therefore, the phenomenon of increased gaming behavior was reasonable during this period (15).

Particularly, during COVID-19, there have been higher levels of anxiety, depression, irritability, hyperactivity, inattention, sleep disturbances, and various mental health problems in children and adolescents (16–20). A growing body of research has found that such problems may lead increase vulnerability to internet and game addictions (21).

It is known that children and adolescents become independent of their parents, gradually forming self-identity and relieving stress through relationships with peers (22). As social connection and emotional support are critical at this developmental stage (23), adolescents tried to connect with their peers online during the COVID-19 pandemic (24). Therefore, a rapid increase in the internet, social media, and game usage time of socially isolated adolescents was reported during the social distancing period of COVID-19 (15, 18, 24–26).

On the other hand, some positive aspects of games (e.g., stress relief, social connections between isolated individuals) were found in previous studies (21, 27, 28). The WHO encouraged individuals who were isolated in their homes to play games as a way to relieve stress in the early days of the pandemic (26). From this aspect, it might be a reasonable approach for people to relieve stress by playing games excessively during the pandemic. However, relieving negative emotions through this type of behavior not only strengthens the behavior but also makes it habitual (29–33). Furthermore, excessive gaming and game addiction may result in a wide variety of emotional and behavioral problems, including social isolation in the relationships of adolescents (e.g., family, friends).

Pathological game use is defined in two ways. First, the Diagnostic and Statistical Manual of Mental Disorders 5 (DSM-5) describes the following symptoms as criteria for internet gaming disorder as a condition warranting further study: preoccupation, withdrawal, tolerance, failure to reduce or stop gaming, neglect other activities, continuing gaming despite problems, deception, gaming to escape, and relationship risk due to excessive gaming (34). A diagnosis of internet gaming disorder (IGD) requires experiencing five or more of these symptoms within a year. Second, gaming disorder (GD), which is classified by the 11th edition of the International Classification of Disease (ICD-11), requires the following symptoms: impaired control, increased priority given to gaming, and continued gaming despite negative consequences. A diagnosis of GD requires three symptoms within a year (35). As such, since there is inconsistency in the diagnostic criteria and evidence of gaming disorder, there is a need to conduct more research in this area and have a comprehensive perspective on the studies that have been conducted thus far.

Additionally, as seen from the DSM-5 diagnostic criteria, IGD is used interchangeably with problematic internet usage clinically, and related research has been generally conducted together. However, problematic internet use and problematic internet gaming have different clinical characteristics (36) and physiologically exhibit different mechanisms in the brain (37). Moreover, it might be more

appropriate to specifically use the term (i.e., game addiction) to conduct research instead of broadly using the term (i.e., media addiction) to better understand the mechanism of addiction (32).

In a previous study, Masaeli et al. (38) synthesized the prevalence of addiction for overall internet addiction, which increased during COVID-19 in 2021, and gave insight into the relationship between COVID-19 and game addiction. However, they focused on all age groups, and did not show the specificity of children and adolescents, and therefore the results presented in the article have limitations in showing only the prevalence of addiction in general. In addition, since the study was conducted only 8 months after the outbreak of COVID-19, it will be meaningful to collect additional studies and conduct the relevant study again.

Research aims

During the COVID-19 period, socially isolated children and adolescents were under significant stress because they did not receive the appropriate support that they should receive through peer relationships (22). It seems that these stresses made children and adolescents vulnerable to game addiction (21). For this study, we limited the groups to children and adolescents, who are vulnerable populations, and conducted a systematic review referring to various literature on the effects of COVID-19 on digital addiction, especially game addiction. We investigated not only the prevalence rate of gaming disorder in children and adolescents but also how various factors experienced by children and adolescents affected gaming disorder during the COVID-19 period. Therefore, in this article, we tried to clarify the following questions: *Did the prevalence of game addiction among children and adolescents increase during the COVID-19 period?* (Research Question 1)

In addition, what makes children and adolescents different from adults in clinical practice is that they are not independent and their lives are influenced by the primary caregiver(s) (22). Therefore, as a second question, we wanted to know: *How did the relationship with caregivers affect the gaming disorder of children and adolescents?* (Research Question 2)

Additionally, children and adolescents experience unique stressful situations compared to those experienced by adults. Therefore, as a third question, we wanted to answer: *How did the special stress experienced by children and adolescents affect their gaming disorder?* (Research Question 3)

Finally, we *investigated game addiction during COVID-19 in children and adolescents with preexisting psychiatric diseases, who are more vulnerable.* (Research Question 4)

Methods

Our review adhered to the steps described in the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement (39).

Data sources and search strategy

We searched PubMed, Embase, psycINFO, and Cochrane on 5 May 2021 to identify relevant literature on game addiction during the COVID-19 pandemic. We used search items related to gaming disorder (game OR game addiction OR gaming OR gaming disorder OR internet gaming disorder) and COVID.

Study inclusion and exclusion criteria

Articles were included if: (1) there was a quantitative scale to measure game addiction, (2) the research was conducted after the COVID-19 outbreak, (3) the target group of research was children or adolescents (under 19 years old), and (4) it was written in English. In addition, the criteria for exclusion in the process of selecting data were as follows: (1) the target of studies was over 18 years old, (2) studies measured only internet addiction, smartphone addiction, or screen addiction, not game addiction, (3) studies only covered the pre-COVID-19 period (we included studies comparing the periods before and after the outbreak of COVID-19, together), or (4) they were not empirical studies.

Study selection

Articles were included in the study through the following process. First, by reading the titles and abstracts of the searched articles. Studies that fit the topic to be addressed in our research were selected by referring to the inclusion and exclusion criteria. Next, the entire texts of the selected articles were read, and those that met the inclusion criteria were selected.

Quality assessment

The quality of the study was synthesized by two researchers independently using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach (40). As in the previous study that conducted a systematic review using this tool (38), we classified the research into four categories and recorded the quality of evidence for each study in Table 1 as follows: high (the authors have a lot of confidence that the true effect is similar to the estimated effect), moderate

TABLE 1 Description of the included studies.

Author, Year, Country	Title	Type	Objecitive	Methodology	Scale	Poulation and age	Conclusion	Certainty in evidence
Chen et al. (2021) China (42)	Internet-related behaviors and psychological distress among schoolchildren during the COVID-19 school hiatus	Original research	To evaluate levels of problematic gaming, problematic social media use, and problematic smartphone use; distress; and time spent on different activities; and test the mediating roles of problematic gaming, problematic social media use, and problematic smartphone use in the associations between psychological distress and screen time use	Quantitative (school-based survey)	IGDS-SF9$_{1)}$	$N = 2,026$ Mean age = 10.71	From the aspect of practice, parents and caregivers need to monitor the use of Internet-related activities of their children while finding ways to facilitate the time spent on exercise and studying, which may contribute to better mental health among their children	High
Chen et al. (2021), China (42)	Problematic internet-related behaviors mediate the associations between levels of internet engagement and distress among schoolchildren during COVID-19 lockdown: A longitudinal structural equation modeling study	Original research	To assess changes in the level of engagement in internet-related activities before and during the COVID-19 outbreak; to investigate the differences of psychological distress before and after COVID-19 outbreak; and to investigate the mediating roles of problematic internet-related behaviors in the causal relationships of psychological distress and time spent on internet-related activities	Quantitative (school-based survey)	IGDS-SF9$_{1)}$	$N = 535$ Mean age = 10.32	Increased problematic use of internet-related activities among schoolchildren was associated with greater psychological distress. Parents should therefore monitor internet-related activities and psychological distress of their children to support their mental health	Moderate
Cuong et al. (2021), Vietnam (43)	Associations between gaming disorder, parent-child relationship, parental supervision, and discipline styles: Findings from a school-based survey during the COVID-19 pandemic in Vietnam	Original research	To assess the prevalence of GD among Vietnamese adolescents in Hanoi, and; to assess the associations between parent-child relationship, parental discipline styles, and GD	Quantitative (school-based survey)	IGD-20$_{2)}$	$N = 2,084$ Mean age = 14.5	"We found associations between gaming disorder and parent-child relationship, parental supervision, and parental discipline. Future interventional studies should consider assessing the effect of fostering healthy	Moderate

(Continued)

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TABLE 1 Continued

Author, Year, Country	Title	Type	Objecitive	Methodology	Scale	Poulation and age	Conclusion	Certainty in evidence
							parent-child relationships and appropriate discipline on the occurrence or prognosis of gaming disorders	
De Pasquale et al. (2021), Italy (44)	Online videogames use and anxiety in children during the COVID-19 pandemic	Original research	To assess the prevalence of videogames use and addiction in a sample of Italian children during the COVID-19 pandemic and their association with anxiety symptoms	Quantitative (school-based survey)	$VASC_{3)}$	$N = 162$ Mean age = 9.4	Recently, a possible use of active video games for improving mental health and physical fitness during isolation periods was reported; however, more studies are needed to define the most adequate interventions to be activated by caregivers to prevent the negative consequences and maximize the developmentally positive effects of videogames	Moderate
Donati et al. (2021), Italy (45)	Gaming among children and adolescents during the COVID-19 lockdown: the role of parents in time spent on video games and gaming disorder symptoms	Original research	To analyze video gaming habits in children and adolescents during the lockdown, starting in March 2020 in Italy, the first European country affected by the pandemic. Specifically, we aim to understand how variables related to parents are related to their offspring's time spent on video games and GD symptoms	Quantitative (web survey)	VGS-P, VGS-A, $VGS-C_{4)}$	Children ($N =$ 206, Mean age = 8.62) Adolescents ($N =$ 248, Mean age = 14.17)	Especially in this pandemic period, parents must provide alternative avenues for social interaction between adolescents in order to maintain their learning motivation and to monitor and regulate their gaming time, thus minimizing addiction risks	Moderate
Elsayed (2021), United Arab emirates (46)	Covid-19 pandemic and its impact on increasing the risks of children's addiction to electronic games from a social work perspective	Original research	To determine the impact of the Covid-19 pandemic on increasing the social, psychological, behavioral, and health risks of children's addiction to electronic games from a social work perspective	Quantitative (online survey)	Questionnaire designed by researcher on the risks of child addiction to	$N = 289$ Mean age = unknown (range = 6–17 years)	It was clearly noticed that after the Covid-19 pandemic and children staying at home for long periods of time, The rates of risks (social - psychological - health - behavioral) of children's addiction to electronic	Low

(Continued)

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TABLE 1 Continued

Author, Year, Country	Title	Type	Objecitive	Methodology	Scale	Poulation and age	Conclusion	Certainty in evidence
					electronic games		games in its various forms have increased, especially violent games	
Fazeli et al. (2020), Iran (29)	Depression, anxiety, and stress mediate the associations between internet gaming disorder, insomnia, and quality of life during the COVID-19 outbreak	Original research	To examine the mediating role of psychological distress in the association between internet gaming disorder and two health outcomes among adolescents during this COVID-19 pandemic	Quantitative (web survey)	IGDS9-$SF_{1)}$	$N = 1,512$ Mean age = 15.51	IGD is associated with different psychosocial outcomes comprising multiple pathways. Parents need to pay special attention to how much time and how frequently their children play videogames. Parents may need to assist their children in coping with psychological distress during the ongoing COVID-19 pandemic period	Moderate
Kim and Lee (2021), Korea (47)	Addictive internet gaming usage among Korean Adolescents before and after the outbreak of the COVID-19 pandemic: a comparison of the latent profiles in 2018 and 2020	Original research	To explore the different profiles of addictive internet gaming behavior among adolescents before and after the outbreak of the COVID-19 pandemic and examine how the pandemic influenced addictive internet gaming usage and time spent playing games on the internet	Quantitative (nationally representative survey data)	$MGUS_{6)}$, average gameplay time	$N = 3,040$ Mean age = 13.46 in 2018 $N = 2,906$ Mean age = 13.62 in 2020	Although the results of the present study indicate that profiles with higher addictive internet gaming usage exhibit longer gameplay time, caution should be exercised when interpreting higher gameplay time as problematic. [...] Most significantly, playing games online should not be stigmatized as gaming is not pathologic and it does have positive effects. In addition, games can be utilized in educational purposes	Moderate
Kim et al. (2021), Korea (48)	Latent profile of internet and internet game usage among South Korean adolescents during the COVID-19 pandemic	Original research	To investigate the latent profiles of the Internet and Internet game usage among adolescents in South Korea	Quantitative (secondary data obtained from a national survey)	$MGUS_{5)}$	$N = 2,984$ Mean age = 13.6	Profiles with higher game usage time scored higher in problematic game use compared to other profiles. Males were more likely to be in the profiles with high gaming time, and females were more likely to be in Internet and Smartphone	Moderate

(Continued)

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TABLE 1 Continued

Author, Year, Country	Title	Type	Objecitive	Methodology	Scale	Poulation and age	Conclusion	Certainty in evidence
							User profiles. The results indicate that Internet and Internet gaming usage patterns could be classified by the type of device used and the content of the Internet	
Ko and Yen (2020), Taipei (49)	Impact of COVID-19 on gaming disorder: Monitoring and prevention	Commentary	To assert that mental health professionals should be aware of how increased gaming during the pandemic may contribute to risk of gaming disorder	N/A	N/A	N/A	Parents and educators must provide alternative avenues for social interaction among adolescents in addition to maintaining their learning motivation and monitoring and regulating their gaming time, all of which could be essential to minimizing GD-related risks during this pandemic. Furthermore, mental health professionals must provide emotional support and advice on coping strategies to relieve pandemic-related stress in individuals	–
Li et al. (2021), Canada (3)	Screen use and mental health symptoms in Canadian children and youth during the COViD-19 pandemic	Original research	To determine whether specific forms of screen use were associated with symptoms of depression, anxiety, conduct problems, irritability, hyperactivity, and inattention in children and youth during COVID-19	Quantitative (longitudinal cohort study)	Video game time	Group 1 $N = 532$ Mean age = 5.9 Group 2 $N = 1,494$ Mean age = 11.3	In this cohort study, higher levels of screen use were associated poor mental health of children and youth during the COVID-19 pandemic. These findings suggest that policy intervention as well as evidence-informed social supports are needed to promote healthful screen use and mental health in children and youth during the pandemic and beyond	Moderate

(Continued)

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TABLE 1 Continued

Author, Year, Country	Title	Type	Objecitive	Methodology	Scale	Poulation and age	Conclusion	Certainty in evidence
Oliveira et al. (2021), Brazil (50)	Children's behavioral problems, screen time, and sleep problems' association with negative and positive parenting strategies during the COVID-19 outbreak in Brazil	Original research	To investigate the group differences among children raised by negative and positive parenting families during COVID-19 pandemic.	Quantitative (online survey)	$GAS_{6)}$	$N = 329$ Mean age = 10.24	Children and adolescents might have an amplified impact during pandemic depending on the parenting strategies mostly used. Considering parental management training is an effective strategy to improve parenting strategies and it is available even online, it might consist of ground to have a potential improvement in developmental competencies and in children and adolescent's mental health even during pandemic times	Moderate
She et al. (2021), China (51)	How COVID-19 stress related to schooling and online learning affects adolescent depression and Internet gaming disorder: Testing Conservation of Resources theory with sex difference	Original research	To test the roles of stress related to schooling and online learning during COVID-19 in depression and IGD among adolescents and the potential mediators of social support, academic stress, and maladaptive emotion regulation based on the framework of Conservation of Resources theory	Quantitative (school-based survey)	DSM-5 IGD Symptoms checklist	$N = 3,136$ Mean age = 13.6	Although stress and disruptions to daily life are inevitable during the pandemic, psychosocial interventions and preventive measures targeting these modifiable mediators have the potential to help reduce the risk of depression and IGD and facilitate students to adapt to the COVID-19 era	Moderate
Shuai et al. (2021), China (52)	Influences of digital media use on children and adolescents with ADHD during COVID-19 pandemic	Original research	To explore the influences of digital media use on the core symptoms, emotional state, life events, learning motivation, executive function and family environment of children and adolescents diagnosed with ADHD during the (COVID-19) pandemic	Quantitative	Average hours on games	ADHD patient $N = 192$, Mean age = 11.02	The ADHD children with problematic mobile phone use (PDMU) suffered from more severe core symptoms, negative emotions, executive function (EF) deficits, damage on family environment, pressure from life events, and a lower motivation to learn.	Low

(Continued)

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TABLE 1 Continued

Author, Year, Country	Title	Type	Objecitive	Methodology	Scale	Poulation and age	Conclusion	Certainty in evidence
							Supervision of digital media usage, especially video game and social media, along with increased physical exercise, is essential to the management of core symptoms and associated problems encountered with ADHD	
Teng et al. (2021), China (53)	Depression and anxiety symptoms associated with internet gaming disorder before and during the COVID-19 pandemic: A longitudinal study	Original research	To examine gaming in the context of the pandemic and its association with depressive and anxiety symptoms	Quantitative (longitudinal study)	IGDS9-$SF_{1)}$	$N = 1,778$ Mean age = unknown(children and adolescents)	Children and adolescents both increased videogame use during the COVID-19 pandemic, but only adolescents significantly increased IGD severity during the COVID-19 pandemic. The findings supported the compensatory hypothesis, and are consistent with the Interaction of Person-Affect-Cognition-Execution model as individual responses to COVID-19 may function as a mediator between personal predisposing variables and IGD	Moderate
Wang et al. (2022), China (54)	Anxiety, depression and stress are associated with internet gaming disorder during COVID-19: fear of missing out as a mediator	Original research	To explore whether the difference exists in the relationship between depression, anxiety, or stress and Internet gaming disorder, and to explore how fear of missing out influences depression, anxiety, or stress	Quantitative (school-based survey)	$IGDS_{7)}$	$N = 324$ Mean age = 13.07	The results indicated that fear of missing out as a mediator regulates the relationship among depression, anxiety, and stress and Internet game disorder.	Moderate

(Continued)

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TABLE 1 Continued

Author, Year, Country	Title	Type	Objecitive	Methodology	Scale	Poulation and age	Conclusion	Certainty in evidence
							Specifically, under the mediation of fear of missing out, teenagers with anxiety are more likely to develop Internet gaming disorder, while teenagers with depression or stress might be prone to other types of Internet use disorders	
Wu et al. (2022), China (55)	Changes of internet behavior of adolescents across the period of COVID-19 pandemic in China	Original research	To describe the internet behavior changes of adolescents and to understand the impact of clinical features on internet addiction after the adolescents back to school in COVID-19 period	Quantitative (cross-sectional cohort study through online survey)	Internet gaming behaviors	$N = 625$ Mean age = 14.90	There are differences in the clinical characteristics between the adolescents with and without Internet addiction. When intervening in adolescents' problematic Internet behavior during the COVID-19 pandemic, the heterogeneity in characteristics between subgroups should be considered	Low
Zhu et al. (2021), China (28)	Leisure and problem gaming behaviors among children and adolescents during school closures caused by COVID-19 in Hong Kong: quantitative cross-sectional survey study	Original research	To examine the associations between loneliness and gaming addiction behaviors among young people in Hong Kong and to investigate how familial factors, psychological distress, and gender differences moderate these relationships	Quantitative (cross-sectional study)	$GAS_{6)}$, Gaming Time	$N = 2,863$ Mean age = 12.6	Loneliness was associated with gaming addiction behaviors; the findings from this study suggested that this association was similar across gender and age groups among young people. Familial support and supervision during school closures can protect young people from developing problematic gaming behaviors. Results of this study have implications for prevention and early intervention on behalf of policy makers and game developers	Moderate

1) Internet Gaming Disorder Scale-Short Form (IGDS-SF9), 2) Internet gaming disorder Test (IGD-20), 3) Videogame Addiction Scale for Children (VASC), 4) Video Gaming Scale for Parents, Adolescents and Children (VGS-P, VGS-A, VGS-C) 5) Maladaptive Game Use Scale (MGUS), 6) Game Addiction Scale (GAS) 7) Internet Gaming Disorder Scale (IGDS).

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(the authors believe that the true effect is probably close to the estimated effect), low (the true effect might be markedly different from the estimated effect), and very low (the true effect is probably markedly different from the estimated effect).

Data extraction and synthesis

Data extraction included the following: year, country, mean age, title of article, research type, objective and results of studies, scale to define game addiction, and gaming hours. As the first question of our study was to measure the global prevalence of game addiction during the pandemic, we extracted prevalence estimates of game addiction from the studies. For studies that did not have prevalence estimates but presented gaming hours, we considered gaming more than 5 h as game addiction (41). Then, we read the articles included in the study several times, found the answers to the questions raised, and synthesized them into several themes. Afterward, we reviewed the synthesized themes to derive the final result.

Results

Study characteristics

We collected studies that were published between June 2020 and February 2022, which was during the pandemic. We identified 2,609 articles. Among them, studies that were not related to the topic, duplicated, conducted through follow-up of previous studies and with most of the contents overlapping with previous studies, and that did not meet the selection criteria were excluded, and 18 studies were selected (Figure 1). Among the 18 studies, there were two studies in 2020, 14 studies in 2021, and two studies in 2022. The majority of studies were original articles. However, one study conducted by Ko et al. (49), which was a commentary, was included as an exception because they played a key role in the overview and review of this study. Although we aimed to include studies that had valid scales, there are a wide variety of valid scales used for GD, which are the internet Gaming Disorder Scale-Short Form (IGDS-SF9), internet Gaming Disorder Test (IGD-20), Videogame Addiction Scale for Children (VASC), Video Gaming Scale for Parents (VGS-P), Video Gaming Scale for Adolescents (VGS-A), Video Gaming Scale for Children (VGS-C), Maladaptive Game Use Scale (MGUS), Game Addiction Scale (GAS), internet Addiction Test (IAT), and DSM-5 IGD Symptoms checklist (Table 1).

As described above, the scales used for game use varied greatly depending on the study, and the definition of pathological game use was also different, so the main results of the studies were heterogeneous. The age range of the subjects also differed from study to study. Therefore, we did not perform statistical meta-analysis due to concerns that differences in study characteristics would materially affect the results. Instead, we descriptively present the prevalence rates suggested by the studies to determine the difference between the prevalence before and after COVID-19.

Quality assessment

Of 18 studies, 14 studies were evaluated as moderate, three studies were evaluated as low, and one study was evaluated as high. Most of the studies were large-scale studies, presenting statistically significant results. We concluded that these studies were evaluated as moderate or low due to their study design (i.e., observational studies).

We reviewed the studies and summarized the conclusions of our previous questions into four themes, which are as follows. (1) Changes in the prevalence of game addiction among children and adolescents during COVID-19. (2) Impact of the relationship with parents on gaming disorder in children and adolescents. (3) Effects of specific stress experienced by children and adolescents on gaming disorder during COVID-19. (4) Effect of the Vulnerable population and COVID-19 on gaming disorder. In addition, reviewing the studies, we found that the prevalence of game addiction and factors influencing it were different according to age and gender, so we added, (5) Gaming disorder according to demographic characteristics.

Changes in the prevalence of game addiction among children and adolescents during COVID-19

The impact of COVID-19 on gaming disorder was examined in two aspects: whether game usage time increased and whether game addiction (e.g., IGD) scores measured on a game addiction scale increased during COVID-19. Several studies found increased game usage time and increased levels of game addiction (42, 47, 48, 56). Among 18 articles, seven presented prevalence estimates of game addiction using scales, and three additional articles presented specific gaming hours. In a total of 10 articles, the prevalence estimates of game addiction that were measured by each study are shown in Table 2. Many studies found that the prevalence of gaming disorder increased, which was estimated to be between 2.3 and 29.4%, and the global prevalence of IGD was 1.96% before the pandemic (43, 45–48, 51, 56). However, there was difficulty demonstrating comprehensive results, as the studies used inconsistent scales, defined addiction differently, and had differences in the prevalence estimates of addiction. Therefore, an agreement on the scale of game addiction should be made through continuous research in this area.

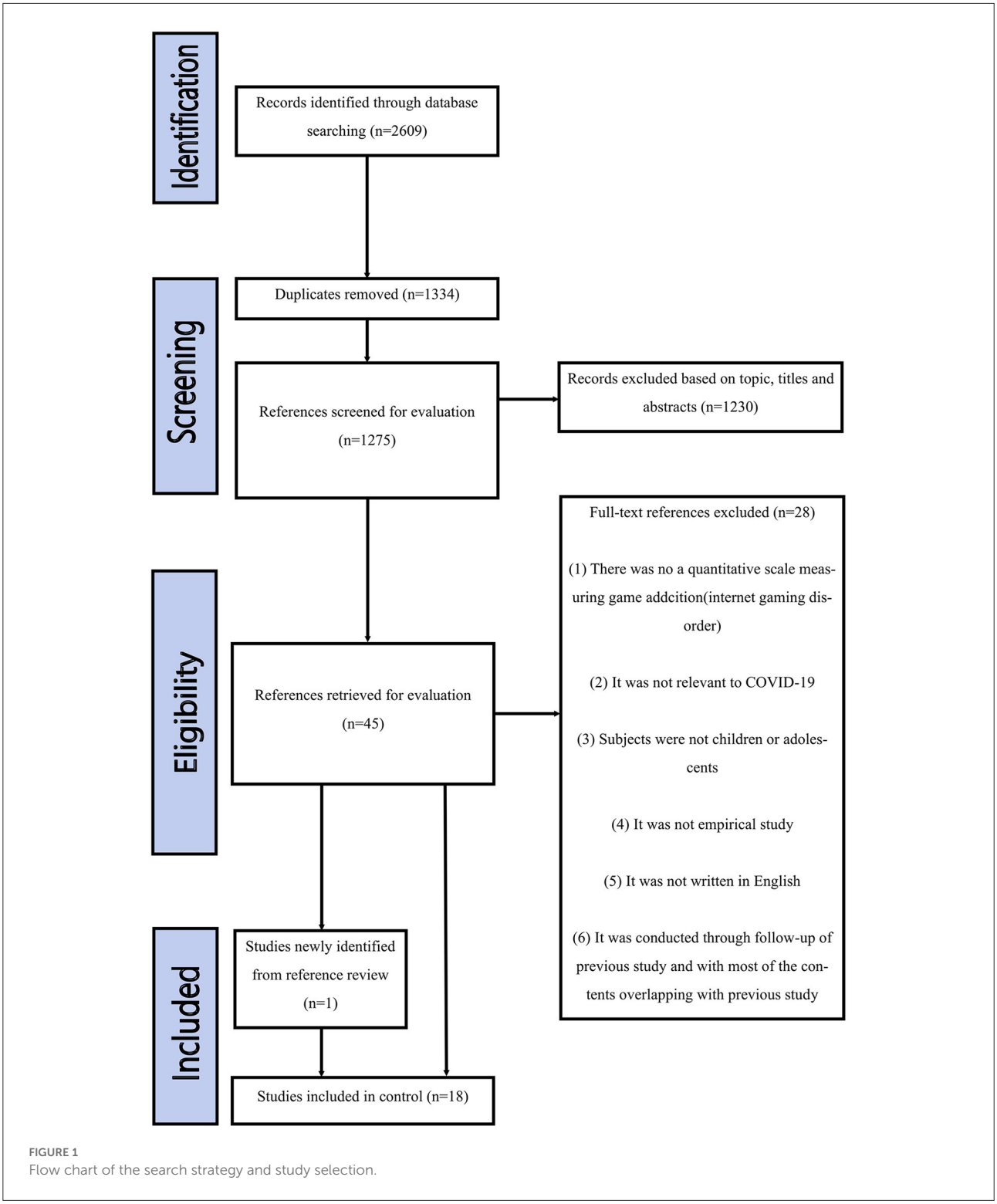

FIGURE 1
Flow chart of the search strategy and study selection.

Many of these studies had a limited study design (i.e., cross-sectional), as they investigated the impact over the limited period of COVID-19. To better investigate its causality, several studies attempted to obtain and examine temporality. Kim and Lee demonstrated that there was a significant increase in game usage time and game addiction during the COVID-19 pandemic by comparing a group that was recruited before COVID-19 with a group that was recruited during COVID-19 (47). In a study

TABLE 2 Prevalence of game addiction according to studies.

Studies	Scale	Game addiction (%)
Kim D. J. et al.	MGUS	2.3
Teng et al.	IGDS-SF9	5
Cuong et al.	IGD-20	11.6
Zhu et al.	N/A*	13.6
She et al.	IGDS-SF9	14.8
Kim et al.	MGUS	16.1
Li et al. adolescent group	N/A*	17.8
Donati et al. child group	VGS	19
Donati et al. adolescent group	VGS	22
Chen, C.Y. et al.	IGDS-SF9	23.7
Elsayed et al.	N/A*	29.4

MGUS, Maladaptive Game Use Scale; IGDS-SF9, Internet Gaming Disorder Scale-Short Form; IGD-20, Internet gaming disorder Test; VGS, Video Gaming Scale; N/A, not available.
*More than five gaming hours were considered as Game addiction in the present study.

conducted in China, students who returned to school after the pandemic were asked to retrospectively report their game usage time and measured their game addiction scores over three different periods (i.e., before, during, and after COVID-19). After their scores were compared, the study found an increase in game usage time and game addiction score that were measured during the pandemic. Moreover , there was a cohort study that demonstrated an association between game time and game addiction score in its cohort group that was compared before and after COVID-19 (3, 53). However, further investigation with different types of groups should be continued, as there are small sample size studies that did not find an increase in game addiction (44, 57).

There have been inconsistent findings on the impact of games on mental health since before COVID-19 (58–66). Many studies have investigated the increased use of games and their effects on mental health during the pandemic. A majority of the studies found a positive correlation between game usage time and game addiction score (45–48). Li et al. (3) demonstrated temporal causality between game usage time and game addiction score by measuring game usage time and game addiction scores of a cohort group of 2,026 participants several times. Moreover, such a correlation increased levels of depression, anxiety, stress, fear of missing out, irritability, inattention, hyperactivity, and hyperactivity/impulsivity, which exhibited the effects of game addiction on mental health (3, 46, 48, 50, 54, 55, 57).

The impact of relationship with parents on gaming disorder in children and adolescents

During the COVID-19 pandemic, there has been a large body of research regarding the impact of parenting on gaming disorder (43, 45, 50, 56). Zhu et al. (56) found that perceived parental supervision played a role in reducing pathological gaming behavior. However, parental support played a role as a protective factor against an increase in game usage time only in primary school students but played a role as a risk factor in secondary school students. Another study in Italy (45) also demonstrated that children's GD symptoms were negatively related to parental video gaming monitoring and parental knowledge of them. These studies demonstrated a perspective that supports parental care and intervention for children.

Some studies more specifically examined parenting behavior (43). For instance, interestingly, the lowest prevalence of GD was shown in participants who were under parental supervision, whereas a high prevalence of GD was shown in those under supervision with severe physical punishment, those under supervision without discipline, and those with no parental supervision. That is, violent parenting increased levels of game addiction in children, but the absence of parental supervision also increased them. However, as the authors revealed, this should be taken into account cautiously to reveal causal inference, considering the possibility that harsh parenting might have occurred due to game addiction of their offspring. From a different perspective, a study focused on parenting style was conducted. Oliveira et al. (50) investigated and measured authoritarian and authoritative parenting styles and their relationship with children's mental health behavior, including gaming behavior. As a result, the children of authoritarian parents reported significantly higher internalizing and externalizing symptoms, excessive game usage time, and game addiction scores. In particular, regulation and punishment were significantly associated with game addiction, and all behavioral problems were associated with less autonomy, physical coercion, and verbal hostility. As the authors highlighted, the regulation used to control behavioral problems fostered the problems

Effects of specific stress experienced by children and adolescents on gaming disorder during COVID-19

Some studies found that game usage time was increased by the social needs of isolated children and adolescents during the COVID-19 pandemic. Among them, Wang et al. focused on the fear of missing out (54). Fear of missing out is a pervasive apprehension that others might be having rewarding experiences from which one is absent, characterized by the desire to stay continually connected with what others are doing. They demonstrated that depression, anxiety, and stress in children and adolescents were linked to internet gaming disorder through the mediating effect of "fear of missing out." This relationship was shown more significantly in anxiety. That is, children and adolescents in emotional pain, play games to communicate with their peers to not be separated from them. In

another study (56), loneliness was quantitatively associated with excessive and pathological gaming behavior. Even after other factors were adjusted, the odds ratio remained increased. The authors of the study indicated that children and adolescents play games to feel less lonely and connect with peers, as there were fewer opportunities to meet friends, which also aligns with some findings that loneliness is associated with psychiatric symptoms during COVID-19 among children and adolescents (20).

Additionally, one study mainly focused on psychosocial factors of adolescents that were associated with COVID-19 (51). The authors exhibited a correlation between COVID-19 stress related to schooling and online learning and IGD in adolescents with an average age of 13.6. They also found mediating effects of social support, academic stress, and emotional regulation on the relationship between COVID-19 and IGD. That is, adolescents faced problems with social support, academic stress, and emotional regulation through online learning, which led to the emergence of IGD problems. In particular, emotional regulation showed the highest correlation, which aligns with some previous findings that displayed the effects of loneliness and depression on problematic internet use in a group of deficient self-regulation (31).

Effect of the vulnerable population and COVID-19 on gaming disorder

During the COVID-19 period, there have few studies regarding game addiction in high-risk groups. Shuai et al. (52) demonstrated increased video game time in patients who were previously diagnosed with attention-deficit/hyperactivity disorder (ADHD) during the COVID-19 pandemic, while children with game and digital use problems showed worsened existing ADHD core symptoms, executive functions, and oppositional systems, as well as worsened emotional problems in their familial relationships . Meanwhile, a longitudinal study with 1,778 subjects found that levels of depression and anxiety in the pre-COVID-19 period increased the prevalence of internet gaming disorder during the COVID-19 period (53). This result remained significant even when the impact due to COVID-19 was set as a mediator. With regard to the result, it might be possible that behavioral addiction, such as IGD, was caused by the impact of COVID-19 in the vulnerable group with predisposing factors. On the other hand, according to one study with a sample of 162 children, the current anxiety state was associated with games but not with trait anxiety. Although this did not coincide with previous findings, it is important to note that it was cross-sectional and limited to a small sample in one area, resulting in some limitations to its interpretation (44).

Gaming disorder according to demographic characteristics

The demographic composition that could affect the association between COVID-19 and gaming disorder was split into age and gender in the present study. Regarding age, both children and adolescents reported increased game usage time (45, 53), but adolescents scored higher on a game addiction scale (45, 53, 56). From the aspect of parenting, children were more likely to be cared for by their parents, have higher monitoring scores, and control their game usage time better (45, 56). As independence is an important issue for adolescents (67), this could be seen as an advantage that younger children who are less independent cooperate well with their parents (53). Additionally, unlike children, loneliness was associated with pathological gaming in adolescents, which indicates that the need to use games might differ based upon age (56). The difference in results according to the age of a target group in each study was not quantitatively corroborated, as various confounding factors could influence the results and their gaming usage scales were heterogeneous. Therefore, it may be necessary for future studies to unify gaming scales and conduct a systematic review including statistical analysis such as meta-regression based on the influence of age, controlling for all possible confounding factors.

Regarding gender, males reported longer game usage time (44, 45, 47, 48, 51, 56) and higher scores of game addiction than females (45, 47, 48, 51, 56). As loneliness played a significant role as a mediator (56) in females with higher scores of game addiction and increased scores of game addiction were reported in those who excessively used smartphones, the mechanism of using games might be different based on gender. Moreover, with regard to parenting, females had a higher degree of parental supervision than males, which might have served as a protective factor (45).

Discussion

This review aimed to determine the effects of COVID-19 on gaming disorder among children and adolescents. Although similar prevalence studies have been conducted (38), we limited the group to children and adolescents and wanted to take a deeper look into how their actual experiences during COVID-19 were related to gaming disorder. We reviewed 18 studies and synthesized five themes: (1) Changes in the prevalence of game addiction among children and adolescents during COVID-19, (2) The impact of the relationship with parents on gaming disorder in children and adolescents, (3) Effects of specific stress experienced by children and adolescents on gaming disorder during COVID-19, (4) Effects of Vulnerable population and COVID-19 on gaming disorder, and (5) Gaming disorder according to demographic characteristics.

Peer relationships and relationships with parents both play an important role in the formation of self-identity and socially healthy development of children and adolescents (22). During the COVID-19 period, isolation from social relationships such as school and frequent conflicts with parents affected the use of games, which varied according to gender, age, and preexisting vulnerabilities.

Regarding the change in prevalence of gaming disorder during COVID-19, consistent with conclusions from previous studies on the general population (38), the proportion of groups included in gaming disorder among children and adolescents increased in most studies. Children and adolescents showed a decrease in gaming disorder with appropriate supervision from parents, but the lack of supervision or harsh discipline increased gaming disorder in children and adolescents, contrary to the parents' intention. During COVID-19, children and adolescents experienced increased stress in peer relationships, which manifested as a fear of missing out, a lack of social support due to online learning, and a feeling of loneliness, which affected gaming disorder. These effects were more severe in the group with ADHD or existing psychiatric symptoms, and gaming disorder inversely worsened the core symptoms of ADHD. Adolescents, in which peer relationships are more important than children, showed a higher game addiction scale due to emotional problems experienced during COVID-19, but they had difficulty receiving supervision by their parents due to their unique preference for independence. In terms of gender, although males overall scored higher in game addiction, female loneliness acted as a more important mediator for game use. Therefore, it was judged that there was a difference in game use according to gender.

Overcoming gaming disorder during the COVID-19 pandemic in children and adolescents

The COVID-19 pandemic continues today, children and adolescents are constantly exposed to stress, and the resulting gaming use disorder continues. Therefore, based on the results found in this study, we intend to examine and find ways to overcome the current situation.

The most important aspect to pay attention to is parenting. Due to social quarantine since the COVID-19 pandemic occurred, social institutions, including schools, were locked down. As a result, parents took on a large part of the supervision that schools would have taken charge of. Since parents spend more time with their children at home as they work from home, the role of parents has become more important. This might explain why many studies examined the role of parents since the pandemic occurred (45). However, during COVID-19, parents have not been well aware of the excessive gaming of their children and have provided supervision well due to their attention to the prevention of COVID-19 and the economic and social effects caused by the pandemic (49).

As seen in the studies, parents are to appropriately guide their children by recognizing their game patterns, helping them control their game usage time, and monitoring their game usage time, since their knowledge of their children serves as a protective factor to develop socially and psychologically (46).

Kiraly et al. (33) published consensus guidance on internet use disorder during COVID-19 in a group that included psychologists and psychiatrists from the United States and several European countries. They recommend monitoring screen time within the guidance and, in particular, regulating children's behavior for rule-making. As in the study conducted by Oliveira et al. (50), authoritative parenting styles, rather than coercive parenting, acts as a protective factor for gaming disorder. Therefore, it seems necessary for parents to maintain their authority but to reach an agreement on game use through rational dialog with their children. As a way to help with this, apps that give feedback on game time seem to be helpful (33).

Király et al. also advised in the consensus guideline mentioned above that by participating in the games that their children play together, parents can learn more about the games their children are playing and help control their children's games (33). Play itself is not harmful but rather helpful for their overall development. Moreover, since play is part of their lives, they accomplish developmental tasks, grow mentally, and relieve mental stress (22). As parents become familiar with their children's games, they will be able to assist their children in avoiding killing or assaulting games, but rather playing age-appropriate games (50, 68). Additionally, parents should choose good games such as educational electronic games or exergame or different activities such as table games, home exercise, and reading (46).

In a study conducted in a region of China during COVID-19, a group with increased reading, studying, or exercising time reported decreased internet-related behavioral problems such as games (42). Accordingly, fostering and encouraging other activities may be one of the strategies to reduce game addiction (45). Furthermore, considering the finding that the game usage time of parents increased the game usage time of their children, we suggest that parents decrease their game usage time and try not to play games in front of them as much as possible (56).

Additionally, there is an association between hostile and less supportive parenting and the stress levels of parents (69, 70). Negative parenting, such as less autonomy, verbal hostility, physical coercion, and punishment, affects different externalizing symptoms, including game addiction in children (43, 50). Taken together, mental health providers should provide

parents with emotional support to prevent them from burning out and teach them supportive parenting techniques.

Intervention in paradoxical situations experienced by adolescents is also important. Although adolescents are generally vulnerable to game addiction, unfortunately, such aforementioned strategies were less effective or had adverse effects on this population in several studies regarding parenting (53). As mentioned above, as independence is critical in adolescence, the supervision of parents seems to be less effective (45), and they tend to be less aware of their offspring. Additionally, emotional regulation, which plays a critical role in game addiction, is relatively less developed than other cognitive functions in adolescence (51). As we have seen, lack of social support and feelings of loneliness among adolescents influenced their gaming disorder (20, 51, 54, 56). Kiraly et al. (33) reported that keeping in touch with friends, relatives, and acquaintances in consensus guidelines would help overcome these emotional difficulties. Instead of their direct interventions, parents or educators should use group calls, social media groups, or remote conferencing services to boost social support or help children reduce their academic stress so that such services could become avenues for social interaction among adolescents (33, 46).

Finally, mental health professionals should offer stress-reduction techniques (e.g., meditation, autigenic training, mindfulness exercises) that are better than using games, helping offspring and their parents stay emotionally healthy. It is also important to create a direct route to help if they encounter any issues related to using the game (33). In particular, mental health providers should provide children and adolescents who have mental health problems such as ADHD, depression, and anxiety with more intensive observations.

Limitations

Our study has several limitations. First, our study included only studies written in English. Therefore, there is a possibility that data from various countries in the environment of writing articles in languages other than English could not be reflected. Second, we did not provide statistically specific figures. Although this was because the results of the studies included in this review were heterogeneous, we did not achieve the purpose of synthesizing the results of our study on gaming disorder in children and adolescents. Third, we tried to examine the solution to the current situation through the results of this review, but it was limited and insufficient. Further studies related to the intervention of gaming disorder are needed. Fourth, most of the included studies were cross-sectional studies, so the quality of the articles was limited. In our evaluation, most of the articles were moderate, but there were also a few articles of low quality. This is thought to be due to the nature of the studies conducted for a special limited period of time called COVID-19, but as the quality of the systemic review is determined by the included articles, it seems necessary to conduct research by collecting more high-quality studies in the future.

Future directions

As mentioned earlier, a limitation of studies related to COVID-19 is that most of them are cross-sectional. Therefore, various high-quality studies, such as cohort studies that track changes over time or randomized controlled studies, are needed in the future. Moreover, recently, as there are articles on long COVID syndrome, the problems caused by COVID-19 are expected to continue, so it seems that research on it should be included (71).

In this review, it was confirmed that demographic characteristics affect gaming disorder. Although male and female differed in the prevalence of gaming disorders, there also appear to be differences in the purpose of gaming (56). Therefore, if studies focusing on gender differences are conducted in the future, effective interventions are likely to be made. We found that differences in developmental stages according to the age of children and adolescents affect gaming disorder. Therefore, we tried to investigate the change in prevalence according to age, but there was no correlation with an exploratory graph. This was presumed to be due to the different scales for each study and the influence of several compounding factors. Therefore, it may be necessary for future studies to unify gaming scales and then conduct a systematic review including statistical analysis such as meta-regression based on the influence of age, controlling for all possible confounding factors.

Although we suggested methods to overcome the current situation, the studies based on the proposed intervention methods were actually close to the suggestions of experts (33, 46, 50, 56, 68). Therefore, systematic intervention studies for various intervention methods should be conducted to establish the level of evidence. Additionally, in relation to COVID-19 and gaming disorder among children and adolescents, there have been few studies on psychiatric risk groups (52, 53). As we saw in our review, the psychiatric risk group was more vulnerable to gaming disorder, and the results were worsening, so it seems that research on the risk group is needed. In particular, mental health providers should provide children and adolescents who have mental health problems such as ADHD, depression, and anxiety with more intensive interventions. Therefore, it seems that various screening methods and studies to verify them will be needed in the future.

Conclusion

The COVID-19 pandemic has had a social impact and isolated all individuals through social distancing. Isolated children and adolescents increased their gaming hours to cope with psychological pain, such as loneliness and anxiety, and avoid social isolation. As a result, internet gaming disorder has become more prevalent. Their parents who should have properly supervised them also failed to provide appropriate support due to the stress caused by the pandemic, which worsened the problem. Considering this, mental health providers should take this into account, educate children, adolescents, and their guardians on how to relieve their stress alternatively and help parents effectively control their children's usage of games. More intensive interventions should be designed for emotionally vulnerable children and adolescents.

Author contributions

Conceptualization, project administration, resource, and supervision: M-HP. Data curation and methodology: TH, HC, and M-HP. Formal analysis, investigation, and visualization: TH and HC. Validation and writing—review and editing: TH, DS, and M-HP. Writing—original draft: TH. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Pathways from self-disclosure to medical coping strategy among adolescents with moderate and major depression during the COVID-19 pandemic: A mediation of self-efficacy

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Background: The prevalence of adolescent depression in China during the COVID-19 pandemic is increasing. Self-disclosing depressive emotions could help release stress. Self-disclosure, which is a prerequisite for self-efficacy, can directly contribute to people's psychological health, and depression and the choice of coping strategy are determined by the level of self-efficacy perceived.

Purpose: We aimed to discuss the relationship between self-efficacy, self-disclosure, and medical coping strategy. Further, we explore the mediation effect of self-efficacy on the influence of self-disclosure on medical coping strategies in adolescents with depression.

Methods: A total of 585 patients aged 11–24 years with moderate and major depression were recruited. All the assessments were completed on the second day after admission, including the General Self-Efficacy Scale (GSE), Distress Disclosure Index (DDI), and Medical Coping Modes Questionnaire (MCMQ). Pearson correlation was performed to explore the relationships of these variables. The bootstrap analysis was used to conduct to assess the mediation effects.

Results: Both direct and indirect effects of self-disclosure on medical coping strategy were found. As predicted, self-efficacy partially mediated the relationship between self-disclosure and medical coping strategy (b = 0.0385, 95% CI: 0.0244–0.0538 for *Confrontation*; b = −0.0466, 95%CI: −0.0651 to −0.0296 for *Resignation*), respectively. The effect size for *Confrontation* and *Resignation* was 0.2659 and 0.2485, respectively.

Conclusion: Self-efficacy played a partial mediating role in the effect of self-disclosure on medical coping strategies for adolescent depression during the COVID-19 pandemic, and the use of a positive self-disclosure mechanism may be anticipated to promote improved self-efficacy and the use of active coping strategies.

KEYWORDS

adolescent depression, self-disclosure, self-efficacy, medical coping mode, mediation

Introduction

Depression has been more prevalent among adolescents during the worldwide COVID-19 pandemic compared to before (1), when it was as high as 52.4% in China (2), 32% in Peru, and 9% in Vietnam (3), which will cause an increased risk of negative health outcomes (4). The previous study has found that self-disclosure can directly contribute to people's psychological health (5), and disclosing depressive emotions could help reduce stress and depression (6).

The onset of depression is important in relationships with coping strategies (7). Coping strategy refers to intrapsychic activities, as well as to the communications and behaviors of patients, designed to the decrease of distress caused by illness. As techniques used by patients to deal with disease, coping strategies are generally categorized into two broad types: active strategies and evasive strategies. Active strategies aim at making an active stress response. Evasive strategies mean evading stressful situations (8), and usually entail maladaptive consequences among adolescents (9–11). Compared with healthy people, depressive patients more often utilize strategies based on avoidance and denial, and experience more difficulty in finding positive characteristics in stressful events (12). However, the influence and pathway of self-disclosure among depressive adolescents in terms of adopting coping strategies has been unclear.

The choice of one coping strategy over another is determined by the level of perceived self-efficacy (13). Self-efficacy is a belief in one's own capacity to face challenges (14), which is a key factor for adolescents' emotional wellbeing. Low subjective wellbeing may significantly predict increased depressive symptoms (15). Based on Bandura's social cognitive theory (16), self-efficacy is the faith in one's ability to perform the behaviors that are necessary to attain a desired goal. Self-efficacy beliefs guide action both directly and indirectly through self-expectations regarding the result of a certain behavior (14). High self-efficacy for dealing with stress can prevent or reduce stress along with its health influences (17). However, the previous study showed that authentic self-disclosure to at least one person is a prerequisite for self-efficacy of psychological adjustment (18). In this situation, the use of a positive self-disclosure behavior may promote improved self-efficacy, the use of active coping strategies, and reduce depression. However, the increase in depression during the COVID-19 pandemic means that many of them need to choose the proper coping strategy to solve their depressive disorders.

However, much of the existing literature focuses on the relationship among self-disclosure, self-efficacy, coping strategies, and depression. Therefore, the present study was designed to discuss the relationship between self-disclosure, self-efficacy, and medical coping strategies and to explore the mediation effect of self-efficacy on the influence of self-disclosure on medical coping strategies in adolescents with depression (**Figure 1**). The outcomes of the present study may ultimately help adolescents to deal with their situations more positively. Moreover, we provide foundational data for developing nursing interventions to improve depression in adolescents before antidepressant therapy.

Materials and methods

Participants

Data of the present study were collected through a cross-sectional research in Beijing, China between June 2020 and July 2021 during the COVID-19 pandemic. Based on the literature recently published (19), the age range of description of adolescence was 10–24 years. A total of 585 patients aged 11–24 years old with moderate and major depression were recruited. All participants were students without married, and they lived with parents and schoolmates.

All participants met the eligibility criteria, i.e., meeting the diagnostic criteria for depression according to the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition. The exclusion criteria for the patients were rigorous, such as neurological disorders, head trauma, intellectual disability, bipolar disorder, and other psychiatric disorders.

Sociodemographic data, including age and years of education, were collected. Clinical data, including

disease course, was obtained according to medical records, and self-report and confirmed by the next of kin and family members.

Approval for the present study was obtained from the Ethics Committee of Beijing HuiLongGuan Hospital which was in accordance with the principles in the Declaration of Helsinki. Written informed consent was obtained from all patients or their guardians before study enrollment.

Measures

In the present study, all the assessments were completed for all patients on the second day after admission, including the General Self-Efficacy Scale (GSE), Distress Disclosure Index (DDI), and Medical Coping Modes Questionnaire (MCMQ).

General self-efficacy scale

The GSE is a 10-item self-report scale which assesses general self-efficacy as a prospective and operative construct. Each item is scored from 1 (not at all true) to 4 (totally true). The total score ranges from 10 to 40, with higher scores showing higher self-efficacy (20). The GSE assesses optimistic self-belief in dealing with the demands, tasks, and challenges of life in general (21). Cronbach's α coefficient was 0.84 (22).

Distress disclosure index

The DDI is a 12-item self-report assessment of one's tendency to disclose personally distressing thought, a construct termed distress disclosure. DDI measures individual typical disclosure of distressing thoughts, personal difficulties, and distasteful emotions across time and circumstances. Participants assessed their agreement with each item from 1 (strongly disagree) to 5 (strongly agree). As a result, the DDI is useful to measure individual differences in emotional self-disclosure which is relevant to the counseling or seeking support process. Cronbach's α coefficient was 0.93 (23).

Medical coping modes questionnaire

The Chinese version of the MCMQ which is aimed to measure three coping strategies that participants may utilize when facing life-threatening diseases, namely, *Confrontation, Avoidance,* and *Resignation*, contains 20 items (1 item was added to keep the original meaning of the scale when it was translated into Mandarin Chinese). For each item, individuals choose the response from the 4 choices that best reflects his or her experience (1 = none, 2 = a few, 3 = quite a few, 4 = a lot). Eight of the 20 items are reverse-scored. Subscale scores are attained by summing each item scores (range = 8–32 for *Confrontation*, 7–28 for *Avoidance*, 5–20 for *Resignation*). Higher scores show that an individual has more behaviors described by that specific coping scale when handle medical incidents. The MCMQ-C was used in the current study, and a good internal consistency was shown in the subscales, with Cronbach's α coefficients as follows: *Confrontation*, 0.74; *Avoidance*, 0.73; and *Resignation,* 0.83 (24).

Statistical analyses

Descriptive statistics were used to calculate the frequency of characteristics of the samples. Continuous variables were described by mean and standard deviation (*SD*), and categorical variables by frequency and percentage (%). Correlation analysis was performed using partial correlation.

Mediation analysis was computed for self-disclosure as an independent variable, medical coping mode as a dependent variable (*Y*), and self-efficacy as a possible mediator (*M*). The PROCESS v3.5 for SPSS (25) was used with bootstrapping with coefficients estimated from 5,000 bootstraps. A simple mediational approach was conducted using Model 4 with 5,000 bootstraps with education and disease course as covariates. The output mediation models were explained as follows: *b (YX)* is the total effect of the independent variable *X* on the dependent variable *Y*; *b (MX)* is the effect of the independent variable on the assumed mediator *M*; *b (YM.X)* is the effect of the mediator on the dependent variable, excluding the independent variable; and *b (YX.M)* is the direct effect of the independent variable on the dependent variable except for the mediator. The indirect effect of *X* on *Y* through *M* was estimated. The ratio of the indirect effect to the total effect was treated as the effect size for mediation (26). The statistical analyses were conducted using IBM SPSS Statistics for Windows (version 23.0; IBM Corp., Armonk, NY). *P*-value < 0.05 was considered significant.

Results

Descriptive statistics

A total of 585 participants were included in the analysis, with an average of 17.04 ± 3.23 years old. As shown in **Table 1**, male participants were 135 (23.08%) and the rest of participants were female (n = 450, 76.92%). There were 346 participants of age ≤ 18 years (14.75 ± 1.55), while 239 participants were aged >18 years (20.36 ± 1.88). The average years of education is 11.04 ± 3.23. The average disease course is 2.18 ± 1.67 years. The distributions of DDI, GSES, *Confrontation*, *Avoidance*, and *Resignation* of MCMQ were 31.73 ± 9.64, 20.07 ± 6.44, 17.53 ± 4.07, 16.40 ± 3.10, 12.43 ± 3.98 (**Table 1**).

Correlation analysis

Table 2 shows the correlation between the variables from the multivariate analysis with education and disease course as covariates. The scores of DDI and GSES were both correlated with the scores of confront and resignation coping strategies, respectively ($r = 0.341/-0.441$ and $r = 0.347/-0.430$, all $p < 0.001$). The scores of DDI were correlated with the scores of GSES ($r = 0.349$, $p < 0.001$). However, neither DDI nor GSES was correlated with avoidance coping strategy (both $p > 0.05$).

Mediation analysis for self-efficacy

Confrontation and *Resignation* coping strategies were, respectively used as *Y*, and mediation analysis results showed that *Model b (YX)* (total effect, $b = 0.1448$, $t = 8.7446$, 95%CI: 0.1123–0.1774 for *Confrontation* and $b = -0.1875$, $t = -11.8580$, 95%CI: −0.2185 to −0.1565 for *Resignation*; both $p < 0.001$), *Model b (MX)* ($X - > M$, for both *Confrontation* and *Resignation,* **b** = 0.2370, $t = 8.9899$, 95%CI: 0.1852–0.2887 and both $p < 0.001$), *Model b (YM.X)* ($M - > Y$, $b = 0.1448$, t = 8.7446, 95%CI: 0.1123–0.1774 for *Confrontation* and $b = -0.1875$, $t = -11.8580$, 95%CI: −0.2185 to −0.1565 for *Resignation*; both $p < 0.001$), and *Model b (YX.M)* ($X - > Y$, $b = 0.1063$, $t = 6.2206$, 95%CI: 0.0727–0.1399 for *Confrontation* and $b = -0.1409$, $t = -8.8305$, 95%CI: −0.1726 to −0.1096; both $p < 0.001$ for *Resignation*). The coefficient of indirect of *Confrontation* and *Resignation* was 0.0385 and −0.0466 ($X - > M - > Y$, 95%CI: 0.0244–0.0538 for *Confrontation* and 95%CI: −0.0651 to −0.0296 for *Resignation*). The ratio of indirect effect/total effect for *Confrontation* and *Resignation* was 0.2659 and 0.2485, respectively. These outputs identified the partial mediation effect of self-efficacy *(M)* on *Confrontation* and *Resignation (Y)* (Figure 2). However, there was no mediation effect of self-efficacy *(M)* on *Avoidance* ($p > 0.05$).

These results above partially support the hypothesis that self-efficacy which mediated medical coping strategies with self-disclosure remains a predictor.

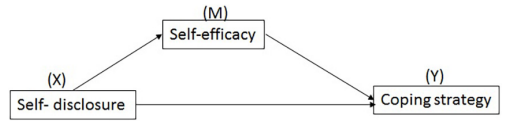

FIGURE 1
Path model for the mediation effect of self-efficacy on the influence of self-disclosure on medical coping strategy of adolescents with depression.

TABLE 1 The demographic and psychotypical characteristics of adolescents with depression on admission ($n = 585$).

Variables	Number/Mean ± *SD*
Gender (Male: Female)	135:450
Age (years)	17.04 ± 3.23
≤18 ($n = 346$)	14.75 ± 1.55
>18 ($n = 239$)	20.36 ± 1.88
Education (years)	11.04 ± 3.23
Disease course (years)	2.18 ± 1.67
DDI	31.73 ± 9.64
GSES	20.07 ± 6.44
MCMQ	
Confrontation	17.53 ± 4.07
Avoidance	16.40 ± 3.10
Resignation	12.43 ± 3.98

GSES, general self-efficacy scale; DDI, Distress Disclosure Index; MCMQ, medical coping modes questionnaire; SD, standard deviation.
All data were reported as mean ± SD using Mann-Whitney sum tests.

TABLE 2 Correlation among psychotypical characteristics of adolescents with depression before ($n = 585$).

Variables	DDI		GSES	
	r	*p*	r	*p*
GSES	0.349	<0.001*	–	–
MCMQ				
Confrontation	0.341	<0.001*	0.347	<0.001*
Avoidance	−0.055	0.182	0.063	0.126
Resignation	−0.441	<0.001*	−0.430	<0.001*

GSE, general self-efficacy; DDI, Distress Disclosure Index; MCMQ, medical coping modes questionnaire.
Partial correlation was used to calculate the correlation between the variables with education and disease course as covariates, *p < 0.05.

Discussion

To the best of our knowledge, much of the existing literature focuses on the relationship among self-disclosure, self-efficacy, coping strategies, and depression, but there are few studies of the mediation of self-efficacy between self-disclosure and medical coping strategy in adolescents with depression. The present study is the first to examine the relationship between self-disclosure and medical coping strategy during the COVID-19 pandemic. Further, we explored the possible pathways underlying this association concerning depressive adolescents' self-efficacy by constructing a mediation model, and offering a more comprehensive picture of self-disclosure-coping strategy pathways. Understanding the coping strategies of depressive adolescents during the COVID-19 pandemic and its underlying psychological mechanisms are crucial for the effective intervention of adolescents with depression before medication and are beneficial for establishing a team of high-quality nurses' and consultants' to fight future public health emergencies.

The primary finding in the present study revealed that self-disclosure has a direct effect on medical coping strategies,

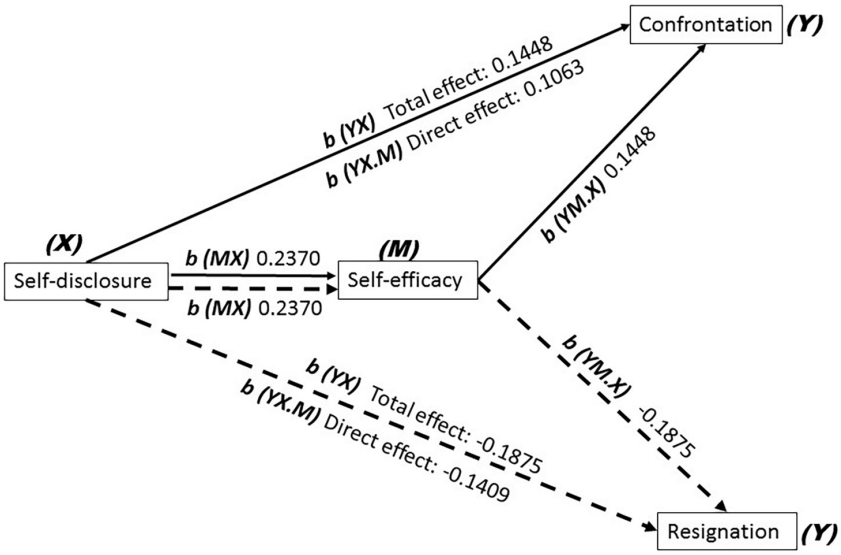

FIGURE 2
On admission, *Confrontation* and *Resignation* coping strategies of adolescents with depression were, respectively used as *Y*, and mediation analysis results showed that *Model b (YX)* (total effect, $b = 0.1448$ for *Confrontation*, and $b = -0.1875$ for *Resignation*; both $p < 0.001$), *Model b (MX)* ($X -> M$, for both *Confrontation* and *Resignation*, $b = 0.2370$, $p < 0.001$), *Model b (YM.X)* ($M -> Y$, $b = 0.1448$ for *Confrontation*, and $b = -0.1875$ for *Resignation*; both $p < 0.001$), *Model b (YX.M)* ($X -> Y$, $b = 0.1063$ for *Confrontation* and $b = -0.1409$ for *Resignation*; both $p < 0.001$). The coefficient of indirect of *Confrontation* and *Resignation* was 0.0385 and −0.0466 ($X -> M -> Y$, for *Confrontation* and for *Resignation*).

mainly the choice of *Confrontation* and *Resignation*. Adolescents would need direct contact with the outside world, and long-term staying at home would have a great influence on emotion. The prolonged home confinement decreased social interactions with peers for children and adolescents (27, 28). They are compelled to lock themselves down comprehensively, and find it harder to articulate their feelings during the COVID-19 pandemic, which has caused a persistent influence on the mental health of children and adolescents and ultimately contribute to the occurrence of depressive symptoms (29). It was found in a domestic study that the occurrence of emotional difficulties in children and adolescents is much higher than that before the pandemic (30).

Previous studies have shown that disclosing depressive emotions could help release depression (6). Self-disclosure refers to the course by which persons open themselves up to others (31), and has long been identified as a key coping behavior in therapeutic situation (32). Several studies have demonstrated self-disclosure as a prerequisite for healthy adjustment (33). An individual with positive self-disclosure can have effective communication with the outside world (30). On the other hand, non-disclosure is often used to refer to non-expression, inhibition, or topic avoidance. A growing body of research documents that non-disclosure is associated with poor psychological adjustment and increased distress (34). The social-cognitive processing model of adjustment to stressors illustrates the impact of non-disclosure on emotional distress (34), which may undermine an individual's ability to confront others. A previous study has demonstrated the negative impact of non-disclosure of stress-related thoughts and feelings on depressive symptoms (35, 36). Disclosing stressful events and discussing related thoughts and feelings with others may present the opportunity to integrate the cognitive discrepancy by receiving new information and/or attaining appropriate support (37) which, in turn, may promote emotional adjustment.

Based on the definition of the coping strategies of stress and the coping theory, self-disclosure can be considered as a coping strategy when people disclose their problems and need to attain social support (38). Coping refers to how people try to deal with traumatic events or everyday stressful situations. It plays a crucial role in adolescence, which is a period during which individuals manage new challenges that can stand for Mayordomo-Rodríguez et al. (39). The previous study has reported that positive coping strategies were connected to a greater feeling of control over occurrences and the search for useful information to cope with difficulties (40). According to the stress-buffering model (41), a positive coping style offers buffering effects in the path of disease and psychological distress (42). Some researchers have confirmed that adopting a positive and effective coping strategy can reduce the psychological pressure on them (43), thus improving depression.

Generally, *Confrontation* is a positive coping strategy, while *Avoidance* and *Resignation* are negative coping strategies (44). The use of active coping is supportive of mental health (45),

which helps prevent depression (46). Avoidance coping strategy is oriented toward denying, minimizing, or else avoiding dealing directly with stressful requests and is closely linked to distress, and the use of *Avoidance*-coping strategy has been related to relapse among patients treated for depression (47). However, the course of depression among the participants was 2.18 ± 1.67 years, and there were fewer patients with recurrent depression. Therefore, the effect of self-disclosure on *Avoidance* was not found in the present study. The literature suggests that *Resignation* is related to depression (48, 49). *Resignation* as a negative orientation has a negative influence on stress and has been associated with an increase in depressive symptoms and poorer wellbeing, and reflects factors related to hopelessness and giving up (49). Consequently, self-disclosure was positively and negatively correlated with *Confrontation* and *Resignation*, respectively, in our study, which will help us understand the direct effect of self-disclosure on medical coping strategy.

The secondary findings demonstrated that self-efficacy partially mediated the relationship between self-disclosure and medical coping strategies. The previous study showed that the prerequisite for self-efficacy is authentic self-disclosure (18). A high self-disclosure may mean a high level of self-efficacy (50, 51). Self-efficacy refers to a person's faith about their ability to mobilize courses of action needed to achieve desired personal goals (52). Further, it is considered an influential motivational, cognitive, and affective determinant of student action, with a significant impact on their involvement, effort, persistence, self-regulation, and achievement (8). These features make self-efficacy a vital variable in controlling stress (8), and it is a protective factor against the influence of day-to-day stressors at school (53, 54). Moreover, a high level of self-efficacy is conducive for patients to take a positive coping strategy (55). *Confrontation* has been shown to be supportive of mental health (45) to protect against depression (46), and *Resignation* has been associated with an increase in depressive symptoms (49), respectively. In the present study, we also found that GSES was positively and negatively correlated with *Confrontation* and *Resignation*, respectively. All the literature above can explain fully the partial mediation of self-efficacy between self-disclosure and medical coping strategy.

Other findings of our current study included that the effect size for *Confrontation* and *Resignation* was 0.2659 and 0.2485, respectively. The previous study has reported that females had more frequent use of support-seeking and active coping strategies than males (56). However, the number of females in our study was more than that of males, therefore, it was reasonable that the effect size for *Confrontation* was higher than that for *Resignation* in our study.

There are some limitations to the present study. First, although the number of the recurrent and the first-episode depression, and the assessment of depressive symptoms were not provided, all participants who were diagnosed with moderate and major depression needed antidepressant medication, which means that their psychological state was assessed without knowing depressive symptoms to decrease the dependence on symptom scores and treatment or not, and there is no need to excessively increase the workload of nurses. Secondly, the effect of age range and gender differences on the pathway of the mediation was not discussed here, because what the whole children and adolescents were analyzed together will help us to take measurements of the effective intervention of the population. Thirdly, although the mediating effect size was very small in the present study, the previous study has reported that the ratio of the indirect effect to the total effect has been a popular measure in mediation analysis (57), and the ratio of indirect effect/total effect for *Confrontation* and *Resignation* was 0.2659 and 0.2485, respectively. Therefore, the mediation effect had been still reported. Finally, although our cross-sectional study did not determine the causality, and a longitudinal study design is better suited for confirming the relationship, the present study did provide evidence for medical coping strategies chosen in adolescents with depression.

Conclusion

In the present study, self-efficacy indeed played a partial mediating role in the effect of self-disclosure on medical coping strategies for adolescent depression during the COVID-19 pandemic. The use of a positive self-disclosure mechanisms may be necessary to promote improved self-efficacy and the use of active coping strategies.

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 study was approved by the Institutional Review Board of the Beijing HuiLongGuan Hospital. Written informed consent to participate in this study was provided by the participants or their legal guardian/next of kin.

Author contributions

YaW designed the study, led the statistical analyses, and drafted the manuscript. JS provided clinical coordination. DZ

and YoW finished the assessments. SW collected the clinical data. YQ and JG provided the input data. YaW and ZW secured funding for the present study. All authors approved the final manuscript for submission.

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Conflict of interest

The handling editor declared a shared affiliation, though no other collaboration, with several of the authors, YaW, JS, DZ, YoW, SW, ZW, YQ, and JG at the time of review.

Publisher's note

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Mental burden among Chinese undergraduate medical students: A prospective longitudinal study before, during, and after the COVID-19 outbreak

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Background: Increasing evidence indicated a clear association between COVID-19 pandemic and mental health. This study aimed to assess the dynamic change of mental burden during and after the COVID-19 outbreak and related predictive factors among Chinese undergraduate medical students.

Methods: This longitudinal survey was conducted among Chinese undergraduate medical students before, during, and after the COVID-19 outbreak. We focused on COVID-19 related mental burdens including psychological distress, stress reaction, and insomnia symptoms, and defined the sum score of the three specific mental burden indexes as the overall mental burden index. The prevalence of specific and overall mental burdens and their changing patterns at two phases of the pandemic (during vs. after the COVID-19 outbreak) were measured. In addition, multinomial logistic regressions were used to assess the associations between the psychosocial status before the pandemic and specific and overall mental burden changing patterns.

Results: Our findings showed that the prevalence of overall mental burden increased (from 27.46 to 37.28%) after the COVID-19 outbreak among the 863 Chinese undergraduate medical students who participated in the surveys at baseline, during, and after the COVID-19 outbreak. Specifically, the prevalence of stress reaction symptoms decreased (from 10.90 to 3.60%), while the rates of psychological distress (from 28.06 to 37.95%) and insomnia symptoms (from 12.54 to 20.71%) increased. Participants, with obsessive-compulsive symptoms, somatic symptoms, internet addiction, childhood adversity, stressful life events, and being neurotic were found to have a higher risk of developing mental burden in at least one survey (during or after the COVID-19 outbreak). Healthy family function and being extravert were found to positively impact mental burden.

Conclusion: Psychological distress, stress reaction and insomnia symptoms have been prevalent among Chinese undergraduate medical students during

the COVID-19 outbreak, and the prevalence of overall mental burden increased after the COVID-19 outbreak. Some students, especially those with the risk factors noted above, exhibited persistent or progression symptoms. Continued mental health care was in demand for them even after the COVID-19 outbreak.

KEYWORDS

COVID-19, undergraduate medical students, psychological distress, stress reaction, insomnia, longitudinal study

Introduction

In December 2019, the outbreak of the novel coronavirus disease (COVID-19) aroused global attention (1). Until 29th June 2022, 543,352,927 patients have been diagnosed globally and 6,331,059 died from COVID-19 (2). Despite the number of patients infected by COVID-19 is under control in China now (2), we are still fighting the virus. Compelling evidence suggested that the Chinese general population (3), especially healthcare workers (4), showed some mental health symptoms, including psychological distress, depression, anxiety, and insomnia during the COVID-19 outbreak in China. Medical students, whose majors are related to healthcare, have also reported that the risk of psychological problems such as anxiety, depression, and perceived stress increased during the COVID-19 outbreak (5) As a unique group, medical students faced profound challenges during the COVID-19 pandemic. For instance, the high contagiousness of the virus has made it challenging to continue regular lectures, which has affected the medical education process, based on lectures and patient-based education (6). Additionally, the availability of bedside teaching opportunities for medical students was constrained by the limited patient care due to the concentration on COVID-19 patients (7). Other challenge includes a fear that medical students may contract the virus while training and spread it to the community (8). It's also reported that medical students have increased stress during previous pandemics, such as the 2003 SARS outbreak in China, underscoring the need for additional support for them during public health crises (9). Therefore, it is necessary to explore the mental health status among medical students during the COVID-19 pandemic.

Increasing evidence indicated that the outbreak of COVID-19 affected mental health (10). Several two-wave studies have revealed that the rates of mental health symptoms changed (11, 12). Due to the ongoing epidemic, long-term longitudinal research on mental health across time is necessary. Previous studies have indicated that personality traits (13), with a prior history of mental illness (14, 15), internet addiction (16), and a stressful life environment (16, 17) are predictors for a broad range of COVID-19 related mental problems. But little is known about the associations between these different kinds of psychosocial status before the COVID-19 outbreak and mental burden at different stages of the epidemic.

From these observations, there are two questions to be explored. How is the dynamic change of mental burden during and after the COVID-19 outbreak among undergraduate medical students? Which factors can predict the dynamic change? Thus, leveraging a prospective cohort of undergraduate medical students in China, which has collected enriched information on psychosocial status before the COVID-19 outbreak and mental burden during and after the local COVID-19 outbreak, we aimed to assess the mental burden changing patterns during and after the COVID-19 outbreak and identify related predictive factors among undergraduate medical students in advance. It can provide more reference for mental health promoting during the COVID-19 pandemic or other infectious diseases.

Methods

Study sample

The study sample was retrieved from the ongoing health professional students' prospective health cohort concerning the psychosocial status of medical students at Sichuan University, China. We invited all undergraduates (2,483 in total) from West China School of Medicine and 2025 undergraduates (81.55%) completed the baseline questionnaires before the unprecedented COVID-19 outbreak (October 2019). During the COVID-19 outbreak in China, we invited all participants for a special assessment of the COVID-19 related mental health and 1,553 undergraduates participated in it from February 7th to 13th, 2020. After excluding 64 undergraduates without information about mental burdens, 1,489 undergraduates (73.53%) were included. During the COVID-19 remission stage in China, 870 undergraduates who volunteered to come back to school after COVID-19 outbreak in China were surveyed from May 6th to June 6th, 2020. After excluding 7 undergraduates

without information about mental burdens, 863 undergraduates (42.62%) were included.

The purpose of our assessment was to investigate the psychosocial status of all participating students, and we included data from all undergraduates who have completed the related questionnaires. With a focus on mental burden changing patterns during the whole COVID-19 period, the analysis was restricted to 863 undergraduates who participated in the surveys at baseline, during, and after the COVID-19 outbreak (Figure 1). The questionnaire survey was conducted through a WeChat applet called Psyclub and approved by the Ethics Committee on Biomedical Research, West China Hospital of Sichuan University-2018 Annual Review (No. 535) and 2020 Annual Review (No. 734).

Measurements

Baseline psychosocial status

To observe the baseline psychosocial status, we collected mental health problems (obsessive-compulsive symptoms and somatic symptoms), mental health related behaviors (excessive internet use), environmental status (childhood adversity, stressful life events, and family function), and personality traits (personality and resilience) in October 2019.

All assessments were conducted using web-based, validated questionnaires. Specifically, the obsessive-compulsive subscale of SCL-90 was designed to assess the obsessive-compulsive symptoms. The instrument contained 10 related items and a score $\geq$2.0 was identified as possibly obsessive-compulsive disorder (18). We used Patient Health Questionnaire-15 (PHQ-15) to assess the severity of somatic symptoms during the past week (19). We identified a possible somatization disorder with a total score $\geq$5 (20). The 20-item Internet Addiction Test (IAT) was a measure of excessive use of the Internet, and its total scores range from 0-100 and a score $\geq$31 indicated the mild-above internet addiction (21). Childhood adversity, recent life events, family functioning, and resilience were assessed by the Childhood Trauma Questionnaire-Short Form (CTQ-SF) (22), Adolescent self-rating life events check-list (ALSEC) (23), General functioning subscale of Family Assessment Device (FAD) (24), and the Ego-Resiliency Scale (ER-89) (25), respectively. In addition, the 60-item NEO-Five Factor Inventory (NEO-FFI) was applied to assess the five broad personality domains of neuroticism, extraversion, openness, agreeableness, and conscientiousness (26). Each dimension had 12 items, and its total scores were dichotomized into low and high by the median.

Specific mental burden

To explore the COVID-19 related mental burden of participants, we focused on three symptoms, psychological distress, stress reaction, and insomnia, which were the most observed mental health outcomes during the COVID-19 outbreak in healthcare personnel (27). In this study, they were considered as specific mental burdens. Each significant symptom of the below three was defined as 1 point, while non-significance was 0 point, considered as a specific mental burden index.

Psychological distress during and after the COVID-19 outbreak was assessed using the Kessler 6-item Psychological distress Scale (K6). K6 was designed to access the severity of mood disorder symptoms, including major depression and generalized anxiety disorders during the past month (28). The K6 was composed of 6 items, and each item was designed with a 5-point scale (0 = never, 4 = all the time). The total score ranged from 0 to 24 points, and more than 5 points were considered as clinically significant psychological distress. The Cronbach's alpha for the survey during and after the COVID-19 outbreak were 0.91 and 0.93, respectively.

Stress reactions, including COVID-19 related intrusion, avoidance, and hyperarousal symptoms were evaluated by the Impact of Event Scale-Revised (ISE-R). The ISE-R included 22 items, and each item was designed with a 5-point scale (0 = not at all, 4 = extremely). Those with a total score over 24 were considered as significant COVID-19 related stress (29). The Cronbach's alpha for the surveys during and after the COVID-19 outbreak were 0.92 and 0.93, respectively.

Insomnia symptoms were evaluated by the Insomnia Severity Index (ISI). The 7-item ISI measured the self-perceived insomnia symptoms and mental burden degree caused by insomnia during the past two weeks (30). Each item was rated on a five-point Likert scale, and those with a total score over 8 were considered as clinically significant insomnia. The Cronbach's alpha for the surveys during and after the COVID-19 outbreak were 0.86 and 0.86, respectively.

Overall mental burden

Besides the above three specific mental burdens, we also developed a rule to evaluate the overall mental burden. The sum score of the above three specific mental burden indexes, ranging from 0–3, was defined as the overall mental burden index, and more than 0 was considered as a significant overall mental burden.

Ascertainment of specific mental burden changing patterns

Evidence indicated there were long-term mental health effects of COVID-19 among healthcare workers (31), and mental health problems increased during remission compared with during the onset of the COVID-19 outbreak (17, 32). In order to clarify the dynamics of COVID-19 related mental burden and to find students who are in stable high, aggravated, recovering

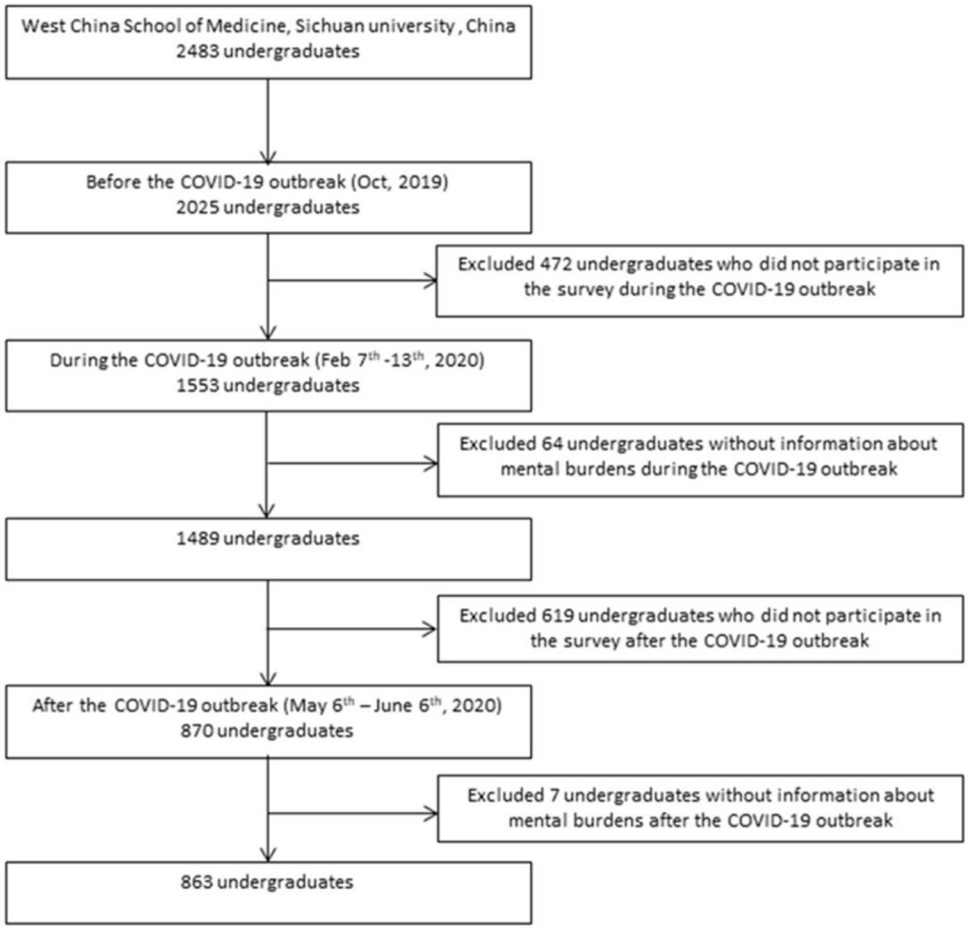

FIGURE 1
The study flow chart.

or stable mild levels, we categorize the entire student population into different groups. We then refer to prior studies (32) to further summarize four changing patterns including persistence, progression, regression, and resilience patterns. To explore the dynamic changes of COVID-19 related mental burden, we defined four specific changing patterns of psychological distress, stress response, and insomnia symptoms by comparing the specific mental burden index during (Feb 2020) and after (May 2020) the COVID-19 outbreak. The four changing patterns include persistence pattern (specific mental burden index was both 1 during and after the COVID-19 outbreak), progression pattern (specific mental burden index was 0 before but 1 after), regression pattern (specific mental burden index was 1 before but 0 after), and resilience pattern (specific mental burden index were both 0).

Ascertainment of overall mental burden changing patterns

As for overall mental burden changing patterns, the persistence pattern was assigned when the overall mental burden index during and after the COVID-19 outbreak was equal and both greater than 0. Progression pattern referred to an increase in overall mental burden index (i.e., the sum score measured after the COVID-19 outbreak was higher than that during the COVID-19 outbreak), while regression pattern was defined as the opposite condition (i.e., a decrease in overall mental burden index). Resilience pattern was considered when the overall mental burden index during and after the COVID-19 outbreak were both 0.

Covariates

Participants provided demographic information on their age, gender, maternal and paternal educational level, and maternal and paternal occupations. Besides, family environment [from urban (yes or no), having siblings (yes or no) and being a left-behind child (yes or no)], school life [training program (medicine, medical technology or nursing)] and physical condition [body mass index (BMI) (calculated and classified into <18.5, 18.5 to <22.9 (reference), 23.0 to <27.5, and ≥ 27.5 kg/m^2)] were surveyed.

COVID-19 related infection condition

Be infected with COVID-19 were more likely to have psychological issues (33, 34). To explore the infection condition, we have surveyed whether these students and their relatives had a COVID-19 infection or not in February 2020.

Statistical analysis

First, we examined the characteristics of all participants and participants in different overall mental burden changing patterns *via* one-way ANOVA (for continuous variables) and Chi-square test (for categorical variables). To explore the loss to follow-up bias, we also compared the differences of characteristics of the loss and the including students. Then, we calculated the prevalence of each specific and overall mental burden during and after the COVID-19 outbreak and in different changing patterns, as well as comparing the differences among three specific mental burdens. Multinomial logistic regressions were used to assess the associations between the baseline psychosocial status and specific and overall mental burden changing patterns, in which the resilience pattern was used as the reference category. Odds Ratios (ORs) with 95% confidence intervals (CIs) were provided. All models were adjusted for demographic information, including age, gender, maternal and paternal educational level, maternal and paternal occupations, family environment, including from urban, having siblings, and being a left-behind child, school life, including training program, and physical condition, including BMI. Additionally, we applied the dose-response analysis to assess the association between the number of identified risk factors and overall mental burden changing patterns. Similarly, the resilience pattern was used as the reference category.

Results

Characteristics

The mean age of the total 863 participants whose majors included medicine, medical technology, and nursing was 20.62 years (Table 1). Among them, 61.65 were females, 68.60% were from urban areas, 60.83% were the only child of their family, and 13.79% were left-behind children. Most of their parents owned middle school education level (paternal: 46.81%; maternal: 48.09%) and white-collar occupation (paternal: 38.93%; maternal: 30.71%). Furthermore, there was no difference ($p > 0.01$) among participants in different overall mental burden changing patterns. None reported COVID-19, while 10 (1.15%) had at least one relative infected. When we compared the differences of the characteristics of the loss and the including students, Results indicated that there were significant differences ($p < 0.01$) in age, training program, whether from urban or not, parental educational level and occupation (Supplementary Table S1).

Overall mental burden changing patterns

There was an increase in the prevalence of significant overall mental burden (from 27.46 to 37.28%) after the outbreak, representing over one-third of participants experienced significant mental burden after the COVID-19 outbreak (Table 2). As for overall mental burden changing patterns, participants in persistence pattern, progression pattern, regression pattern, and resilience pattern were 11.72% (99/863), 25.56% (216/863), 15.74% (133/863), and 46.98% (397/863), respectively.

Specific mental burden changing patterns

As for specific mental burdens, we observed an increase in the prevalence of self-reported significant psychological distress (from 28.06% to 37.95%) and insomnia (from 12.54% to 20.71%) after the COVID-19 outbreak. By contrast, the prevalence of significant stress reaction decreased from 10.90% to 3.60% after the outbreak. Furthermore, there were significant differences ($p < 0.01$) among participants experienced three specific mental burdens during and after the COVID-19 outbreak and in different changing patterns.

For psychological distress, 18.98% of participants were in the persistence pattern, which is equivalent to the proportion in the progression pattern. For insomnia, 8.17% and 12.54% of participants were in persistence and progression patterns, respectively. For stress reaction, 1.97% and 1.62% of participants were in persistence and progression patterns, respectively.

Predictive factors of mental burden changing patterns

For overall mental burden, with obsessive-compulsive symptoms (OR 3.21, 95% CI 1.99–5.20), somatic symptoms (OR 2.84, 95% CI 1.72–4.67), internet addiction (OR 2.96, 95% CI 1.80–4.86), childhood adversity (OR 3.01, 95% CI 1.83–4.93), stressful life events (OR 3.44, 95% CI 2.10–5.65) and being neurotic (OR 2.92, 95% CI 1.80–4.74) at baseline were positively associated with being in the persistence pattern (Table 3). These predictive factors were also associated with being in the progression and regression pattern, which indicated that the likelihood of developing any mental burden symptoms in at least one wave ("non-resilience pattern") would increase if the students endorsed these risk factors before the COVID-19 outbreak. On the contrary, healthy family function

TABLE 1 Characteristics of the 863 undergraduate medical students[a].

	Total *n* (%)	Persistence pattern *n* (%)	Progression pattern *n* (%)	Regression pattern *n* (%)	Resilience pattern *n* (%)	F/χ^2	df	*p*
Characteristics	863 (100)	99 (11.47)	216 (25.02)	133 (15.41)	397 (46.00)			
Age, years (M ± SD)	20.62 ± 1.45	20.53 ± 1.41	20.50 ± 1.41	20.76 ± 1.42	20.60 ± 1.45	1.01	844	0.89
Gender								
Female	532 (61.65)	64 (64.65)	135 (62.5)	84 (63.16)	239 (60.2)	0.92	3	0.82
Male	331 (38.35)	35 (35.35)	81 (37.5)	49 (36.84)	158 (39.8)			
BMI, kg/m^2								
<18.5	148 (17.15)	15 (15.15)	41 (18.98)	19 (14.29)	69 (17.38)	14.51	9	0.11
18.5–22.9	533 (61.76)	64 (64.65)	143 (66.2)	83 (62.41)	232 (58.44)			
23.0–27.5	146 (16.92)	16 (16.16)	23 (10.65)	22 (16.54)	83 (20.91)			
>27.5	36 (4.17)	4 (4.04)	9 (4.17)	9 (6.77)	13 (3.27)			
Training program								
Medicine	401 (46.47)	44 (44.44)	93 (43.06)	62 (46.62)	191 (48.11)	2.61	6	0.86
Medical technology	330 (38.24)	38 (38.38)	90 (41.67)	48 (36.09)	150 (37.78)			
Nursing	132 (15.3)	17 (17.17)	33 (15.28)	23 (17.29)	56 (14.11)			
From urban								
Yes	592 (68.6)	62 (62.63)	141 (65.28)	103 (77.44)	271 (68.26)	7.52	3	0.06
No	271 (31.4)	37 (37.37)	75 (34.72)	30 (22.56)	126 (31.74)			
Having siblings								
Yes	338 (39.17)	47 (47.47)	93 (43.06)	43 (32.33)	151 (38.04)	6.99	3	0.07
No	525 (60.83)	52 (52.53)	123 (56.94)	90 (67.67)	246 (61.96)			
Being a left-behind child								
Yes	119 (13.79)	15 (15.15)	35 (16.2)	18 (13.53)	47 (11.84)	2.50	3	0.48
No	744 (86.21)	84 (84.85)	181 (83.8)	115 (86.47)	350 (88.16)			
Paternal educational level								
Primary school	102 (11.82)	13 (13.13)	35 (16.2)	16 (12.03)	35 (8.82)	17.45	6	0.01
Middle school	404 (46.81)	39 (39.39)	106 (49.07)	50 (37.59)	200 (50.38)			
College and above	357 (41.37)	47 (47.47)	75 (34.72)	67 (50.38)	162 (40.81)			
Paternal occupation								
White collar	336 (38.93)	33 (33.33)	81 (37.5)	59 (44.36)	156 (39.29)	10.31	15	0.80
Blue collar	141 (16.34)	17 (17.17)	33 (15.28)	21 (15.79)	66 (16.62)			
Farmers	130 (15.06)	17 (17.17)	35 (16.2)	18 (13.53)	58 (14.61)			
Self-employed	132 (15.3)	13 (13.13)	32 (14.81)	17 (12.78)	68 (17.13)			
Unemployment	53 (6.14)	10 (10.1)	16 (7.41)	8 (6.02)	17 (4.28)			
Other	71 (8.23)	9 (9.09)	19 (8.8)	10 (7.52)	32 (8.06)			
Maternal educational level								
Primary school	167 (19.35)	23 (23.23)	45 (20.83)	21 (15.79)	74 (18.64)	12.51	6	0.05
Middle school	415 (48.09)	42 (42.42)	113 (52.31)	54 (40.6)	197 (49.62)			
College and above	281 (32.56)	34 (34.34)	58 (26.85)	58 (43.61)	126 (31.74)			
Maternal occupation								
White collar	265 (30.71)	27 (27.27)	51 (23.61)	57 (42.86)	124 (31.23)	23.30	15	0.08
Blue collar	137 (15.87)	16 (16.16)	39 (18.06)	20 (15.04)	60 (15.11)			
Farmers	147 (17.03)	20 (20.2)	40 (18.52)	13 (9.77)	72 (18.14)			
Self-employed	113 (13.09)	9 (9.09)	28 (12.96)	19 (14.29)	53 (13.35)			
Unemployment	109 (12.63)	13 (13.13)	34 (15.74)	11 (8.27)	51 (12.85)			
Other	92 (10.66)	14 (14.14)	24 (11.11)	13 (9.77)	37 (9.32)			

[a]18 (2.09%) individuals did not have the overall mental burden changing pattern indexes, because they missed the measurement of the Kessler 6-item Psychological distress Scale, the Impact of Event Scale-Revised, or the Insomnia Severity Index.

TABLE 2 Prevalence of the COVID-19 related mental burden during and after the COVID-19 outbreak.

	Overall Mental burden[a] Case, *n* (prevalence %)	Psychological distress[b] Case, *n* (prevalence %)	Insomnia[c] Case, *n* (prevalence %)	Stress reaction[d] Case, *n* (prevalence %)	χ^2	df	*p*
During the COVID-19 outbreak							
Significant	232 (27.46)	241 (28.06)	106 (12.54)	94 (10.90)	108	2	<0.01
Non-significant	613 (72.54)	618 (71.94)	739 (87.46)	768 (89.1)			
After the COVID-19 outbreak							
Significant	315 (37.28)	326 (37.95)	175 (20.71)	31 (3.60)	308.99	2	<0.01
Non-significant	530 (62.72)	533 (62.05)	670 (79.29)	831 (96.4)			
Changing Patterns							
persistence pattern	99 (11.72)	163 (18.98)	69 (8.17)	17 (1.97)	340.63	6	<0.01
progression pattern	216 (25.56)	163 (18.98)	106 (12.54)	14 (1.62)			
regression pattern	133 (15.74)	78 (9.08)	37 (4.38)	77 (8.93)			
resilience pattern	397 (46.98)	455 (52.97)	633 (74.91)	754 (87.47)			

[a]18 (2.09%) individuals did not have the overall mental burden changing pattern indexes, because they missed the measurement of the Kessler 6-item Psychological distress Scale, the Impact of Event Scale-Revised, or the Insomnia Severity Index.
[b]4 (0.46%) subjects missed the measurement of the K6 and were not included in the corresponding analysis.
[c]18 (2.09%) subjects missed the measurement of the ISI and were not included in the corresponding analysis.
[d]1 (0.12%) subject missed the measurement of ISE-R and was not included in the corresponding analysis.

(OR 0.41, 95% CI 0.25–0.67) and being extravert (OR 0.44, 95% CI 0.27–0.72) were negatively associated with being in the persistence pattern. These predictive factors were also negatively associated with being in the progression and regression pattern, which indicated that the likelihood of developing any mental burden symptoms in at least one wave ("non-resilience pattern") would decrease if the students endorsed these protective factors before the COVID-19 outbreak. Similar results were observed in psychological distress, insomnia, and stress reaction changing patterns (Supplementary Table S2).

Dose-response relationships were observed between the number of identified psychosocial risk factors (obsessive-compulsive symptoms, somatic symptoms, internet addiction, childhood adversity, stressful life events, and neuroticism) and overall mental burden changing patterns (Table 4). The higher number of identified psychosocial risk factors, the higher risk of being in the overall mental burden persistence pattern, regression pattern, and progression pattern were observed.

Discussion

To our best knowledge, this is the first study to explore the changing patterns of COVID-19 related mental burden and its predictive factors among Chinese undergraduate medical students using 3-wave data before, during, and after the COVID-19 outbreak. Our findings showed that the prevalence of overall mental burden increased after the COVID-19 outbreak. Specifically, the prevalence of stress reaction symptoms decreased, while the rates of psychological distress and insomnia symptoms increased from the COVID-19 outbreak to the COVID-19 remission stage in China. The study revealed four changing patterns of mental burden, i.e. persistence pattern, regression pattern, progression pattern, and resilience pattern. Multiple factors, including obsessive-compulsive symptoms, somatic symptoms, internet addiction, childhood adversity, stressful life events, and being neurotic were significant risk factors for overall mental burden persistence pattern, regression pattern, and progression pattern among medical students. Healthy family function and being extravert were significant protective factors of them.

Evidence supported that mental health problems increased during remission compared with during the onset of the COVID-19 outbreak (17, 32). Consistent with previous studies, our study also indicated that the proportion of significant overall mental burden increased after the COVID-19 outbreak. Notably, among the medical students who participated in both surveys, the prevalence of psychological distress (from 28.06% to 37.95%) and insomnia (from 12.54% to 20.71%) increased after the COVID-19 outbreak. This inverse increase phenomenon of psychological distress and insomnia was consistent with previous studies about mental health during the COVID-19 pandemic (17) and longitudinal trajectories of insomnia symptoms among college students (32), respectively. Consistent with related previous studies on college students, our results also indicated that the prevalence of stress reaction symptoms decreased (17). It is expected that the prevalence of acute stress reduced following the epidemic since the

TABLE 3 Predictors associated with the overall mental burden changing patterns of the 863 undergraduate medical students[a].

	Persistence pattern OR (95% CI)	Progression pattern OR (95% CI)	Regression pattern OR (95% CI)	Resilience pattern OR (95% CI)
Obsessive-compulsive symptoms	3.21 (1.99–5.20)	2.71 (1.88–3.90)	2.89 (1.88–4.47)	Ref.
Somatic symptoms	2.84 (1.72–4.67)	3.37 (2.32–4.91)	2.64 (1.71–4.07)	Ref.
Internet addiction	2.96 (1.80–4.86)	1.78 (1.25–2.54)	1.96 (1.28–2.98)	Ref.
Childhood adversity	3.01 (1.83–4.93)	2.28 (1.58–3.28)	2.36 (1.52–3.66)	Ref.
Stressful life events	3.44 (2.10–5.65)	2.76 (1.93–3.96)	3.19 (2.07–4.89)	Ref.
Family functioning	0.41 (0.25–0.67)	0.43 (0.30–0.62)	0.27 (0.17–0.43)	Ref.
Resilience	0.66 (0.40–1.08)	0.89 (0.62–1.27)	0.83 (0.55–1.27)	Ref.
Neuroticism	2.92 (1.80–4.74)	2.13 (1.49–3.04)	2.56 (1.67–3.90)	Ref.
Extraversion	0.44 (0.27–0.72)	0.68 (0.48–0.97)	0.56 (0.37–0.86)	Ref.
Openness	0.78 (0.48–1.28)	0.79 (0.55–1.13)	0.72 (0.47–1.12)	Ref.
Agreeableness	0.65 (0.39–1.06)	0.81 (0.56–1.16)	0.84 (0.55–1.29)	Ref.
Conscientiousness	0.78 (0.48–1.28)	0.92 (0.64–1.31)	0.98 (0.65–1.49)	Ref.

[*] *OR*, odds ratio; *CI*, confidence interval; *Ref*, reference.
[a] 18 (2.09%) individuals did not have the overall mental burden changing pattern indexes, because they missed the measurement of the Kessler 6-item Psychological distress Scale, the Impact of Event Scale-Revised, or the Insomnia Severity Index.

IES-R is intended to measure stress reactions to traumatic events (35).

There are some possible explanations about the effect on mental health. For instance, being a medical student during a pandemic may be a stigma at this time due to the contact history with confirmed or suspected COVID-19 patients (36). Previous study also indicated COVID-19-related discrimination is associated with internalized stigma, which in turn predict psychological symptoms over time (37). Moreover, there is direct evidence that COVID-19 affected psychiatry problems and brain function. Previous studies indicated that children infected with COVID-19 were more likely to have psychological issues, such as affective disorders, somatic, internalizing, and externalizing problems by comparing the outcome in the children and pre-schoolers who had COVID-19 and those who did not (33, 34). The hypothalamic-pituitary-adrenal axis, which can interfere with different physiological processes throughout the early stages of development, was affected by the COVID-19 pandemic distress by increasing the creation and release of inflammatory mediators. This imbalance may cause problems with the immunological, endocrine, and nervous systems as well as an increased risk of developing psychiatric illnesses in later life (38). Our results on adolescents can help clear the outcome of COVID-19 on the next generation's mental health.

Previous studies identified that people with a prior history of mental illness are more likely to have greater psychological symptoms during the COVID-19 pandemic (14, 15). Consistent with these results, our study indicated that medical students with obsessive-compulsive symptoms and somatic symptoms were found to have a higher risk of developing mental burden in at least one survey (during or after the COVID-19 outbreak). As for obsessive-compulsive symptoms, those with obsessive-compulsive symptoms may be sensitive to a dangerous situation or a threatening situation (39, 40), resulting in more mental burden especially when exposed to the negative news about COVID-19. As for somatic symptoms, previous studies have reported a significant association between somatic symptoms and psychological outcomes during the COVID-19 pandemic (41, 42). It can be explained that somatic symptoms, such as dyspnea, cough, and headache, are easily confused with COVID-19 symptoms (43), thus increasing individual excessive health attention and even anxiety.

Worth noting that internet addiction was associated with elevated risks of distress and acute stress reaction during the COVID-19 outbreak in our previous finding (16). The current study further indicated that internet addiction was related to an increased risk of mental burden after the COVID-19 outbreak. We assumed that those with internet addiction tended to spend much time on social media, which may serve as a stress source via receiving COVID-19 related negative news from social network updates (44). Besides, to keep the medical education process on track during the lockdown, online lectures were frequently used. Excessive internet users will be less engaged in real life and more concentrated on the internet (45). Therefore, increasing other activities instead of internet use may promote mental health.

The role of environmental status, i. e., childhood adversity, stressful life events, and family function in mental health has already been evidenced in previous COVID-19 studies (16, 17). Our data showed that students with childhood adversity, having

TABLE 4 Dose-response analysis between the number of identified baseline psychosocial risk factors and overall mental burden changing patterns.

	OR (95% CI)[a]
Psychosocial risk factors = 1	
Persistence pattern	1.61 (0.45–5.70)
Regression pattern	1.75 (0.62–4.94)
Progression pattern	2.08 (0.81–5.33)
Resilience pattern	Ref.
Psychosocial risk factors = 2	
Persistence pattern	2.98 (0.91–9.77)
Regression pattern	4.08 (1.53–10.90)
Progression pattern	5.12 (2.09–12.54)
Resilience pattern	Ref.
Psychosocial risk factors = 3	
Persistence pattern	3.26 (0.98–10.81)
Regression pattern	5.05 (1.89–13.46)
Progression pattern	5.80 (2.39–14.11)
Resilience pattern	Ref.
Psychosocial risk factors = 4	
Persistence pattern	4.16 (1.25–13.86)
Regression pattern	5.67 (2.09–15.38)
Progression pattern	8.42 (3.44–20.59)
Resilience pattern	Ref.
Psychosocial risk factors = 5	
Persistence pattern	18.46 (5.50–62.00)
Regression pattern	10.66 (3.53–32.16)
Progression pattern	20.76 (7.98–54.00)
Resilience pattern	Ref.
Psychosocial risk factors = 6	
Persistence pattern	70.00 (15.96–306.89)
Regression pattern	67.63 (17.31–264.24)
Progression pattern	28.25 (7.51–106.25)
Resilience pattern	Ref.

[*] *Ref*, reference.

[a]Estimates were adjusted for age, sex, BMI, training program, family background, being the only child, being a left-behind child, paternal and maternal occupation, and paternal and maternal educational level.

stressful life events were significant risk factors for overall mental burden persistence pattern, regression pattern, and progression pattern, which was in line with the previous demonstration that a stressful environment was a risk factor for mental burden after trauma (46, 47). By contrast, it has been indicated that family support after trauma can protect survivors from developing psychological distress (48). Consistent with it, our findings confirmed family function was a protective factor for the mental health of undergraduate medical students after the COVID-19 outbreak. Students with stronger family functioning could receive more family support, promoting successful resiliency in the face of public health catastrophes (49).

Personality traits are predictors for a broad range of COVID-19 related mental problems. Specifically, neuroticism is a risk factor for mental health in the COVID-19 emergency (50), while extraversion is a protective factor (13). Consistent with these, our study further indicated that these two personality traits also influence the mental health status after the COVID-19 outbreak. Importantly, our study indicated undergraduate medical students with more identified psychosocial risk factors have higher risks of persistence and progression patterns of mental health burden. Therefore, we should preferentially offer psychological support and interventions to undergraduate medical students with multiple risk factors.

In sum, our study provides further information on COVID-19 related mental burden particularly among medical students. Mental burdens have been prevalent among them during the COVID-19 outbreak, and even the prevalence of overall mental burden increased during the COVID-19 remission stage in China. We has also identified related predictive factors of COVID-19 mental burden changing patterns, which can provide more reference for mental health preventing of other infectious diseases in the future. Importantly, Medical students were perceived as having professional training and extensive medical knowledge of COVID-19 (51), which raised their awareness of the threats and impending pressure in the early stages of the outbreak. Additionally, medical students were encouraged to participate in the prevention and control of the epidemic (52), which added further difficulties to their already demanding academic schedules. In fact, a recent study of ours found that healthcare students who were more psychologically distressed during the training stage ended up changing their career paths and choosing to work in non-medical industries instead (53). Thus, as a unique group facing so many challenges, continued mental health care was in demand for medical students, especially those with the risk factors noted above, even during the COVID-19 remission stage in China. Both family and medical schools should provide support to improve mental health status and take initiatives directed at reducing excessive internet use among medical undergraduates.

Strengths and limitations

There are several strengths to this study. First of all, this prospective longitudinal study made a unique contribution to the literature by examining mental burden changing patterns and related predictors among undergraduate medical students using 3-wave data before, during, and after the COVID-19 outbreak. Second, the prevalence of stress reaction declined but psychological distress and insomnia symptoms increased from the early epidemic stage to the remission stage were observed, implying the long-term influence of COVID-19 on mental health. Third, we found different kinds of risk factors for mental

burden, including mental health problems, behavior conditions, environmental status, and personality traits. Continued mental health care was in demand for those with the risk factors noted above, even after the COVID-19 outbreak.

Despite the strengths, some limitations should be considered in this study. First of all, we only included 863 students who voluntarily returned to school. Considering the small sample size and the possible selection bias, our study may not provide a thorough mental health profile of undergraduate medical students. Second, there may be some potential impact due to sample loss. More senior, medical technology students were included, perhaps because they had more graduation pressure or clinical work. Third, despite the effect of age, sex, BMI, training program, family background, being the only child, being a left-behind child and socioeconomic status have been adjusted for the analysis, residual confounding such as current location and ever having contact with COVID-19 confirmed patients remain due to the absence of application or collection. Finally, our studied cohort was composed of students at a single medical school. Further studies from more centers with larger samples are expected in the future.

Conclusion

Our findings indicate that psychological distress, stress reaction, and insomnia symptoms have been prevalent among Chinese undergraduate medical students during the COVID-19 outbreak, and the prevalence of overall mental burden increased after the COVID-19 outbreak. Some students, especially those with the risk factors noted above, exhibited persistent or progression symptoms. Future studies can focus on stress management and psychological interventions for those with multiple risk factors.

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 authors.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee on Biomedical Research, West China Hospital of Sichuan University-2018 Annual Review (No. 535) and 2020 Annual Review (No. 734). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

XL and SZ participated in the study design, data analysis, interpretation of findings, literature search, writing, implementation, and approval of the final manuscript. YL and WZ conceived and designed the study. JJ and YW participated in the study data analysis. All authors have approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2022.982469/full#supplementary-material

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Impact of the COVID-19 pandemic on children's mental health: A systematic review

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Background: The outbreak of COVID-19 in December 2019 has caused unprecedented disruption to the structure of children's daily lives due to school closures, online learning, strict social distancing measures, limited access to outdoor activities and many other restrictions. Since children are more susceptible to stress than adults and there is a growing concern about the potential debilitating consequences of COVID-19 for children's mental health, the present review aims to provide empirical evidence on the groups who are most at risk of mental health problems and uncover the risk and protective factors of children's mental health.

Methods: A systematic search was performed, in accordance with PRISMA guidelines, in the electronic databases Web of Science (including SSCI and A&HI) and EBSCOhost (including ERIC, MEDLINE and APA PsycArticles and APA PsycINFO), for any empirical studies published between January 2020 and February 2022 that focused on children ≤12 years old.

Results: An initial search identified 2,133 studies. A total of 30 studies fulfilled the inclusion criteria and were analyzed. The evidence showed that many children were affected by the COVID-19 pandemic and experienced internalizing and externalizing behaviors. Worsened child mental health outcomes reflected socioeconomic inequalities as most at-risk children had parents with low educational attainment, were from families of low socioeconomic status and lived in small homes. Key risk factors were identified, including unhealthy lifestyle behaviors (extended screen time, sleep disturbances and less physical activity), increased pandemic-related stressors among parents and deteriorated mental health of parents, which were directly or indirectly associated with the pandemic safety measures, such as home confinement or social distancing. Protective factors including parents' resilience, positive parent-child relationship and school connectedness in relation to children's mental health were reported.

Conclusion: The overall results highlight the urgent need for the implementation of tailor-made interventions for children with signs of internalizing and externalizing behaviors. Health promotion and prevention strategies by the government to maintain the mental health of children, particularly those from lower SES families who are at higher risk of worsened mental health are essential for post-pandemic policies.

KEYWORDS

COVID-19, mental health, internalizing behaviors, externalizing behaviors, children, systematic review

Introduction

The coronavirus disease of 2019 (COVID-19) has been a pandemic with destructive human, social and economic consequences since December 2019. In the absence of effective pharmaceutical interventions for the prevention and control of the novel coronavirus, stringent public health measures such as mask-wearing, strict social distancing, school and workplace closures as well as tough travel restrictions have been extensively implemented to mitigate the spread of COVID-19 (1, 2). Therefore, the pandemic has impacted people's daily lives with differential effects on various age groups (3).

Children are one of the groups who were unprecedently affected by the pandemic [i.e., temporary closure of daycare centers and schools, online homeschooling, limited access to recreational facilities and many other restrictions; (4–8)]. They experienced social isolation from peers, teachers, extended family and community which increases the risk of developing mental health issues such as anxiety and depression (9). In addition, with the disruption of their daily routine due to school closures, some children who are confined at home spend more time on using computers, iPhones or watching television but lack enough physical activities (10, 11). Prior studies found that excessive screen time negatively affected the cognitive and socio-emotional development of children (12, 13) and was associated with sleep disruption (14, 15) which aggravated the physical and psychological health of children (16).

As children have fewer personal resources than adults to cope with the sudden changes brought about by the pandemic (17), parents are the closest ones whom they turn to when unable to have direct contacts with other adults such as teachers and grandparents. However, during the pandemic, most parents have faced many challenges including financial difficulties (wages or salary reductions, job losses) and coping with parenting (working from home while taking care of children's homeschooling, managing their free time and dealing with their demands). Coupled with the parents' own needs but lacking sufficient support from either extended family, friends or other community organizations (18), high levels of parental stress can have a detrimental effect on children's physical and psychological health *via* parenting (19). Cheng et al. (18) found that parental stress predicted child abuse and neglect.

Since children's mental health is strongly related to their parents' mental health (20), with a recent study reporting that living with a parent with poor mental health increased the odds of poor child mental health (OR = 2.80, 95% CI 2.59–3.03) (21), parents are one of the key factors influencing the development of psychological problems in children (22). Given the increased stress and responsibilities of parents during the pandemic, children may have received insufficient adult support in their daily lives. The exposure to stressors can undermine children's neurobiological and socioemotional development (23). A study by the United Nations International Children's Emergency Fund (UNICEF) on 1,700 children and adolescents from 104 countries found that the brain development of children experiencing high levels of stress can be affected (24). With the escalating fear of contracting the disease and various risk factors, there was an increase in irritability, sleep disorders, anxiety and depression in children (7, 25–27).

Understanding how the pandemic undermines children's mental health is imperative as the effects can be long lasting (28). As argued by Henderson et al. (29), using Bronfenbrenner's ecological systems theory (EST) (30) can help better understand how the impact of the pandemic affects the mesosystem, exosystem, macrosystem and chronosystem which become risk factors for children's microsystem.

Till now, studies on children's mental health remain limited as most studies focus on either adolescents or adults (31, 32). Thus, designing suitable interventions to improve children's mental health becomes difficult without strong empirical evidence (33–35). This systematic review aimed to gather evidence on the current state of knowledge of the types of children who are at greater risk of mental health problems and the associated risk and protective factors for the pediatric population aged 12 years or below. Based on the timely evidence reported, the current review can inform policy makers, school administrators working in kindergartens and primary schools, researchers and healthcare providers and can prompt them to develop tailor-made interventions and devise relevant support programs to strengthen children's resources and help them cope with the risk factors that were identified in this review.

Methods

Search strategy

We searched the electronic databases of Web of Science and EBSCOhost including ERIC, MEDLINE, APA PsycArticles and APA PsycINFO, from January 2020 to February 2022. The Boolean operator was used in the search strategy, with "OR" and/or "AND" used to link search terms. The asterisk "*" was used as a wildcard symbol appended at the end of the terms to search for variations of those terms. We describe the complete search strategy below:

(a) "covid-19" OR "coronavirus" OR "2019-ncov" OR "SARS-CoV-2" OR "cov-19" OR "2019 pandemic" OR "pandemic."
(b) "mental health" OR "mental illness*" OR "mental disorder*" OR "psychiatric illness*" OR "depress*" OR "anxiety."
(c) "children*" OR "kids" OR "child*" OR "childhood."
(d) a AND b AND c;
(e) Remove duplicates from d (if any);

(f) Limit f to "full-text" and "academic journal."

In addition to electronic databases, the reference section of the included studies was hand-searched for additional relevant studies.

Eligibility criteria

Inclusion and exclusion criteria

The articles included in this review are original studies published in peer-reviewed journals in English. The following inclusion criteria were applied: (i) mental health outcomes quantitatively or qualitatively measured; (ii) children aged 12 years or below; (iii) cross-sectional or longitudinal designs; (iv) original empirical data. The exclusion criteria include: (i) studies published not in English; (ii) children with pre-existing mental health condition (e.g., anxiety disorder or neurodevelopmental disorder) or disability (e.g., cerebral palsy), those who are homeless and those with substance abuse problems) as our objective is to understand the impact of the pandemic on children's mental health, so excluding children with pre-existing mental health/ health issues can provide us with clearer results; (iii) interventions; (iv) case reports, case studies, reviews, meta-analyses, opinions, editorials, commentaries, letters to the editor and conference abstracts.

Selection of sources of evidence

The search of the Web of Science and EBSCOhost including ERIC, MEDLINE and APA PsycArticles and APA PsycINFO yielded a total of 2,133 records. Figure 1 presents the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart describing the search process and the reasons for exclusion in this review (36). Both authors

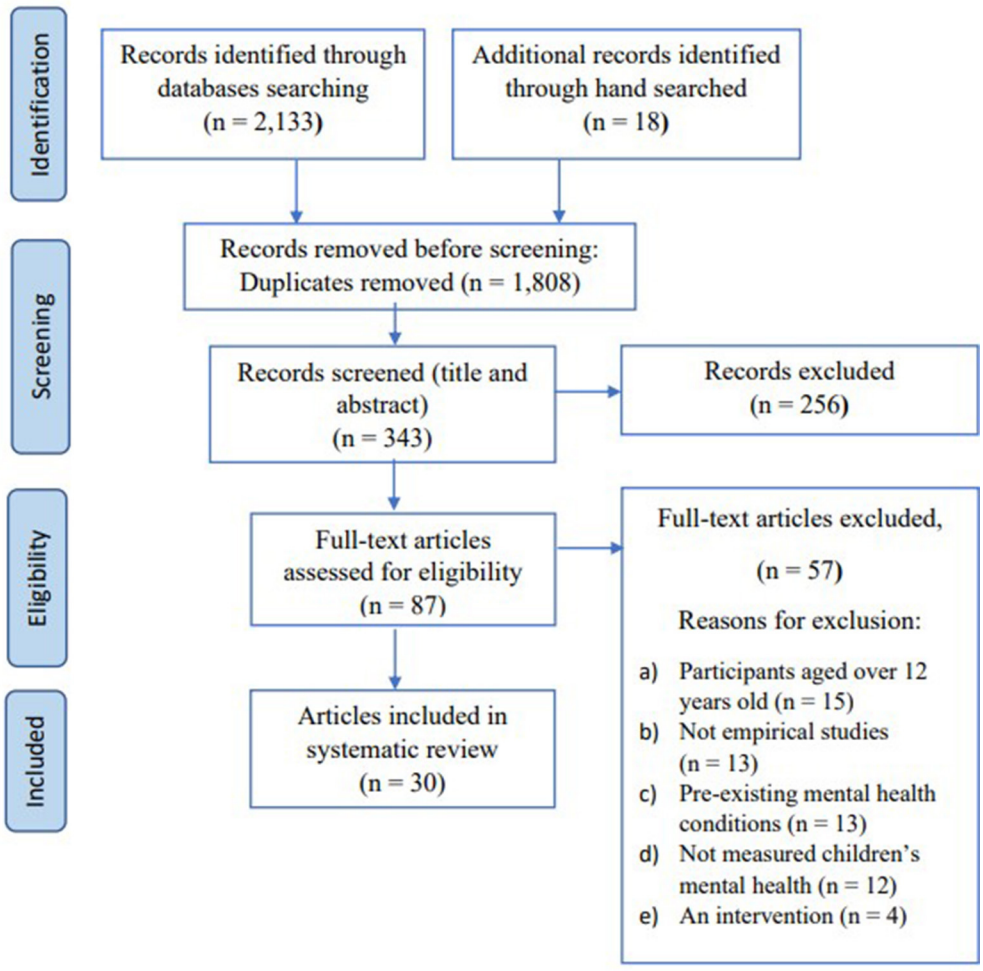

FIGURE 1
PRISMA flow chart outlining the study selection process.

(CSMN and SSLN) first screened all the titles and abstracts independently. We discussed the disagreements and revised the selection. Then SSLN reviewed the full-text articles and 20% of the full-text articles assessed for eligibility were reviewed by CSMN. The inter-rater reliability was 85%. Any disagreements were resolved through discussion and consensus.

Quality assessment, analysis and data synthesis

All the included articles were assessed in accordance with a reported structured questionnaire and its criteria (i.e., good, fair, poor and very poor) with detailed descriptions of the ratings (37). The results were shown in Supplementary Table A1. All the included articles were extracted under a structured frame (38) (i.e., study design, sample size, the selection of participants, measurements, key findings, limitations and implications).

Results

Overview of included studies

A total of 30 original studies were identified, subsequently analyzed and summarized (see Tables 1, 2 for basic information, findings and limitations of the studies). The included empirical studies were conducted globally, including North America (Canada and U.S.A.), Europe (Denmark, France, Germany, Italy, Norway, Portugal, Sweden, U.K.,), Asia (China, India, Israel, Japan, and South Korea) and Oceania (Australia). Cross-sectional designs were used in 19 studies whereas 11 studies were longitudinal. Data were collected between February 2020 and July 2021 through phone or online surveys. The sample size varied significantly, from 40 to 21,526 participants. Most of the scales [e.g., Strengths and Difficulties Questionnaire (SDQ), Screen for Child Anxiety Related Disorders (SCARED), Child Behavioral Checklist (CBCL) and Children's Sleep Habits Questionnaire (CSHQ)] were validated or widely published in empirical studies on those topics.

Study participants

Although children's mental health is one of the objectives of the current review, children were asked to complete surveys in three included studies only (50, 54, 59). The participants of the 30 included studies were mostly parents except Browne et al.'s study (41) which invited educators to assess children's mental health.

Children's mental health and other associated factors were mainly reported by parents. Among parents, mothers aged between 18 and 65 years were the main participants. Mothers were even the sole participants in seven included studies (43, 44, 47, 52, 53, 57, 65). Compared with mothers, the fathers' participation in research studies was low, so fathers were one of the respondents in ten included studies only [e.g., (32, 39, 45, 46, 48, 49, 51, 60–62, 64)]. Studies using both parent-child dyads as informants were also dearth (40, 45, 56, 58, 60).

Summary of the included studies

Children's mental health during COVID-19

The included studies assessed children's mental health by measuring the levels of internalizing (stress, anxiety, depression, anger, irritation, withdrawal, trauma-related symptoms) and externalizing behaviors (aggressive behaviors, hyperactivity/inattention problems, conduct problems) and the level of prosocial behavior. Based on the findings of the included studies, children's mental health was generally on the decline. Children exhibited more stress-related behaviors, anger, irritability, withdrawal symptoms, fear and anxiety (of COVID-19) and higher levels of depressive symptoms. Using repeated cross-sectional surveys before and after the onset of the pandemic, Moore et al. (59) examined the changes in mental health difficulties, life satisfaction, school connectedness and feelings about the transition to secondary school among children aged between 10 and 11 in Wales. The results showed that emotional difficulties increased from 17% in 2019 (prior to the pandemic) to 27% in 2021 among children (OR 1.65; 95% CI 1.23–2.20). Based on 432 parent participants, Moulin El-Aarbaoui et al. (32) reported that 7.2% of French children showed signs of emotional difficulties. In a large population-based study (n = 21,526) by Li et al. (55), 32.3% indicated mental health problems. Sama et al. (63) reported alarmingly high figures - 73.15 and 51.25% of Indian children showed signs of increased irritability and anger, respectively. Christner et al. (42) showed that over 50% of German children reported to be rather or clearly stressed, irritated or lonely during the lockdown.

Apart from internalizing behaviors, children also displayed more externalizing behaviors during the pandemic. Liu et al. (56) reported that the prevalence of behavioral problems among school-aged Chinese children varied from 4.7 to 10.3% while in home quarantine during the pandemic. Moulin El-Aarbaoui et al. (32) found that 24.8% had symptoms of hyperactivity/inattention. Table 3 summarizes the prevalence of mental health problems among children in the included studies. Overall, the results of the included studies consistently point to a decline in child wellbeing globally.

Types of children at greater risk of negative mental health outcomes

The results from the included studies demonstrate that there are some children at greater risk of internalizing or externalizing behaviors. Those children are: (1) only child in the family; (2) from parents with low education qualifications; (3) from

TABLE 1 Basic information of the 30 included studies.

Study No.	References	Country	Year of study	Study design	Participants	Child age M ± SD age range (AR)	% of boys (A)	Parent age M ± SD age range (AR)	% of mothers (B)	Mental health measures	Child mental health outcomes
1	Bate et al. (39)	USA	31 Mar—15 May 20	C	158 parents	8.73 ± 2.01years AR: 6–12 years	56%	39.14 ± 5.96 years AR: NR	96%	CRIES, PSC	Int, Ext, H/I, PTSD
2	Bhogal et al. (40)	USA	T1: May 20 T2: Aug 20	L	64 parent-child dyads	8.2 ± 0.7 years AR: 7–10 years	37.5%	NR	NR	PSC, FIVE	Int, Ext, Fears of illness, Fears about social distancing
3	Browne et al. (41)	Canada	T1: Dec 19–Jan 20 T2: Feb 20 T3: Mar 20	L	231 educators	5.69 ± 2.09 years AR: 3–12 years	54.2%	NR	NR	IRS, SDQ	Int, Ext
4	Christner et al. (42)	Germany	End of Apr–Early May 20	C	2,672 parents	NR AR: 3–10 years	NR	NR	NR	SCQ on Child's strain (stress, irritability or loneliness); KIDSCREEN-52, SDQ	Child's strain, Int, Ext, H/I,
5	Di Giorgio et al. (43)	Italy	1–9 Apr 20	C	245 mothers	4.1 ± 0.92 years AR: 2–5 years	52%	37.31 ± 4.61 years AR: 23–49 years	100%	PSQI, BRIEF-P, SDQ-P, DERS	H/I, Ext, EF, ER, Sleep,
6	Dollberg et al. (44)	Israel	Mid Mar–end of Apr 20	C	140 mothers	4.17 ± 0.87 years AR: 3–6 years	50%	35.55 ± 4.59 years	100%	CBCL	Int, Ext
7	Dubois-Comtois et al. (45)	Canada	18 Apr – 18 May 20	C	144 parent-child dyads	10.44 ± 1.09 years AR: 9–12 years	51.4%	40.1 ± 5.11 years AR: 27–59 years	91%	12-item Negative Experienced Aloneness Scale, CBCL, FCV-19S, YSR	Anx, Int, Ext, Child aversion to aloneness
8	Foley et al. (46)	Australia, China, Italy, Sweden, UK, USA	1 Apr—7 Jul 20	C	2,516 parents	5.77 ± 1.1 years AR: 3–8 years	52.1%	37.15 ± 5.39 years, AR: 21–65 years	81.5%	SDQ	Int, Ext, H/I

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TABLE 1 (Continued)

Study No.	References	Country	Year of study	Study design	Participants	Child age M ± SD age range (AR)	% of boys (A)	Parent age M ± SD age range (AR)	% of mothers (B)	Mental health measures	Child mental health outcomes
9	Frigerio et al. (47)	Italy	T1 (pre-pandemic): child aged 1 year T2 (pre-pandemic): child aged 3 years T3 (Lockdown): child aged 4 years	L	T1: 94 mothers T2: 88 mothers T3: 59 mothers	4.2 ± 0.61 years AR: NR	54.2%	T3: Mother: 37.17 ± 3.51 years	100%	CBCL	Anx/Dep, Ext, H/I, Int, Sleep
10	Gassman-Pines et al. (48)	USA	20 Feb–27 Apr 20 23 Mar–26 Apr 20 (Sub-sample)	C	645 parents	4.9 ± 2.6 AR: 2–7 years	50%	31.0 ± 7.0 years AR: NR	83.1%	SCQ	Int, Daily child uncooperative behavior, Child sad or worry, Sleep
11	Giannotti et al. (49)	Italy	20 Apr–18 May 20	C	602 parents	AR: 3–11years	47.3%	Mothers: 40.58 ± 6.47 years Fathers: 41.96 ± 6.43 years	87%	SDQ	Ext
12	Hyunshik et al. (50)	Japan	T1 (Pre-COVID-19): Oct 19 T2 (During COVID-19): Oct 20	L	T1: 301 T2: 290 children	T1: 3.6 ± 0.3 years T2: 4.8 ± 0.3 years AR: 3–5 years	T1: 52.9% T2: 52.2%	NR	NR	SDQ, SCQ on sleep duration	Int, Ext, H/I, Sleep
13	Kerr et al. (51)	USA	Apr 20	C	1,000 parents	6.17 ± 3.67 years AR: 0–12 years		36.5 ± 6.0 years AR: 21–64 years	88.7%	PROPS National Survey of Children's Health	Stress, Positive behaviors
14	Köhler-Dauner et al. (52)	Germany	Jul 20	C	91 mothers	6.03 ± 0.61 years AR: 5–7 years	52.7%	38.14 ± 4.08 years AR: 31–46 years	100%	SDQ	Int, Ext, H/I
15	Köhler-Dauner et al. (53)	Germany	T1: child at 3 months T2: child at 12 months, T3: child at age 3 18 May–31 Jul 20	L	73 mothers	6.03 ± 0.61 years AR: 4.98–7.14 years	52%	38.20 ± 4.06 years AR: 31–46 years	100%	SDQ	Int, Ext, H/I

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TABLE 1 (Continued)

Study No.	References	Country	Year of study	Study design	Participants	Child age M ± SD age range (AR)	% of boys (A)	Parent age M ± SD age range (AR)	% of mothers (B)	Mental health measures	Child mental health outcomes
16	Larsen et al. (54)	Norway	T1 and T2: Dec 17–Jul 19 T3: 1 Apr—25 May 20	L	422 children	11.43 ± 2.59 years AR: 7–11	45%	NA	NA	SCARED, SMFQ, Emotional and Somatic/cognitive reactions scales	Anx, Dep, Emotional reaction, somatic/cognitive reactions, worry reactions
17	Li et al. (55)	China	15–29 Mar 20	C	21,526 parents	5.21 ± 1.4 years AR: 3–12 years	52.41%	NR	NR	CSHQ SDQ	Total difficulty (Int, Ext, H/I), Sleep
18	Liu et al. 2021 (56)	China	25 Feb—8 Mar 20	C	1,264 parent-child dyads	9.81 ± 1.44 years AR: 7–12 years	55.9%	NR	NR	SDQ	Int, Ext, H/I
19	Mariani Wigley et al. (57)	Italy	18 May—4 Jun 20	C	158 mothers	8.88 ± 1.41 years AR: 6–11 years	48.1%	43.27 ± 4.20 years AR: NR	100%	PMK-CYRM-R SCQ	Child's individual resilience Stress-related behaviors include ✓ Difficulty standing still ✓ Concentration difficulties ✓ Nervousness and irritability ✓ Tendency to cry without reasons ✓ Difficulty in sleeping ✓ Restless sleep with frequent waking ✓ Refuse to eat ✓ Excessive food seeking
20	McArthur et al. (58)	Canada	T1: 2017–19 T2: May–Jul 20 T3: Jul–Aug 20	L	846 mother-child dyads	9.85 ± 0.78 years AR: 9–11 years	52.8%	NR	100%	BASC-3 MDI SCQ on duration of sleep	Anx, Dep, Subjective wellbeing, Sleep

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TABLE 1 (Continued)

Study No.	References	Country	Year of study	Study design	Participants	Child age M ± SD age range (AR)	% of boys (A)	Parent age M ± SD age range (AR)	% of mothers (B)	Mental health measures	Child mental health outcomes
21	Moore et al. (59)	Wales, UK	T1: Feb–June 19 T2: Apr–Jul 21	L	4,032 children	NR AR: 10–11 years	47%	–	–	MMSQ	Int, Ext
22	Moulin et al. (32)	France	24 Mar—28 Apr 20	C*	432 parents	6.8 ± 4.10 years AR: NR	51%	NR AR: 27–46 years	65%	SDQ, SCQ on sleep difficulties	Int, Ext, Sleep
23	Oliveira et al. (60)	Portugal	middle of Jun–end of Jul 20	C	110 parent-child dyads	9.09 ± 0.80 years AR: 7–11 years	50%	NR	85%	KIDSCREEN-27, SDQ	Int, Ext Health-related quality of life
24	Park et al. (61)	South Korea	24–28 May 20	C	288 parents	5.56 ± 3.31 years AR: 1–12 years	NR	NR	92%	SCQ	Anx, Dep, Loneliness, Stress, Physical and psychological health, Sleep
25	Robertson et al. (62)	USA	T1: Apr 20 T2: Jun 20 T3: Jul 20	L	286 caregivers	6.21 ± 4.93 years AR: 1–7 years	NR	34.31 ± 6.68 years AR: 18–54 years	79.4%	SDQ	Int, Ext
26	Sama et al. (63)	India	2020	C	310 parents	NR	57.7%	NR	NR	SCQ	Anx, dep, anger, irritation, Diet, Weight, Sleep, Quarrels, Frequency of illness
27	Specht et al. (64)	Denmark	T1: 20 Feb—11 Mar 20 T2: Apr 20	L	40 parents	5.0 ± 0.7 years AR: 3.5–6.8 years	45%	NR	82%	SDQ	Int, Ext, H/I

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TABLE 1 (Continued)

Study No.	References	Country	Year of study	Study design	Participants	Child age M ± SD age range (AR)	% of boys (A)	Parent age M ± SD age range (AR)	% of mothers (B)	Mental health measures	Child mental health outcomes
28	Thompson et al. (65)	USA	T1: Apr 20 T2: Oct 20	L	147 mothers	21.35 ± 8.47 months AR: 7.76–37.18 months	48%	26.93 ± 6.15 years AR: 18–43 years	100%	CBCL	Int, Ext
29	Wang et al. (66)	China	26 Jun−6 Jul 20	C	6,017 caregivers	NR AR: NR	54.6%	NR	NR	SDQ	Total difficulties (Int, Ext, H/I)
30	Wang et al. (67)	China	15–29 Mar 20	C	16,398 parents	4.69 ± 0.75 years AR: 3–6 years	51.9%	NR	NR	SDQ, CSHQ,	Int, Ext, H/I, Sleep

Child age, mean age ± SD; AR, age range; (A) represents the percentage of boys; (B) represents the percentage of mothers; L, Longitudinal study design; C, Cross-sectional study design; NR, Not reported; "-", not included in the study; C*, data collected from a longitudinal study; Anx, Anxiety; Dep, Depressive symptoms; Diet, Diet affected; Weight, Weight changed; EF, Executive functioning; ER, Emotion regulation; Int, Internalizing symptoms; Ext, Externalizing symptoms; H/I, Hyperactivity/Inattention; MH, Mental health; PTSD, Post-traumatic stress disorder; Sleep, Sleep quality.

BASC-3, Behavior Assessment System for Children; BRIEF-P, Behavior Rating Inventory of Executive Functions-Preschool version; CBCL, The Child Behavioral Checklist; CRIES, Child Revised Impact of Events Scale-13; CSHQ, Children's Sleep Habits Questionnaire; DERS, Difficulties in Emotion Regulation; FCV-19S, 7-item Fear of COVID-19 Scales 19S; FIVE, Fear of Illness and Virus Evaluation; IRS, Impairment Rating Scale; KIDSCREEN-27, Health-Related Quality of Life Questionnaire for Children and Adolescents 27-items; KIDSCREEN-52, Health-Related Quality of Life Questionnaire for Children and Adolescents 52-items; MDI, Middle Years Development Instrument; MMSQ, Me and My School Questionnaire; PMK-CYRM-R, Person Most Knowledgeable version of the Child and Youth Resilience Measure-Revised; PROPS, Parent-Report of Post-Traumatic Stress; PSC, 35-item Pediatric Symptom Checklist; PSQI, Pittsburgh Sleep Quality Index; SCARED, Screen for Child Anxiety Related Disorders; SCQ, Self-constructed questionnaire; SDQ, Strengths and Difficulties Questionnaire; SDQ-P, Strengths and Difficulties Questionnaire–Parent version; SMFQ, Short Mood and Feelings Questionnaire; YSR, Youth Self-Report.

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TABLE 2 The key findings and acknowledged limitations of included studies.

Study No.	References	Key findings extracted from included study	Acknowledged limitations
1	Bate et al. (39)	Positive parent-child relationship was a significant moderator between parents' and children's emotional health during the COVID-19 pandemic. Parents with lower education level, younger children and lower household income reported to have higher anxiety and depressive symptoms. Parental mental health was adversely influenced by COVID-19 impact.	The study was cross-sectional and correlational so it did not establish any causality regarding the relationship between parents' and children's emotional health. The samples were mostly White, middle-class and healthy individuals so the results cannot be generalizable to other populations. The study used self-report questionnaires which were subject to biased reporting.
2	Bhogal et al. (40)	When compared to children with higher SES, lower SES children reported more fears about social distancing. In addition, children's fear of illness increased over time during the pandemic which was independent of SES and race. Lower SES children reported more internalizing problems at baseline but decreased following home confinement.	The survey relied on surveys which was subject to biased reporting. With small sample size and most participants being Black Americans, the results cannot be generalizable to other populations.
3	Browne et al. (41)	Male children studying in early childhood education showed increased mental health problems before the announcement of the outbreak of the pandemic. After the announcement, their mental health problems deteriorated significantly. No differences over time were observed for female children.	The study had small sample size. The data were collected from childcare workers which may be subject to reporter bias. The two time points for data collection were close which could not study the long-term effects of the pandemic. The study did not collect data on the socioeconomic status of families.
4	Christner et al. (42)	Both children (>50%) and parents (31%) experienced high level of stress during the lockdown. Older children aged 7-10 years experienced more emotional symptoms but less conduct problems and hyperactivity than younger children aged 3–6 years. The level of stress was influenced by social isolation and housing conditions. More older children reported that they had more problems with their homework and they lacked sports and hobbies during the pandemic. Children from single-parent families showed more emotional symptoms. Only child showed more emotional symptoms and hyperactivity/inattention. Externalizing behaviors in children were associated with housing conditions.	The study used parental report which was subject to reporter bias. Since the study used online survey, there may be sample bias as only the participants who were accessible to good internet and technical devices joined the study. Cross-sectional study design did not allow to detect the long-lasting effects of the pandemic.
5	Di Giorgio et al. (43)	Worsening sleep quality predicted increasing emotional symptoms and self-regulation difficulties in both children and mothers. Mothers' trait emotional fatigue was associated with children's ability to control their behavior. During home confinement, parental time pressure, limited space for children to discharge energy and disruption of daily routines were the risk factors which contributed to negative children's psychological outcomes.	The small sample size reduced the statistical power. The sample was not representative. The study used retrospective questions to compare the current situation to a baseline before the outbreak which were subject to biases.
6	Dollberg et al. (44)	Mothers who experienced more anxiety symptoms perceived more children's externalizing and internalizing behaviors. Maternal anxiety symptom was a mediator of children's behaviors during the pandemic. Mothers with higher mentalization skills, i.e., higher mind-mindedness, weakened the indirect effect of anxiety on the link between COVID-19 and children's externalizing behaviors.	The limitations included a small sample size, concurrent data collection in each group and a reliance on mothers as the only source of information.

(Continued)

TABLE 2 (Continued)

Study No.	References	Key findings extracted from included study	Acknowledged limitations
7	Dubois-Comtois et al. (45)	Family factors such as parent-child relationship, parents' mental health and family dysfunction and chaos were strongly associated with children's psychological functioning. Greater depressive symptoms in parents and lower attachment security to parents were associated with higher internalizing problems in children. More family dysfunction and chaos and poor parent-child relationship predicted more externalizing behavior problems. Children's anxiety toward COVID-19 was associated with parents' anxiety of the pandemic and more child aversion to aloneness.	The design of the study was cross-sectional and no direction of effects could be made. The sample size was small. It might be likely that children answered the questions with the presence of family members so their responses might be influenced.
8	Foley et al. (46)	Familial risk factors such as parental distress, poor parent-child relationship and chaotic household predicted greater hyperactivity, emotional and conduct problems in children. Parental distress mediated the relationship between social disruption by the pandemic and child difficulties.	The convenience sample of parents from middle to high SES limited the generalizability of the findings. The reliance on online research designs during the pandemic increased selection bias and collider bias. Cross-sectional study design cannot be used to infer causality. Single informant might subject to reporter biases.
9	Frigerio et al. (47)	Children's internalizing and externalizing behaviors including emotional reaction, anxious-depression, withdrawal and aggression in preschool children were significantly increased during the lockdown. Greater maternal mood symptoms were significantly associated with the increase in children's internalizing and externalizing behaviors. Increased caregiving responsibilities due to the closure of childcare facilities triggered parenting hardships which adversely impacted maternal mood.	The study recruited a relatively small sample of mother-child dyads. Both maternal mood symptoms and children's problems were reported by mothers. The research design of the study did not allow to infer any causality of the association between maternal and children's wellbeing. Paternal mental wellbeing was not included in the analysis.
10	Gassman-Pines et al. (48)	Parents of vulnerable families reported higher frequency of daily negative mood since the outbreak of the pandemic. Parents' psychological wellbeing decreased during the post-COIVID-19 restrictions period. Parents' daily negative mood was significantly more frequent during post- than pre-restrictions. Those who experienced COVID-19-related hardships including unemployment, household income declines, caregiving burden and illness reported worse psychological wellbeing. Both caregiving burden and household illness were significantly associated with children's uncooperative behavior and worry.	The sample was limited to a vulnerable group of the population which was impacted by the pandemic. Therefore, the generalizability of the findings was limited.
11	Giannotti et al. (49)	There was higher level of parental stress particularly in mothers. There were heightened externalizing behaviors in children particularly younger boys during home confinement. Coparenting, being a mother, having younger child, less time to take care of the child and less feasibility to work remotely predicted parental stress. Child externalizing behaviors were predicted by gender (male), higher level of parental stress, less time devoted by parents to the child and the workload due to online learning.	Imbalanced sample size with more mothers compared to fathers. The participation in the study may be limited to parents who owned digital device and used social media. Cross-sectional study design did not allow us to understand the prolonged effects after the home confinement.

(Continued)

TABLE 2 (Continued)

Study No.	References	Key findings extracted from included study	Acknowledged limitations
12	Hyunshik et al. (50)	Physical activities, recommended screen time and prosocial behaviors decreased significantly. There was increased sedentary time and hyperactivity-inattention behaviors.	The study was targeted a specific age group and region in Japan so it limited generalization. Parents completed the questionnaires which might subject to reporter biases.
13	Kerr et al. (51)	Parents perceived more psychological impacts from the pandemic reported higher levels of parental burnout, more children's stress behaviors and less positive behavior in children. Family income moderated the relationship between parents' psychological impacts and children's stress behaviors.	The convenience sample limits the generalizability of the findings. The study was cross-sectional so it did not infer any causality. Reporter bias existed as the child behavior questions were retrospectively reported by parents.
14	Köhler-Dauner et al. (52)	Maternal depression significantly and fully mediated the relationship between maternal attachment representations and children's mental health during the pandemic. However, the indirect effect of maternal attachment representations on children's mental health before the pandemic through maternal depression did not reach any statistically significance.	The sample was limited to mothers of the birth cohort of mother-child dyads. Mothers retrospectively provided their responses regarding their own depressive symptoms and their children's mental health which might be affected by social desirability and their memory. The study consisted of a small sample size.
15	Köhler-Dauner et al. (53)	A high level of mothers' perceived daily stress during the pandemic was found. Children's hyperactivity level during the pandemic was closely associated with mothers' perceived daily stress before the pandemic. However, there was no significant relationship between mothers' perceived daily stress and children's behavioral problems.	The study consisted of small sample size and the samples were not representative. Retrospect and self-report bias existed.
16	Larsen et al. (54)	Home school experience, child perceived family stress and instability, missing friends and worry about virus infection were significantly associated with all three outcomes (children's emotional, somatic/cognitive and worry reactions). Family stress and instability were found to be the strongest predictors. Older children were found more adversely impacted during the pandemic.	Retrospective questionnaires might be subject to recall bias.
17	Li et al. (55)	Parental education, sleep disturbance, less physical activity, higher media exposure, non-parental care, poor parental mental health and harsh parenting were independently associated with increased child mental health problems regardless of SES.	Data collection was restricted to the participants with internet access only. The study used cross-sectional design which could not reflect a long-term impact of the pandemic on socioeconomic inequality. Parents self-rated their own mental health which may subject to bias and social desirability.
18	Liu et al. (56)	Home quarantine during COVID-19 pandemic increased behavioral problems and emotional symptoms in school-aged children. Children with physical activity had a lower hyperactivity-inattention risk and less prosocial behaviors problems. Parental anxiety was associated with increased risks of emotional symptoms and total difficulty in children.	The study used cross-sectional design which failed to infer causality. The potential self-selection bias in the study should be noted.
19	Mariani Wigley et al. (57)	The COPEWithME positively correlated with mothers' and children's resilience. The relationship between mothers' resilience and children's stress behaviors was mediated by the ability of mothers to support and promote child resilient behaviors in school-age children.	The study has the following limitations: cross-sectional design, convenient sampling, small sample size and no paternal responses.

(Continued)

TABLE 2 (Continued)

Study No.	References	Key findings extracted from included study	Acknowledged limitations
20	McArthur et al. (58)	Connection with caregivers (parent-child relationship), child sleep and their screen time were significant predictors of anxiety symptoms. On the other hand, connection with caregivers and screen time predicted depression. Connection with caregivers significantly predicted child happiness.	Selection bias existed because only mothers residing in an urban setting which was a portion of the cohort were recruited. Some child-reported variables were measured cross-sectionally.
21	Moore et al. (59)	When compared to pre-pandemic, elevated emotional difficulties among children were observed during the pandemic. The prevalence of emotional difficulties among girls was higher than boys. Children reported a high degree of school connectedness prior to and after the pandemic. Better teacher-pupil relationship predicted better mental health and life satisfaction. The positive feelings about the transition to secondary schools among children remained unchanged.	Cross-sectional study design could not detect the cause-and-effect direction. Significant cultural and social differences between countries may limit the generalizability of the findings.
22	Moulin et al. (32)	Children's psychological difficulties were associated with family financial difficulties, parental symptoms of anxiety and depression and the disruption of daily routine (i.e., children's sleeping difficulties and higher screen time exposure).	All measures were based on parents' self-report which was subject to bias and social desirability. There was no data on children's emotional difficulties and hyperactivity/inattention prior to the pandemic.
23	Oliveira et al. (60)	The lifestyles of children, in particular socioeconomically disadvantaged children, were characterized by a higher prevalence of sedentary behaviors (screen time) and fewer active leisure and playing activities. When compared with boys, girls engaged more in play and social activities, not physical activities. Protective factors such as regular sleep, active leisure, playing and learning activities and positive family coping strategies were linked to better child wellbeing.	The study used cross-sectional design which could not infer causality. The sampling did not allow for the generalization of the findings. Missing values, social desirability and recall bias (i.e., self-report) may have influenced the findings.
24	Park et al. (61)	The caregivers' childcare time increased significantly during the pandemic. For children, they spent significantly more time on online interactions and screen while time for face-to-face interactions and learning decreased significantly. The stress levels of both parents and children increased significantly during the pandemic.	Data were based on parents' self-report which was subject to recall bias and social desirability. The survey consisted of limited variables for the analysis. The sample was not representative as the online survey only reached the parents with access to the internet.
25	Robertson et al. (62)	Poor caregiver mental health at Time 1 predicted increased pandemic-related stress in caregivers at Time 2. Caregiver pandemic-related stress at Time 1 predicted the increase in internalizing problems in children at Time 2, which increased caregiver pandemic-related stress at Time 3. Poor mental health of caregivers at Time 2 was a predictor of increased child externalizing behaviors at Time 3.	The study did not use a standardized measure of resilience or measures of other risk factors which may affect the relationship between constructs. The study may not engage the vulnerable families which were most impacted by COVID-19 but may not have joined the study. The samples were from a large south-eastern city in the USA so the findings cannot generalize to other populations.
26	Sama et al. (63)	There was an increase in emotional problems (irritation, anger, anxiety and depression) in children during COVID-19. The correlation analyses showed that children's mental health was significantly related to increased screen time, sleep disorder, reduced outdoor activities, the area of their house, the number of children in the family, maternal education qualification and socio-economic status of their family.	The study did not include limitations.

(Continued)

TABLE 2 (Continued)

Study No.	References	Key findings extracted from included study	Acknowledged limitations
27	Specht et al. (64)	There was a change of emotional and behavioral functioning in children during COVID-19. Those children who had leisure time activities prior to lockdown showed greater changes in functioning than those who did not have. An increased externalizing behavior in children was found. The decline in mental wellbeing in children was potentially due to parental stress and other risk factors such as the loss of private space, room for active play and the socialization with peers.	The study used a small sample size which made it impossible to conduct interaction analysis across the sample. The follow-up was short (only 3 weeks). In addition, it is probable that parents remembered their previous answers at baseline which could have affected the results.
28	Thompson et al. (65)	COVID-19 health risk and contextual hardships worsen maternal mental health significantly. Deteriorated maternal mental health at COVID-T1 predicted children's adjustment problems, and the concurrent children's adjustment problems at COVID-T2 were predicted by the COVID-19 contextual hardship and changes in maternal mental health. Poor maternal resilience in coping with COVID-19 health risk and hardships was related to increased children's adjustment problems.	The samples were mothers with young children who lived in low income contexts so the samples limited the generalizability of findings to other populations. The study did not examine a broader set of resilience factor before the pandemic and so, some of the resilience factors were assessed together with mental health. This might have been biased by mothers' mental health status. The study did not include second caregivers to understand maternal and child adjustment during the pandemic.
29	Wang et al. (66)	Children whose caregivers with low education level, were from low SES families and male tended to have more emotional and behavioral problems. The COVID-19-related knowledge and precautions predicted lower emotional and behavioral problems among children and the relationship was partially explained by the emotional problems in caregivers.	The study was cross-sectional so it cannot infer causality. A self-report online survey was not representative as it restricted to those who could access the internet. COVID-19-related knowledge and precaution was assessed by a single-item scale.
30	Wang et al. (67)	A higher parental wellbeing index was associated with lower child mental health problems. Harsh parenting and child sleep problems significantly mediated the relationship between parental wellbeing and child mental health.	The data cannot differentiate the findings between urban and suburban areas. Several variables were assessed by one or two self-constructed items. Some information was retrospectively reported by parents who might be biased. Cross-sectional study design did not infer the direction of causality.

families of low socioeconomic status (SES); and (4) from a small size home.

Being the only child in the family puts a child at higher risk of mental health problems. Christner et al. (42) revealed that children without siblings experienced more emotional symptoms and hyperactivity/inattention than children with siblings. Sama et al. (63) found that there was a positive correlation between children's mental health (anxiety, depression, anger and irritation) and the number of children in the family ($r = 0.04$). Since Pearson's correlation was used, which merely provides an indication that there was a relationship between the two variables, and the p- value was not reported, whether the number of children in the family was a predictor of poor mental health for children requires further investigation.

Children of parents with low educational qualifications are also at greater risk of mental health issues. Four of the included studies observed significant links between parental education and children's mental health problems [e.g., (40, 48, 55, 66)]. Bhogal et al. (40) found that children of parents with lower educational qualifications were at higher risk of mental health difficulties by 40%. Li et al. (55) highlighted those children whose parents had low educational qualifications such as middle school or below had a 6% higher risk of mental health difficulties than those whose parents graduated from university. Similar findings were reported by Wang et al. (66) showing a higher prevalence of emotional and behavioral problems in children of caregivers with a lower educational level.

Children of low SES were also burdened by the effects of the pandemic. Bhogal et al. (40) found that children with

TABLE 3 Prevalence of children's mental health problems during the COVID-19 pandemic based on the 30 included studies.

Study No.	References	Prevalence of children's mental health problems	Stress	Anx.	Dep.	Int.	Ext.	H / I	PTSD
1	Bate et al. (39)	Hyperactivity: 18.4% Internalizing behaviors: 20.3% Externalizing behaviors: 18.4% PTSD: 15.8%				✓	✓	✓	✓
2	Bhogal et al. (40)	Fears of getting illness: 60%		✓					
4	Christner et al. (42)	Feeling stressed, irritated or lonely: 59%	✓						
5	Di Giorgio et al. (43)	Self-control Difficulties: (Before lockdown) 14.29% (During lockdown) 21.23%					✓		
10	Gassman-Pines et al. (48)	Child daily sad or worried (Pre-COVID-19 restrictions): 22.5% (Post-COVID-19 restrictions): 24.1% Child daily uncooperative behavior: (Pre-COVID-19 restrictions): 41.7% (Post-COVID-19 restrictions): 45.1%				✓	✓		
17	Li et al. (55)	Total difficulty (SDQ): 32.31% Male: 33.67% vs. Female: 30.82%				✓	✓	✓	
18	Liu et al. (56)	Internalizing behavior: 6.3% Externalizing behavior: 4.7% Peer problems: 6.6% Total difficulty (SDQ): 8.2%				✓	✓	✓	
20	McArthur et al. (58)	Anxiety symptoms: 13.8% Depressive symptoms: 8.2%		✓	✓				
21	Moore et al. (59)	Emotional difficulties: 2019: 17.5% vs. 2021: 27.4% Boys: 2019: 14.4% vs. 2021: 21.6% Girls: 2019: 20.3% vs. 2021: 29.5% Behavioral difficulties: 2019: 13.3% vs. 2021: 14.6%				✓	✓		
22	Moulin El-Aarbaoui et al. (32)	Emotional difficulties: 7.2%, Hyperactivity / Inattention: 24.8%				✓		✓	
24	Park et al. (61)	Nervousness: 17.4% Anxiety: 2.1% Depression: 2.1% Loneliness due to limited social interactions: 46.9%	✓	✓	✓	✓			
25	Robertson et al. (62)	Internalizing behavior: T1: 63.6% vs. T2: 37.4% vs. T3:43.7% Externalizing behavior: T1:63.3% vs. T2: 37.4% vs. T3: 43.7%				✓	✓		
26	Sama et al. (63)	Overall / Ludhiana / Sangrur / Ferozepur / Sangrur Anxiety 21.3% / 21.4% / 23.5% / 12.2% / 28.8% Depression 20.9% / 22.9% / 21.2% / 11.0% / 30.1% Quarrels 40.0% / 70.0% / 68.0% / 63.5% / 77.0% Signs of irritability 73.15% / 85.7% / 68.2% / 63.4% / 75.3% Anger 51.25% / 80.0%; / 58.8% / 53.7% / 75.3%		✓	✓	✓	✓	✓	
29	Wang et al. (66)	Emotional and behavioral problems (EBPs) Shanghai and Taizhou: 12.5% ✓ SDQ total difficulties (slightly raised): 7.2% ✓ SDQ total difficulties (high and very high): 5.3%				✓	✓	✓	

Anx., anxiety; Dep., Depressive symptoms; Int., Internalizing behaviors; Ext, Externalizing behaviors; H/I, Hyperactivity/Inattention; PTSD, Post-traumatic stress disorder.

low SES reported more fears about social distancing than their counterparts with higher SES. Moore et al. (59) found that children from low SES families reported an increase in emotional difficulties from 19.5 to 33.8%, compared to those from more affluent families who reported an increase from 11.7 to 18.5%. Li et al. (55) reported that Chinese children of low SES reported more mental health problems.

Sama et al. (63) found that the size of a child's home was associated with the mental health of children. It is likely that children in cramped living conditions are at greater risk of emotional and behavioral problems in cramped living conditions which may intensify conflicts among siblings or family members resulting in higher levels of psychological stress. Christner et al. (42) found that children living in an apartment reported higher hyperactivity/inattention (M = 4.38, SD = 2.33) than those with a large garden at home (M = 3.93, SD = 2.27).

Risk factors for children's mental health

Identifying the risk and protective factors is essential to understand why an unprecedented situation such as the COVID-19 pandemic is detrimental to children's mental health (40, 53, 65). Based on the 30 included studies, we identified the following risk factors:

Unhealthy lifestyle factors

Extended screen time

The temporary closure of schools and home confinement to mitigate the spread of COVID-19 translated to a sedentary lifestyle for children, including increased use of screen time and online interactions whereas face-to-face interaction time decreased significantly (68). Based on the cross-sectional data from Portuguese children studying in 3rd and 4th grade and their parents, Oliveira et al. (60) found that there was a higher prevalence of sedentary behaviors including TV and gaming/internet, i.e., activities that required a higher amount of screen time, particularly among socioeconomically vulnerable children. There were gender differences in screen time, with girls spending more time on watching TV and socializing online. Children from families with a negative socioeconomic change spent more time on watching TV and gaming/internet but less time on sleeping. Li et al. (55) assessed Chinese children's mental health problems in relation to factors including socioeconomic inequalities, lifestyle and family environment factors and found that media exposure (≥2 h per day) was independently associated with child mental health problems, regardless of SES.

Based on 846 mother-child dyads, McArthur et al. (58) reported that screen time predicted anxiety and depression in Canadian children. Those who engaged in excessive screen time reported higher levels of anxiety (Beta = 0.11; 95% CI 0.04–0.17) and depression (Beta = 0.09; 95% CI 0.02–0.16) after controlling for pre-pandemic anxiety and depression, respectively. French children with emotional difficulties or symptoms of hyperactivity/inattention reported more screen time (>1 h per day) during COVID-19 (32). It is worth noting that gaming/internet also predicted higher levels of externalizing behavior.

Although most included studies consistently found that there was an association between excessive screen time and children's mental health, Larsen et al. (54) found contradictory results. They did not find any association between the screen time and poor mental health outcomes in children.

Sleep disturbances

Of the 30 included studies, about one-third explored the association between sleep and children's mental health during COVID-19 (32, 43, 47, 48, 50, 55, 58, 61, 63, 67). With the closure of schools, home confinement and social isolation which led to significant changes in children's daily routines and activity patterns, children's sleeping patterns, such as sleep timing (delayed bedtime and rise time) and quality, were altered. Di Giorgio et al. (43) found that children's sleeping time has changed as they go to bed 53 min later and wake up about 66 min later than usual. Another study on 21,526 Chinese parents found that 74.7% parents said their children showed sleep disturbances in terms of bedtime resistance, sleep duration, sleep anxiety, sleep onset delay and night waking (55).

The quality of sleep impacted children's psychological wellbeing. Moulin El-Aarbaoui et al. (32) found that children's emotional difficulties and hyperactivity/inattention symptoms were significantly linked to sleeping difficulties. McArthur et al. (58) found that child sleep (Beta = −0.11; 95% CI −0.19−0.04) predicted anxiety. All the results point to the importance of sleep for children's psychological health.

Less physical activity

The existing literature supports the idea that physical activity is associated with many physical and mental health benefits across all age groups (69). Since children were forced to stay at home due to school closures and home confinement, the limited space at home as well as the restricted outdoor opportunities for children to be physically active were drastically reduced (70). Of the 30 included studies, eight studies (50, 55, 56, 58, 60, 61, 63, 67) examined the relations between physical activity and children's internalizing or externalizing behaviors. In an internet-based survey of 1,264 children, Liu et al. (56) found that when compared with children who did not do any physical activity, children with physical activity had a lower risk of hyperactivity-inattention (OR 0.44 for 1–2 days/week; OR 0.56 for more than 2 days/week) and fewer prosocial behavior problems (OR 0.65 for 1–2 days/week; OR 0.55 for more than 2 days/week). Overall, the results from the included studies consistently showed that there was a decrease

in physical activity among children during the pandemic and a decrease in outdoor playtime. This substantial impact on the level of physical activity of children may affect children's physical and mental health (50, 63).

Unfavorable family environment factors

Increased COVID-19-related stressors among parents/primary caregivers

Of the 30 included studies, thirteen studies examined the association between perceived parental stress and children's emotional and behavioral problems during the pandemic (42, 46, 49, 51, 53, 54, 57, 61–66). Parents experienced mounting pandemic-related stress and COVID-19 contextual hardship (65), including an increase in childcare responsibilities, greater home-schooling demands and worries about the balance between increased caring responsibilities and work, family financial instability, fear of the future and many other difficulties, therefore they had higher levels of worries, anxiety and even parental burnout (a syndrome characterized by overwhelming exhaustion and the feeling of lacking achievements as parents) (51), which is detrimental to children's mental health, as children are particularly sensitive to the emotional status of their parents (71). Köhler-Dauner et al. (53) found that there was a positive and significant effect of maternal perceived stress on children's emotional problems and hyperactivity and inattention behaviors. Kerr and colleagues (51) utilized path modeling to analyze cross-sectional data from 1,000 parents and reported that parents who perceived more psychological impacts from the pandemic reported higher levels of parental burnout and less positive behavior in their children. Robertson et al. (62) investigated 286 linguistically, racially and ethnically diverse caregivers and found that caregivers' pandemic-related stress at Time 1 predicted increased child internalizing symptoms at Time 2 which, in turn, predicted increased caregivers' perceived stress at Time 3. The findings based on longitudinal data provided strong evidence for the reciprocal relationship between caregivers' perceived stress and children's mental health. The results further gave prominence to what is highlighted by the family system theorists - families are interconnected and mutually influenced (72).

Noteworthy, parents' negative affect may have spillover effects on their children *via* parenting (19, 73). The results of a large meta-analysis showed that parents' negative emotions were associated with harsher discipline whereas positive emotions were associated with more supportive parenting (74). Based on a cross-sectional study on 1,264 primary school children, Li and colleagues (55) found that Chinese parents reported exerting harsh parenting (i.e., scolded their child by yelling or shouting to discipline their children and regulate their misbehavior) during the pandemic (aOR 2.06; 95% CI 1.91–2.23). Harsh parenting was independently associated with child mental health problems, regardless of SES.

Deteriorated mental health of parents

Child mental health is closely linked to the wellbeing of the family members (58). This fact is supported by many existing studies, which provide strong empirical evidence that maternal wellbeing predicts child wellbeing (75, 76). About one-fifth of the included studies examined how parents' mental health impacted children's internalizing and externalizing behaviors (32, 39, 44, 45, 55, 56, 66, 67). Wang et al. (67) stressed that better parental wellbeing was associated with a decrease in child mental health problems. Liu et al. (56) found that children with anxious parents were associated with higher levels of emotional symptoms (OR 5.64, 95% CI 2.18–14.58) and total difficulty (i.e., emotional symptoms, conduct problems, hyperactivity/inattention and peer relationship problems) (OR 3.78, 95% CI 1.56–9.15) than children without anxious parents. The findings from the multiple regression analyses showed that more parental depressive symptoms predicted children's internalizing behaviors during the lockdown (45).

The longitudinal data yielded similar results. Frigerio et al. (47) found that children's emotional and behavioral problems significantly increased from the period preceding the lockdown to the period during which the lockdown was taking place and greater maternal mood symptoms were associated with an increase in anxious-depressed, withdrawn and aggressive symptoms of children during the lockdown.

Protective factors for child mental health

Resilience of parents

COVID-19 is a good instance of traumatic stress which creates significant impacts on the parents' resilience to deal with many stressors outlined in the foregoing paragraphs. Of the 30 included studies, only two studies explored the relationship between parents' resilience and children's mental health (57, 65). In Mariani Wigley et al.'s study (57), mothers' resilience was positively correlated with children's resilience. The relationship between mothers' resilience and children's stress-related behaviors was mediated by the mothers' ability to support and promote children's resilient behaviors which influences children's positive adjustment in the face of stressful situations. Therefore, parents' resilience is vital to children's mental health.

Positive parent-child relationships

It is well documented that positive parent-child relationships, which are fostered by positive parenting and supportive parental behavior, can mitigate the child negative outcomes from stressors (77). Some of the included studies examined the association between parent-child relationship and child mental health problems (39, 45, 46, 58). For instance,

in Dubois-Comtois et al.'s study (45), closeness in the parent-child relationship was significantly negatively correlated with children's externalizing behaviors. Bate and colleagues (39) revealed that the emotional and behavioral health of children was moderated by positive parent-child relationships during the COVID-19 lockdown. McArthur et al. (58) found that child happiness during the COVID-19 pandemic was predicted by the connectedness to parents/caregivers (Beta = 0.36; 95% CI 0.28–0.39). In addition, lower levels of connectedness to parents/caregivers predicted child anxiety (Beta = −0.16; 95% CI −0.22 to −0.09) and depressive symptoms (Beta = −0.26; 95% CI −0.32 to −0.21) during COVID-19. Therefore, fostering positive parent-child relationships can help improve the mental health outcomes of children.

School factors

School connectedness

Schools cannot alleviate harms caused by the pandemic (59). However, they can play a crucial role in supporting children through maintaining virtual contacts throughout lockdowns and school closures. Therefore, school connectedness is important to children. School connectedness has been defined in many ways, but it encompasses engaging students academically and in school activities, having a sense of belonging and fairness, developing positive peer relationships as well as feeling supported by teachers and feeling secure at school (78). In Moore et al.'s study (59), surprisingly, there were no changes in school connectedness before and after the pandemic. The participating children reported that they had a good teacher-student relationship which was significantly associated with better mental health and life satisfaction.

Discussion

This systematic review aimed to identify the types of children at risk of developing mental health issues and summarize the risk and protective factors of children's mental health during the pandemic. Overall, the results of the 30 included studies consistently suggested that a negative impact of COVID-19 was observed on children's mental health who exhibited an increase in internalizing and externalizing behaviors. As the included studies were conducted in different countries, it is evident that children's mental health has become an area of concern globally.

Based on the 30 included studies, the worsened child mental health outcomes reflect socioeconomic inequalities. Parents with low education attainment tend to be employed in occupations that do not allow to work from home such as drivers, waiters/waitresses or supermarket workers. Their unstable income has been further affected by the pandemic resulting in either significantly reduced income or loss of employment. Financial insecurity is harmful to individuals' mental health as this can increase stress or anxiety which can worsen parenting practices leading to neglect or physical or verbal punishment or even abuse. Harsh parenting increases the risk of children's mental health problems. In addition, economically disadvantaged children normally live in crowded apartments. However, during the pandemic, housing has been a key determinant of health. Overcrowding and the size of private outdoor space play significant roles in how families adjust to social distancing restrictions and how to minimize the chance of contracting the virus from family members. It is not surprising that children living in cramped homes are more stressed (79). As Patel et al. (80) pointed out, "the pandemic has highlighted the stark inequalities within society, and it will likely exacerbate them" (p. 110). Now is therefore an opportune time for policy makers to introduce legislation to support those disadvantaged families.

Interestingly, being the only child in the family can be a risk factor. It is likely that larger household sizes mitigate some of the negative effects of social isolation, so the number of children in the household is protective of child mental health (81).

Using Bronfenbrenner's ecological systems theory (EST) (82, 83) as a lens enables us to better understand why the pandemic has had considerable impact on children's mental health. According to the EST, a child develops through the interaction of different systems (i.e., the micro-, meso-, exo-, macro- and chronosystems) from the closest to the broadest (84). During the pandemic, the children's microsystem has been compromised (38, 85) by a number of restrictions, such as the prolonged closure of schools, homeschooling and the absence of social support (peer relationships and extended families). All these persistent stressors, including a change in children's structured daily routine, increase the vulnerability of children. In addition, for parents, many pandemic-related stressors, such as juggling on-going work obligations with added childcare responsibilities and trouble in paying bills due to financial problems etc., may amplify any pre-existing mental health problems and result in higher levels of stress, anxiety and distress. If individual resilience is low, the negative psychological effects of stressors cannot be buffered. As a result, stressors may further deteriorate parents' mental health which can adversely affect family functioning resulting in problems such as more family conflicts and poor parent-child relationship. More importantly, due to the bidirectional relationship between parents and children in the microsystem, both parents and children are affected in a reciprocal manner.

During home confinement, the mesosystem has also been affected. With reduced support from collaborations between school and family (86), it is difficult for children to connect with teachers to seek support due to the closure of schools. However, it is vital for students to feel connected with schools as school connectedness has a buffering effect in helping mitigate negative mental health outcomes as shown in the current review (87).

Since both the micro- and mesosystem are embedded within the exosystem which is the layer that a child does not have direct interactions with, the exosystem impacts child development indirectly. For instance, many parents who worked remotely from home during home confinement experienced an increase in negative emotions which may have spillover effects on children indirectly *via* parenting practices.

The macrosystem can affect other systems as it includes political disturbances, cultural characteristics or economic disruption. During COVID-19, the shutdown measures have caused a substantial decline in the global economy. Some companies were forced to close permanently. Many people had to spend their emergency savings or borrowed loans to support their expenses, so parents have been under a heavy financial burden which is detrimental to their mental health.

The chronosystem, which incorporates the effect of time on individuals' development, includes both normative (e.g., graduation from school) and non-normative life transitions (e.g., parental divorce), environmental events and historical events. In our review, Moore et al. (59) found that there was no evidence that the pandemic had any consequences on children's feelings about the transition from primary to secondary school. The transition from primary to secondary education is a challenge and can be very stressful for children. During the pandemic, children were deprived of a well-planned transition by schools and families which can normally help remove barriers to learning and allow children to reach their full academic potential later on and not feel isolated. Future studies can explore the impact of the pandemic on children's transition in their schooling and psychological wellbeing.

Unhealthy lifestyle factors affect children's mental health. One of the root causes of unhealthy lifestyle is a lack of structured daily routines. Maintaining a structured and pre-planned day is a protective factor of children's mental health (88). Therefore, good and healthy daily habits for children can reduce the risk of mental health problems and improve their psychological wellbeing (89–91). Parents are encouraged to create and maintain healthy structured routines including sleep schedules and family media plans that foster the healthy use of recreational mobile devices (e.g., limits on duration). However, interventions focusing on reducing infants' and toddlers' screen time should be more targeted to parents, particularly parental mental health, screen time, intention to offer mobile devices to children and the needs of using mobile devices (92). Furthermore, since physical activity is associated with psychological health, promoting physical activities that can be performed in a limited space at home should be highly recommended to better support the psychological health of children.

Overall, the included studies have shown the negative impacts of the pandemic on children's mental health through the interaction of different factors. We need to support children's mental health recovery from the pandemic and it is a public health priority which requires effective actions at multiple levels of the society. Since children are particularly vulnerable and need adequate parental support, it is essential to ensure parents' mental health remains good, therefore the provision of more enhanced mental health resources and support programmes to parents to help them reduce stress, anxiety and depressive symptoms is urgently needed. With concerted efforts, children's lives can be improved.

Implications for research

When reviewing all the studies, we observed that first, many empirical studies included both children and adolescents in the same study. The limitation is that the results generated from the studies were imprecise. Designing tailor-made interventions for children becomes more difficult as children and adolescents are at different developmental stages, so future studies on children's mental health are recommended. Second, studies define the age range of children differently, so this makes the comparison of findings difficult. Third, children's data were mostly collected from mothers' reports as they are generally the primary caregivers for children. Although the literature supports this method, it is essential to take into consideration not only mothers but also other caregivers, particularly fathers whose perspectives are limited in the existing literature. Fourth, future research is needed to investigate the longitudinal impact of maternal and paternal mental health on child development due to the COVID-19 pandemic, taking into account multiple time points instead of only two. In addition, since the majority of included studies are quantitative studies, future studies could use mixed methods or longitudinal qualitative studies to capture the experience and impact of the pandemic on children's mental health over time.

Limitations of the review

The present systematic review has several limitations. First, the articles were retrieved from two large electronic databases and hand searched. Only those consisting of the relevant search terms in the title or abstract were reviewed for further analysis. Therefore, the selection of reviewed studies was limited. Second, studies that were not in English, published in conference abstracts, letters, government reports, textbooks and unpublished dissertations were excluded. Third, children with special education needs are excluded in the selection so the mental health of this group of children is less known.

Conclusion

The systematic review summarized important information about children who are at risk of mental health problems in the

context of COVID-19 as well as the risk and protective factors of children's mental health. The current review serves as a wake-up call to the government to provide targeted mental health care in the community to support children, especially those severely stressed by the pandemic. Children's mental health should be one of the top priorities of the post-pandemic recovery 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 author.

Author contributions

CN contributed to the design of the search strategy, conducted the initial searches, analysis of the findings, and prepared the first draft of the manuscript. SN conducted updated searches, reviewed the articles, and conducted the analysis of the findings. Both authors contributed to the revisions of the manuscript and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2022.975936/full#supplementary-material

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Screen time and adolescents' mental health before and after the COVID-19 lockdown in Switzerland: A natural experiment

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Background: During the COVID-19 lockdown in 2020, adolescents' mental health was largely undermined. A general increment in screen time was reported. However, the long-term effects of the latter on adolescents' mental health are still little explored.

Methods: In the present natural experiment, we investigated these effects using longitudinal data collected before and after the first lockdown in Switzerland. Data come from 674 Swiss adolescents (56.7% females, M_{age} = 14.45, SD_{age} = 0.50) during Spring 2019 (T1) and Autumn 2020 (T2) as part of the longitudinal MEDIATICINO study. Self-reported mental health measures included somatic symptoms, inattention, anxiety, irritability, anger, sleep problems, obsessive-compulsive symptoms, loneliness, and depression. Measures for screen-media activities included time spent on the Internet, smartphones, social media, video gaming, instant messaging, and television viewing. They were all assessed at T1 and T2.

Results: Paired-sample *t*-tests with Bonferroni's correction showed that most mental health problems increased over time with an overall medium effect size (Hedge's g = 0.337). In particular, medium effect sizes were found for anxiety, depression, and inattention; small-to-medium effect sizes were reported for loneliness, sleep problems, and obsessive-compulsive symptoms; and a small effect size was found for somatic symptoms. Screen-media activities increased, with the exception of television viewing and video gaming. The results of the hierarchical regression analyses showed that, controlling for covariates, increased time spent on social media – calculated as the difference between T2 and T1 – was the only screen-media activity significantly associated with worse mental health at T2 ($\beta = 0.112$, $p = 0.016$). More time spent in structured media activities like television viewing diminished levels of inattention ($\beta = -0.091$, $p = 0.021$) and anxiety ($\beta = -0.093$, $p = 0.014$). Among covariates, being female, experiencing two or more life events, having mental health problems at T1, and using screens for homeschooling negatively influenced mental health at T2.

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Conclusion: These results align with literature indicating a small but negative effect of social media time on mental health. Underlying mechanisms are manifold, including increased exposure to COVID-19 news, heightened fear of missing out, social comparison, and time-displaced for activities such as physical activity and green time. However, in line with the *structured days hypothesis*, getting involved in media-structured activities like television viewing might protect against mental health symptoms.

KEYWORDS

screen time, social media, mental health, COVID-19, lockdown, longitudinal, natural experiment, adolescents

Introduction

On March 11, 2020, the WHO declared COVID-19 a worldwide pandemic (1). Within a few weeks, countries around the globe, including Switzerland, adopted a nationwide lockdown as one of the most drastic containment measures to counter the spread of the disease. For adolescents, the measures included school closure, the interruption of all extracurricular activities such as sports and music lessons, and strict social distancing from contacts outside their own households. By June 2020, the lockdown in Switzerland was lifted, and schools moved to hybrid formats of in-person and online lectures. Yet, in-person extracurricular activities remained forbidden and social distancing measures were highly recommended. The disruption of adolescents' everyday life and social contacts has profoundly impacted their wellbeing and mental health (2–7), especially considering that adolescence is a developmental period with many challenges. The challenges include discovering and understanding of own identity, establishing a sense of independence, forming important close and intimate relations, and achieving important goals or decisions for the future (8). Biologically, brain regions undergo significant changes (9, 10). Adolescence is a period of higher vulnerability and propensity to carry out risk-taking as well as reward-oriented and novelty-seeking behaviors (11), especially if a social component is involved (12). The gradual development of the cognitive-control system helps to augment adolescents' capacity to self-regulate their behaviors, particularly their emotions (13, 14). This stage of life is also the most common time for the onset of psychological difficulties, including externalizing (e.g., conduct disorder, substance use, and abuse) and internalizing (e.g., depression, anxiety) problems. Indeed, half of the mental health disorders with long-lasting effects start in mid-adolescence (15–17), which overlaps with the age of the heaviest digital media use (18).

Numerous systematic reviews and meta-analyses have reported an increase in mental health problems such as depression, stress, anxiety, loneliness, and attention problems during the COVID-19 pandemic in adolescents (3, 6, 7, 19–33). In particular, Catling et al. (21) underlined how stress represented an essential factor that mediates the increase in depression and anxiety (34). Other factors related to lower mental health included, among others, school closures and the associated disruption of daily routines (35), changes in lifestyle behaviors such as sleep, physical activity, nutrition, and substance use (36, 37), lack of social contact, especially with peers (38), conflict with parents and domestic violence (3, 39), and (excessive) screen time (6, 40, 41). The latter is of particular interest since a more nuanced look at the effects of screen time revealed that it was not bad *per se*, but its effects depended on the type of screen-media activities. For example, a systematic review and meta-analysis of 30 studies (41) revealed that social media use mitigated feelings of loneliness and stress during the pandemic when its use included one-to-one or one-to-few communications (e.g. VoIP apps such as Skype, Viber, WhatsApp), and when online disclosure was promoted in the context of reciprocal friendships. In addition, positive feedback and communication, including humor, augmented feelings of social connection and happiness. On the other hand, one-to-many communication in the form of browsing through other users' social media profiles or websites was associated with worse mental health as users experienced, among others, fear of missing out (FoMO), a tendency to ruminate and distress due to being repeatedly exposed to an overload of negative information about the pandemic (41). There was a three-fold increase in mental health symptoms when social media time augmented drastically (e.g., 3 h) with respect to the pre-pandemic period, and symptoms were worse in adolescents already experiencing mental health problems. Additionally, screen time – when not related to social activities – was associated with lower social wellbeing, including less perceived social support and a higher feeling of loneliness (41).

The above-mentioned review has furthermore revealed that many of the included studies, 24 out of 30, used a cross-sectional design, thus limiting conclusions on the actual effect of screen-media use on adolescents' mental health. The six longitudinal studies showed mixed results but also differed regarding the study design, observed time period, and screen

time measurement. For example, a day-by-day assessment over 2 weeks during the lockdown identified increased levels of social media use and television viewing while gaming remained relatively stable (42). Furthermore, applying a week-by-week assessment for 3 weeks during the lockdown. Furthermore, Fumagalli et al. (43) found that social networking and VoIP app usage increased during the lockdown. Looking at the different type of screen-media activities, this study with weekly assessments found that social networking app use was positively associated with loneliness in the subsequent week (43). Yet another study on 844 Swiss children and adolescents, screened monthly over 5 months – between Autumn 2020 and Spring 2021 after strict lockdown measures were lifted – found stable levels of electronic device use within children and adolescents (44). Although participants spent an average of 2 h and 40 min of leisure screen time at each time point, adolescents aged 15 or older were the ones spending more time, with an average of 4 h and 20 min. With respect to the development of mental health problems, a study with two assessments, including 1,64,101 Chinese college students at the onset of the pandemic and 68,685 participants about 2.5 months later, showed that acute stress diminished, whereas depressive and anxiety symptoms augmented. To note, social media exposure was a risk factor for mental health problems, especially when participants spent more than 3 h per day on social media platforms (45). Furthermore, the authors found a positive effect of social media use on stress and anxiety symptoms (45). Also Rosen et al. (46) found no effect of screen time and a negative effect of news consumption on internalizing symptoms among adolescents.

The abovementioned longitudinal studies lacked an accurate baseline measure before the pandemic's onset. Of course, nobody could have expected the COVID-19 pandemic, and only a few longitudinal studies that had already started before the pandemic could collect follow-up data, thus becoming "natural experiments" and providing a comprehensive picture of what has changed with the emergence of a life-changing event of this scale. Available natural experiments with screen time data collected in young people stemmed from Germany (47, 48), China (49), and Australia (50). For example, drawing from 1711 4- to 17-year-olds, Schmidt et al. (47) revealed an increase in television viewing, gaming, and recreational Internet use during the lockdown in Germany compared to the pre-pandemic assessment, especially in the adolescent group. However, the study did not include measures of mental health. Another study, using the same panel data from Germany, found an increase in screen time among adolescent girls and boys and a decrease in health-related quality of life, capturing both physical and psychological wellbeing indicators. However, pre-pandemic screen time did not influence the negative changes in health-related quality of life, which was mainly predicted by previous levels on the same variable (48). Xiang et al. (49) surveyed 2426 children and adolescents aged 6 to 17 years between January and March 2020 (immediately before and during the first lockdown in China). The authors reported an increase from 7 to 31% of children and adolescents with long leisure screen hours (defined as more than 2 h per day). However, also in this case, no data on mental health were reported. Finally, Magson et al. (50) collected data on 248 Australian adolescents aged 14 years. They found a significant increase in depression and anxiety and a decrease in life satisfaction from before the pandemic to 2 months into the pandemic with a modest effect size (from 0.2 to 0.6 standard deviations). Media exposure measures included traditional and social media use. In particular, television viewing and newspaper reading about COVID-19 had a negative relationship with changes in anxiety, and no relationship with changes in depression and life satisfaction, whereas social media exposure during the lockdown was unrelated to changes in mental health outcomes.

Overall, there are two main shortcomings of the abovementioned natural experiments: (i) they considered a comparably short time frame of a few weeks into the pandemic, thus lacking evidence on long-term changes in screen-media activities and mental health; (ii) three of the four studies looked at changes in screen time in relation to other variables than mental health (like physical activity) and only one (50) looked at the bidirectional associations between changes in mental health and screen time measures (although the latter was limited to overall traditional and social media exposure). In the present natural experiment, we aimed to investigate the long-term effects of the COVID-19 pandemic, over 1 year, on adolescents' mental health by using longitudinal data collected before and after the lockdown in Switzerland. In particular, we wanted to estimate how adolescents' mental health and screen-media use changed from Spring 2019 to Autumn 2020 and (ii) how changes in screen-media use at T1 influenced adolescents' mental health in Autumn 2020. The study leverages the unforeseen COVID-19 pandemic that emerged during an ongoing longitudinal study with adolescents in Switzerland.

Methods

Study design and sample

For the current paper, we drew on data collected in spring 2019 (wave 6) and autumn 2020 (wave 7), following labeled as "T1" and "T2", of the MEDIATICINO prospective cohort study (www.mediaticino.usi.ch). The study started in the spring of 2014 with a cohort of 9- to 10-year-old students in elementary schools randomly selected across the entire Canton Ticino, Southern Switzerland. In 2020, participants entered high schools, and additional students were randomly invited to compensate for drop-outs. The study sample represents approximately one-third of the entire underlying population of that age in Switzerland. They have been followed up once a

year through the middle and high school years. Data for each wave were collected through a paper-and-pencil questionnaire distributed by teachers at school and matched with the help of a unique identifier, which was assigned to each student by the regional education administration. This procedure assured anonymity during data collection and analysis. Ethical approval of the study was received by the regional education administration. For further information on the study design, see also Camerini et al. (51).

Of the distributed questionnaires (n = 1391 at T1 and n = 1476 at T2), schools returned 1224 at T1 (88%) and 1088 at T2 (74%). The main reasons for sample attrition were students being absent from school during the day of data collection, school dropouts, or moving to another Swiss Canton or country. When matching participants from T1 and T2, n = 575 did not participate in both waves or had more than 10% missing data of the included variables. Two participants were removed due to outlier data defined as z-scores > |−3.5| on the continuous variables (52).

Measures

Measures were translated from English into Italian when necessary, and independent back-translation was performed to assure linguistic validity. A complete list of items and response options can be found in Supplementary Table 1. Means and standard deviations for each concept at each measured wave are summarized in Table 1.

Mental health

Mental health was measured at T1 and T2 with an adapted version of the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) Self-Rated Level 1 Cross-Cutting Symptom Measure for children aged 11–17 yrs. This checklist asks if, in the past month, participants experienced psychopathological symptoms on a scale from 1 to 5, where 1 = never (none), 2 = rarely (slight), 3 = several days (mild), 4 = more than a half of days (moderate), and 5 = almost every day(severe). Symptoms included somatic symptoms (1 item), inattention (3 items), anxiety (2 items), irritability (1 item), anger (1 item), sleep problems (3 items), and obsessive-compulsive disorder (OCD) symptoms (1 item). Multi-item indicators were averaged to obtain one score for each symptom (inattention $\alpha_{T1=}$ 0.791, $\alpha_{T2=}$ 0.807; anxiety $r_{T1=}$ 0.656, $r_{T2=}$ 0.683; sleep problems $\alpha_{T1=}$ 0.690, $\alpha_{T2=}$ 0.618). Higher values indicate higher levels of mental health problems.

Loneliness

Loneliness was measured at T1 and T2 with the 3-item version of the UCLA Loneliness Scale recommended for large population-based surveys (53). Items were measured on a scale from 1 = never to 4 = always ($\alpha_{T1=}$ 0.752, $\alpha_{T2=}$ 0.729).

Depression

Depression was measured at T1 and T2 with seven items from the Center for Epidemiologic Studies Depression Scale [CES-D; (54)]. Items were measured on a scale from 1 = not at all to 4 = a lot ($\alpha_{T1=}$ 0.911, $\alpha_{T2=}$ 0.918).

Screen-media activities

Screen-media activities were measured at T1 and T2 as time spent in different online activities on "a typical school day" and on "a typical weekend day". Response options were 0 = never, 1 = up 0.5 h, 2 = 0.5 h−1h, 3 = 1–1.5h, 4 = 1.5–2h, 5 = 2–3h, 6 = 3–4h, 7 = 4–5h, and 8 = 5h or more. Activities included: Internet use, smartphone use, social media use, video gaming, instant messaging, and television viewing. For each activity, we calculated a weighted average of daily use by applying the formula [(screen-media activity on a weekday*5 + screen-media activity on a weekend day*2)/7)]. In addition, we created an overall screen time measure by calculating an average of the six weighted averages ($\alpha_{T1=}$ 0.817, $\alpha_{T2=}$ 0.737).

Covariates

Covariates assessed at T1 included gender coded as 0 = male and 1 = female. At T2, we assessed the current subjective socio-economic status (SES) measured with the single item "How would you evaluate the financial situation of your family?" on a scale from 0 = very wealthy to 4 = definitely not wealthy. For further analyses, answers were categorized as 0 = wealthy or very wealthy and 1 = not wealthy or definitely not wealthy. In addition, we assessed the experience of life events. These included parents' divorce, a parent with a new partner, a parent's loss of his/her job, a family member who had deceased or had severe disease, the worsening of a significant relationship, or any other important negative life events. For each of these events, participants reported if it happened to them during the past year, coded as 0 = no and 1 = yes. We categorized all events into 0 = none, 1 = one, and 2 = two or more two life events for the analyses. Also, we controlled for the at-home living situation in 2020 by asking the following question: "Who is living at home with you?". Answer options, coded as 0 = not present and 1 = present, included mother, father, older sibling(s), younger sibling(s), mother's partner, father's partner, grandparents, and others. We summed up the answers by creating two categories 0 = one or two other people and 1 = three or more other people. Finally, we controlled for the time spent on screens for homeschooling by asking participants, "In general, how often do you use the following device (laptop/smartphone/tablet) for

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TABLE 1 Means, standard deviations, and paired-samples t-tests results.

Variables	Before COVID-19 lockdown M(SD)$_{T1}$	After COVID-19 lockdown M(SD)$_{T2}$	*t*	*df*	*P*-value	Hedges' g
Psychopathological symptoms						
Depression	0.72 (0.71)	1.07 (0.82)	10.189	668	<0.001	0.394
Loneliness	2.19 (0.79)	2.37 (0.77)	5.374	669	<0.001	0.207
Inattention	2.24 (0.85)	2.54 (0.93)	7.779	668	<0.001	0.301
Sleep problems	2.29 (0.98)	2.51 (0.95)	5.528	668	<0.001	0.214
Anxiety	2.33 (1.07)	2.91 (1.18)	12.099	667	<0.001	0.468
Somatic problems	2.47 (1.08)	2.57 (1.03)	2.245	667	0.025	0.087
Irritability	2.34 (1.14)	2.41 (1.11)	1.271	661	0.204	0.049
Anger	1.83 (1.02)	1.87 (1.07)	0.687	662	0.492	0.027
Obsessive-compulsive disorder	2.10 (1.15)	2.37 (1.22)	4.668	660	<0.001	0.181
Overall mental health problems	2.05 (0.67)	2.29 (0.68)	8.76	673	<0.001	0.337
Screen-media activities						
Internet use	4.16 (1.85)	4.83 (1.77)	8.442	651	<0.001	0.330
Smartphone use	4.08 (1.86)	4.71 (1.73)	8.395	659	<0.001	0.327
Messaging	2.76 (1.89)	2.99 (1.77)	3.118	660	0.002	0.121
Video gaming	1.55 (1.95)	1.36 (1.74)	−2.812	660	0.005	−0.109
Social media use	3.04 (1.95)	3.31 (1.67)	3.560	659	<0.001	0.139
Television viewing	2.61 (1.77)	1.73 (1.50)	−10.784	640	<0.001	−0.426
Overall screen time	3.03 (1.37)	3.15 (1.12)	2.547	673	0.011	0.098
Social screen time (excl. video gaming, television viewing)	3.50 (1.66)	3.95 (1.53)	7.407	674	<0.001	0.285

homeschooling?". Answers options ranged from 1 = never to 5 = always.

Analytical plan

First, we described the levels of cross-cutting mental health symptoms, loneliness, depression, and screen-media activities before and after the COVID-19 lockdown in Switzerland. Second, after checking that data were normally distributed according to the values of skewness and kurtosis, we estimated how mental health changed over time by running paired-sample t-tests to compare mental health symptoms, loneliness, and depression between T1 and T2. A Bonferroni correction was applied to ensure that possible differences were not due to chance. To better interpret the magnitude of the difference between pre- and post- COVID-19 lockdown assessments, we computed Hedge's *g* as a measure of effect size. The magnitude of the effect was interpreted as small = 0.10, mediu*M* = 0.30, and large = 0.50 effect (55). Third, we computed a difference index of screen-media activities (Δ_{T2-T1}), i.e., subtracting the time spent on screen media of T1 from T2. Thus, positive values in the Δ index indicate increased time spent with screen media from T1 to T2. We computed Δ indices for each screen media activity and overall screen time. Fourth, we computed bivariate Pearson's correlation coefficients for all measures (see Table 2). Fifth and last, we ran hierarchical regression analyses with mental health at T2 as the outcome by adding a new block of predictors at each step, in addition to the baseline model with only covariates (Model 1), including gender, life events, subjective SES, the at-home living situation at T2, and the use of screens for homeschooling at T2. In particular, mental health at T1 was further added as a predictor in Model 2, and the Δ indices in screen-media activities were additional predictors in Model 3. To avoid problems of multicollinearity, a model including covariates, overall mental health problems at T1, and the Δ index for overall screen time was run separately (Model 4; see Table 3).

Results

The final analytical sample was composed of 674 Swiss adolescents, 56.7% (n = 382) females, with a mean age of 14.45 years at T1 (SD = 0.50). At T2, most of them reported being wealthy or very wealthy (n = 410, 60.8%). Also, 301 students (44.7%) reported having not experienced any life event, whereas 173 (25.7%) and 190 (28.2%) indicated having experienced one and two or more life events, respectively. In particular, the worsening of a significant relationship was the most reported

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TABLE 2 Correlation table of all the variables included in the regression models.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Mental health problems at T1	1												
2. Mental health problems at T2	0.475**	1											
3. Internet use$_{\Delta T2-T1}$	−0.112**	−0.004	1										
4. Smartphone use$_{\Delta T2-T1}$	−0.080*	0.017	0.646**	1									
5. Social media g$_{\Delta T2-T1}$	−0.205**	0.011	0.469**	0.556**	1								
6. Messaging$_{\Delta T2-T1}$	−0.142**	0.008	0.395**	0.504**	0.584**	1							
7. Television viewing $_{\Delta T2-T1}$	−0.084*	−0.086*	0.067	0.072	0.164**	0.145**	1						
8. Video gaming$_{\Delta T2-T1}$	0.061	0.046	0.185**	0.164**	0.121**	0.163**	0.119**	1					
9. Overall social screen time $_{\Delta T2-T1}$	−0.169**	0.008	0.788**	0.843**	0.810**	0.770**	0.137**	0.190**	1				
10. At-home living situation at T2	−0.058	−0.012	0.037	0.039	0.042	0.064	0.006	0.047	0.056	1			
11. Subjective SES at T2	0.018	0.014	−0.069	−0.066	−0.012	−0.032	−0.063	0.006	−0.042	−0.076*	1		
12. Life-changing events at T2	0.214**	0.294**	0.016	0.021	−0.033	−0.015	−0.015	0.038	0.004	−0.168**	0.142**	1	
13. Use of screens for home schooling at T2	0.028	0.126**	0.132**	0.061	0.076	0.093*	0.027	0.014	0.117**	−0.057	−0.015	0.043	1
14. Gender	0.277**	0.306**	−0.057	−0.049	−0.090*	−0.045	−0.046	0.232**	−0.071	−0.019	−0.033	0.149**	0.034

*p < 0.05, **p < 0.01.

one (31.8%). Concerning the at-home living situation, 31.5% of participants reported living with one (6.2%) or two (25.2%) other people, and the remaining adolescents with three (59.2%) or more (9.4%). Both the laptop ($M = 3.45$, SD = 1.07) and the smartphone ($M = 3.49$, SD = 1.16) were used quite often for homeschooling, whereas the tablet was used less for this aim ($M = 1.66$, SD = 1.10).

The results of the paired-sample *t*-tests showed that most mental health problems increased from T1 to T2 (see Table 1 and Figure 1) with an overall medium effect size ($g = 0.337$). In particular, medium-to-large effect sizes were reported, in descending order, for anxiety ($g = 0.468$), depression ($g = 0.394$), and inattention ($g = 0.301$); small-to-medium effect sizes were found for sleep problems ($g = 0.214$), loneliness ($g = 0.207$), and OCD symptoms ($g = 0.181$); and small effect size for somatic problems ($g = 0.087$), although the latter was not significant when Bonferroni's correction was applied ($p < 0.005$). No differences were found with respect to irritability and anger.

Pairwise comparisons further showed that screen-media activities increased, except for television viewing and video gaming, which decreased from the pre-lockdown to the post-lockdown assessment (see Table 1 and Figure 2). In particular, a medium effect was found for Internet use ($g = 0.330$) and smartphone use ($g = 0.327$), whereas a small effect was found for social media use ($g = 0.139$) and instant messaging ($g = 0.121$). Television viewing decreased with a medium-to-large effect ($g = -0.426$), whereas videogaming decreased with a small effect ($g = -0.109$) in the same direction. All differences were statistically significant, even after applying Bonferroni's correction ($p < 0.007$). Overall screen time augmented with a small effect size ($g = 0.098$). However, when TV viewing and videogaming (which decreased) were excluded from overall screen time, changes in screen time were of medium size ($g = 0.285$). Thus, we opted to use the latter measure of screen time as more representative of online activities, and we further referred to this overall average of time spent on the Internet, social media, messaging and on the smarphone as "social" screen time.

The correlation table (see Table 2) shows that mental health problems at T1 were positively related to mental health problems at T2, but negatively related to the difference indices of all screen-media activities with the exception of videogaming. Conversely, mental health problems at T2 positively correlated with gender (i.e., being female), the frequency of screen time for homeschooling, the number of life events, and negatively with television viewing. The results of the hierarchical regression analyses (see Table 3) show that the final model with single screen-media activities (Model 3) accounted for 32.6% of the variance in mental health problems at T2. At each step, a significant proportion of the variance was explained. In Model 1, with covariates as the only predictors, being female ($\beta = 0.181$, $p < 0.001$) and having experienced one ($\beta = 0.263$, $p < 0.001$), two ($\beta = 0.262$, $p < 0.001$) or more ($\beta = 0.453$, $p < 0.001$) negative

TABLE 3 Hierarchical regression results with Mental health problems at T2 as outcome.

	Model 1				Model 2				Model 3				Model 4			
	B	**(SE)**	**Beta**	***P*-value**	**B**	**(SE)**	**Beta**	***P*-value**	**B**	**SE**	**Beta**	***P*-value**	**B**	**(SE)**	**Beta**	***P*-value**
(Constant)	1.505	0.120		0.000	0.866	0.128		<0.001	0.806	0.127		<0.001	0.865	0.122		<0.001
Gender (1 = female)	0.359	0.052	0.263	<0.001	0.246	0.050	0.180	<0.001	0.264	0.050	0.193	<0.001	0.226	0.047	0.163	<0.001
Life events at T2 ($n = 1$)	0.262	0.064	0.168	<0.001	0.199	0.060	0.127	<0.001	0.216	0.059	0.138	<0.001	0.226	0.056	0.145	<0.001
Life events at T2 ($n \geq 2$)	0.453	0.063	0.304	<0.001	0.337	0.059	0.226	<0.001	0.343	0.059	0.230	<0.001	0.309	0.056	0.204	<0.001
Subjective SES at T2 (1 = not wealthy)	0.018	0.054	0.013	0.738	0.016	0.050	0.011	0.751	0.016	0.050	0.011	0.748	−0.018	0.047	−0.013	0.694
At-home living situation at T2 (1 = with 3 or more other people)	0.092	0.056	0.064	0.097	0.102	0.051	0.071	0.046	0.099	0.051	0.069	0.051	0.069	0.049	0.046	0.163
Use of screens for home schooling at T2	0.111	0.035	0.119	0.002	0.105	0.033	0.113	0.001	0.095	0.033	0.102	0.004	0.094	0.031	0.100	0.003
Overall mental health problems at T1					0.372	0.037	0.371	<0.001	0.390	0.037	0.389	<0.001	0.401	0.036	0.394	<0.001
Internet use$_{\Delta T2-T1}$									−0.006	0.016	−0.017	0.715	–	–	–	–
Smartphone use$_{\Delta T2-T1}$									0.007	0.018	0.019	0.699	–	–	–	–
Messaging$_{\Delta T2-T1}$									0.015	0.016	0.041	0.364	–	–	–	–
Video gaming$_{\Delta T2-T1}$									−0.020	0.015	−0.050	0.171	–	–	–	–
Social media use$_{\Delta T2-T1}$									0.041	0.017	0.112	0.016	–	–	–	–
Television viewing$_{\Delta T2-T1}$									−0.023	0.012	−0.069	0.053	–	–	–	–
Overall social screen time$_{\Delta T2-T1}$													0.036	0.015	0.083	0.014
R^2			0.188**				0.311**				0.326**				0.301**	

**p <0.01. $_{\Delta T2-T1}$ = difference index between T2 and T1 (SE) = standard error.

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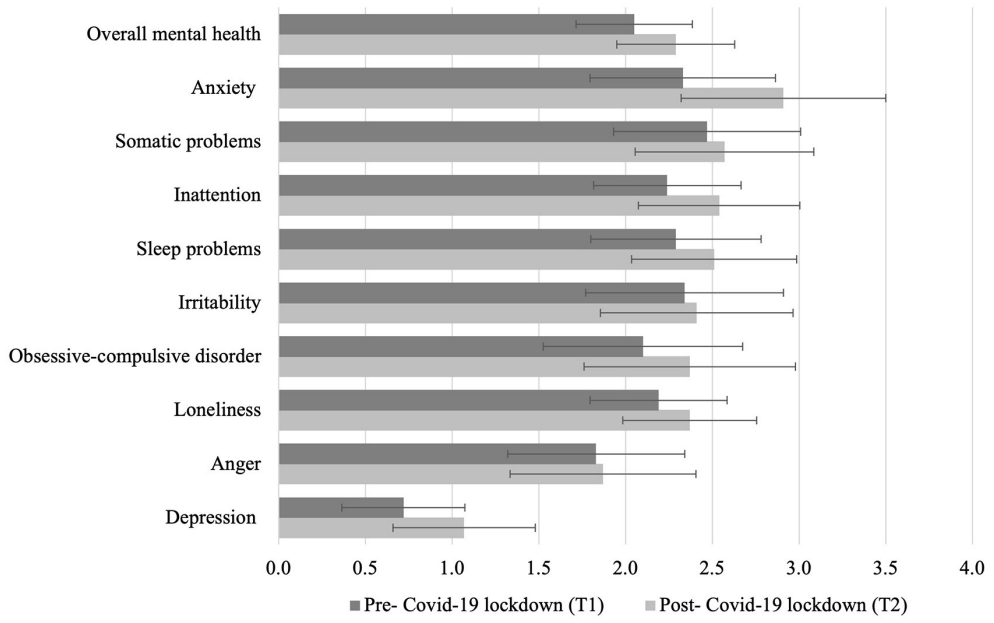

FIGURE 1
Mental health before and after the COVID-19 lockdown in Switzerland. Means and standard deviations are shown.

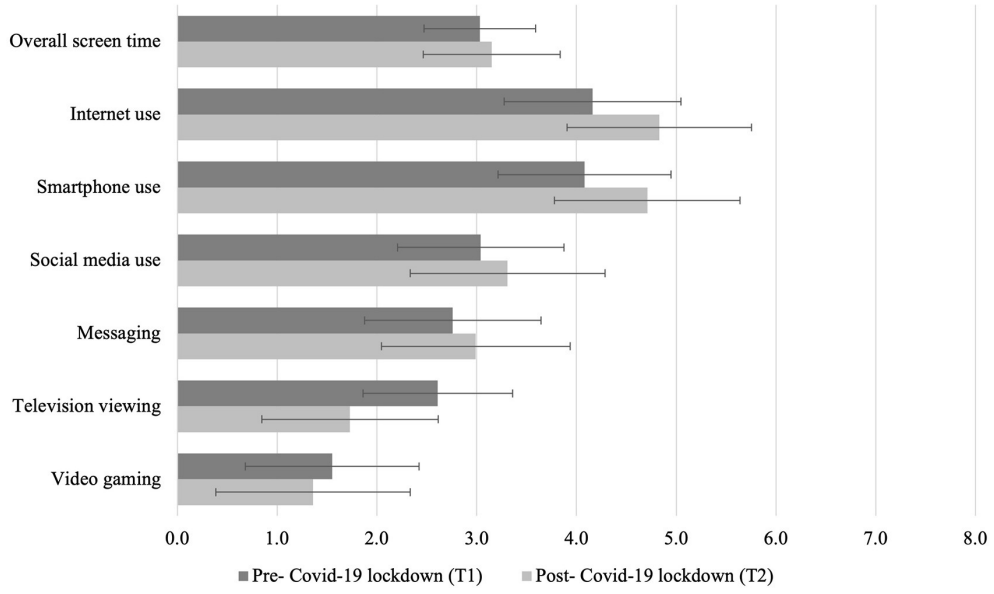

FIGURE 2
Daily duration of screen-media activities before and after the COVID-19 lockdown in Switzerland. Means and standard deviations are shown.

life events, and the frequency of using screens for homeschooling ($\beta = 0.119$, $p = 0.002$) significantly predicted higher levels of mental health problems at T2. Subjective SES did not show a significant effect, neither did the at-home living situation. In Model 2, overall mental health problems at T1 significantly predicted themselves at T2 ($\beta = 0.371$, $p < 0.001$). Significant predictors in Model 1 remained significant in Model 2. In Model 3, including difference indices in screen-media activities, one further significant effect was found: Increased time spent on social media ($\beta = 0.112$, $p = 0.016$) was associated with worse

mental health at T2. When single screen-media activities were substituted with overall social screen time (i.e., Internet, use, social media use, messging, and smartphone use; Model 4), the effect on mental health problems at T2 was positive but small ($\beta = 0.083$, $p = 0.014$), and the model explained 30% of the variance in the outcome.

In further linear regression analyses replicating previous models, we examined the impact of changes in screen-media activities and overall screen time on specific mental health symptoms that significantly worsened from the pre-lockdown to the post-lockdown assessment (see Supplementary Tables 2–7). We thus excluded somatic problems, irritability, and anger, which did not change from T1 to T2. Controlling for covariates, increased time spent on social media significantly and positively predicted depression ($\beta = 0.143$, $p = 0.004$) and inattention ($\beta = 0.133$, $p = 0.011$) at T2. With these two exceptions, social media use did not predict other mental health symptoms. However, the more time adolescents spent viewing television, the lower were their levels of inattention ($\beta = -0.091$, $p = 0.021$) and anxiety ($\beta = -0.093$, $p = 0.014$). On the other hand, augmented time spent on video games predicted less depressive symptoms ($\beta = -0.081$, $p = 0.037$), sleep problems ($\beta = -0.085$, $p = 0.035$), and OCD symptoms ($\beta = -0.096$, $p = 0.024$). None of the screen-media activities showed an influence on loneliness. However, when overall social screen time was entered in the analyses, it positively predicted loneliness ($\beta = 0.109$, $p = 0.002$), depressive symptoms ($\beta = 0.085$, $p = 0.037$), and inattention ($\beta = -0.075$, $p = 0.042$). With respect to the covariates, gender (being female) and having experienced two or more life events had a significant effect on all symptoms. However, attention problems were not predicted by gender, and only having experienced more than two life events positively influenced this outcome. Interestingly, the use of screens for homeschooling had a positive and significant effect on specific mental health symptoms, such as anxiety ($\beta = 0.122$, $p = 0.001$) and OCD symptoms ($\beta = 0.096$, $p = 0.019$). The at-home living situation did not influence any of the outcomes, neither did subjective SES.

Discussion

In the present study, we investigated the long-term effects of the COVID-19 pandemic in Switzerland on adolescents' mental health by conducting a natural experiment including longitudinal data collected before and after the lockdown. In particular, we estimated how adolescents' mental health changed from Spring 2019 to Autumn 2020, and how overall screen time and specific screen-based activities predicted adolescents' mental health throughout this 1.5-year time period. The present study revealed four major findings.

First, and not surprisingly, adolescents' mental health worsened over time, with a particular increase in internalizing problems such as anxiety and depression, but also inattention, which showed medium to large effect sizes. This result is in line with a systematic review (6) that included 61 articles for a total of 54,999 children and adolescents, showing that anxiety and depressive symptoms were the most reported problems since the COVID-19 outbreak and associated containment measures i.e. lockdowns, closure of schools and workplaces as well as distancing measures, especially in females and adolescents. Peer relationships during adolescent years are of great importance since this developmental period is characterized by a high need of social interaction and interpersonal relationships outside the family to develop personal identity. The interruption of in-person schooling and recreational events likely increased feelings of anxiety and depression and augmented general mental health problems. Additionally, we should consider that the onset of internalizing problems increases as children transition into adolescence (16). Hence, the experience of a stressful life event like the COVID-19 lockdown during Spring 2020 might have increased the likelihood to develop mental health problems, especially in adolescents due to reduced resilience and coping skills, which usually develop during adulthood thanks to the maturation of specific brain regions (56). Also, parental stress and family conflict could have modulated adolescents' stress response and, consequentially, their levels of anxiety and depression during the lockdown (23, 57). Parents' perception of COVID-19 has been found to be related to their children's psychological symptoms, and when family living situation during the lockdown was problematic, adolescents tended to show more emotional problems. Furthermore, inattention increased over time. This result is in line with another study carried out by Orgilés et al. (57), who investigated the emotional impact of quarantine on adolescents living in two of the European countries most affected by COVID-19: Italy and Spain. The authors reported that 76.6% of the sample experienced symptoms such as difficulties in concentrating. This may be mainly due to the disruption of daily routines and the change to homeschooling. However, symptoms of inattention including fatigue and cognitive impairment might also be long-term consequences of infections with the COVID-19 virus (58). However, as we did not assess if they have been infected from COVID-19 during that period, the interpretation of this result is limited.

The second main result is that most screen-media activities increased. Internet and smartphone use showed the highest increment between Spring 2019 and Autumn 2020, with an average leisure time spent on them between 2.5 and 3 hours per day, followed by social media use and messaging. Several studies have indicated increased time spent on screen media during COVID-19 (16, 56). Our result is also in line with another Swiss study that analyzed data from before the pandemic. Using a repeated cross-sectional design, the study showed the highest increment in time spent on online activities in the last 10 years in Switzerland (18). The COVID-19 pandemic accelerated this

trend. In the US, early in the COVID-19 pandemic, adolescents' average daily screen time was 7.70 hours per day, whereas pre-pandemic estimates were lower (3.8 hours per day) (59). However, time spent watching television and video gaming decreased in our sample. This result might also be due to the way questions were formulated. For many students, watching TV has been mainly replaced by watching online videos or films or series on streaming platforms such as Netflix and Amazon Prime (which we did not ask). Also, playing video games can be interpreted in many ways, since these days online games also include a social component – for which players are usually continuously connected to each other – but classic video games (as the ones the question refers to) lack that component.

Third, when looking at how differences in screen-media activities impacted mental health symptoms after the COVID-19 lockdown, only social media use showed a positive effect, i.e., adolescents reporting to have increased their time spent on social media use after the onset of the pandemic also showed more frequent symptoms of mental health problems. This result is in line with previous literature indicating small but negative effects of social media use on mental health (e.g., for reviews of reviews) (33, 54, 58–62). Underlying mechanisms are manifold. Social comparison and envy might have been heightened by spending more time on social media (63). Likewise, screen time might have displaced time spent on offline activities such as physical activity and green time that proved to be beneficial for adolescents' mental health (44, 64). Heavy social media use has also been related to a (maladaptive) emotional coping process to escape from negative emotions, especially in response to environmental stressors (65–67). Additionally, the exposure to COVID-19-related news augmented stress by increasing feelings of FoMO (e.g., with respect to COVID-19-related news and updates or about other people's whereabouts) and fostering rumination (41). Despite significant concerns about COVID-19, adolescents might also have other everyday-life worries and issues that did not end with the pandemic but probably increased, thus fueling feelings of anxiety and depression (68). However, greater time spent on watching television and video gaming was related to less mental health problems. One explanation could be that, for example, watching television is an activity that adolescents might carry out together with other family members in a specific space, e.g., in the living room, and time determined by broadcasters' TV programming schedule. Hence, it is more routinized, and it might give them a structured time of consumption of media contents. Routined activities were found to be beneficial for health outcomes in a context where any kind of structure has been lost (69, 70). Indeed, according to the *structured days hypothesis*, a "pre-planned, segmented, and adult-supervised compulsory environment plays an overall protective role" (p. 2, 69) against the occurrence of negative health outcomes (including obesogenic activities like long time spent in front of screens). Also, according to a review and meta-analysis (69), screen time is less healthy on less structured days. In addition, the positive aspect of video gaming could be mainly related to entertainment reasons but also to the possibility to completely detach from COVID-19-related news and worries and find momentary relief in the gaming space. In fact, although escaping from negative emotions is a criterion used to diagnose Online gaming disorder, it can also be interpreted as a problem-oriented coping mechanism, which aims to change stressful situations, or as an avoidance strategy, which aims to orient away from the stressful situation (71). In this regard, video gaming could have facilitated coping strategies, which already exist without screen media, or it could stand as a new coping strategy itself, thus belonging to a different dimension that should be further conceptualized – especially in the context of life events like a pandemic. That is particularly relevant for the adolescent period, during which young people are still developing their coping styles (72).

Last, among covariates, being female was a consistent risk factor for developing mental health problems. From a biological viewpoint, girls at that age are more at risk of internalizing problems like depression (73, 74) as they tend to produce an increased cortisol response to stressful events (75), and pubertal hormone changes, e.g., estradiol, are also associated with mental health problems in girls (76). Girls carrying the short 5-HTTLPR allele (77), a genetic variant associated with various mood and anxiety problems (78), react differently with respect to males (79) to environmental (social) stress factors, thus they are at higher risk for depressive symptoms. From the socio-cultural viewpoint, female adolescents show higher interpersonal dependence, more self-image and self-esteem concerns, and a higher need for external approval and success (80). Also, the experience of two or more life events – in addition to the COVID-19 lockdown in Spring 2020 – was related to worse mental health outcomes in Autumn 2020. This should be considered in the context of the adolescent development period, during which the hypothalamic-pituitary-adrenal axis (responsible for the biological response to stress through the release of cortisol) is still maturing and adapting to the current environment, and stress response is repeatedly heightened with respect to adulthood (81). We should recall that almost 32% of adolescents in our sample reported the worsening of a significant relationship since the onset of the pandemic. Although we do not know which relationship in particular worsened, we know from other studies that the lockdown increased parent-child conflict as family members were confined to oftentimes small spaces and had less room for privacy, which is particularly important during adolescence (82, 83). In addition, it is likely that heightened stress experienced by parents due to the COVID-19 pandemic negatively impacted the parent-adolescent relationship (84). Furthermore, intimate friendships and romantic relationships were put to the test due to strict social (physical) distancing measures during the early lockdown in Switzerland. Eventually, the use of digital devices, especially laptops and smartphones, for homeschooling revealed a negative

influence on two specific mental health problems: anxiety and OCD symptoms. School is a crucial component in sustaining adolescents' physical, emotional, social, and moral development, however, according to our results, the use of digital devices in this context contributed to the spread of anxiety and worry, and this may be due to the fact that neither schools nor students were prepared for online or hybrid forms of schooling. This lack of preparedness likely increased uncertainty and anxiety, especially in the first year high school characterized by new school structures, classmates, and teachers, during which our sample had to face the early phases of the COVID-19 pandemic.

Limitations and future directions

Some methodological limitations should be acknowledged. Given the topical variety of the larger longitudinal study from which the data were taken, we did not include any measure referring to the COVID-19 pandemic, e.g., COVID-19-related stress or infection with the virus. Additionally, some screen-media activities, like watching television or video gaming, were formulated in a way that no longer captures the actual consumption of mostly online media content. For example, we did not consider other related activities like streaming or staying socially connected while using online video games. In addition, we did not measure specific activities and processes such as social comparison or FoMO as potential mechanisms between significant relationships. Hence, further (longitudinal) studies should implement more information about the context and a more detailed screen-media assessment (85). Similarly, we did not assess the subjective SES in a comprehensive way. According to the social determinat approach to health outcomes (86), more information on the socio-economic status, community, and societal characteristics should be collected. In addition, our sample might not be representative of the more vulnerable and underprivileged populations (e.g. under-represented races and ethnicities, lesbian, gay, bisexual, transgender & queer (LGBTQ) communities), thus contributing to what has been called "data absenteeism" during the COVID-19 pandemic, defined as "absence or limits of data on groups experiencing social vulnerability" [p. 208, (87)]. Hence, we suggest that future studies focus on the "hardly reached" populations. At the same time, although we included a comprehensive assessment of mental health, some symptoms that the pandemic might exacerbate were not investigated, for example, the presence of eating disorders, suicidal ideation, psychotic symptoms, post-traumatic stress disorder, and mania. Furthermore, the present cohort of students does not extend to other age groups, which showed differential effects of social media use (88). Although the dropout of participants was mainly due to the change of school (from middle to high school), it is possible that some students dropped out because they were particularly suffering the consequences of the pandemic in the post-lockdown assessment. Finally, we did not consider if there were any students with special educational needs and disabilities and/or neurodevelopmental disorders that might have experienced more psychological stress since they prefer routine and predictable environments (6). Challenges of remote learning are especially difficult for disadvantaged and minority families and likely augmented social and economic disparities since young people remain left behind in their education (89). Hence, future studies should better consider specific disabilities in studying the consequences of screen media on mental health during COVID-19.

Conclusion

Mental wellbeing in adolescents significantly decreased from the pre-pandemic to the post-lockdown period in Switzerland. At the same time, screen-media activities with a social component, such as smartphone use, social media use, messaging, and Internet use, increased. The increase in social media use was significantly associated with worse mental health in the post-lockdown period, even after controlling for other significant predictors, including mental health before the onset of the COVID-19 pandemic, being female, the presence of at least one life event on top of the pandemic, the at-home living situation, and the use of screen media for homeschooling. These findings shed light on the impact of the early phases of the COVID-19 pandemic on adolescents, who are in a crucial developmental period and particularly vulnerable, thus requiring more attention both among researchers and policymakers.

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.

Ethics statement

Ethical review and approval were not required for the study on human participants in accordance with the local legislation and institutional requirements. However, the regional education administration of Canton Ticino and the Ethics Committee of the USI Università della Svizzera italiana (Switzerland) approved this study design. Written informed consent from participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements. However, consent was implied *via* completion of the questionnaire.

Author contributions

LM and A-LC conceived the project, collected the data, and provided funding. LM performed the statistical analysis and wrote the first draft of the manuscript. A-LC, RM, and KV wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2022.981881/full#supplementary-material

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Cross-lagged relationship between anxiety, depression, and sleep disturbance among college students during and after collective isolation

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Object: Repeated quarantine policies over the past 3 years have led to poor psychological consequences for the public. Previous studies have proved that the quarantine policy leaves individuals vulnerable to anxiety, depression, and insomnia, especially among college students. This study aims to explore whether psychological problems during isolation continue with the release of isolation.

Methods: Overall, 2,787 college students both answered a web-based survey during and after the closure management was lifted. The Patient Health Questionnaire, Generalized Anxiety Disorder Scale, and Youth Self-rating Insomnia Scale were measured. The cross-lagged path model was used to explore the influence of psychological impact during isolation on the individual after the release.

Results: We found that anxiety and sleep disturbance levels alleviated significantly after quarantine, except for depression. As expected, a bidirectional relationship exists between anxiety, depression, and sleep disturbance. Moreover, depression and sleep disturbance can predict post quarantine depression, sleep disturbance, and anxiety, yet anxiety cannot predict sleep disturbance afterward.

Conclusion: Timely and effective intervention for anxiety, depression, and insomnia during isolation is essential for individuals to repair themselves quickly after the release.

KEYWORDS

anxiety, depression, sleep disturbance, cross-lagged panel model, college students

Introduction

At the end of 2019, Coronavirus disease was reported in China. COVID-19 spread quickly throughout the world to its highly contagious property, and the World Health Organization (WHO) declared it a global pandemic (1). Containment measures, including social distance, quarantine, or even city lockdown, are effective in disease containment, whereas stringent measures have introduced a greater risk of mental illness to the public (2). Evidence shows that the prevalence of mental illness during the pandemic was higher than in pre-pandemic (2–4). For college students, the impact of the pandemic on mental and physical health was worse (3, 5). Among mental health problems, depression and anxiety are the most prevalent in college students (6), negatively affecting mental health and daily performance (7). Meanwhile, data from several studies also suggest that sleep disturbance is prevalent in college students, impairing daytime function (5, 8). Previous research has established that anxiety, depression, and sleep disturbance are intertwined (8, 9). However, due to different measurements, no longitudinal studies, whether the relationship between anxiety, depression, and sleep disturbance alters with time is not yet clear (3, 10), as if the interpretation of this relationship will benefit the prevention and intervention of anxiety, depression, and sleep disturbance after the pandemic. Given this, our study aims to reveal the relationship between anxiety, depression, and sleep disturbance.

In terms of the relationship between anxiety and depression, previous studies established that depression and anxiety are two quotidian comorbidities (8, 11, 12). However, a much-debated question is whether the longitudinal relationship between anxiety and depression is bidirectional. Several studies demonstrate that anxiety precedes the advent of depression (12–14). Different from these studies, other studies suggest that depression precedes the advent of anxiety (15, 16). Apart from the statement that the relationship between anxiety and depression is unidirectional, a meta-analysis focusing on longitudinal studies demonstrates that the relationship between anxiety and depression is bidirectional (11). However, with a sample from western countries, we cannot establish a bidirectional relationship between anxiety and depression in Chinese samples (11). Considering the controversy of the relationship between anxiety and depression, further research about this will be needed, and we put forward the following hypothesis:

> Hypothesis 1. There would be a bidirectional relationship between anxiety and depression during the pandemic.

There are mainly three different viewpoints regarding the relationship between depression, anxiety, and sleep disturbance. According to cognitive models, the first viewpoint is that depression and anxiety are predictors of sleep disturbance, for fear, worry, and anxiety can cause insomnia (17). However, Buysse et al. (18) asserted that sleep disturbance is the prefigure of depression through a longitudinal cohort study. Furthermore, several review articles show that sleep disturbance is a risk factor for both anxiety and depression (7, 19, 20). Inspired by two unidirectional viewpoints, recent evidence suggests that the relationship between depression, anxiety, and sleep disturbance is bidirectional instead. On the one hand, depression and anxiety will lead to sleep disturbance. And conversely, suffering from sleep disturbance will result in the occurrence or development of anxiety and depression. Cui et al. (3) has done a cross-sectional survey in China, suggesting that the relationship between anxiety, depression, and sleep disturbance is bidirectional. The result of this study is consistent with several other studies (21–23). However, to our knowledge, many studies that suggest bidirectional relationships are cross-sectional or meta-analysis studies. Little longitudinal studies determine the directionality and causality between anxiety, depression, and sleep disturbance (3, 8). Although debate continues, given the situation that the last viewpoint is the combination of the first two ideas, we pose the following hypothesis:

> Hypothesis 2. There would be a bidirectional relationship between sleep disturbance and depression.
> Hypothesis 3. There would be a bidirectional relationship between sleep disturbance and anxiety.

In addition, previous research established that gender may influence the relationship between anxiety, depression, and sleep disturbance. First of all, as for the prevalence of anxiety, depression, and sleep disturbance, evidence shows that there is a discrepancy between males and females. Using meta-analysis, a study collected and analyzed 98 previous studies, suggesting that female students had a higher prevalence of depression and anxiety than male students (2). In terms of the prevalence of sleep disturbance, large-scale research showed that females had higher total Pittsburgh Sleep Quality Index (PSQI) scores than males, indicating that females had more sleep problems (8). Consistent with this result, other studies demonstrated that females were prone to symptoms of anxiety, depression (24, 25), and sleep disturbance (26, 27). Conversely, some studies suggest that the incidence of anxiety, depression, and sleep disturbance is higher in males than females (28), even not significant (29). However, as for the question of whether gender affects the relationship between anxiety, depression, and sleep disturbance, few studies have investigated it (30, 31), and further study is worthy. Considering the controversy and paucity of this area, we put up the following hypothesis:

> Hypothesis 4. There would be a gender difference in the relationship between anxiety, depression, and sleep disturbance.

The current longitudinal study collected data from Chinese college students, conducting cross-lagged analysis to examine

the relationship between anxiety, depression, and sleep disturbance. Additionally, this study examined the gender difference in the relationship between anxiety, depression, and sleep disturbance through multiple-group analysis. The results of this study will provide further evidence of the relationship between anxiety, depression, and sleep disturbance. Moreover, given that COVID-19 worsens people's mental and physical health, the results of this study will also provide information on the prevention and intervention of anxiety, depression, and sleep disturbance.

Methods

Participants

The first wave of data was obtained from 6,710 college students during the COVID-19 pandemic lockdown in Harbin on September 26, 2021. The second wave of data was collected from 3,731 college students from the same school after the closure management was lifted on December 27, 2021. When the datasets from two waves were combined according to the students' school numbers, 2,787 participants (58.6% females, $Mean_{age} = 18.34$, $SD_{age} = 0.92$, range from 15 to 28) were finally recruited. Students and their parents had to provide signed informed consent before participating in the assessment. All participants answered the questionnaires through the Wenjuanxing online questionnaire platform (https://www.wjx.cn/). The research was examined and approved by the ethical committee of Beijing Normal University (Reference number: 202112220084).

Measures

Patient health questionnaire (PHQ-9)

The Patient Health Questionnaire (PHQ-9) is a widely used scale for screening depression symptoms (32). Participants were asked about the frequency [not at all (0), several days (1), more than half of the days (2), nearly every day (3)] of experiencing given symptoms in the last 2 weeks, and higher scores indicate more severe depression symptoms. The Chinese version of PHQ-9 was proved valid and reliable (33). In the current study, PHQ-9 has a high internal consistency with Cronbach α values of 0.89 and 0.92 in wave 1 and wave 2, respectively.

Generalized anxiety disorder scale (GAD-7)

The Generalized Anxiety Disorder Scale (GAD-2) is a valid and reliable assessment to screen for generalized anxiety symptoms (34). Participants answered seven questions about the frequency of anxiety symptoms that occurred over the last 2 weeks. Each item scored from 0 (not at all) to 3 (nearly every day), with a higher score indicating more severe anxiety symptoms. The Chinese version also has good psychometric properties for identifying anxiety (35). In the current study, GAD-7 has a high internal consistency with Cronbach α values of 0.93 and 0.95 in wave 1 and wave 2, respectively.

Youth self-rating insomnia scale (YSIS-8)

The Youth Self-rating Insomnia Scale (YSIS-8) is a 5-point Likert questionnaire assessing sleep disturbance in the last month. Participants answered two questions about overall sleep quality and six about the frequency of specific sleep disturbance symptoms. Total scores range from 3 to 15, and higher scores indicate poorer sleep quality. Previous studies have shown that YSIS-8 in Chinese is valid and reliable (36). In the current study, YSIS-8 has a high internal consistency with Cronbach α values of 0.91 and 0.93 in wave 1 and wave 2, respectively.

Data analyses

Preliminary analyses were conducted in SPSS 22.0. The cross-lagged paths and multiple-group analysis were performed *via* Mplus 8.3. Because depression and anxiety symptoms in adolescents and young adults change over time (37), age was included as a covariate in the model. It should be mentioned that all variables were assumed to be related to all others; therefore, this model had zero degrees of freedom, and it did not make sense to assess model fit (38) except for multiple-group analysis.

Results

Preliminary analyses

Means, standard deviations, correlations, and *t*-test results of major variables are shown in Table 1. The results demonstrated that anxiety, depression, and sleep disturbances were significantly and positively related to each other at each wave. Additionally, after 3 months when the lockdown ended, there was no significant change in the level of depression. At the same time, the level of anxiety and sleep disturbances have decreased significantly.

The cross-lagged path model

The cross-lagged regression model was performed to analyze the causal link between anxiety, depression, and sleep disturbances while controlling by age. As shown in Figure 1, all three constructs demonstrated strong stability over 3 months, with autoregression path coefficients ranging from 0.25 to 0.35. Moreover, after controlling the autoregression of anxiety, depression, and sleep disturbances, as well as the correlation of three constructs at the same wave, depression at wave 1 could significantly predict anxiety ($\beta = 0.16$, $p < 0.001$) and sleep disturbances ($\beta = 0.10$, $p < 0.001$) at wave 2. Anxiety

TABLE 1 Preliminary analysis for major variables (n = 2,787).

Variables	M	SD	1	2	3	4	5	t	p
1. Wave 1 depression	2.79	3.91						−0.92	0.35
2. Wave 2 depression	2.86	4.44	0.45**						
3. Wave 1 anxiety	1.83	3.18	0.82**	0.42**				3.80	<0.01
4. Wave2 anxiety	1.58	3.17	0.40**	0.78**	0.42**				
5. Wave 1 sleep	12.3	5.29	0.64**	0.39**	0.60**	0.31**		2.13	0.03
6. Wave 2 sleep	12.1	5.60	0.37**	0.65**	0.35**	0.64**	0.45**		

**$p < 0.01$.

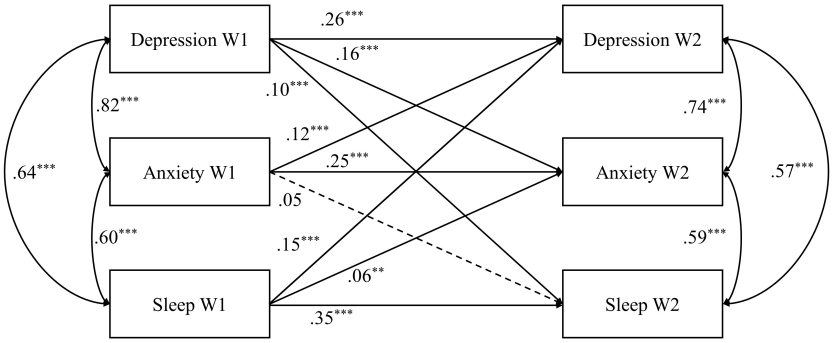

FIGURE 1
The standardized cross-lagged model between depression, anxiety, and sleep disturbances. The residuals were not shown; **$p < 0.01$, ***$p < 0.001$.

TABLE 2 Pairwise parameter comparisons.

Path	Male		Female	
	β	p	β	p
Wave 1 depression→ Wave 2 depression	0.19	<0.01	0.32	<0.01
Wave 1 depression→ Wave 2 anxiety	0.12	< 0.01	0.19	<0.01
Wave 1 depression→ Wave 2 sleep	0.12	=0.02	0.08	=0.03
Wave 1 anxiety→ Wave 2 depression	0.16	<0.01	0.09	=0.01
Wave 1 anxiety→ Wave 2 anxiety	0.28	<0.01	0.22	<0.01
Wave 1 anxiety→ Wave 2 sleep	0.08	=0.10	0.03	=0.35
Wave 1 sleep→ Wave 2 depression	0.12	<0.01	0.18	<0.01
Wave 1 sleep→ Wave 2 anxiety	0.02	=0.53	0.09	<0.01
Wave 1 sleep→ Wave 2 sleep	0.26	<0.01	0.42	< 0.01

at wave 1 could significantly predict depression ($\beta = 0.12$, $p < 0.001$) at wave 2. Sleep disturbances could significantly predict depression ($\beta = 0.15$, $p < 0.001$) and anxiety ($\beta = 0.06$, $p < 0.01$) at wave 2. However, anxiety at wave 1 could not significantly predict sleep disturbances ($\beta = 0.05$, $p = 0.08$). These results indicated that the relationship between anxiety and depression, sleep disturbances, and depression is bidirectional, while the relationship between anxiety and sleep disturbances is unidirectional.

A multi-group analysis grouped by gender was conducted to examine gender differences in the cross-lagged model. We constructed a structural weights equivalent model, supposing that regression coefficients were equal between genders. Fitting results were excellent referencing to Hu and Bentler's criteria (39): $\chi^2 = 15.99$, $df = 9$, $CFI = 0.99$, $TLI = 0.99$, $RMSEA = 0.02$ (90% $CI = [0.00, 0.04]$). We compared the structural weights equivalent model to the unconstrained model to test whether there is a gender difference. The results showed that $\Delta\chi^2 = 15.99$, $\Delta df = 9$, $p > 0.05$) indicated no significant gender difference in the cross-lagged model of depression, anxiety, and sleep disturbances among Chinese college students (see Table 2).

Discussion

Studies on sleep disturbance, depression, and anxiety have lasted for over 40 years (40). However, with the foreground of the pandemic of COVID-19, depression, anxiety, and sleep disturbance have become more prevalent, especially among college students. Lack of longitudinal studies, our results portrayed several findings as follows. Some points are worth discussing.

Inconsistent with the result of Wang et al. (41), which indicated that anxiety levels of high school students in Wuhan raised with the new semester after being quarantined for

several months in the first wave of the pandemic. Our result provides sequential proof that after home quarantine, anxiety alleviated significantly in the situation that the pandemic has already lasted for over 1 year. Our results also may support the hypothesis that increased physical activities can mitigate the anxiety level of college students (42), for the anxiety level is reduced after quarantine which means more space and opportunities for physical activities can buffer anxiety. Even if no previous studies revealed the fluctuation of sleep disturbance, after quarantine, sleep quality also resurrects to some degree. Combined with previous studies, besides physical activities, augmentation, improvement, or a stable diet may contribute to sleep disturbance resurrection (43).

In contrast, as if levels of depression seemed to increase with time, the comparison is not significant on a statistical level. To deduce why college students did not get rid of the shackle of depression after home quarantine, clues from Xiang et al. (42) implied that only when physical activities reach a moderate level can depression be mitigated. Therefore, in the situation that college students did not do enough physical activities, depression was not meliorated at an effective level.

Referring to associations between anxiety, depression, and sleep disturbance, only could anxiety just predict depression and anxiety afterward, while depression and sleep disturbance can simultaneously predict anxiety, sleep disturbance, and depression. However, previous studies portrayed a bidirectional relationship between anxiety and sleep disturbance, which indicated that anxiety and sleep disturbance could predict mutually (44, 45). However, from our results, the situation varies with the foreground of COVID-19, a pandemic. Tao et al. (46) researched symptoms of sleep disturbance, anxiety, and depression, a change in sleep disturbance can change the anxiety and depression structure. Hence, it is proper to speculate that before anxiety is alleviated after quarantine, sleep quality improves in advance. Therefore, from this point of view, anxiety cannot predict sleep disturbance.

Besides disease association, though no studies contain a comparison between pre-pandemic, during the pandemic, and post-pandemic, we can draw some clues from previous studies to raise surmises and supply information to patch a holistic view. From the perspective of cross-sectional data, correlations exist between anxiety, depression, and sleep disturbance which is coherent with the results of Becker et al. (8). From data of wave 1 and wave 2, there is a significant bidirectional relationship between anxiety, depression, and sleep disturbance. When we make the comparison between wave 1 and wave 2, the relationship between anxiety, depression, and sleep disturbance becomes less close. Though no studies were done during the pandemic and post the pandemic, research done by Deng et al. (2) showed that levels of anxiety, depression, and sleep disturbance reached the peak level during the pandemic. Our results provide information from another facet after quarantine, the relationship between anxiety, depression, and sleep disturbance becomes sparser. In the domain of hopelessness, a factor related to anxiety and depression, Tao et al. (47) drew the same trend in college students, which implied that after quarantine, hopelessness was reduced. Combining previous studies' results, we estimate that less time spent on mobile phones and more physical activities can reduce anxiety, depression, and sleep disturbance and further dilute the bidirectional relationship (42, 48).

Limitation

First, as discussed above, the severity of depression, anxiety, and sleep disturbance can be affected by many externals, such as school schedule and containment measurement. Some other information, such as time of sleep and frequency of physical activities can be confounding factors influencing degrees of anxiety, depression, and sleep disturbance. Second, anxiety, depression, and sleep disturbance can alter with quarantine duration and time after quarantine duration. Hence, in future studies, more time points, time duration, and other pandemic containment measures can be pinned for investigation.

Conclusion

In our current study, three main findings were (1) levels of anxiety and sleep disturbance alleviated significantly after quarantine except for depression; (2) a bidirectional relationship exists between anxiety, depression, and sleep disturbance; (3) depression and sleep disturbance can predict post quarantine depression, sleep disturbance and anxiety, yet anxiety cannot predict sleep disturbance afterward. Our current study clearly shows that quarantine adds great pressure and stress on college students while, after quarantine, college students' mental status resumes great resilience.

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 Beijing Normal University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

CS took the lead in writing the manuscript. YL conceived the study design and supervised the data collection. SW performed

the data analysis. QT, XL, and YL provided critical feedback and helped shape the research, analysis, and manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Bibliometric and visualization analysis of research trend in mental health problems of children and adolescents during the COVID-19 pandemic

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Objectives: To analyze the evolution of research on children and adolescents mental health issues during COVID-19 pandemic and discuss research hotspots and cutting-edge developments.

Methods: The literature obtained from the web of science core collection as of June 28, 2022, was analyzed using Citespace, VOSviewer bibliometric visualization mapping software.

Results: A total of 6,039 relevant papers were found, of which 5,594 were included in the study. The number of literatures is growing since 2020; and the country, institution, and journal publications were analyzed. The co-citation analysis shows that there are more research articles among the highly cited articles and a lack of systematic reviews that use critical thinking for review. In the cluster analysis, mental health and life change were the most representative. The timeline view of the keywords shows that Online learning (#0), Public health (#1), and Mental health (#2) are the three largest clusters and shows the change over time.

Conclusion: This study helped analyze the mental health of children and adolescents during the COVID-19 pandemic and identified hot trends and shortcomings, which are important references for the theoretical basis of future research and decision making and technical guidance for systematic reviews.

KEYWORDS

COVID-19, children, adolescent, mental health, Citespace, bibliometric analysis

1. Introduction

Since the first case of unexplained pneumonia was reported and identified as 2019-nCoV in Wuhan, Hubei Province, China, in December 2019, the novel coronavirus pneumonia outbreak has assumed a global pandemic pattern (1). The emergence of COVID-19 has resulted in the most serious global infectious disease pandemic in nearly 100 years, resulting in a huge development challenge for all of humanity. COVID-19 causes human-to-human transmission primarily through respiratory infections, and

countries have taken extensive measures to reduce the spread of COVID-19 in order to control the epidemic. At the meantime, countries worldwide are concerned about the potential impact of the COVID-19 epidemic in other aspects.

To control the further spread of the infection, many governments have issued disease prevention and control measures, mainly through quarantine of patients, asymptomatic infected persons and close contacts, following by targeted treatment of patients according to the features of COVID-19 (2). Further transmission of COVID-19 is effectively controlled through quarantine measures, but the mental health effects on people in an outbreak quarantine situation should also be taken into consideration. There will be negative psychological effects on people experiencing quarantine, including post-traumatic stress symptoms, confusion, and anger. Stressors include longer periods of quarantine, fear of infection, depression, boredom, inadequate supplies, lack of information, financial loss, and stigma (3). A more important but easily overlooked issue is the mental health impact on children and adolescents under the COVID-19 pandemic. Children and adolescents are more likely to be affected by environmental factors than adult. Sprang and Silman have shown posttraumatic stress symptoms in isolated children by comparing parents and isolated children with non-quarantined children, suggesting that the average posttraumatic stress score of isolated children was four times higher than that of non-isolated children (4). Children and adolescents in prolonged home quarantine may experience increased loneliness and therefore increased mental health problems in children and adolescents due to social restrictions and school closures (5). In addition, the interaction between psychosocial stress caused by lifestyle changes in the context of the pandemic may further exacerbate the adverse effects on children's physical and mental health, leading to a vicious cycle (6). Children and adolescents will have a higher risk of mental health problems under the pandemic, so it is of research significance to focus on mental health problems of children and adolescents and propose effective solutions.

The purpose of this paper is to conduct a bibliometric and visualization analysis of the distribution and trends of research on mental health issues in children and adolescents during the COVID-19 pandemic. This study will help researchers to better understand the current research progress and identify future research directions. This paper explores the following questions: (1) What are the general publication trends worldwide for research on mental health issues in children and adolescents in the context of the COVID-19 pandemic? (2) Which countries or regions have been dominant in this research direction? (3) Which journals, institutions, and authors are most influential in this area of research? (4) What are the current research hotspots on the mental health of children and adolescents during the COVID-19 pandemic? (5) What are the future trends in mental health of children and adolescents? (6) What recommendations can be made to scholars and policy makers?

2. Methods

2.1. Data source

This study searched the web of science core collection, a database commonly used in bibliometric analysis, which contains the most important and commonly used journals in the world, covering a wide range of fields, with the neutrality and informativeness needed for analysis (7–9).

2.2. Methodology

Scientific mapping is an important method in bibliometric analysis (10) and can help to analyze and visualize a field in order to obtain revolutionary changes and new trends in the structure of the field (11). In this paper, we used CiteSpace (Chaomei Chen, China) (12, 13), VOSviewer (14) (Centre for Science and Technology Studies, Leiden University, The Netherlands), Scimago Graphica (Scimago Lab, Portugal) to create visualization maps. Co-citation networks analysis and co-occurrence keyword analysis were performed using time slices from Citespace. Origin 2022 (Origin Lab, Northampton, Massachusetts, USA.) was used to plot histograms. The analysis process is shown in Figure 1A.

Using bibliometric methods and knowledge mapping visualization software, we analyzed the distribution and development trends of studies on mental health issues in children and adolescents during COVID-19 pandemic. Our search terms were set as followed. TS = ("coronavirus 2019" OR "COVID 19" OR "coronavirus disease 2019" OR "2019 novel coronavirus" OR "2019-novel CoV" OR "COVID 2019" OR "2019 ncov" OR "COVID19" OR "nCoV-2019" OR "nCoV2019" OR "nCoV 2019" OR "COVID-19" OR "Severe acute respiratory syndrome coronavirus 2" OR "2019-ncov" OR "SARS-CoV-2") AND TS = ("children" OR adolescen* OR "student") AND TS = ("mental" OR "psychological" OR "psychiatry" or "psychiatric" OR "emotional" OR "stress" "stressed" OR "stressful" OR "anxiety" OR "anxious" OR "depression" OR "depressed" OR "depressive" OR "depress" OR "anger" OR "angry" OR "loneliness" OR "lonely" OR "burnout" OR "insomnia" OR "fear" OR "worry" OR "frustration" OR "posttraumatic stress disorder" OR "post-traumatic stress" OR "posttraumatic stress" OR "PTSD").

The inclusion criteria used to determine the studies in this study were (1) studies about mental health in children and adolescent during COVID-19 pandemic, (2) research articles and review articles (3) published in English in all years. All literature was downloaded on June 28, 2022, with a total of 6039 literature obtained. After screening, a total of 5594 studies from the perspective of mental health of children and adolescent were included.

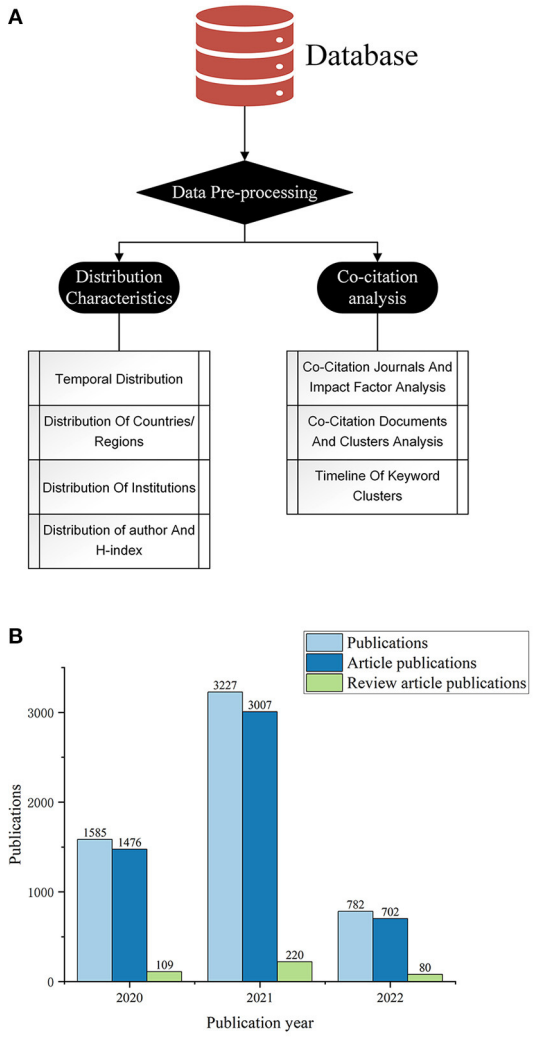

FIGURE 1
Bibliometric and visualization analysis framework **(A)** and Annual publication distribution **(B)**.

3. Distribution characteristics

3.1. Temporal distribution

Among the 5,594 studies included, 409 were review articles and 5,185 were research articles. Figure 1B shows the distribution of publications in the 3 years since the outbreak of COVID-19. The first literature was published by Rehma (15) in 2020, suggesting the need for mental health support for children in Pakistan during the COVID-19 pandemic. Since the onset of the new crown pneumonia outbreak in 2020, there has been a growing interest in mental health issues for children and adolescents, however, it has been a relatively short period of time and is still in its infancy.

3.2. Global geographic distribution

3.2.1. Distribution of countries/regions

A total of 144 countries or regions were involved in the study of mental health of children and adolescents during COVID-19 pandemic. Data on national collaborations were exported through VOSviewer software, with a minimum number of 50 articles per country, and the national collaboration network was mapped through Scimago Graphica software as shown in Figure 2A.

Table 1 and Figure 2B shows the relationship between the number of articles published and the average time of publication in different countries. The Italian research started earlier, while the studies in China, United States, and United Kingdom were relatively later, but have a higher volume of publications and play an important role in the core collaborative network.

3.2.2. Distribution of institutions

To demonstrate the collaboration network among institutions, we used VOSviewer software for visualization mapping, and the minimum number of papers was set to 30. The relationship between the number of papers and the average publishing time of institutions is shown in Table 2 and Figure 3. A total of 39 institutions were selected, and the width of the connecting line represents the number of collaborations. The University of Toronto, University of London, and Harvard Medical School have a large number of publications and average number of citations, started their research earlier, and have closer links with other institutions in the map. Among the top ten institutions in terms of the number of publications, University of Melbourne is the latest to start its research.

3.3. Distribution of author

We counted the publications of different authors and created a visualization map of the author collaboration network by Citespace software, as shown in Table 3 and Figure 4, with the selection criteria set as G-index of 25. G-index, as a derivative of H-index, is more sensitive than H-index in measuring the impact of researchers (16). Table 3 shows the statistical characteristics of the top 10 productive authors, including the number of publications, author's affiliation, country, and H-index, etc. Chungying Lin was the author with the highest number of publications, having 12 articles. Mohammed A Mamun and Claudia Mazzeschi ranked second with 9 articles.

4. Co-citation analysis

4.1. Co-citation journals analysis

Co-citation is when two prior papers are cited together by another paper. Multiple co-citations can form a co-citation

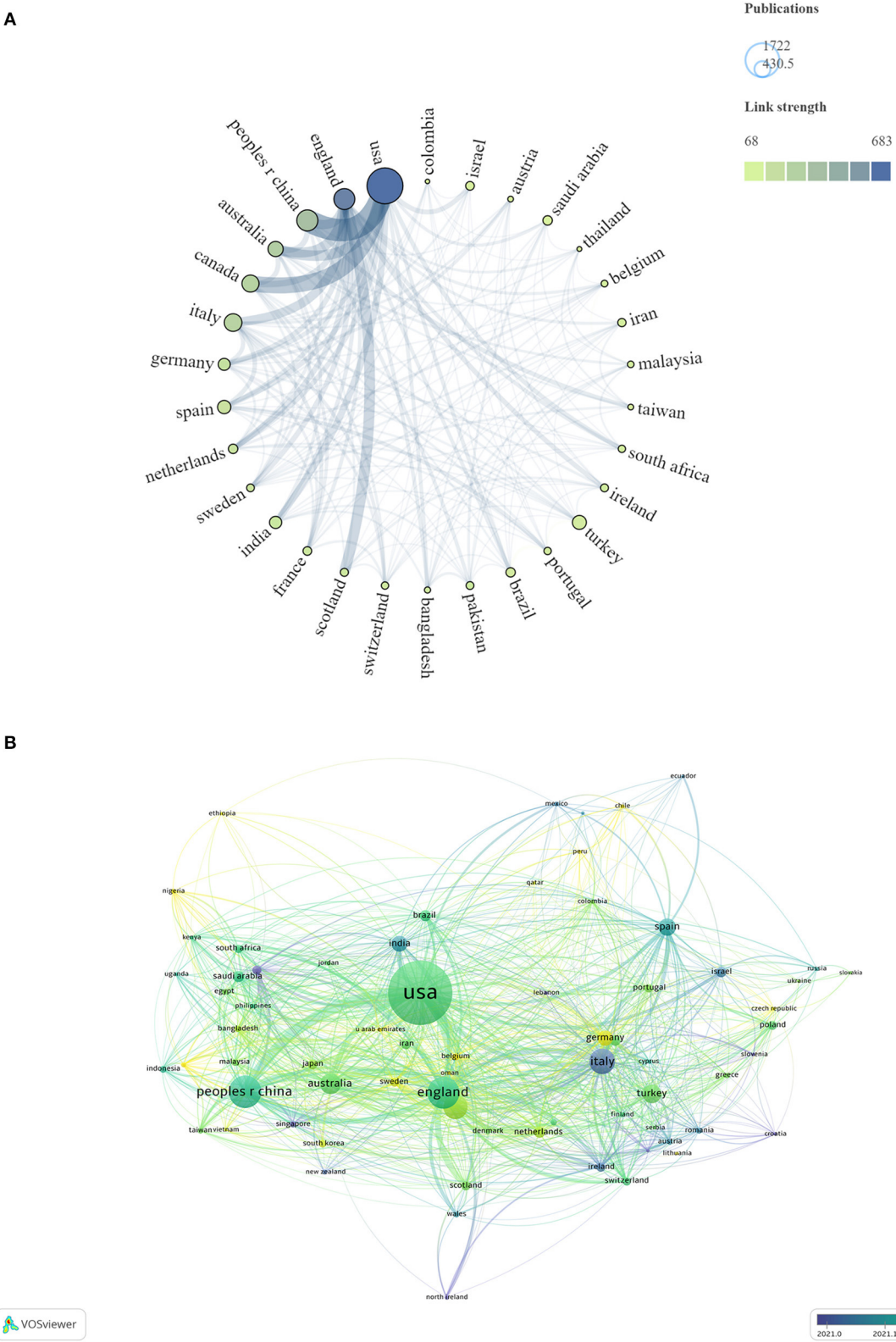

FIGURE 2
Geographical distribution in the past 3 years **(A)**. The size of the circle displays the number of publications, and the thickness of links represents cooperation strength between countries. Overlay Geographical visualization was based on publication-weights and average publication year scores **(B)**.

TABLE 1 Top 10 countries/regions according to publications.

Rank	Country/regions	Publications (%)	TC	AC	Avg. pub. year
1	USA	1,722 (35.23%)	15,800	9.18	2021.19
2	China	593 (12.13%)	9,503	16.03	2021.16
3	England	584 (11.95%)	8,610	14.74	2021.18
4	Italy	416 (8.51%)	5,243	12.60	2021.03
5	Canada	387 (7.92%)	5,839	15.09	2021.25
6	Australia	306 (6.26%)	3,049	9.96	2021.21
7	Turkey	259 (5.30%)	1,340	5.17	2021.22
8	Spain	234 (4.79%)	2,243	9.59	2021.11
9	India	197 (4.03%)	2,324	11.80	2021.09
10	Germany	190 (3.89%)	2,160	11.37	2021.29

TC, total citations; AC,average citations per paper; Avg. pub. year, the score of average publication year.

TABLE 2 Top 10 productive institutions according to publications.

Rank	Institution	Publications (%)	TC	AC	Avg. pub. year
1	UNIV TORONTO	100 (15.43%)	2,959	29.59	2021.22
2	UCL	85 (13.12%)	2,102	24.73	2021.14
3	UNIV MELBOURNE	75 (11.57%)	664	8.85	2021.33
4	HARVARD MED SCH	66 (10.19%)	728	11.03	2021.07
5	KINGS COLL LONDON	65 (10.03%)	1,107	17.03	2021.19
6	UNIV WASHINGTON	56 (8.64%)	573	10.23	2021.12
7	COLUMBIA UNIV	55 (8.49%)	402	7.31	2021.31
8	MONASH UNIV	52 (8.02%)	475	9.13	2021.30
9	UNIV MICHIGAN	47 (7.25%)	413	8.79	2021.18
10	UNIV OXFORD	47 (7.25%)	566	12.04	2020.89

network, which can help to quickly understand developments in a particular field (17). Citespace software was used for co-citation analysis, and the top 10% of cited articles each year were selected for the analysis, generating 124 nodes, and the network visualization map is shown in Figure 5, where the different colored circles represent the citation volume in different years. The lines between the circles represents co-citation relationship. The thickness and number of connections between the nodes indicate the strength of links between journals. Table 4 shows the statistical parameters of the top 10 highly cited journals, including citation volume, centrality, and impact factor. Betweenness centrality is commonly used within a cluster to identify potential that could lead to transformative discoveries (11). Impact factors, although having their own limitations and drawbacks, are still an irreplaceable and quantifiable measure (18). The frequency of citations and centrality of INT J ENV RES PUB HE, hosted by Switzerland, and LANCET, hosted by the UK, are higher than other journals. The top eight journals are all cited more than 1,000 times with an average impact factor of 39.98 with high influence in this field.

4.2. Co-citation documents analysis

Citespace software was used to produce the literature co-citation network shown in Figure 6. The top 35% of the publications cited per year were selected for analysis. Table 5 lists the top ten highly cited articles. *The psychological impact of quarantine and how to reduce it: rapid review of the evidence* is the most highly cited, with 680 citations. In this article, Brooks et al. evaluated measures during quarantine in 24 papers on the psychological effects of quarantine, including studies of children and adolescents (19), and proposed responses to reduce the psychological effects of quarantine, including the need for effective communication of information, the need for those in quarantine to be informed, and compliance with clear rules and regulations. *Immediate Psychological Responses and Associated*

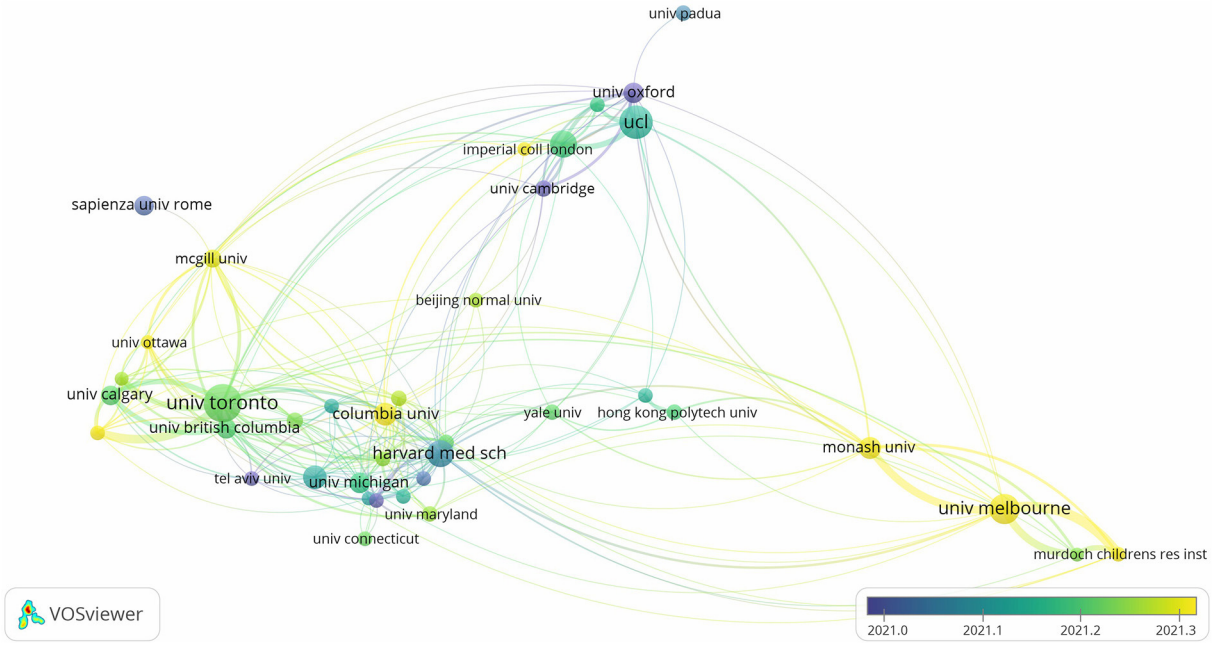

FIGURE 3
Visualization map of cooperation network between institutions, based on the publication-weights and average publication year scores.

TABLE 3 Top 10 productive authors.

Rank	Author	Publications	Starting year	Institution	Country	H-index
1	Chungying Lin	12	2021	National Cheng Kung University	China	51
2	Mohammed A. Mamun	9	2021	Jahangirnagar University	Bangladesh	34
3	Claudia Mazzeschi	9	2020	University of Perugia	Italy	26
4	Yutao Xiang	8	2021	University of Macau	China	59
5	Teris Cheung	8	2021	Hong Kong Polytechnic University	China	28
6	Mark D. Griffiths	8	2021	Nottingham Trent University	England	167
7	Elisa Delvecchio	8	2020	University of Perugia	Italy	20
8	Nicholas Chadi	7	2021	Sainte-Justine University Hospital Centre	USA	19
9	Hui Li	7	2021	Huazhong University of Science and Technology	China	11
10	Han Qi	7	2021	Capital Medical University	China	6

Factors during the Initial Stage of the 2019 Coronavirus Disease (COVID-19) Epidemic among the General Population in China published by Wang et al. was cited 383 times. The paper presents a retrospective cross-sectional study of students facing high levels of stress, anxiety and depression due to uncertainty about school closures (20). However, snowball sampling was used in this study, and the questionnaire was first distributed to college students, who then spread it to people around them to fill out, making the sample less representative and still in need of further study. In *The psychological impact of the COVID-19 epidemic on college students in China*, Cao et al. conducted a cross-sectional study of college students and found that economic impact, impact on daily life, and delay in academic activities were risk factors for anxiety symptoms, while stable family income and co-residence with parents were protective factors (21). The subjects of this study were university students in medical school, and since their knowledge of the novel coronavirus is more advanced than that of the general student population, whether there is a difference in anxiety status from other students still needs to be examined. In general, there were more research articles among the high cited articles, with two of the top three articles conducting cross-sectional studies; the review articles lacked

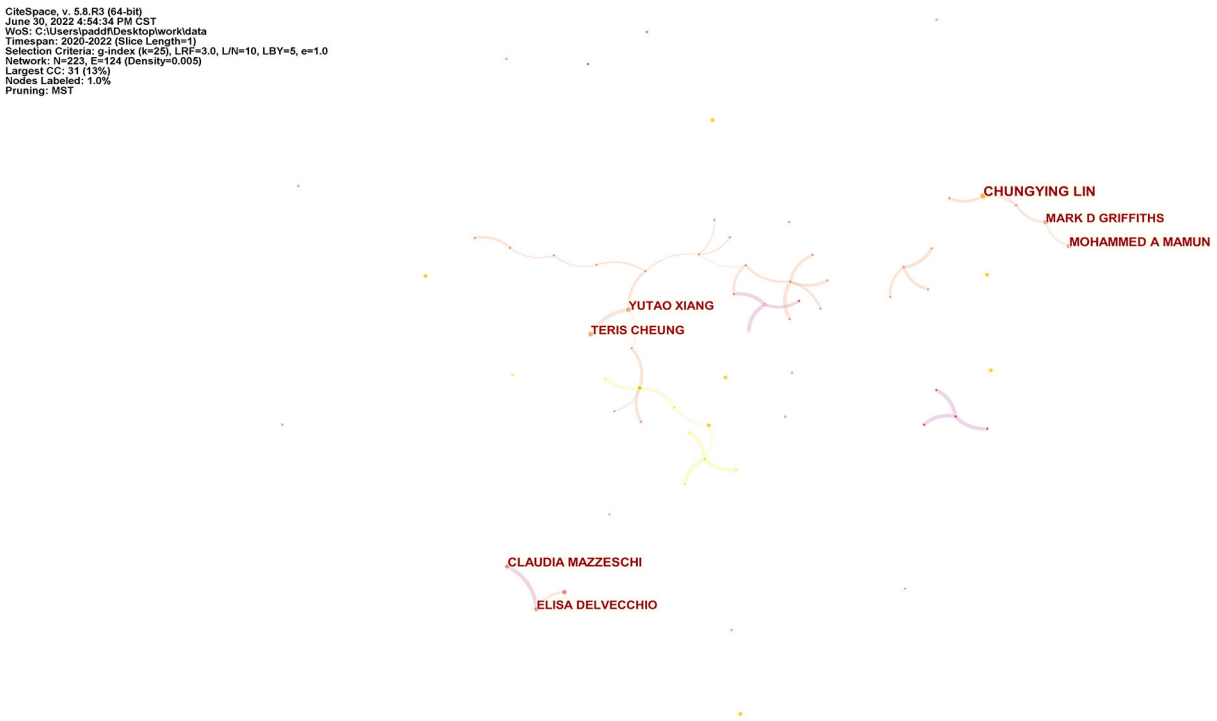

FIGURE 4
Visualization map of author network. The size of the circle displays the number of publications of this author.

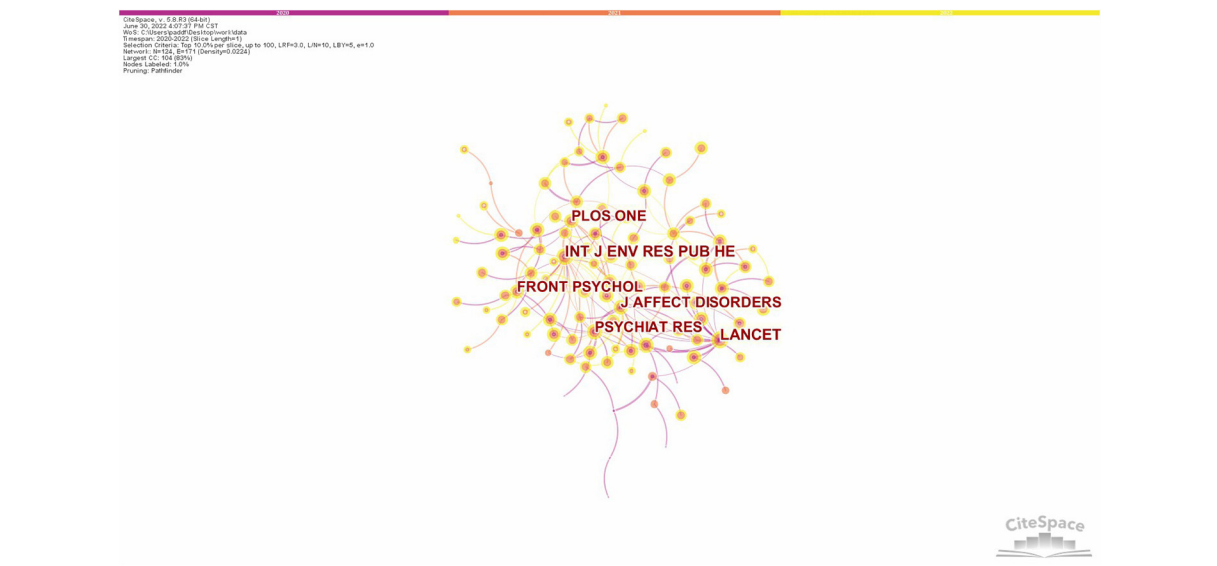

FIGURE 5
Visualization map of co-citation journals.

systematic reviews that used critical thinking to conduct the review. Researchers are primarily concerned with the measures currently in place and the economic and social conditions in which they live.

4.3. Cluster of co-citation document

Cluster analysis of highly cited literature was performed by Citespace software, as shown in Figure 7. The time slice

TABLE 4 Top 10 highly cited journals.

Rank	Journal	Citations	Centrality	Impact factor (2021)	Host country/region
1	Int J Env Res Pub He	1,925	0.47	4.614	Switzerland
2	Lancet	1,918	0.45	202.731	England
3	Psychiat Res	1,764	0.37	11.225	Ireland
4	PLOS ONE	1,735	0.11	3.752	USA
5	Front Psychol	1,476	0.19	4.232	Switzerland
6	J Affect Disorders	1,384	0.22	6.533	Netherlands
7	Lancet Psychiat	1,116	0.11	77.056	England
8	Pediatrics	1,027	0.07	9.703	USA
9	Lancet Child Adolesc	938	0.1	37.746	England
10	Jama-J Am Med Assoc	895	0	157.335	USA

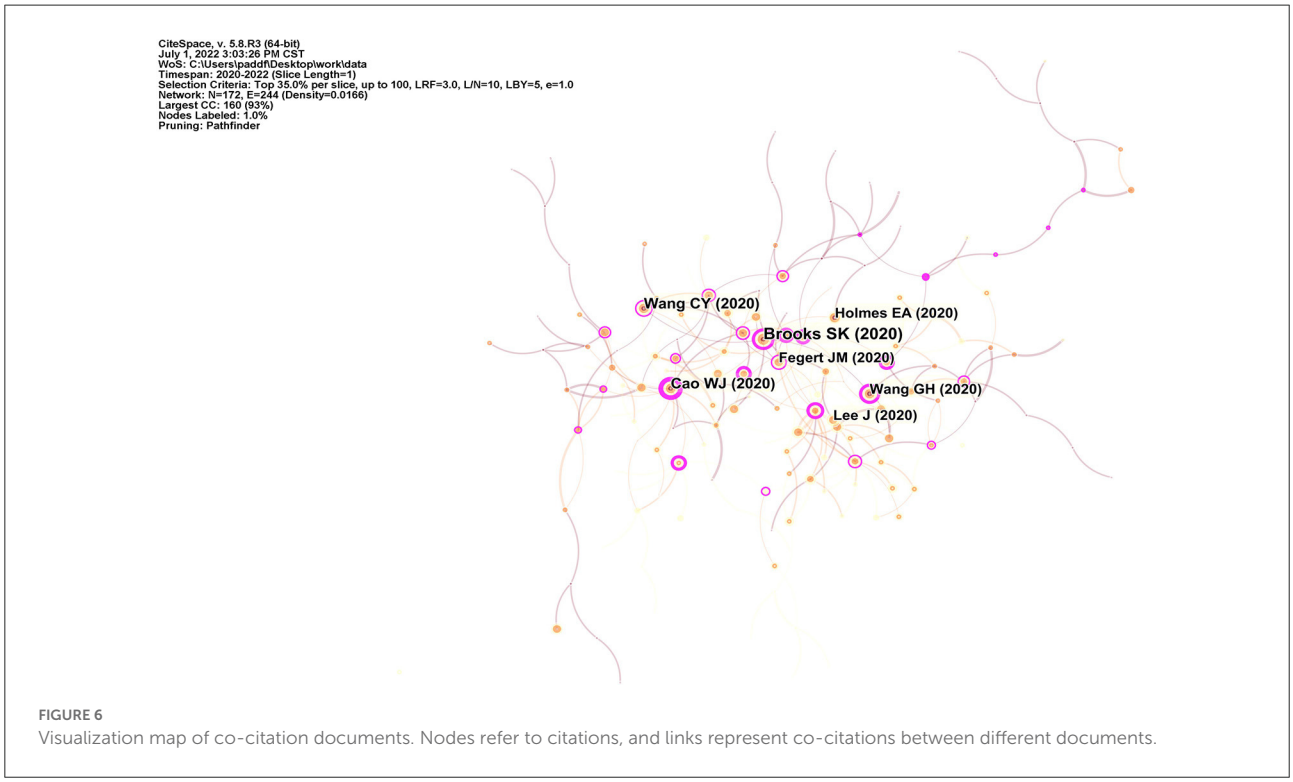

FIGURE 6
Visualization map of co-citation documents. Nodes refer to citations, and links represent co-citations between different documents.

was set to 1 year, and the top 35% of the literature in each slice was selected. Each cluster label was extracted from the titles of the articles cited in the cluster by Latent Semantic Indexing (LSI) method. Too much or too little cluster results can affect the clarity and accuracy of the network (9). In order to evaluate the effect of network mapping, two metrics are set, the modularity and the silhouette, and the cluster's silhouette value above 0.7 is generally convincing (22). The silhouette value of the clusters in this study is 0.9103 and the modularity value is 0.6956, which is a good fit. The larger the area of the clusters represents the more attention the researcher has paid to the field, and the intersection between clusters means that the article covers two or more fields. COVID-19 pandemic (#5) has an area of intersection with most of the remaining clusters, indicating that all studies were conducted primarily focusing on mental health issues following the COVID-19 pandemic. Mental health (#0) has a large intersection with life change (#3), child abuse (#4), indicating that researchers believe that life change and child abuse are important influential factors affecting mental health of children and adolescents (23–25). Physical activity (#1) and suicidal thoughts (#6) partially overlap, and several studies have found both decreased physical activity and

TABLE 5 Top 10 highly cited documents.

Rank	Title	Citation frequency	Centrality	Author	Type	Year
1	The psychological impact of quarantine and how to reduce it: rapid review of the evidence	680	0.38	Brooks SK	Review	2020
2	Immediate Psychological Responses and Associated Factors during the Initial Stage of the 2019 Coronavirus Disease (COVID-19) Epidemic among the General Population in China	383	0.18	Wang CY	Article	2020
3	The psychological impact of the COVID-19 epidemic on college students in China	375	0.46	Cao WJ	Article	2020
4	Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science	292	0.05	Holmes EA	Review	2020
5	Challenges and burden of the Coronavirus 2019 (COVID-19) pandemic for child and adolescent mental health: a narrative review to highlight clinical and research needs in the acute phase and the long return to normality	286	0.13	Fegert JM	Review	2020
6	Mitigate the effects of home confinement on children during the COVID-19 outbreak	283	0.21	Wang GH	Article	2020
7	Features Mental health effects of school closures during COVID-19	274	0.02	Lee J	Article	2020
8	Rapid Systematic Review: The Impact of Social Isolation and Loneliness on the Mental Health of Children and Adolescents in the Context of COVID-19	271	0.15	Loades ME	Review	2020
9	Behavioral and Emotional Disorders in Children during the COVID-19 Epidemic	267	0.1	Jiao WY	Article	2020
10	Prevalence and socio-demographic correlates of psychological health problems in Chinese adolescents during the outbreak of COVID-19	242	0.32	Zhou SJ	Article	2020

increased suicidal ideation in children and adolescents during COVID-19 pandemic (26), therefore reduced outdoor time may be associated with poor mental health symptoms such as suicidal ideation (27), but the exact degree of association still needs further study. Meanwhile, some researchers investigated the suicide rate of children and adolescents during the first wave of COVID-19 pandemic on school closure in Japan and found no significant increase (28), but it remains to be studied whether the duration of quarantine and the number of repeated experiences of quarantine affect the mental health status of children and adolescents as COVID-19 is continuously prevalent in various regions. Nine representative clusters with the largest area are summarized in Table 6. Representative clusters from the nine clusters are selected for discussion below.

Class 1: mental health (#0). This cluster has the largest area with a silhouette value of 0.921 and contains 29 publications. The researchers focused on the occurrence of psychiatric symptoms in children and adolescents during COVID-19, summarized the associated risk and protective factors found, and gave relevant recommendations (5). The Delta variant of SARS-CoV-2 is spreading rapidly worldwide and the strain is extremely infectious (29), which means that more confirmed cases will emerge and people are faced with repeated quarantine for observation. a, while children and adolescents had increased reporting rates of depressive symptoms, anxiety symptoms during and after mandatory quarantine (5, 30, 31); however, a review of several studies by Racine et al. (32) found large differences in the conclusions reached by different scholars. Based on the above analysis of the highly cited literature, this phenomenon may be attributed to the poor representativeness of study sample selection, poor randomization, the suddenness of the COVID-19 outbreaks, the lack of baseline data before COVID-19 outbreak, and the short time span of the studies and the lack of studies on changes in symptoms due to the lapse of time. Therefore, more targeted, representative studies are still needed.

Class 2: life change (#1 and #3). The silhouette values were 0.935 and 0.851, respectively, and the number of highly cited articles was 24 and 17. The COVID-19 pandemic has significantly changed the lifestyle of children and adolescents, with schools closed indefinitely, online classes, parents infected with the novel coronavirus, and even children and adolescents infected or at risk of infection needing to be quarantined. The impact of this policy on their mental health is undoubtedly enormous and can even cause post-traumatic stress symptoms (19). Multiple studies have shown that COVID-19 stressors on families, including financial stressors, intimate relationship breakdowns, and psychosocial effects, may directly affect the mental health of both parents and children, with the two interacting with each other, with almost one in ten families reporting a concurrent deterioration in the mental health of children and parents (3, 21, 33–35). Severe Acute Respiratory

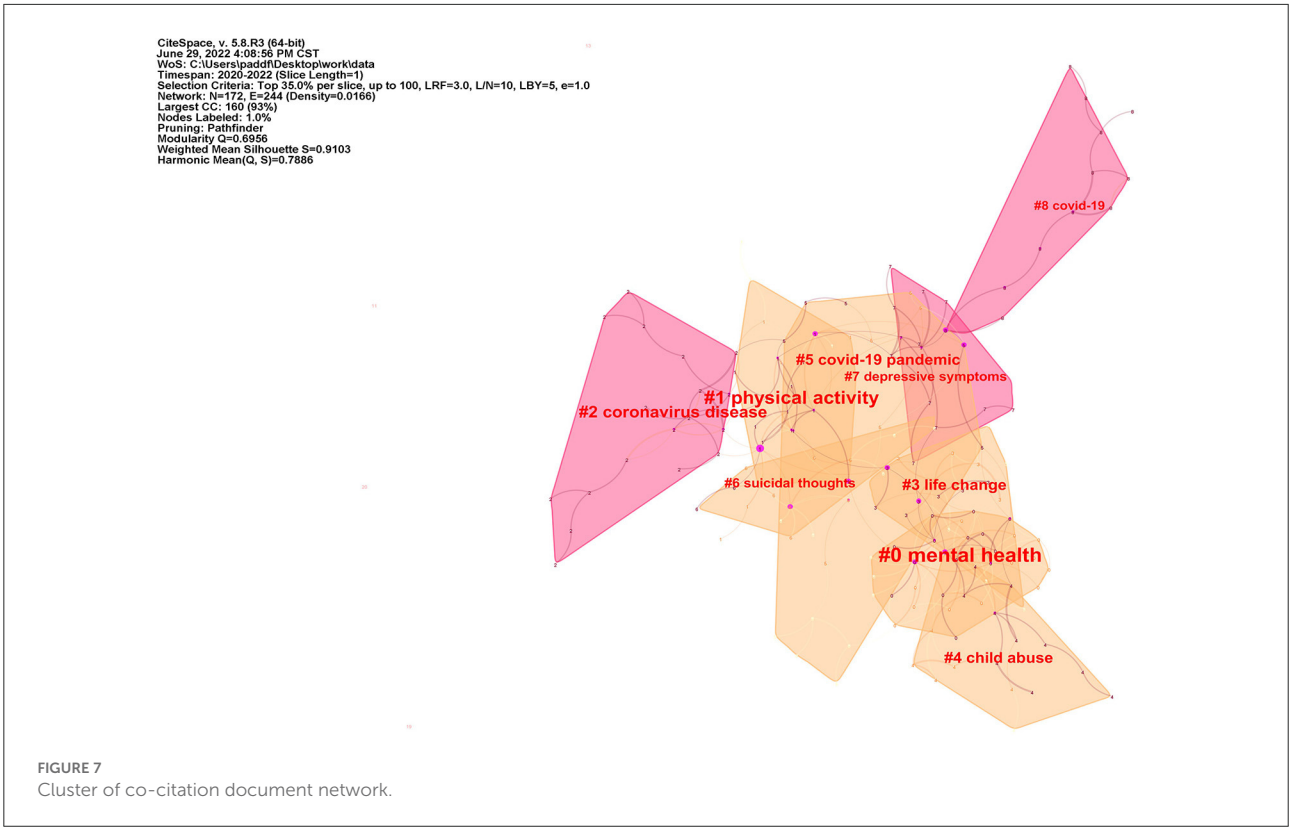

FIGURE 7
Cluster of co-citation document network.

Syndromes (SARS), a pandemic disease, was associated with an increased risk of mental illness and suicide after 12 years of follow-up of study subjects with an HR of 2.805 (36). COVID-19 has similar characteristics to its widespread prevalence, however, the extent to which these risk factors or protective factors are dangerous to the mental health of children and adolescents still needs to be specifically and systematically reviewed.

4.4. Timeline of keyword clusters

Figure 8 shows a keyword timeline analysis of the cluster network formed by the top 10% of citations per year. Table 7 lists the details of the 10 largest clusters in terms of area. Online learning (#0), Public health (#1), and Mental health (#2) were the three largest clusters in terms of area, demonstrating the highest frequency of occurrence of these three keywords in the researcher's study.

Also, we summarized the objectives and keywords of the researcher's study. The drivers for the researchers focused on which social, family, or personal influences caused by the COVID-19 pandemic could have positive or negative effects on the mental health of children and adolescents, such as strict isolation measures, school closures, increased use of mobile media devices, changes in food and physical activity habits, changes in socialization patterns, domestic violence, and child abuse. Meanwhile, other authors explored what the mental health effects of COVID-19 on children and adolescents include, such as the prevalence of depression and anxiety symptoms, and made targeted recommendations.

TABLE 6 The largest 9 clusters by size.

Cluster ID	Size	Silhouette	Label (LSI)
0	29	0.921	Mental health
1	24	0.935	Physical activity
2	19	0.929	Coronavirus disease
3	17	0.851	Life change
4	17	0.963	Child abuse
5	16	0.816	COVID-19 pandemic
6	13	0.89	Suicidal thoughts
7	13	0.874	Depressive symptoms
8	12	1	COVID-19

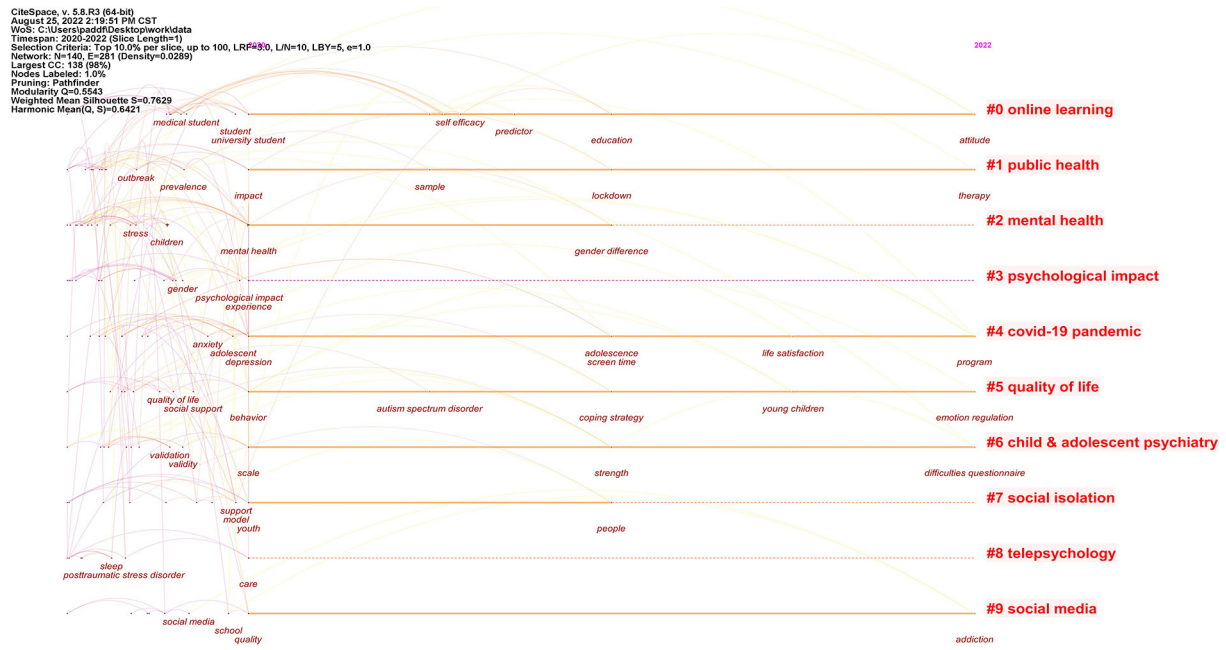

FIGURE 8
Timeline visualization of keyword clusters.

TABLE 7 The largest 10 clusters by size.

Cluster ID	Size	Silhouette	Label (LSI)	Mean (year)
0	17	0.69	Online learning	2020
1	17	0.6	Public health	2020
2	17	0.899	Mental health	2020
3	16	0.892	Psychological impact	2020
4	15	0.818	COVID-19 pandemic	2020
5	13	0.701	Quality of life	2020
6	12	0.758	Child and adolescent psychiatry	2020
7	11	0.728	Social isolation	2020
8	11	0.671	Telepsychology	2020
9	9	0.884	Social media	2020

5. Discussions and conclusions

Based on the literatures on mental health issues of children and adolescents during the COVID-19 pandemic, this study discusses the temporal trends and geographical distribution of the literature published on mental health issues of children and adolescents during the COVID-19 pandemic using bibliometric and visualization methods, analyzes the influence of journals, institutions, and authors in this research direction, and discusses research hotspots and development trends. We can derive the following findings.

(1) Since the outbreak of SARS-CoV-2, the research time is still short, and the research on the mental health problems of children and adolescents after the COVID-19 pandemic is still in the initial stage, but the attention to the problem is continuously increasing.

(2) From the perspective of geographical distribution, a total of 144 countries or regions were involved in the study of child and adolescent mental health during the COVID-19 pandemic, with the United States having the highest number of publications. Research on mental health issues in children and adolescents during the pandemic in the United States, China, the United Kingdom, and Italy has played an important role in the core collaborative network. Among the top ten countries in terms of number of articles published, Germany started its research later. While China has the highest average number of citations for each article which is acknowledged by a larger number of scholars.

(3) By analyzing the cooperation network among institutions, we can see that three institutions, University of Toronto, University of London, and Harvard Medical School, have a high volume of publications, while University of Melbourne, which started its research late, cooperates more closely with the above three institutions with 75 publications, ranking

fourth, therefore it may make more contributions to this field in the future.

(4) By counting the publications of different authors, Chungying Lin is the first in terms of the number of publications, whose article published in 2020 focused on children's internet behavior and psychological distress during COVID-19 suspension, with a baseline before the new crown outbreak and a follow-up 5 months after the baseline, suggesting that parents should focus on problematic mobile apps and social media use (37). This author also studied mental health problems in other populations during COVID-19 and proposed several related scales. Mohammed A Mamun and Claudia Mazzeschi are ranked second in terms of their contributions. Five of the top ten authors are from China, indicating that Chinese scholars are contributing more to this field. The top ten scholars focused on mental health issues such as internet addiction due to cell phone use among children and adolescents during COVID-19 and fear due to the SARS-CoV-2 epidemic.

(5) Co-citation analysis of journals, the citation frequency and centrality of INT J ENV RES PUB HE, hosted by Switzerland, and LANCET, hosted by the UK, were higher than other journals. Three of the above ten highly cited journals were from the United States and three from the United Kingdom, the same results as the above analysis of the distribution of descriptive characteristics of countries or regions, revealing that the United States and the United Kingdom-based research groups were the main areas of concentration of child and adolescent mental health research during COVID-19 pandemic. The literature co-citation analysis concluded that there were more research articles among the highly cited articles, with two of the top three articles conducting cross-sectional studies; the review articles lacked systematic reviews that used critical thinking for review. Researchers mainly focus on the measures currently implemented and the economic and social conditions in which they are located.

(6) A cluster analysis of highly cited literature was conducted to reveal the knowledge base and research hotspots of mental health issues in children and adolescents during the COVID-19 pandemic. A total of nine clusters were obtained in this area of research, among which mental health and life change were the most representative. As the pandemic continues to spread globally, physical and psychological symptoms in children and adolescents increase over time (38), and the current review of factors that contribute to mental health and life change in children and adolescents due to the COVID-19 pandemic found that the study sample is not representative enough, whether the impact is the same for children of different genders and ages, and how large the specific impact of different factors is needs further research is needed.

(7) A cluster analysis of keywords from the top 10% of articles cited each year and a timeline view was developed to reveal keyword clusters and temporal changes during the COVID-19 pandemic targeting mental health issues in children and adolescents. A total of ten clusters were obtained. Due to the need for closure and quarantine in schools, students have had to turn to online instruction, and several studies have shown that children who are taught by remote learning are at higher risk for psychological problems and are more likely to have problems at older ages (39–42). Public health (#1) and Mental health (#2), on the other hand, can be merged into one category, with researchers' focus shifting from blocking isolation (43, 44) to what policies to put in place to maximize therapy (45–47), and with studies finding gender differences in mental health problems among children and adolescents, but different researchers have come up with opposite effects of gender on mental health (48–50), which still needs to be further explored.

While studying the physical health risks associated with COVID-19, mental health issues should not be overlooked, especially when children and adolescents are at an important stage of growth and development, requiring us to continue to conduct more in-depth studies in frontier areas and hotspot directions. Our findings are generally consistent with the results of cross-sectional studies on the impact of pandemic (51, 52), these studies reported the negative impact of the COVID-19 pandemic in children and adolescents with mental health problems. The current global pandemic of COVID-19 warns us that the emergence and spread and dissemination of pathogens are unpredictable, and our findings suggest that children and adolescents with mental health risks need appropriate social support at an earlier period to avoid mental health problems from developing into diseases. In-depth research in this direction will play an important guiding role in the future response to epidemics, disasters, and other public health emergencies in the protection of children and adolescents' mental health.

Finally, there are several limitations of this study that need to be acknowledged. The bibliometric analysis and visualization can bring effective clustering results in terms of authors, locations, and hotspot directions. However, due to the broad coverage of the subject matter selected in this paper, we enriched the selection of search terms to make the data source more accurate, nevertheless, we searched only one source, the web of science core collection, and included only English literature, thus inevitably leading to some omissions. In addition, due to the space limitation of this paper, we cannot state all the results and details of the analysis in this paper. It is undeniable that research trends will be subject to many factors. High citation rates and journal dynamics are complex processes, and the current results do not necessarily reflect true trends, which need to be further discussed in the context of multiple factors. In spite of this, this paper is not only an important reference for child and adolescent mental health researchers to better understand the

current state of research on child and adolescent mental health issues in the context of the epidemic, but also a theoretical basis for further research and decision making and a technical guide for systematic reviews.

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.

Author contributions

ZG and YZ acquired, analyzed the data, and drafted the manuscript. ZG analyzed the data. ZG, YZ, and QL designed the research and revised the manuscript. All authors agreed to be accountable for the content of the work. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Mental health during the COVID-19 pandemic: Stress and strain profiles in the German population

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Clinical observations indicate that people frequently display stress-related behavior during the COVID-19 pandemic. Although numerous studies have been published concerning pandemic-related psychological distress, systematic data on the interrelationships between stress sensitivity, personality, and behavioral characteristics of people are still lacking. In the present cross-sectional online survey study, we applied a German version of the COVID Stress Scales (CSS) and standard psychological questionnaires to systematically identify the complex interplay between stress sensitivity, gender, and personality in the modulation of quality of life and mental health in the German population (N=1774; age≥16years). A CSS-based cluster analysis revealed two clusters characterized by higher and lower stress levels. Study participants in each cluster differed significantly with respect to neuroticism, extraversion, agreeableness, quality of life, depression, and anxiety. Females were significantly overrepresented in the higher stress cluster, while there was an overrepresentation of males in the lower stress cluster. Neuroticism was identified as a risk factor and extraversion as a protective factor for enhanced pandemic-related stress responses. For the first time our data show a taxonomy of factors, which modulate pandemic-related stress sensitivity and warrant consideration as key indicators of quality of life and psychological distress during the COVID-19 pandemic. We suggest that our data may advise governmental regulation of pandemic-related public health measures, to optimize quality of life and psychological health in different groups of the population.

KEYWORDS

pandemic-related stress, SARS-CoV-2 infection, quality of life, phases of pandemic, personality, gender, extraversion, neuroticism

1. Introduction

On the 30th of January 2020, the World Health Organization (WHO) declared the coronavirus disease (COVID-19) outbreak a health emergency of international concern. The COVID-19 pandemic was and still is an enormous challenge for the world, impacting societies in various ways. Social isolation, fear of virus transmission, economic uncertainty, physical

discomfort, and the daily deluge of news regarding the numbers of infections and related deaths negatively affect the quality of private, social, and occupational life (1–3). It has repeatedly been shown that both psychological health and quality of life have been negatively affected by the pandemic (4). Vindegaard and Benros (5) reported lower psychological well-being and higher levels of anxiety and depression in the general population. According to Xiong et al. (4), female gender, previous mental or physical illness, socioeconomic status (e.g., unemployment), age, and COVID-19 infections in relatives need to be considered as risk factors for the development of psychological distress and reduced quality of life during the pandemic.

Stress-related experiences during the COVID-19 pandemic are reaching a new level. For example, recent studies found that 25–50% of the German population suffers from symptoms related to stress and emotional distress (5–9). Some authors also report severe stress-related posttraumatic stress symptoms in COVID-19 infected patients (10). Given that half of the German population suffers symptoms of pandemic-related stress (5–9), one needs to consider that the other half must possess specific abilities that are protective against stress symptoms. Risk and protective factors for the development of stress symptoms have not been systematically investigated. Whereas Taylor et al. (11) reported that there is little evidence that personality traits influence COVID-related threat beliefs in adults in voluntary self-isolation, there is some evidence that personality characteristics need to be considered as factors in cognitive and behavioral responses to stress (12). For example, Liu et al. (13) showed that neuroticism might negatively influence pandemic-related stress perception. Some authors have also demonstrated that people with higher extraversion show increased stress reaction during the COVID-19 pandemic (13, 14), while Shokrkon and Nicoladis (15) reported that extraversion is related to better pandemic-related mental health.

A model that has proven particularly useful in explaining the effects of stress in crisis situations like the COVID-19 pandemic is the *Transactional Model of Stress and Coping* by Lazarus and Folkman [*TSC*; (16–18)]. This model posits that stress is a result of the relationship between individuals and their environment, and that sociodemographic factors such as age, gender, socioeconomic status may influence the type and intensity of experienced stress. The model also states that individual perceptions of stressors and their appraisal as either threats or challenges determine the degree of stress experiences. In particular, factors such as knowledge, beliefs, and emotions can influence the individual perception and appraisal of stressors. Furthermore, the TSC suggests that individual coping strategies and resources such as social support and individual skills and competencies play an important role in the processing of stress experiences (16–18). In a pandemic, risk and protective factors related to stress can be influenced by the interaction of individual factors, perceptions, coping strategies, and resources. Personality traits, general health, anxiety, depression, obsessive–compulsive symptoms (OCS) as well as demographic parameters may act as key moderators of stress experiences. Personality traits influence the perception and evaluation of stressors. A low general health status and high levels of anxiety and depression can also lead to a higher sensitivity for stressors and less efficient coping strategies. OCS can itself be seen as a strategy of stress coping by attempting to control situations and reduce uncertainty. At the same time, the symptoms themselves also act as stressors in that they may severely impair everyday living.

Additional contextual factors may be integrated into the theoretical framework of the TSC. Applicable factors are included in the *COVID Stress Scales* (*CSS*) developed and validated by Taylor et al. (19) in population-representative Canadian and North-American samples to better understand and assess pandemic-related distress. A stable 5-factor solution was identified: danger and contamination fears, fear about economic consequences, xenophobia, compulsive checking and reassurance seeking, and traumatic stress symptoms. Subscales were intercorrelated, providing evidence of a COVID Stress Syndrome. The CSS has been translated into 26 languages to date (20–24), validated for the German population (25) and become a gold standard in the assessment of COVID-related stress.

Although numerous studies concerning stress and psychological health during the COVID-19 pandemic have been published, a systematic concept of the interrelationship between the relevant facets is still lacking. Knowledge of the interrelation of specific personality traits, psychological symptoms, pandemic-related stress reactions, and quality of life can provide more detailed information on the taxonomy of individual behavior during the pandemic. In our online survey study, we applied a German version of the CSS of Taylor et al. (19, 25) and standard psychological questionnaires to identify the interplay between stress, personality, and behavior in the German population. We expected that (i) distinct populational clusters related to the amount of stress and strain during the COVID-19 pandemic can be extracted from the data, (ii) that demographic and personality characteristics act as key features in the definition of clusters, and (iii) that quality of life is lowest during the pandemic in population clusters with high levels of stress and strain.

2. Methods

2.1. Study design

The Psychological Institute of the Johannes Gutenberg-University Mainz, the Faculty of Health of Witten/Herdecke University, and the Psychotrauma Center of the Hospital of the German Armed Forces Berlin conducted the longitudinal online survey entitled "Stress and Strain during the COVID-19 Pandemic" in the German population from August 2020 to June 2021. For each participant, the survey scheduled two time points of measurement 8 weeks apart between August 2020 to June 2021. The timepoint of inclusion in the study was the first response to the questionnaire. Completion of the questionnaire at the second timepoint of measurement was the end of study participation and was carried out 8 weeks after the beginning of study participation. In the case of consent from a participant, the follow-up questionnaire was sent automatically *via* e-mail. The present work analyzes exclusively cross-sectional data of the first timepoint of measurement of this longitudinal study.

2.2. Sampling

Participants were invited by flyers, regional and national press releases, e-mail distribution lists, and social media. Inclusion criterium was an age ≥ 16 years. A reimbursement was offered by the opportunity of entering a competition to gain 25 € vouchers for online shopping for participation at the first and second time point of measurement.

All included participants gave written informed consent to take part in the study. The study complies with the recommendations of the World Medical Association published in the current version of the Declaration of Helsinki and was approved by the ethics committee of the Psychological Institute of the Johannes Gutenberg-University Mainz.

2.3. Sample

Participation in the study was tied to the questionnaires being completed in full. This was ensured by the fact that in the survey software SoSci Survey[1] it was set by default that the survey could only be ended when the questionnaires were completely filled in. This excluded the possibility of missing data points in the data set. The number of valid participants for the first timepoint of measurement was $N = 1964$. $N = 118$ of these participants did not explicitly indicate informed consent to participate in the study. Moreover, 72 duplicate data sets were detected. The resulting $N = 190$ inaccurate data sets were excluded from statistical analyzes. The final sample included a total of $N = 1774$ adults (females: $N = 1269$; males: $N = 497$; diverse: $N = 8$) with an age range from 16 to 85 years ($M = 41$ years, SD = 14). The sample is representative only for the higher educated German population, with an overrepresentation of females. Table 1 summarizes the sociodemographic characteristics of the sample.

2.4. Procedure

2.4.1. COVID stress scales

Data were acquired using the online platform SoSci Survey (see text footnote 1). Questionnaires included a German adaptation of the CSS (25), which consists of 36 items. The translation-back-translation process followed the guidelines for translating foreign language self-report measures. The original English items were transformed into German by Professors Jun.-Prof. Dr. S. M. Jungmann and Univ.-Prof. Dr. M. Witthöft and then back into English by a professional bilingual translator whose mother tongue is English. Although there were slight variations in wording between the two English versions (e.g., "keep me safe" vs. "protect me," "mail handlers" vs. "postman," "professionals" vs. "experts"), these differences were retained due to the preservation of the overall content. The German version consisted of 36 items, organized into six items per scale, and responses were recorded on a 5-point Likert scale ranging from 0 (not at all) to 4 (extremely), except for the Traumatic Stress and Compulsive behavior/reassurance related to frequency scales, which were answered on a scale ranging from 0 (never) to 4 (almost always). For the final German version of the CSS, see https://coronaphobia.org/professional-resources/ (25) The initial CSS construct includes 6 domains: COVID danger, COVID contamination fear, COVID fear about socioeconomic consequences, COVID xenophobia, COVID traumatic stress symptoms, and COVID compulsive checking and reassurance seeking related to the COVID-19 pandemic. In the Canadian validation of the CSS, Taylor et al. (19) found that the subscales COVID danger and COVID contamination fear loaded on the same factor, suggesting a 5-factor CSS model. However, the authors retained the 12 items of the two domains in the CSS, such that the option of assessing COVID danger separately from COVID contamination fear remains methodologically and in terms of content justified. Since we aimed at assessing the German COVID situation in most detail, we separated the two scales in our cluster analysis approach. The CSS was shown to be reliable and valid in a nonclinical German population (ranging from $\omega = 0.70–0.94$ and $r_{tt} = 0.62–0.82$; 25).

2.4.2. Psychological standard test procedures

We applied a short form of the World Health Organization Quality of Life Assessment (WHOQOL-BREF; 26), the Patient Health Questionnaire-4 (PHQ-4; 27), the Obsessive Compulsive Inventory-Revised (OCI-R; 28), and the 10-item Big Five Inventory (BFI-10; 29).

The WHOQOL-BREF is a questionnaire developed by the World Health Organization for the subjective assessment of one's quality of life (26). The questionnaire measures a self-report health status across the four health domains Physical Health (Physical), Psychological (Mental), Social Relationships (Social relations), and Environment. Respondents indicate their perceived health status for each item on a 5-point Likert scale. The questionnaire includes three negatively pooled items. The internal consistency of the WHOQOL-BREF ranges from $\alpha = 0.57$ to $\alpha = 0.88$ (27, 28).

The PHQ-4 is a self-report questionnaire on depression and anxiety (29). Participants determine the severity of symptoms for the past 2 weeks on a 4-point Likert scale. Validity and reliability was demonstrated in non-clinical and clinical samples (30). In this study, the internal consistency of the PHQ-4 McDonald's omega was $\omega = 0.88$. (25).

The OCI-R measures symptoms of obsessive–compulsive disorder (31). The questionnaire consists of 18 items across the six subscales *washing, checking, ordering, obsessing, hoarding*, and *neutralizing*. Respondents indicate on a 5-point Likert scale the individual intensity related to the symptoms described by each item for the past month. The OCI-R was shown to be reliable and valid in nonclinical and clinical samples (31, 32). In this study, the internal consistency of the OCI-R was $\omega = 0.88$ (25).

The BFI-10 measures personality traits based on the five-factor model (33). The questionnaire consists of 10 items. Each of the five dimensions (extraversion, agreeableness, conscientiousness, neuroticism, openness) is represented by two items of the questionnaire (one positive and one negative pooled item). The items are answered using a 5-point rating scale. Reliability and validity of the BFI-10 was demonstrated based on a population-representative sample (33).

2.4.3. Further measures

Furthermore, a self-constructed questionnaire on cognitive models of a pandemic was integrated into the survey (6 items, e.g., "I think the spread of the virus resulted from an "accident" in a genetics laboratory," "I think the spread of the virus is bad for people's lives, but good for the environment"). Items of this questionnaire had to be rated on a 5-point Likert scale ranging from "not at all" to "extremely." In addition to the questionnaire data, the online survey collected sociodemographic data on age, sex, highest educational

1 https://www.soscisurvey.de.

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TABLE 1 Summary of sample demographic characteristics.

		Frequency	Percent (%)	Minimum	Maximum	*M*	SD	Mdn	Modus
Age				16	85	41.23	14	40	27
Sex ($N = 1766$)	Male	497	28						
	Female	1269	72						
Marital status ($N = 1774$)	Married/in a relationship	1258	71						
	Single	377	21						
	Widowed	27	2						
	Divorced	112	6						
Children ($N = 1774$)	Yes	944	53						
	No	830	47						
	Number of children			0	7	2	1	2	2
Education degree ($N = 1774$)	Still in School	28	2						
	School finished without graduation	47	3						
	Secondary−/elementary school diploma	224	13						
	Secondary school leaving certificate (Mittlere Reife)	11	1						
	Polytechnic high school	141	8						
	Advanced technical college	387	22						
	High school diploma	907	51						
	University degree	29	2						
Employment ($N = 1774$)	Pupil	37	2						
	Apprentice	17	1						
	Student	269	15						
	Employee	875	49						
	Public servant	154	9						
	Self employed	108	6						
	Unemployed/Jobseeker	31	2						
	Pensioner	112	6						
	Housewife/Houseman	41	2						
	On parental leave	37	2						
	Other	93	5						
Occupational situation in connection with the pandemic ($N = 1774$)	No change	749	42						
	Occasionally home office	261	15						
	Mainly home office	326	18						
	Completely home office	262	15						
	Short-time work	56	3						
	Currently exempted	37	2						
	Financial benefits to support the self-employed	14	1						
	Other financial support	69	4						
Physical illness ($N = 1755$)	No	1314	74						
	Yes	441	25						
Mental illness ($N = 1764$)	No	1539	87						
	Yes	225	13						

attainment, marital status, profession, occupational situation related to the pandemic, health status (physical and/or mental illness), own coronavirus infection or infections of relatives, friends etc., quarantine situations due to coronavirus infection, and one's occupational situation during the COVID pandemic.

2.5. Statistical analysis

To identify classes from the total sum score of the CSS, a two-step cluster analysis was performed. This cluster analysis is particularly suitable for large data sets. It allows for extraction of the optimum number of clusters from the data in 98% of cases according to Chiu et al. (34). Moreover, it is an exact and powerful procedure even in the presence of overlap for metric variables (35). Demographic characteristic variables were not included in the cluster analysis to avoid mixed-scaled grouping, which has the disadvantage of giving higher weights to differences in categorical variables such that the clustering procedure could be biased. This effect is amplified, when a large difference in the group size of a categorical classification (36) occurs. This is the case in our data set including considerably more females than males. For the cluster analysis, a log-likelihood measure was selected as the distance measure. Schwarz's BIC was chosen for automatic clustering. Cases were randomly ordered, and variables were standardized by cluster analysis. A noise cluster of 5% was applied in the clustering procedure to eliminate outliers. Cluster divisions resulting from the analysis were stored in the dataset using cluster variables. These provided the basis for subsequent statistical post-hoc analyzes.

For testing the factor solution of the CSS total sum score and to extract the relevance of CSS subscales for cluster classification, a second two-step cluster analysis was performed with the CSS subscales as variables. For automatic clustering, the cluster criterion BIC according to Schwarz (37) and the log-likelihood measure were used as distance measures. A noise cluster of 5% was applied to eliminate outliers. To test the factor solutions of the two cluster procedures for independence, a Chi^2-test was performed between the cluster variables of the two cluster solutions.

To identify additional potentially discriminating characteristics between clusters, a statistical post-hoc comparison of scores on the WHOQOL-BREF, OCI-R, PHQ-4, BFI-10, and cognitive model questionnaire, split by cluster variables of the sum score of the CSS, was performed using T-tests (Welch-tests were applied in cases of variables without variance homogeneity). The level of statistical significance for separate group comparisons for each single variable was set to $p < 0.05$. To test putative differences in sociodemographic characteristics (age, gender, occupational situation, marital status, children, mental illness, physical illness, educational attainment, employment, quarantine due to Corona infection, own Corona infection, Corona infection in close environment, Coronavirus infection in professional environment, vacations) between the two clusters for independence, a contingency analysis was performed using a Monte Carlo Simulation (given an expected cell frequency < 5). To detect a potential overrepresentation of sociodemographic characteristics between clusters, a comparison of column proportions was applied using Z-tests, adjusted for multiple comparisons. All statistical analyzes were implemented using SPSS, version 27 (Statistical Package for the Social Sciences; https://www.ibm.com/de-de/products/spss-statistics).

3. Results

3.1. Identification of clusters

3.1.1. COVID stress scales total Sum score cluster analysis

Cluster analysis of the CSS total score resulted in two clusters with sufficient scores for cluster cohesion and cluster separation. The silhouette measure of 0.7 corresponds to an acceptable to strong indication of cluster structure according to Kaufman and Rousseeuw (28). The size ratio of the two clusters is a value of 1.49. Cluster 1 contains 1049 (~60% of the sample) individuals with a mean CSS total score of $M = 15.90$ (SD = 7.63). Cluster 2 includes 702 (~40% of the sample) individuals with a mean CSS total sum score of $M = 42.84$ (SD = 12.18). Based on the mean scores of each cluster, a designation of Cluster 1 as "Lower CSS" and Cluster 2 as "Higher CSS" was made.

3.1.2. COVID stress scales subscales cluster analysis

The clustering procedure of the CSS subscales also resulted in a factor solution of two clusters. The procedure yielded a moderate result for cluster cohesion and cluster separation, which corresponds to a low indication of a cluster structure with a silhouette measure of 0.4. The size ratio of the two clusters has a value of 1.62, with Cluster 1 containing 1081 (~62% of the sample) individuals and Cluster 2 containing 666 (~38% of the sample) individuals. Mean scores of subscales in Cluster 1 were lower than the mean scores of the same subscales in Cluster 2, and the subscales in each of the two clusters had the same gradation in importance of the subscales as predictors of cluster classification. Accordingly, Cluster 1 was named "Lower CSS subscales," and Cluster 2 was named "Higher CSS subscales." There was minor overlap between the clusters for the Xenophobia and Traumatic Stress subscales and medium overlap for the Compulsive Checking and Socioeconomic Consequence subscales. Table 2 shows the descriptive scores for each subscale of the CSS, split by cluster assignment and graded by predictor influence.

The Chi^2 test between cluster divisions showed a significant relationship between cluster divisions of cluster procedures of both the total score and the subscales of the CSS ($X^2(1) = 1425$, $p < 0.001$, $\varphi = -0.90$). Due to the comparable size ratio and the significant correlation with a high effect size between the cluster solutions of the two cluster procedures, it can be expected that cluster division is stable across factor solutions of the two cluster procedures.

3.2. Questionnaires

T-tests indicated that the lower (compared to the higher) CSS cluster was characterized by significantly lower scores on the neuroticism dimension as well as higher scores on the extraversion and agreeableness dimensions of the BFI-10. Moreover, the lower CSS stress cluster scored significantly lower on the depression and anxiety dimensions of the PHQ-4. The higher (compared to the lower) CSS cluster showed significantly lower scores on the physical social

TABLE 2 Mean values and standard deviations of the subscales of the CSS, divided by cluster classification, sorted by predictor weighting.

	Cluster 1 Lower CSS subscales (n=1081)		Cluster 2 Higher CSS subscales (n=666)		Importance (predictor weighting)
	M	SD	*M*	SD	
Danger (domain)	5.47	3.87	12.75	3.92	1
Contamination (domain)	3.58	2.77	9.36	4.09	0.7
Xenophobia	2.58	2.82	7.53	4.72	0.4
Traumatic stress	1.33	1.95	4.96	4.16	0.3
Obsessive control	1.72	2.08	4.55	3.49	0.2
Socioeconomic consequence	1.22	2.01	3.70	3.68	0.2

CSS = Covid Stress Scale. The subscales can range from 0 (no symptoms) to 24 (severe symptoms); Domains Danger and Contamination = Subscale "COVID Danger and Contamination fears," Xenophobia = Subscale "COVID Xenophobia," Traumatic stress = Subscale "COVID traumatic Stress symptoms," Obsessive control = Subscale "COVID compulsive checking and reassurance seeking," Socioeconomic consequence = Subscale "COVID fears about socioeconomic Consequences"; N = 1774.

relationships and environment subscales of the WHOQOL-BREF, as well as significantly higher scores in the washing, obsessive–compulsive ideation, hoarding, ordering, controlling, and thought neutralizing subscales of the OCI-R. Furthermore, the subjects in higher CSS cluster were significantly older and scored higher in the pandemic background questionnaire than subjects in the lower CSS cluster. Table 3 gives detailed statistical information on questionnaire data divided by cluster classification. Figure 1 illustrates WHOQL-BREF, BFI-10, and PHQ-4 data divided by cluster classification.

3.3. Cluster demographics

There was a significant relationship between cluster classification and gender [$X^2(1) = 4.40$, $p < 0.05$, $\varphi = 0.05$], the variables mental illness [$X^2(1) = 7.12$, $p < 0.01$, $\varphi = -0.06$], physical illness, [$X^2(1) = 43.25$, $p < 0.001$, $\varphi = -0.16$], educational attainment, [$X^2(7) = 51.61$, $p < 0.001$, $V = 0.17$], employment, [$X^2(10) = 38.89$, $p = 0.001$, $V = 0.13$], occupational situation during the pandemic [$X^2(7) = 17.40$, $p < 0.05$, $V = 0.10$], the variable "quarantine due to Corona infection" [$X^2(2) = 7.57$, $p < 0.05$, $V = 0.06$], and the variable "Coronavirus infection in occupational environment" [$X^2(7) = 5.44$, $p < 0.05$, $V = 0.06$]. Table 4 shows the cross tabulation of column proportion tests

TABLE 3 Means and standard deviations of the BFI-10, WHOQoL, OCI-R, and PHQ-4, age, and Pandemic background questionnaire, divided by cluster classification.

		Cluster 1 Lower CSS Cluster (n=1049)		Cluster 2 Higher CSS Cluster (n=702)		t (1749)	p two-sided	Cohen's d
		M	SD	*M*	SD			
BFI-10	Extraversion	3.33*	0.98	3.22	1.01	−2.28	0.0230	−0.111
	Neuroticism	2.81***	0.97	3.09	0.94	6.05	<0.001	0.295
	Openness to experience	3.66	0.94	3.65	0.96	−0.06	0.949	0.003
	Conscientiousness	3.69	0.80	3.70	0.77	0.22	0.829	0.011
	Agreeableness	3.22***	0.74	3.11	0.78	−2.91	0.004	−0.142
WHOQoL-BREF	Physical	77.33	14.75	68.53***	17.18	−11.09	<0.001	−0.557
	Mental	70.17	17.73	61.91***	17.91	−9.52	<0.001	−0.464
	Social relations	67.25	20.16	60.58***	21.47	−6.53	<0.001	−0.322
	Environment	78.66	12.79	72.12***	13.98	−9.91	<0.001	−0.492
OCI-R	Washing	0.84	1.42	1.97***	2.16	12.22	<0.001	0.645
	obsessive–compulsive ideation	1.69	2.15	2.90***	2.59	10.28	<0.001	0.520
	Hoarding	2.24	2.23	2.88***	2.52	5.52	<0.001	0.276
	Order	2.26	2.53	3.32***	2.85	7.96	<0.001	0.397
	Controlling	1.74	1.99	2.73***	2.43	8.96	<0.001	0.454
	Thought neutralization	0.78	1.39	1.30***	1.90	6.26	<0.001	0.324
PHQ4	Depression	1.44***	1.40	2.09	1.49	9.32	<0.001	0.455
	Anxiety	1.21***	1.41	1.98	1.66	10.07	<0.001	0.507
Age		40.57	13.89	42.06*	14.40	2.18	0.030	0.106
Pandemic background questionnaire		9.88	3.20	10.22*	3.07	2.25	0.024	0.110

BFI-10, 10-item Big Five Inventory; WHOQOL-BREF, short form of the World Health Organization Quality of Life Assessment; OCI-R, Obsessive Compulsive Inventory-Revised; PHQ-4, Patient Health Questionnaire. N = 1774. * p two-sided < 0.05 *** p two-sided < 0.001.

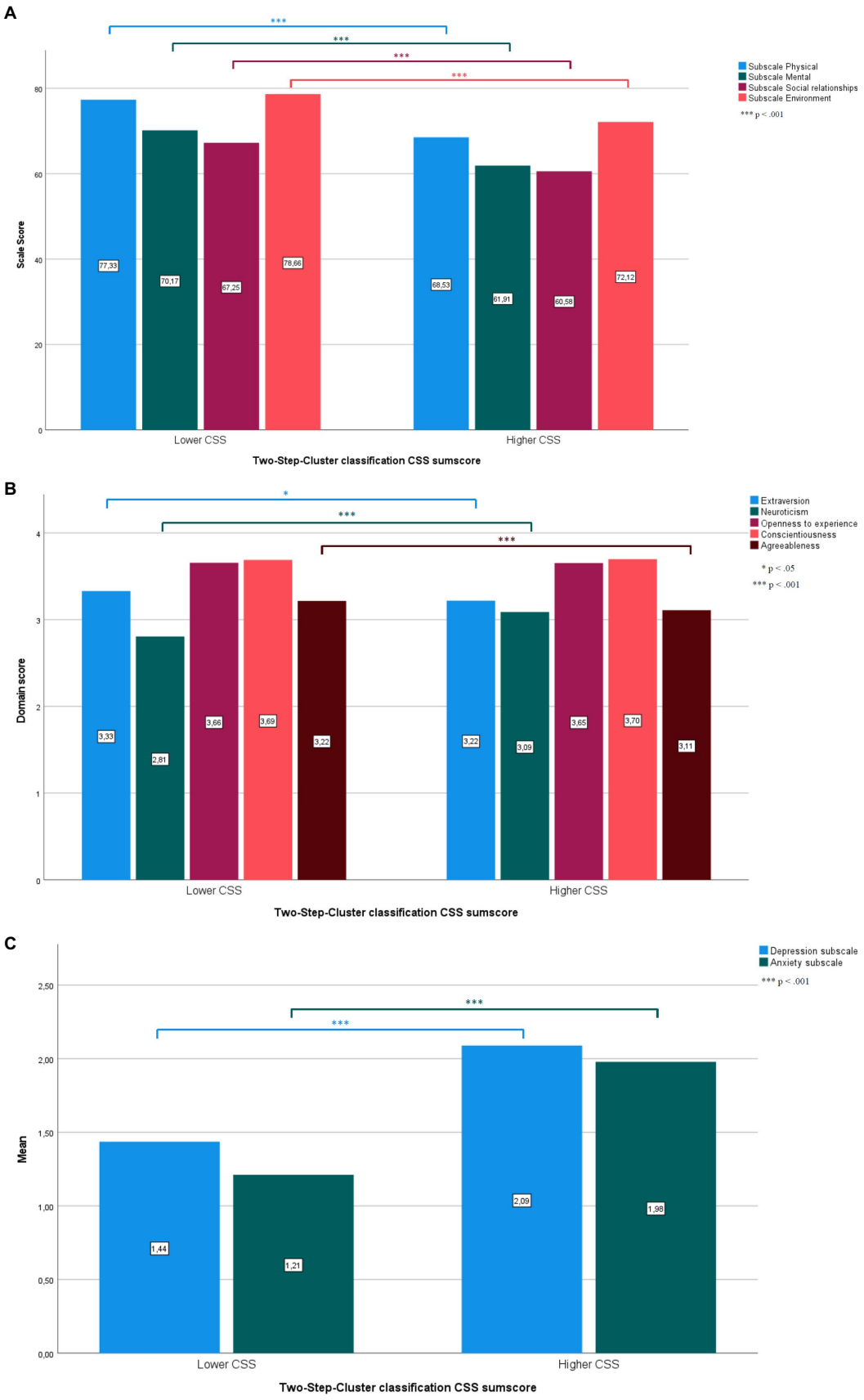

FIGURE 1
Significant and non-significant differences between the higher and lower CSS clusters in the WHOQoL-BREF **(A)**, BFI-10 **(B)**, and PHQ-4 **(C)**. Detailed statistical data are given in Table 3. **(A)** Scale values of the WHOQoL-BREF split by Cluster classification. **(B)** Domain Scores of the BFI-10 split by Cluster classification. **(C)** Mean values of the PHQ-4 split by Cluster classification.

TABLE 4 Cross tabulation of column proportion tests for sociodemographic characteristics between lower CSS and higher CSS.

		Cluster 1 lower CSS (n=1049)	Cluster 2 higher CSS (n=702)
		Number as columns (%)	Number as columns (%)
Psychiatric illment	No	89_a	85
	Yes	11	15_b
Physical illness	No	81a	67
	Yes	19	33b
Gender	Male	30_a	25
	Female	70	75_b
Education degree	Pupil	1	2
	School finished without graduation	0	0
	Secondary−/elementary school diploma	2	4_b
	Secondary school leaving certificate (Mittlere Reife)	11	16_b
	Polytechnic high school	0	1
	Advanced technical college	6	10
	High school diploma	21	23
	University degree	58_a	42
	Other high school diploma	1	2
Employment status	Pupil	2	3
	Apprentice	1	1
	Student	18_a	11
	Employee	50	49
	Public servant	9	9
	Self employed	7	5
	Unemployed / Jobseeker	1	2
	Pensioner	5	8_b
	Housewife / Houseman	1	4_b
	On parental leave	2	3
	Other	5	6
Quarantine due to Corona infection	No	87	83
	Yes, currently	1	1
	Yes, in weeks past	12	16_b
Coronavirus infection: Yes, myself.	No	98	97
	Yes	2	3
Coronavirus infection: Yes, someone in my personal environment.	No	58	56
	Yes	42	44
Coronavirus infection: Yes, someone in my professional environment.	No	70_a	65
	Yes	30	35_b
Vacation	No	55	51
	Yes	45	49

(Continued)

for sociodemographic characteristics between lower CSS and higher CSS, adjusted for multiple comparisons. Women, people with physical or mental illness, people with secondary school, junior high school and technical college degrees, pensioners, housewives or housemen, people who had been in quarantine in the previous weeks before the survey, participants who knew about infected people in their occupational

TABLE 4 (Continued)

		Cluster 1 lower CSS (n=1049)	Cluster 2 higher CSS (n=702)
		Number as columns (%)	Number as columns (%)
Occupational situation in connection with the pandemic	No change	43	40
	Occasionally home office	15	15
	Mainly home office	19	18
	Completely home office	15	15
	Short-time work	3	3
	Currently exempted	2	3
	Financial benefits to support the self-employed	1	1
	Other financial support	2	6_b
Children	Yes	54	52
	No	46	48
Marital status	Married/partnership	71	72
	Single	22	21
	Widowed	1	2
	Divorced	6	6

A The columns show the percentage distribution of each item of a variable within each cluster; The subscripts indicate which proportion of the respective item is significantly overrepresented in which cluster; $N = 1774$.
*a higher proportion in the lower CSS Cluster than in the higher CSS Cluster; comparison of column proportions with correction for multiple comparisons; $p < 0.05$.
*b higher proportion in the higher CSS Cluster than in the lower CSS Cluster; comparison of column proportions with correction for multiple comparisons; $p < 0.05$.

environment, and persons who received other financial support were significantly overrepresented in the higher CSS cluster (all $p < 0.05$). Males, people without physical or mental illness, participants with a university degree, students, and participants who did not knew about infected people in their occupational environment were significantly overrepresented in the lower CSS cluster (all $p < 0.05$). For the variables "marital status," "children," "Corona infection," "Corona infection in close environment," and "vacations" no significant relationship to cluster classification was detected (all $p > 0.05$).

4. Discussion

In this study, we identified two CSS-based clusters in the German population characterized by higher and lower stress levels during the COVID-19 pandemic. Clusters mainly differed significantly with respect to neuroticism, extraversion, agreeableness, quality of life, symptoms of obsessive–compulsive disorder, depression, anxiety, and cognitive models of a pandemic. Females, people with mental or physical illness, secondary school, junior high school, and technical college degrees, retirees and housewives/−men, people dependent on financial support, people who had been in quarantine in the previous weeks before the survey, and participants who knew about infected people in their occupational environment were significantly overrepresented in the higher stress cluster. Our data show for the first time the complex implications of pandemic-related stress sensitivity in the German population, which may act as key modulators of quality of life and psychological distress during the COVID-19 pandemic. Importantly, we also demonstrate relationships of modulating effects of stress-sensitivity with personality and gender. We propose that our data may advise governmental regulation of pandemic aiming at the optimization of quality of life and psychological health in different groups of the population.

4.1. Risk factors according to the cluster analysis approach

Around 36–40% of people experienced heightened stress and strain during the pandemic. This is consistent with prior research showing that 25–50% of Germans exhibited symptoms related to stress and emotional distress during COVID-19 (5–9). However, our study reveals that pandemic-related stress and strain caused significant psychosocial distress in almost half of the German population from the beginning of the first wave to the end of the third. Although CSS scores in the higher cluster were moderate, the results showed a strong impairment in different dimensions of quality of life (see Quality of life and mental health). Our study focused primarily on pandemic-related stress. Even moderate CSS scores add a substantial pandemic-related burden to the individual's already complex daily stress, leading to chronic stress. Chronic stress may cause physiological changes and health problems (38, 39) and further psychosocial effects on the individual and society. However, moderate scores indicate that most people can establish efficient adaptation processes to prevent clinically relevant physiological and mental illnesses from developing despite the pandemic's significant demands on the population. Cluster classification indicates a gradual relevance of pandemic related triggers of additional stress on the population. Worry about the dangerousness of COVID-19 represents the highest stress burden

of the pandemic. This is supported by the study of Taylor et al. (3), who also used the CSS and identified the dangerousness of COVID-19 as a central feature of the Covid-19 Syndrome in Canadian and American people. The finding that the CSS subscale "Worry about the dangerousness of COVID-19" (COVID danger) represents the highest stressor, and that the CSS subscales "fear of contamination" (COVID contamination fear) and "danger of contagion by foreigners" (COVID xenophobia) act as key factors for the accumulation of stress during the pandemic fits into the secondary stage of appraisal of the TSC. During secondary appraisal, individuals evaluate whether a stressor represents a harmful threat or a challenge. In the case of the COVID-19 pandemic, above stressors are subjectively interpreted as threats to an individual's health and the convincement that life will continue as before. Worry in the face of these threats can be influenced by various factors, including personal beliefs, cultural background, and exposure to information about the pandemic by media. Moreover, individuals who have pre-existing health problems or belong to high-risk groups may experience higher worry about the potential danger of COVID-19. In our study, trauma experiences, obsessive control, and socioeconomic consequences of the pandemic turned out to be less relevant for pandemic-related stress accumulation (COVID traumatic stress symptoms, COVID compulsive checking and reassurance seeking related to the COVID-19 pandemic and COVID fear about socioeconomic consequences). Given these data, existential health-related fear can be considered as the most important target for qualified information of heterogeneous groups of the population, psychotherapeutic interventions, and support of the population for ameliorating the pandemic-related stress accumulation. Given the high concerns of contagion by foreigners, xenophobia also needs to be considered in successfully managing pandemic-related stress in the population. This perceived threat related to foreigners can be explained by unconscious distal defense mechanisms. These may come into play when individuals are confronted with their mortality. They then tend to show national identification and hostility toward outgroups (40). For example, a prototypical distal defense mechanism is the designation of COVID-19 as a "Chinese virus." This interpretation is also supported by multidisciplinary neuroscience studies showing that stress favors the release of oxytocin, which in turn contributes on the behavioral level to the occurrence of a "tend and defend" reaction in favor of the ingroup (41–45).

4.2. Further protective and risk factors of pandemic-related stress sensitivity

Analyzes of cluster-specific socio-demographic characteristics revealed protective and risk factors for stress and strain in the pandemic. These are in particular related to gender, personality, education, quarantine, current mental and/or physical illnesses and older age.

4.2.1. Gender

The influence of gender on the experience of stress during the pandemic emerges from a complex interaction of a wide variety of factors. In our study, we identified female gender as a risk factor for increased pandemic stress and strain. Stress arises from the relationship between individuals and their environment. Individual sociodemographic differences such as gender may influence the type and intensity of perceived stress (16–18). It is known that women use other strategies to cope with stress than men do. Such gender-related differences may be due to social and cultural factors, for example, gender-specific role expectations, as well as biological factors such as hormones and genetics. These factors are likely to contribute to a higher stress levels and reduced capacities of efficient stress coping strategies in females. Our finding is in accordance with the narrative review by Almeida et al. (46) and the systematic review by Xiong et al. (4), who concordantly reported that female gender is a risk factor of distress during the pandemic and that women who are pregnant, postpartum, miscarrying, or experiencing intimate partner violence are at high risk for developing mental health problems during the pandemic. It is known that males and females differ in their perception of stressors and coping with perceived stress. Females more frequently report health-related and family events as sources of stress than do males. In contrast, men perceive themselves as mainly stressed by financial and work-related events (47, 48). Given these data, one explanation for the elevated stress levels in women during the pandemic may be that they anticipate and ruminate more intensely than men about putative negative health consequences for themselves and their family.

Gender differences also need to be considered with respect to stress coping strategies. Some older studies indicate that females tend to use social support and help-seeking as primary strategies to cope with stress (49, 50). A lockdown including drastic restrictions on social contact during the pandemic may thus prevent females from using their preferred stress coping strategies, leading to the enhancement of their subjective feelings of stress. Moreover, in our society females face specific burdens that have become more virulent during the pandemic. For example, unpaid care work has been reported as a special stress factor–especially for the female gender (51, 52). Care work is the main basis of everyday life (e.g., childcare, household, etc.), but often remains unnoticed and acts as an invisible stressor. Since this work is predominantly shouldered by women, the invisible stressor exacerbated for females by the pandemic (52).

4.2.2. Personality

Importantly, our data also indicate that subjects in the cluster with lower stress had higher scores in extraversion, suggesting that this personality trait protects against pandemic-related stress accumulation. Available studies show heterogeneous results concerning this issue. This heterogeneity of data results at least in part from data collection during distinct time windows in the pandemic. For the severe first COVID-19 wave Engert et al. (14) demonstrated that extraversion is related to higher cortisol levels, indicating a more intense stress response of the organism. During the same time frame, Liu et al. (13) also showed in a Canadian sample, that higher extraversion is associated with higher general stress levels in the pandemic. In the period after the first wave, Getzmann et al. (53) reported that extraversion had no influence on stress in the population. Bellingtier et al. (54) reported for the third wave of the pandemic that only the sociability facet of extraversion was related to higher stress levels. In contrast, the assertiveness facet was found to act as a protective factor against stress. Our survey had a more extended time frame than all previous studies. We started data collection after the first wave of the pandemic and finished the study after the third wave

of the pandemic. Across these distinct phases of the COVID-19 pandemic, extroverted people showed lower stress levels than non-extroverted people. Most likely, people developed efficient coping strategies during the long time frames with pandemic-related socializing restrictions, in particular, in summer 2020 where we started data collection. Moreover, extroverted people may have acquired stress resilience during phases with relaxed social restrictions and then profited from resilience in following phases with enhanced restrictions (55). This interpretation is in line with the reports for the first wave of both Engert et al. and Liu et al. (13, 14). It also fits with the data of Getzmann et al. (53) and does not contradict the findings of Bellingtier et al. (54). Our arguments are also supported by a study of Shokrkon and Nicoladis (15), who demonstrated a positive effect of extraversion on overall mental health during the COVID-19 pandemic. Besides extraversion, we identified agreeableness as a protective factor against stress and strain during the pandemic. This result is in line with previous reports of the protective impact of this personality trait against stress in general and with respect to the pandemic (56–58). Interestingly, Gori et al. (57) demonstrated by a mediation analysis, that agreeableness is only indirectly involved in protection against stress during the pandemic, due to its negative association with maladaptive defense mechanisms. While extraversion may actively trigger efficient coping strategies, agreeableness may be rather passively involved in defense mechanisms, which actively dominate stress-related coping behavior during the pandemic. In line with the TSC, individuals with higher levels of extraversion and agreeableness may be better equipped to handle altered living conditions and restrictions during a pandemic. Extraverted individuals typically possess a stable and extended social network, are able to fulfill their social desires by virtual communication, and search continuously for novel ways to experience social joy. Doing so, they are supported by their positive attitude and optimistic thinking. Individuals with higher levels of agreeableness typically possess enhanced empathy and aim at avoiding conflicts. Accordingly, they also tend to follow rules set by society and authorities. Adherence to rules, which are perceived as a form of security by people with high levels of agreeableness, could therefore reduces stress.

The results of our study demonstrate that the personality trait neuroticism acts as a key factor in the identification of risk groups for elevated stress in the Covid-19 pandemic. Neuroticism has been linked by previous studies to elevated stress levels and depression in the pandemic (13, 14, 54, 59, 60). Furthermore, Liu et al. (13) and Zager Kocjan et al. (61) showed that neuroticism functions as a predictor of diminished adaptive behavior and may lead to reduced perceived self-efficacy. According to the TSC (62) this finding can be related to secondary appraisal of stressors. Individuals with neuroticism possess few stress coping strategies that could efficiently help in resolving pandemic-related stressful situation and phases. This may reinforce low perceived self-efficacy and the persistence of threat-guided stress reactions. In summary, elevated stress responses may arise from a specific appraisal of stressors and the efficacy of stress coping mechanisms (62). Accordingly, individuals with neuroticism may exhibit an enhanced perception of stressors as uncontrollable threats.

4.2.3. Education

A further modulator of pandemic-related stress is an individual's level of education. In line with the study of Taylor et al. (3) in Canadian and US samples, we show increased pandemic-related stress levels for groups with lower education in the German population. Given that people with low education are typically exposed to higher levels of stress than people with high education (63), this could be an effect of cumulative stress experience during the pandemic. This interpretation is in good accordance with reports that lower income and reserves causing financial problems during the pandemic were frequently associated with the emergence symptoms of anxiety and depression (64–66). A second explanatory approach relates to the fact that people with lower levels of education are more likely to hold jobs that require face-to-face contact than people with high educational levels (67). This situation increases the probability of getting infected with COVID-19 and may also explain our finding that people who knew about infected people in their occupational environment showed elevated stress levels. We here detected facets of dynamics of interaction between low education and occupation-related stress during the pandemic.

4.2.4. Quarantine

Our result of an overrepresentation of people who have previously been in quarantine in the higher stress cluster is in line with previous research on psychological health in the population during the COVID-19 pandemic. For example, the TMGH-Global COVID-19 Collaborative study (68) demonstrated, that a longer duration of quarantine significantly correlated with higher stress levels. This finding is also in line with the TSC since quarantine itself needs to be considered as a significant source of stress. Quarantine can be appraised as a loss of freedom and a threat to one's well-being within the secondary evaluation of the stressor.

4.2.5. Illness

Consistent with two studies of Asmundson et al. and a study of Xiong et al. (4, 69, 70) we identified previous or current mental and/or physical illnesses as risk factors for increased stress in the pandemic. Physical pre-existing conditions can increase the risk of experiencing severe complications in the event of a COVID-19 infection. This health threat can lead to an increased perception of stress and influence the behavior of affected individuals, for example, by isolating themselves due severe anxiety of contamination. Pre-existing mental diseases or Symptoms such as anxiety disorders, depression and OCS can also increase threat of COVID-19 infection and lead to the avoidance of social contacts. Both pre-existing physical and mental disorders may therefore lead to an enhanced secondary threat evaluation of COVID-19 according to the TSC. Lifetime strain of affected people is too severe for an appraisal of the pandemic as a challenge. Although cluster analysis indicated a lower importance of OCS in the COVID Stress Scale (CSS), our results suggest that individuals showed increased OCS during the pandemic. Specifically, during the COVID-19 pandemic, people exhibited symptoms of compulsive behaviors, such as frequent hand washing or obsessive cleaning of surfaces. These symptoms can be understood as a reaction to the threat posed by the pandemic and the associated uncertainties and changes in daily life. In the TSC, the primary appraisal in this case may be focused on the threat posed by the virus and its potential consequences for health (16–18, 62). The secondary appraisal could then lead to individuals attempting to cope with the threat by performing behaviors such as frequent hand washing or obsessive cleaning of surfaces. Furthermore, increased

OCS may suggest that some of the measures recommended by the government, such as the frequent washing of hands, have been effective.

4.2.6. Age

Concerning age, our data diverge from those of Xiong et al. (4). Our results indicate that older age (> 40 years) is a risk factor for higher levels of pandemic-related stress, while Xiong et al. (4) reported younger age (< 40 years) to be a risk factor for enhanced stress levels during the pandemic. The effect of age on stress experience during the pandemic may also depend at least in part on the societal and cultural background of investigated samples. Overall, our data indicate that older age interacts with the variables female gender, low educational level, quarantine experience, previous or current mental and/or physical illnesses in the emergence of pandemic-related high stress levels.

4.3. Quality of life

Our data show a severe pandemic-related decline in quality of life in at least half of the German population. These data are in line with previous studies on quality of life during the pandemic (4, 71). Xiong et al. (4) specifically reported increased anxiety, depression, post-traumatic stress, and psychological stress in both eastern and western countries. It is also known that neuroticism is frequently related to a higher risk for the development of depression, anxiety, and obsessive–compulsive behavior (72, 73). Available data well fit with our finding of a close interrelationship between high levels of neuroticism and enhanced pandemic-related stress. Published data on the role of gender for quality of life during the pandemic are heterogeneous. Some authors reported an increased vulnerability for depression and anxiety of females (4, 74, 75), others did not (76, 77). Distinct cultural backgrounds of investigated samples may at least in part account for the heterogeneity of data. For Germany, Abreu et al. (78) demonstrated that women had higher levels of depression., while men showed enhanced aggression in the pandemic. Available data suggest that a modulating role of gender most likely depends on culture, society, population subgroups, and further demographic and historical variables.

Finally, it also needs to be taken into consideration that a biologically based stress sensitivity (e.g., due to variations of gene polymorphisms) may trigger pandemic-related depression and therefore diminish quality of life (79–81). For example, Caspi et al. (79) showed that a polymorphism in the promoter region of serotonin transporter gene modulates resilience against stressful life events with respect to their influence on the incidence of depression.

4.4. Limitations

Limitations of the study include the high educational level of the sample and the overrepresentation of women in the sample, as well as the exclusion of children and adolescents under 16 years of age. In terms of statistics, cluster analyzes provide only moderate information on the mode of action and integration of the identified protective and risk factors for pandemic-related stress. Nevertheless, this was the optimal approach for the purpose of this study, as we initially wanted to limit ourselves to an identification of risk factors for stress experience within the pandemic. Regarding the statistical methodology, it should be taken into account that high correlations between the questionnaire results and the parameters of the CSS clustering could lead to an overestimation of the significant differences between the questionnaire results in the individual clusters. To minimize this problem, we ensured that correlations between questionnaire and CSS subscales were either absent or at least low to moderate. It should be noted that the study conducted was an online survey. This type of survey involves various biases that need to be taken into account. Several types of bias can occur in surveys regarding access to the internet, which can affect the accuracy and representativeness of the results. These include the technological divide, where people without access to the internet cannot participate in online surveys and therefore above-average technology-savvy and affluent respondents are captured. Another factor is age bias, where older people have less access to or are less familiar with the internet than younger people. There may also be education bias, where people with lower levels of education have less access to the internet and computer skills. Another important limitation of the study is that the individual measurement points are collected over a longer period of time. This poses several problems in terms of cross-sectional data. The data of the analyzes of this study only contain data on an individual survey of the subjects in the course of the entire study period, without a follow-up survey. However, the condition of these subjects could have changed over the course of the study duration, but was no longer recorded in the study, as only one measurement was taken. Although the data do not allow us to explain exactly whether certain groups of people experienced more or less stress in the course of the pandemic or in different waves, the large number of participants provides a representative sample of the groups of people over the entire course of the measurement period, which allows general statements to be made about the experience of stress and strain. In addition, the data from several different waves were combined in the analysis, which means that we cannot make any statements in this study about the influence of specific measures to contain the pandemic on people's stress experience. Longitudinal studies with several measurement points are needed to clarify questions in this regard. Furthermore, future studies on pandemic-related stress and mental health in different populations and cultures should include the influence of government regulations during a pandemic as a target variable.

4.5. Conclusion

Our data show that pandemic-related stress sensitivity needs to be considered as a key modulator of quality of life and mental health during the COVID-19 pandemic. We specify both protective and risk factors for the development of pandemic-related stress in a non-clinical sample of the German population. We propose that our data may advise governmental regulation of pandemics to optimize quality of life and psychological health in different groups of the population. Societal support and psychological help such as interventions targeting existential health-related fear should

be among the central targets of governmental regulation. Finally, psychotherapeutic and medical treatment of citizens suffering from long-term consequences of pandemic-related stress and strain need to be adapted to the complex and rapid changing challenges. To accomplish this adaptation, novel multidisciplinary psychotherapeutic and medical health care structures need to be established. These require both financial and institutional support by the government.

Data availability statement

The datasets presented in this article are not readily available because it will be used for other publications that are in the process of being analyzed and published. Requests to access the datasets should be directed to Martina.Piefke@uni-wh.de.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics committee of Psychological Institute of the Johannes Gutenberg-University Mainz. 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

VN and SJ organized data collection. MP planned, conceptualized, and supervised the study. VN and MP conceptualized the submitted paper and wrote the main parts of the manuscript. VN accomplished statistical data analysis. GW contributed his psychiatric and scientific expertise to the study and was involved in data collection. GA developed the English version of the COVID Stress Scales (CSS) and contributed his scientific expertise. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Effects of media exposure on PTSD symptoms in college students during the COVID-19 outbreak

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Objective: We aimed to investigate the influence of media on college students' mental health during the COVID-19 pandemic.

Methods: After the COVID-19 outbreak, we used cross-sectional surveys through online questionnaires to investigate the mental health of college students in lockdown at home. We identified the influencing factors of PTSD symptoms using the Chi-Square test and ordinal logistic regression analysis.

Results: In 10,989 valid questionnaires, 9,906 college students with no PTSD symptoms, 947 college students with subclinical PTSD symptoms (1–3 items), and 136 college students with four or more PTSD symptoms were screened out. The results showed that media content impacted the mental health of college students in lockdown at home. Positive media content was negatively correlated with PTSD symptoms among college students. PTSD symptoms were not associated with sources of information. Moreover, College students with PTSD symptoms would reduce their willingness to learn and could not complete online learning efficiently.

Conclusion: PTSD symptoms are related to media exposure and excessive information involvement of COVID-19 in college students, which influences the willingness to attend online classes.

KEYWORDS

media content, mental health, COVID-19, post-traumatic stress disorder, college students, media exposure

Introduction

"Coronavirus Disease" was first diagnosed in December 2019 and officially named "COVID-19" on February 11, 2020 (1), which still has a massive impact on global public health and healthcare to date (2, 3). When COVID-19 broke out in China, the country's public health policy adopted locking down cities to stop the spread of the virus, and the policy had a pronounced effect on blocking the spread of the virus in the population. Until now, China has been the only country that insists on this policy. However, the sudden and continuous lockdown not only causes economic losses and inconvenience in life, work, and transportation but also affects the emotional state of individuals living in these areas, thus having a clear impact on mental health (4, 5). In March 2022,

China again implemented long-term and large-scale closure measures in cities, including Shanghai, indicating that centralized isolation or quarantine at home is still the main China epidemic prevention policy. Therefore, the impact of this epidemic prevention strategy on psychiatric disorders still deserves our continued attention.

Among these most common psychiatric disorders, Post-traumatic stress disorder (PTSD) is one of the more serious mental illnesses. The prevalence of PTSD following the COVID-19 outbreak has been widely documented. The incidence of PTSD was 10.4% among adolescents, 16.3% among master's and doctoral students, 3.16% among children, and 3.53% among parents (6). After a month of lockdown, 19.5% of French university students have PTSD (7). In a meta-analysis of nearly 100,000 healthcare workers in 21 countries, the incidence of PTSD was 21.5% (8). The researchers screened 421 Chinese healthcare workers for PTSD after the outbreak of COVID-19. They found that 13.2% had PTSD symptoms, and only in low-risk areas, non-medical staff has risk factors for PTSD symptoms (9).

College students are a relatively particular group affected by the lockdown measures. Since the lockdown Policy, most students began a long period of school suspension, quarantined at home, and online courses. Nevertheless, most college students leave their hometown [91.1% (10009/10989) in this study] to study in other cities or provinces (10). Their peer social networking or interpersonal circle depends more on the school classmate group. The impact on academics and social interaction is more prominent with lockdown measures and restricted travel. Also, the primary age group of college students is 17–23. This age group also has various emotional disorders and mental health problems, such as bipolar disorder, anxiety, depression, insomnia, and Post-traumatic stress disorder (11, 12). When COVID-19 first became popular, an online questionnaire study found that among 5,982 medical students in school, moderate to severe depression occurred. The symptom rate was 35.2%; mild-to-severe anxiety was 22.8%; students with poor social support were also found to be more severely ill (13). During the mass lockdown, most staff was quarantined at home. It is difficult for colleges to carry out mental health censuses, let alone related interventions. Therefore, online questionnaires for college students' mental health screening are a few practical approaches. Based on the above reasons, this study focuses on college students. The online questionnaires surveyed the mental health of more than 10,000 college students during the lockdown period.

According to the DSM-5, PTSD is a mental and behavioral disorder that develops in individuals following one or more traumatic events. Specific symptoms may include avoidance of reactions to triggering events, changes in mood and cognition, perception of imminent threat, disturbed sleep, and hypervigilance (14). PTSD is a long-term mental disorder of delayed onset. Symptoms of PTSD typically begin within 6 months after trauma (3.8%) and persist through at least 1 month; some can reach 12 months, with a prevalence of ~4.7% and a lifetime risk of 8.3% (15). In modern society, human beings are often faced with public events or natural disasters, and the relevant media coverage is generally sufficient and continuous, but individuals may often have excessive media usage and inappropriate attention to harmful media content. For this reason, the odds of PTSD, trauma, and stress-related illnesses significantly increase after public events or natural disasters (16–19). Research by Rebecca R. Thompson et al. found that after major violent events (massacres, bombings), people exposed to the media will feel increased stress and distress, and media exposure to related events within a few months will increase their susceptibility to PTSD. Therefore, researchers point out that trauma-related media exposure can lead to a long-term cycle of high stress and media use (20). Brian J. Hall et al. proposed that media exposure after major natural disasters can indirectly impact PTSD. His research found that after typhoons, the prevalence of PTSD was 5.1%. Media coverage of residents' emotional reactions and information about drowning victims raised the risk of PTSD, while reports of heroic deeds and the storm were associated with lower odds of PTSD (21). Therefore, media use and certain content may impact individuals' physical and mental health. The consequences of PTSD caused by media exposure are severe over time, comprehensively affecting peoples' learning and social functions. Currently, there is less research on the impact of media on PTSD under China's lockdown policy (22–24). The former research shows that for college students, the incidence of PTSD in previous studies was 6–17%, and the main risk factors were: female and socioeconomic status (25). During the lockdown caused by COVID-19, most people, including college and middle school students, are affected by media information and experience various psychological reactions, such as insomnia, anxiety, panic, confusion, irritability, and even PTSD (4, 6, 23, 26, 27). Gao et al. surveyed the degree of public media exposure and mental health status during the COVID-19 incident among 4,827 adults. They found that compared with media exposure within 1 h, media exposure for more than 3 h can lead to a 1.30-fold and 1.23-fold increase in the risk of moderate anxiety and depression, respectively (22).

During the COVID-19 pandemic, media is the primary way for people to obtain relevant information. Everyone has to pay more attention to news reports and track various media information, which are the issues that everyone has to face. Because college students are familiar with various electronic information sources, they use social media most actively. So they are easy to contact and be influenced by external information through various channels, including traditional media (newspapers, TV, mobile news), social media, and direct human-to-human conversations (28–34).

On traditional and social media, much news about COVID-19 emerges 24 h a day. Some studies have shown that continuous media exposure after public events or natural disasters is related to the psychological problems of exposed people (16, 17, 35–43). Furthermore, this tendency to search for information will, in turn, affect media exposure. Nowadays, social media platforms generally use recommendation systems to push content that viewers care about, making it easier for users to see the content they are concerned about. This reality has led to the mutual influence of media and mental health. While evaluating the impact of epidemic-related media reports and quarantines on college students' mental health, we found that "media content" relates to PTSD. What are the main influencing factors? There are fewer related studies and even less research on "media content" with a separate study. Therefore, we focused our research on the impact of media content on PTSD symptoms in college students in the early stages of the COVID-19 outbreak. We hope our research can help and guide how media content can be adapted to support mental health during the disaster better.

Methods

Source and study population

This research is a cross-sectional study of valid online questionnaires submitted from March 10, 2020, to April 9, 2020. The

participating students are (1) registered at Nanjing Institute of Technology (2), voluntarily participating in this study and completing the online questionnaire (additional details of the questionnaire can be found in Appendix A), Students on maternity leave and long-term sick leave were excluded from the study. We sent an online questionnaire to 25,609 students. About 11,011 questionnaires were collected, with a response rate of 42.9%. After excluding students who did not provide valid information, 10,989 valid questionnaires were included in the analysis. Among them, 7,264 were male (66.1%), and 3,725 were female (33.90%).

Measurement

The Short Screening Scale was used as a self-report measure for PTSD symptoms and was revised in 1998 by Naomi Breslau et al. The Short Screening Scale mainly involves the screening self-rating scale for Post-traumatic stress disorder, including seven main symptoms, five symptom items are related to avoidance and numbness, and two are related to hyperarousal. A score of 4 or higher was judged as screening positive. In PTSD-positive cases aged 18–45 years old, the sensitivity was 80%, the specificity was 97%, the positive predictive value was 71%, and the negative predictive value was 98% (44). The scale is an effective and convenient clinical screening tool for PTSD symptoms (45–47). Based on this score, we divided all people into three groups, group 1 with no PTSD symptoms, group 2 with one to three PTSD symptoms, and group 3 with four or more PTSD symptoms.

According to the residence region of the participating students, the participants are divided into two categories: those in Hubei Province and those not in Hubei Province. Sociodemographic data were collected, including age, gender (male/female), and class presidency or class cabinet. The information related to COVID-19 includes knowledge about COVID-19, the quarantine period, the number of masks used during the quarantine period, the attitude toward online courses, and the willingness to return to school. Media exposure-related information includes the time point of beginning to pay attention to COVID-19, the main ways to know the latest developments of the epidemic, what information you most want to know in your home quarantine, and reasons for optimism.

Data analysis

First, a descriptive analysis was performed to understand the characteristics of the sample and determine the prevalence of PTSD symptoms. Second, the proportion of students in different groups was calculated by PTSD score. Count data is expressed in quantity (percentage). Third, chi-square analysis was used to screen out the factors related to PTSD groups preliminarily. Forth, an ordinal logistic regression model was established to test the influence of geographical, sociodemographic, media content, and other factors on the PTSD groups. Two different models were established by ordinal logistic regression analysis. Model 1 was a model that included only seven reasons associated with optimism. Model 2 not only includes the seven reasons of Model 1 but also includes gender, the time point of beginning to pay attention to COVID-19, and the region of residence (Hubei province). These three factors have statistical differences in the chi-square test. Last, ordinal logistic regression was used to analyze the PTSD group relation to attitude toward online courses and willingness to return to school. All analyses were performed using SPSS software (version 22.0, IBM, Armonk, NY, United States). The statistical significance threshold p was 0.05. The risk coefficient (RO), associated two-tailed p-value (p), and 95% confidence interval (CI) were parameters in the regression model.

Results

Epidemiological characteristics

Table 1 summarizes the general demographic characteristics of all participants and results in the survey, presented by the number and percentage (n/%) of each group. In a total 10,989 college students, group 1 (without PTSD symptoms) was 9,906 (90.1%); group 2 (with 1–3 PTSD symptoms) was 947 (8.3%); group 3 (with 4 or 3 PTSD symptoms) was 136 cases (1.2%).

There was less proportion of age 18 and under 18 in group 3 (5.88%) than in groups 1 (11.44%) and 2 (11.51%). Conversely, the age group of 19 and over 20 years old in group 3 (94.12%) is lower than in groups 1 (88.56%) and 2 (88.49%). However, it has no statistical significance.

We found that gender was significantly associated with PTSD symptoms ($\chi^2 = 34.358$, $p = 0.000$), and females were more likely to have more PTSD symptoms. There was 41.39% in group 2 and 44.85% in group 3, higher than the population participating female in the survey (33.9%).

The region and PTSD symptoms significantly correlate ($\chi^2 = 14.138$, $p = 0.001$). Hubei Province was more likely to have PTSD symptoms, and the proportion of group 2 (1.8%) was higher than that of all participants (0.79%). However, there was no Hubei Province student in group 3, which may be the limitation of voluntary participation in the online survey (see the discussion section).

The impact of PTSD symptoms on online courses

According to the preliminary statistics results (Table 1), we found that PTSD symptoms are also significantly related to the willingness of college students to take online classes ($\chi^2 = 80.441$, $p = 0.000$). The proportions of groups 1 and 2 who want to take online classes are 45.64 and 35.8%, respectively. Group 3 (29.41%) was significantly lower than group 1 and group 2. On the other hand, group 3, who did not want to take online classes, was 18.38%, which was higher than group 1 (10.06%) and group 2 (14.36%). So, the more PTSD symptoms, the more reluctant to take online classes.

We further evaluated the effect of the PTSD group on attitudes toward online courses in the regression analysis of the PTSD group, as shown in Table 2. Compared with students who "liked online classes," the PTSD group increased the relative risk of all negative attitudes (just to listen: OR = 1.301, 95% CI = 1.148–1.475, $p < 0.001$; a task must be completed: OR = 1.981, 95%CI = 1.647–2.382, $p < 0.001$; do not like: OR = 1.768, 95%CI = 1.5–2.085, $p < 0.001$).

The survey had no statistical difference overall in a willingness to return to school. However, the unwilling students accounted was

TABLE 1 Characteristics of cases

	Study Groups				Statistical Analysis	
	group 1:No PTSD Symptoms(n=9906[90.1%])	group2:1-3 PTSD Symptoms(n=947 [8.6%])	group3:≥4 PTSD Symptoms(n=136 [1.2%])	All(n=10989)	χ^2	*P*
Age						
<18y	63(0.64)	7(0.74)	0(0.00)	70(0.64)	5.414	0.492
18	1070(10.80)	102(10.77)	8(5.88)	1180(10.74)		
19	2402(24.25)	223(23.55)	39(28.68)	2664(24.24)		
>=20	6371(64.31)	615(64.94)	89(65.44)	7075(64.38)		
Gender						
male	6634(66.97)	555(58.61)	75(55.15)	7264(66.10)	34.358	0.000***
female	3272(33.03)	392(41.39)	61(44.85)	3725(33.90)		
Region of residence						
None Hubei province	9836(99.29)	930(98.20)	136(100.00)	10902(99.21)	14.138	0.001**
Hubei province	70(0.71)	17(1.80)	0(0.00)	87(0.79)		
Class president or class cabinet						
Class president	586(5.92)	62(6.55)	6(4.41)	654(5.95)	8.128	0.229
Student Union leader	930(9.39)	90(9.50)	17(12.50)	1037(9.44)		
Other committee leader	2323(23.45)	249(26.29)	36(26.47)	2608(23.73)		
None	6067(61.25)	546(57.66)	77(56.62)	6690(60.88)		
Knowledge about COVID-19						
A lot	4212(42.52)	398(42.03)	47(34.56)	4657(42.38)	4.033	0.402
A little	5659(57.13)	545(57.55)	88(64.71)	6292(57.26)		
None	35(0.35)	4(0.42)	1(0.74)	40(0.36)		
Quarantine period						
1-3d	1663(16.79)	155(16.37)	27(19.85)	1845(16.79)	7.202	0.515
4-7d	1431(14.45)	140(14.78)	16(11.76)	1587(14.44)		
8-15d	1714(17.30)	172(18.16)	16(11.76)	1902(17.31)		
16-30d	1870(18.88)	168(17.74)	33(24.26)	2071(18.85)		
>30d	3228(32.59)	312(32.95)	44(32.35)	3584(32.61)		
During the quarantine, number of masks used						
10 or less	1140(11.51)	133(14.04)	22(16.18)	1295(11.78)	8.2	0.085
10-20	3290(33.21)	303(32.00)	40(29.41)	3633(33.06)		
20 or more	5476(55.28)	511(53.96)	74(54.41)	6061(55.16)		

(Continued)

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TABLE 1 (Continued)

	Study Groups				Statistical Analysis		
Attitude toward online courses							
Like	4521(45.64)	339(35.80)	40(29.41)	4900(44.59)	80.441	0.000***	
Just to listen	3759(37.95)	374(39.49)	52(38.24)	4185(38.08)			
A task must be completed	629(6.35)	98(10.35)	19(13.97)	746(6.79)			
Do not like	997(10.06)	136(14.36)	25(18.38)	1158(10.54)			
Willingness to return to school							
Be willing to	5697(57.51)	556(58.71)	76(55.88)	6329(57.59)	5.946	0.203	
whatever	3837(38.73)	351(37.06)	50(36.76)	4238(38.57)			
Do not want to return to school	372(3.76)	40(4.22)	10(7.35)	422(3.84)			

$\chi 2$ test for categorical variables to assess differences across PTSD groups. Abbreviations: PTSD, posttraumatic stress disorder.**$P<0.01$,***$p < 0.001$.

3.84% of the total, which was 7.35% in group 3, about double higher than group 1 (3.76%) and group 2 (4.22%). Furthermore, the students who want to go back to class are also fewer in group 3 (55.88%) than in group 2 (58.71%) and group 1 (57.51%). We also had no positive results when further regression analysis was used to explore the relationship between PTSD symptoms and willingness to return to school (Table 3).

The preliminary analysis did not find that PTSD symptoms were significantly correlated with age, class presidency or class cabinet, knowledge about COVID-19, quarantine period, number of masks used, and willingness to return to school (Table 1).

PTSD symptoms and social media exposure

Table 4 focuses on the association of media exposure with PTSD symptoms. First, it was found that PTSD symptoms significantly correlated with the time point of beginning to pay attention to COVID-19 ($\chi^2 = 21.83$, $p = 0.016$). Specifically, in the early stage of the epidemic, "Wuhan Health Commission officially reported the first death case (2020.1.11)" and "Wuhan announced a "lockdown" (2020.01.23)," the proportion of students who began to pay attention to the COVID-19 at these two-time points was higher in group 3 (26.47 and 10.29%, respectively). In contrast, the students who paid attention to COVID-19 at other time points do not have this characteristic. The proportion of students who chose "other or never cared" was also higher in group 3 (5.15%).

In addition, PTSD symptoms were correlated with reasons of optimism ($\chi^2 = 22.825$, $p = 0.029$). Among the total student, the proportions of choosing "The shock of China's construction speed," "The increasing number of cured patients," "Sufficient protective appliances," "Public awareness of protection," and "National unity can control the COVID-19 pandemic" were 78.6, 72.91, 63.84, 76.89, and 81.88%, respectively. The proportion of these options is lower in groups 2 and 3, but higher in group 1. Unexpectedly, all college students who chose "Have more time with families" as an optimistic reason were the least (46.92%). While among the three groups who chose this reason, group 3 was the highest (51.47%), higher than the other groups and all populations. In addition, group 3 (8.09%) chose the option "Other" significantly higher than the other two groups.

Regarding the main ways to know the latest news on COVID-19, there was no statistically significant relationship between different ways and PTSD symptoms. The percentage of group 3 is higher than the overall level in all news acquisition ways except television, indicating that they are unusually concerned about the media information. At the same time, we can see that there are multiple ways for college students to obtain information, and "social media" occupies the most significant proportion (90.93%), which has surpassed "television" (82%), while newspapers (23.64%) have the lowest percentage of all access to news.

Although the overall statistics did not find a significant correlation between the PTSD group and "information you most want to know in your home quarantine." It can be found that paying attention to most of the COVID-19 information is higher in group 3. It indicated that students in this group 3 are more concerned about measures and results in various situations related to the epidemic.

The preliminary correlation analysis in Tables 1, 4 suggests that the PTSD group is related to gender, region of residence, the time

TABLE 2 Association between PTSD groups and risk of attitude on online courses.

	Attitude toward online courses								
	Just to listen			A task must be completed			Do not like		
	OR	OR (95% CI)	*p*-value	OR	OR (95% CI)	*p*-value	OR	OR (95% CI)	*p*-value
PTSD group	1.301	1.148–1.475	0.000***	1.981	1.647–2.382	0.000*	1.768	1.500–2.085	0.000***

PTSD, posttraumatic stress disorder. ***$p < 0.001$.

point of beginning to pay attention to COVID-19, and reasons for optimism. In order to further examine the relationship between various factors and PTSD symptoms, an ordinal logistic regression model was performed based on correlation analysis. First, the correlation between the PTSD group and reasons for optimism was analyzed (Table 5, Model 1). Both "sufficient protective appliances "and "public awareness of protection "reduced the risk of PTSD symptoms in group 2 (OR = 0.769, 95%CI = 0.649–0.911, $p = 0.002$ and OR = 0.696, 95%CI = 0.583–0.832, $p = 0.000$, respectively). "public awareness of protection "also reduced the risk of PTSD symptoms in group 3 (OR = 0.556, 95%CI = 0.345–0.895, $p = 0.016$). Moreover, "Others" increased the risk in group 3 (OR = 2.53 [95%CI = 1.286–4.978], $p = 0.007$).

After controlling for the effects of three factors, including gender, region of residence, and "the time point of beginning to pay attention to COVID-19," we analyzed the risk of PTSD symptoms among college students (Table 5, Model 2). The results showed that females have more odds of PTSD symptoms. In group 2, the risk of females developing PTSD symptoms was 1.446 times that of males (OR = 1.446, 95%CI = 1.260–1.659, $p = 0.000$), while the risk increased 1.729-fold in group 3 (OR = 1.729, 95%CI = 1.226–2.438, $p = 0.002$). In group 2, "the time point of beginning to pay attention to COVID-19" (OR = 1.055, 95% C = 1.005–1.107, $p = 0.031$) and region of residence (Hubei province) (OR = 2.295, 95% CI = 1.338–3.939, $p = 0.003$) were more risk to PTSD symptoms, but not significantly risk in group 3.

TABLE 3 Association between PTSD groups and risk of willingness to return to school.

	Willingness to return to school					
	Whatever			Do not want to go back to school		
	OR	OR (95% CI)	*p*-value	OR	OR (95% CI)	*p*-value
PTSD group	0.956	0.855–1.069	0.432	1.239	0.966–1.590	0.091

PTSD, posttraumatic stress disorder.

Discussion

Some factors related to PTSD symptoms in college students

In this study, an ordinal logistic regression model has been used to analyze the factors that significantly impacted the PTSD symptoms of college students during the epidemic. Among them, gender is closely related to the risk of PTSD symptoms in college students, indicating that females are more likely to have PTSD symptoms. In group 2, the risk of females developing PTSD symptoms is 1.446 times that of males, while this risk increased 1.729-fold in group 3. This result has also been confirmed in other studies (48).

In group 2, the time point of beginning to pay attention to COVID-19 and residence in Hubei province will also affect the odds of PTSD symptoms, while these factors were not added odds in group 3. This statistically significant difference may be due to the limitations of the online questionnaire survey. The sample size in Hubei is too small, leading to a selection bias. At the same time, the people with the most severe PTSD symptoms (group 3) may lack the willingness to participate online questionnaire survey due to the influence of the situations and emotions.

PTSD symptoms in college students can affect their day-to-day attitudes and perspectives. We found that PTSD symptoms are significantly correlated with the willingness of college students to take online courses, which is reflected in the lack of willingness of college students with PTSD symptoms to participate in online courses. Relative to "like ", PTSD symptoms increased the risk of "just to listen" of students by 1.301 times; the risk of "a task must be completed" increased by 1.981 times; the risk of "Do not like" increased by 1.768 times. Therefore, among college students with fewer PTSD symptoms, more students are willing to take online courses. However, there was no similar statistical difference in willingness to return to school. From groups 1 to 3, the number of students unwilling to return to school gradually increased, indicating that more severe PTSD symptoms exacerbated the students' social inhibition and inability to complete daily learning and life tasks.

During the epidemic, Chinese schools stopped traditional offline teaching and turned to online courses. College students with PTSD symptoms lack flexibility and adaptability when faced with a crisis. They have weak adaptability to the online teaching model and a low willingness to learn online. In response to this situation, college should improve their efficiency of screening and assessment, provide more targeted support and guidance, and provide psychological counseling services. Only by paying special attention to the unique needs of college students with PTSD symptoms can they navigate the crisis successfully.

The influence of media content on PTSD symptoms

Due to the development of modern media, the influence of media on the public has become more and more significant. Research has shown a positive correlation between media content and PTSD symptoms, and media consumption time was also a risk factor for

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TABLE 4 Comparisons of media exposure across PTSD groups.

	Study groups			All (n =10,989)	Statistical analysis	
	group1: No PTSD Symptoms (n =9,906[90.1%])	group2: 1–3 PTSD Symptoms (n =947[8.6%])	group3: ≥4 PTSD Symptoms (n =136[1.2%])		χ^2	p-value
The time point of beginning to pay attention to COVID-19						
At the end of December 2019, the Wuhan Health Commission issued a notification for the first time that 27 people were infected with viral pneumonia	2,554 (25.78)	276 (29.14)	34 (25.00)	2,864 (26.06)	21.83	0.016*
On January 11, 2020, the Wuhan Health Commission officially reported the first death case	2,336 (23.58)	207 (21.86)	36 (26.47)	2,579 (23.47)		
On 19 January and 20 January 2020, cases occurred in Shenzhen and Beijing	1710 (17.26)	178 (18.80)	20 (14.71)	1908 (17.36)		
On January 20, 2020, Zhong Nanshan affirmed that the new coronavirus pneumonia was human-to-human transmission and that medical staff were infected	2,139 (21.59)	179 (18.90)	25 (18.38)	2,343 (21.32)		
On January 23, 2020, Wuhan announced a "lockdown"	1,004 (10.14)	87 (9.19)	14 (10.29)	1,105 (10.06)		
Other or Never cared	163 (1.65)	20 (2.11)	7 (5.15)	190 (1.73)		
Main ways to know the latest developments of the epidemic						
Television news	8,127 (82.04)	773 (81.63)	111 (81.62)	9,011 (82.00)	3.736	0.88
Newspaper	2,335 (23.57)	226 (23.86)	37 (27.21)	2,598 (23.64)		
Weibo, WeChat and other social media	8,996 (90.81)	866 (91.45)	130 (95.59)	9,992 (90.93)		
Quora or Zhihu etc.	4,006 (40.44)	395 (41.71)	67 (49.26)	4,468 (40.66)		
Others	3,295 (33.26)	318 (33.58)	58 (42.65)	3,671 (33.41)		
What information do you most want to know in your home quarantine?						
Medical knowledge about effective prevention and protection of COVID-19	8,550 (86.31)	816 (86.17)	118 (86.76)	9,484 (86.30)	4.615	0.997
Potential risk of COVID-19 in the area of oneself, family, relatives and friends	8,404 (84.84)	810 (85.53)	118 (86.76)	9,332 (84.92)		
Efforts of doctors, nurses, NHC (National Health Commission) officials, and the police to save lives	6,729 (67.93)	647 (68.32)	106 (77.94)	7,482 (68.09)		
Operation of government to resist the COVID-19 pandemic	7,275 (73.44)	698 (73.71)	107 (78.68)	8,080 (73.53)		
Measures and experience of other countries or areas to resist the COVID-19 pandemic	5,277 (53.27)	511 (53.96)	90 (66.18)	5,878 (53.49)		
Information and statistical data on infection and spread of the COVID-19 pandemic	7,128 (71.96)	668 (70.54)	110 (80.88)	7,906 (71.94)		
Research progress of COVID-19 by professional and scientific institutions	6,368 (64.28)	602 (63.57)	101 (74.26)	7,071 (64.35)		
Analysis and interpretation of COVID-19 by experts, scholars and professionals	6,300 (63.60)	609 (64.31)	100 (73.53)	7,009 (63.78)		
Do not care about COVID-19	65 (0.66)	8 (0.84)	1 (0.74)	74 (0.67)		

(Continued)

TABLE 4 (Continued)

	Study groups			All (n =10,989)	Statistical analysis	
	group1: No PTSD Symptoms (n =9,906[90.1%])	group2: 1–3 PTSD Symptoms (n =947[8.6%])	group3: ≥4 PTSD Symptoms (n =136[1.2%])		χ^2	p-value
Reasons for optimism						
The shock of China's construction speed	7,830 (79.04)	702 (74.13)	105 (77.21)	8,637 (78.60)	22.825	0.029*
The increasing number of cured patients	7,251 (73.20)	667 (70.43)	94 (69.12)	8,012 (72.91)		
Sufficient protective appliances	6,420 (64.81)	515 (54.38)	80 (58.82)	7,015 (63.84)		
Public awareness of protection	7,717 (77.90)	641 (67.69)	91 (66.91)	8,449 (76.89)		
National unity can control the COVID-19 pandemic	8,170 (82.48)	722 (76.24)	106 (77.94)	8,998 (81.88)		
Have more time with families	4,666 (47.10)	420 (44.35)	70 (51.47)	5,156 (46.92)		
Others	293 (2.96)	29 (3.06)	11 (8.09)	333 (3.03)		

χ^2 test for categorical variables to assess differences across PTSD groups. PTSD, posttraumatic stress disorder. *$p < 0.05$.

PTSD symptoms. Whether or not previous exposure, the psychopathological state prior to disaster or trauma was also associated with PTSD symptoms (23, 49).

Some studies found an interaction between media exposure and sympathetic response. Adolescents are more likely to develop PTSD after exposure to natural calamities and artificial misfortunes in media content, which may be related to a lower threshold of sympathetic response. They are more likely to have psychopathological responses (50). Therefore, media content and duration of media exposure can more effectively influence the occurrence of PTSD symptoms in adolescents.

Mass violence and natural disasters spread through the modern media have become more common since the advent of 24-h television news. Exposure to trauma through media also has a variety of psychopathological consequences, such as anxiety, depression, and insomnia, of which PTSD is the most common (16, 21, 39, 43). The outbreak of COVID-19 has thrown people into a sea of information overload. Whether excessive exposure to information from media can damage the public's mental health is a significant concern.

This study shows that the occurrence of PTSD symptoms is related to exposure to information. The proportion of students in group 3 who first began to pay attention to the epidemic under the impact of essential and catastrophic news (Wuhan closure, death cases) is higher than the other groups, indicating that students who started paying attention to the outbreak earlier were also associated with PTSD symptoms. Such students are more likely to develop PTSD symptoms, consistent with previous research findings (13, 27).

In addition, a significant increase in risk in the epicenter (Hubei province) suggests that other non-media information dissemination will also significantly impact PTSD symptoms. These results suggest that PTSD symptoms among college students relate to media content and media exposure. It is worth noting that it is not only related to the degree of excessive attention and the length of attention to information but also the negative impact of the news itself.

We can reasonably speculate that we did not start paying attention to the epidemic until we knew the information that "Wuhan announced a lockdown." This sudden news will surprise students and let them not know what is happening around them. It will also quickly lead to anxiety and panic, a normal mental and psychological reaction. Therefore, college students must avoid sudden or excessive, long-term harmful information exposure to maintain mental health.

The influence of access to media on PTSD symptoms

The advancement of technology is constantly changing how people obtain information, and the leap of technology has also broadened how people obtain information. In addition to traditional newspapers and TV, college students' acquisition of media content extends to the Internet and social media. Through our survey, we found that the current media information channels of college students mainly tend to be Weibo, WeChat, and other social media (90.93%), followed by TV news (82.00%), and newspapers became the most minor used media (23.64%). This phenomenon is related to the reading habits changed by social media, the limited logistics of the newspaper industry during the epidemic, and the lag in newspaper news delivery.

Due to the convenience and speed of the Internet, college students have become accustomed to using Internet platforms to obtain all kinds of information they want. It is worth noting that the students with more PTSD symptoms have a higher proportion of obtaining information through social media, while there is no significant difference in the proportion of students in each group obtaining information from TV news. Because TV news reports are more generalized and moderated, it can be recommended that students prone to panic and anxiety use TV news as the primary channel to obtain information daily. It may be a better way to be adopted psychological intervention during large-scale disasters.

When faced with hot issues, it is easy for people to be attracted by the viewpoints and topics they accept and fall into them unconsciously. Therefore, in today's increasingly popular social media, college students may not obtain different opinions due to the automatic

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TABLE 5 Odds ratios of different PTSD groups by related factors compared with the No PTSD Symptom using multinomial logistic regression model.

	Group 2: 1–3 PTSD Symptoms (*n* =947)						group 3: ≥4 PTSD Symptoms (*n* =136)					
	Model 1[a]			Model 2[b]			Model 1[a]			Model 2[b]		
	OR	OR (95% CI)	*p*-value	OR	OR (95% CI)	*p*-value	OR	OR (95% CI)	*p*-value	OR	OR (95% CI)	*p*-value
Gender	–	–	–	1.446	1.260–1.659	0.000***	–	–	–	1.729	1.226–2.438	0.002**
The time point of beginning to pay attention to COVID-19	–	–	–	1.055	1.005–1.107	0.031*	–	–	–	0.976	0.865–1.100	0.688
Region of residence (Hubei province)	–	–	–	2.295	1.338–3.939	0.003**	–	–	–	0.000	0.000–Infinity	1.000
Reasons for optimism												
The shock of China's speed	0.899	0.759–1.065	0.217	0.930	0.785–1.102	0.401	1.147	0.720–1.828	0.564	1.200	0.754–1.911	0.442
The number of people cured is increasing	1.074	0.914–1.262	0.388	1.048	0.892–1.232	0.567	0.937	0.614–1.430	0.764	0.920	0.604–1.401	0.698
Sufficient protective appliances	0.769	0.649–0.911	0.002**	0.786	0.663–0.931	0.005**	0.927	0.588–1.460	0.743	0.956	0.608–1.501	0.844
Public awareness of protection	0.696	0.583–0.832	0.000***	0.681	0.570–0.814	0.000***	0.556	0.345–0.895	0.016*	0.542	0.338–0.869	0.011*
National solidarity against COVID-19 pandemic	0.891	0.741–1.072	0.222	0.872	0.725–1.049	0.146	1.073	0.649–1.772	0.784	1.037	0.629–1.711	0.886
Have more time with families	1.071	0.928–1.236	0.348	1.053	0.912–1.215	0.485	1.432	0.990–2.071	0.056	1.424	0.986–2.058	0.060
Others	0.762	0.508–1.142	0.188	0.784	0.522–1.177	0.241	2.53	1.286–4.978	0.007**	2.691	1.365–5.308	0.004**

[a]Regression model included reasons for optimism.

[b]Regression model included sex, the timing to start paying attention to COVID-19, Hubei province, reasons for optimism.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

recommendation algorithm of social media, and the sources of information may become homogenized and monolithic (20, 42). Some scholars consider this phenomenon to be an "information echo chamber" phenomenon, where social media may limit the exposure of different viewpoints and facilitate the formation of like-minded groups of users to build and strengthen a standard narrative, known as "echo chambers" (51). Psychological intervention should consider this phenomenon in college students who use social media as the primary information source.

The effect of positive media content on PTSD symptoms

In some cases, after hearing or seeing some information about the catastrophe， we may experience strong empathy, evoke related traumatic experiences in the past, and generate emotions about the suffering of trauma or falling into a post-traumatic state. A study found that exposure to disaster-related social media content, including messages related to drowning persons and the emotional responses of residents, was associated with PTSD (21). On the other hand, viewing images of the storm and heroic behavior was significantly associated with lower odds of PTSD. This result puts forward higher requirements for the professionalism of the media, which should minimize the dissemination of sad messages, reduce excessive trauma, and avoid vicarious trauma.

This study used ordinal logistic regression analysis; regardless of whether gender, region of residence, and "the time point of beginning to pay attention to COVID-19" had effects on the results, both "adequate protective equipment" and "public awareness of protection" reduced PTSD symptoms in group 2. The risk of occurrence of the group 3 symptoms was also reduced by "public awareness of protection." This result reminds us that the media's dissemination of optimistic information can be a positive factor for students to maintain optimism and has a psychological support role. In addition, the overall proportion of students who regard being with their families as an optimistic factor is the least, which is somewhat unexpected. It may be related to the long-term quarantine at home and the outbreak of more potential intra-family conflicts.

Interestingly, in group 3, 'other' factors increased the risk of PTSD symptoms, a consistent result in both models. This is a question worthy of further exploration. Under the limitations of this study,

some factors may not have been taken into account but potentially influence the risk of PTSD symptoms.

Conclusion

Compared with traditional media, although the environment for individuals to obtain information has gotten rid of the closed state, the high technicalities of information have created new problems and worries. In the current environment of information overload, when college students are imprisoned and enclosed in their own "information echo chamber," it is easy to make people blindly confident or narrow-minded, exclude others, and think that their prejudice is the truth (51).

For college students in the crisis of the epidemic, the first thing to do is to avoid sudden, excessive, and long-term negative information involvement. At the same time, it is necessary to enrich information exchange channels and moderately reduce dependence on a single media. Obtaining information by selecting popular, moderate and objective, and screened media is conducive to breaking the barriers of narrow information. Ultimately, it can help reduce the risk of panic, anxiety, and PDST symptoms to a certain extent.

The media should minimize the dissemination of pessimistic, negative, or exaggerated information, reduce excessive trauma, and avoid vicarious trauma in the audience or readers.

Schools and mental health organizations must pay special attention to the unique needs of college students with PTSD symptoms. Efficient screening and evaluation mechanisms are necessary, followed by timely help and referral to medical institutions.

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 Ethical Committee of Research with Shanghai Mental Health Center (2020-33). Written informed consent for participation was not required for this study by the national legislation and the institutional requirements.

Author contributions

X-LZ conducted the online questionnaires tests. W-BY analyzed the data. W-BY and ZW revised and finalized the manuscript. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1050759/full#supplementary-material

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New and continuing physician-based outpatient mental health care among children and adolescents during the COVID-19 pandemic in Ontario, Canada: a population-based study

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Objective: To assess physician-based mental health care utilization during the COVID-19 pandemic among children and adolescents new to care and those already engaged with mental health services, and to evaluate differences by sociodemographic factors.

Study design: We performed a population-based repeated cross-sectional study using linked health and administrative databases in Ontario, Canada among all children and adolescents 3–17 years. We examined outpatient visit rates per 1,000 population for mental health concerns for those new to care (no physician-based mental healthcare for ≥1 year) and those with continuing care needs (any physician-based mental healthcare <1 year) following onset of the pandemic.

Results: Among ~2.5 million children and adolescents (48.7% female, mean age 10.1 ± 4.3 years), expected monthly mental health outpatient visits were 1.5/1,000 for those new to mental health care and 5.4/1,000 for those already engaged in care. Following onset of the pandemic, visit rates for both groups were above expected [adjusted rate ratio (aRR) 1.22, 95% CI 1.17, 1.27; aRR 1.10, 95% CI 1.07, 1.12] for new and continuing care, respectively. The greatest increase above expected was among females (new: aRR 1.33, 95% CI 1.25, 1.42; continuing: aRR 1.22 95% CI 1.17, 1.26) and adolescents ages 13–17 years (new: aRR 1.31, 95% CI

1.27, 1.34; continuing: aRR 1.15 95% CI 1.13, 1.17). Mood and anxiety concerns were prominent among those new to care.

Conclusions: In the 18 months following onset of the pandemic, outpatient mental health care utilization increased for those with new and continuing care needs, especially among females and adolescents.

KEYWORDS

psychiatry, continuity of care, coronavirus, children, adolescents, mental health

Introduction

The COVID-19 pandemic has created a unique set of risk factors for the development of new mental health disorders and exacerbation of pre-existing illness among children and adolescents. Concerns for increasing psychological distress and mental health disorders among children and adolescents emerged early in the COVID-19 pandemic, as school closures and physical distancing orders isolated young people from their peers and significantly disrupted existing routines (1, 2). In Canada and other jurisdictions, many children and adolescents have experienced significant increase in emotional distress, changes in mood, symptoms of anxiety and depression, and this has translated into greater utilization of mental health services (3–6). However, as more research has materialized during the pandemic, it is evident that study findings on the magnitude of the mental health impacts on young people are conflicting (7). While many studies have reported negative mental health outcomes for children and adolescents during the pandemic such as increases in depression, anxiety, and eating disorders (4, 5, 8, 9), others have reported stable or declining rates of self-harm, suicidality, and substance use (4, 5, 8–11). Given the rapidly evolving nature of the pandemic and predicted long-term economic and social consequences, there is a need to better understand the impact on children and adolescents' mental health over time. Likely, the short-and long-term effects on mental health will differ across age and sociodemographic groups (12, 13), with some being exceptionally vulnerable.

Given the major biologic and psychosocial developmental changes during childhood and adolescence, young people may be particularly vulnerable to pandemic-related stressors including loss of routines and supports, social isolation, lack of control, fear of infection and loss, and parental/caregiver stress (1, 2, 12, 14–17). However, the frequency with which children and adolescents have presented to care with acute mental health concerns during the pandemic has not matched the level of distress that has been reported in pediatric populations in the community (7, 18). For example, while pediatric emergency department visits and hospitalizations for mental health concerns decreased or remained near expected levels for the first year following the pandemic in many health jurisdictions (6, 19–23), mental health-related outpatient visits sustained a 10% to 15% increase above expected following the first few months of the pandemic onset (6).

One major limitation of the literature to date has been a failure to distinguish those who newly needed to seek mental health care from those who were already engaged in care. This distinction may help to explain some of the conflicting findings in the existing literature. Challenges resulting from the COVID-19 pandemic may have heightened the risk for new-onset disorders, and/or exacerbated mental health issues for children and adolescents with pre-existing mental health disorders, but the nature of the presentations and the extent of care and resources required might differ greatly. The issue of access to health care during the pandemic might have affected these two groups differently, with the massive shift in outpatient care from in-person to virtual and a likely general reluctance, particularly early in the pandemic, to visit hospital settings and/or reduced mental health services in acute care settings (6, 19). Further, help-seeking patterns related to new engagement in care may differ greatly from that in ongoing care, especially for marginalized groups facing barriers to care (1, 2, 11, 13, 24–28).

This study aimed to examine physician-based outpatient mental health care visits before and during the COVID-19 pandemic among children and adolescents with new and continuing mental health care needs, and to evaluate differences by sociodemographic factors. We hypothesized that mental health care utilization among children and adolescents would increase disproportionately for those new to mental health care, especially among adolescent females as these groups may be uniquely vulnerable to the pandemic stressors.

Materials and methods

Study design and population

This population-based repeated cross-sectional study including all children and adolescents ages 3 to 17 years living in Ontario, Canada and eligible for provincial health insurance using linked health administrative databases housed at ICES, an independent, non-profit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care and demographic data, without consent, for health system evaluation and improvement. We identified all physician-based pediatric mental health-related visits before (January 1, 2017, to February 29, 2020) and during (March 1, 2020, to December 31, 2021) the COVID-19

Abbreviations: CI, Confidence Interval; OHIP, Ontario Health Insurance Plan; aRR, Adjusted Relative Rate; RPDB, Registered Persons Database; PCCF, Postal Code Conversion File; ON-MARG, Ontario Marginalization Index; IRCC, Immigration, Refugees and Citizenship Canada; RIO, Rurality Index of Ontario; GEE, Generalized Estimating Equations; SD, Standard Deviation; RECORD, Reporting of Studies Conducted Using Observational Routinely-Collected Data.

pandemic for those new to mental health care and with continuing service needs. We excluded non-Ontario residents, individuals with invalid birth dates and deaths within the study period, and those with missing data on sex.

Data sources

Health and demographic administrative data were accessed from several databases linked using unique ICES encoded identifiers. The Ontario Health Insurance Plan (OHIP) physician claims database for insured services was used to determine outpatient visits to family physicians, pediatricians, or psychiatrists for mental health care. We used the Registered Persons Database (RPDB) to capture sociodemographic variables including date of birth, sex, date of death (if applicable), and postal code of all Ontario residents eligible for the province's publicly funded universal health coverage, Ontario Health Insurance Plan (OHIP). Mental health-related emergency department visits were identified using the National Ambulatory Care Reporting System (NACRS), and the Canadian Institute for Health Information's Discharge Abstract Database (CIHI-DAD) and the Ontario Mental Health Reporting System (OMHRS) were used to identify for mental health-related hospitalizations. Immigrant and refugee status was ascertained from the Immigration, Refugees and Citizenship Canada (IRCC) Permanent Resident Database. The linkage rate of the IRCC to population registries has been found to be 86% in Ontario (29). The Ontario Marginalization Index (ON-Marg) for neighbourhood material deprivation combines census information on income and education and was used as a measure of socioeconomic status. Quintiles are used to define the marginalization index, with 1 representing the least deprived neighbourhoods and 5 representing the most deprived neighbourhoods. Urban/rural region of residence was determined by the Rurality Index of Ontario (RIO) score, which is a continuous and broader measure of rurality used for policy development purposes in Ontario based on census subdivision (CSD), linked with Statistics Canada Postal Code Conversion File (PCCF) from postal code to Canadian Census data. Scores on the RIO are on a 100-point scale, with rural residence defined as a score of ≥40.

Outcome measures

The primary outcome was monthly outpatient mental health-related visits (e.g., mental health diagnoses and concerns) to a family physician, pediatrician or psychiatrist per 1,000 population (Supplementary Table S1). The numerator represents unique mental health-related visits, not individual children and adolescents. This outcome was chosen as it measures a concept that combines both patient need and demand for services as well as physician access (6, 8, 13, 30). During the pre (January 1, 2017, to February 29, 2020) and peri-COVID (March 1, 2020 to December 31, 2021) periods, we identified individuals with these visits to create two monthly rolling cohorts consisting of (1) those new to mental health care (defined as no prior mental health claims, acute or outpatient, within 1 year prior to the 1st mental health visit date in the given month), and (2) those with continuing mental health care needs (any mental health-related claim in the year prior to the 1st mental health visit date in the given month). For example, if an individual from the new to mental health care cohort had a mental health visit in a given month, then all visits for this patient during the month would count into the numerator of new visits. The continuing care cohort the represents the number of visits per 1,000 among those already in care, not how many children and adolescents already in care had a visit.

Visit rates were expressed per 1,000 population overall and by three social determinants of health: neighbourhood socioeconomic status as measured by material deprivation, urban/rural region of residence, and individual immigration and refugee status. We also stratified by age, sex, and nature of the mental health disorder using physician diagnostic codes (psychotic disorders, mood and anxiety disorders, substance use disorders, social problems, and neurodevelopmental and other concerns) based on validated mental health physician service billing codes (Supplementary Table S1) widely used for mental health system performance reporting in Ontario and Canada (31, 32).

Statistical analysis

Monthly outpatient mental health care visit rates per 1,000 children and adolescents were calculated, denominated on the Ontario population aged 3–17 years of the corresponding study year. We used Poisson generalized estimating equations (GEE) models for clustered count data to measure monthly and overall changes in rates of outpatient mental health visits among those new to and continuing mental health care. We modeled 3 years pre-COVID trends and used these to predict the expected trends during the COVID period (the first 18 months of the COVID-19 pandemic, from March 1, 2020, to December 31, 2021, representing the period of complete data availability following the pandemic onset) in the absence of public health restrictions, separately for each stratum. The model included age group-sex indicators, a continuous linear term measured as months since January 1, 2017 to estimate any overall trend in pre-COVID visit rates, and pre-COVID month indicator variables to model monthly variations, with April as the reference month. An autoregressive correlation structure with a lag of 1, to account for correlations in visit rates over time was used. The dependent variable was the stratum-specific count of visits among the specific cohort (new or continuing) in the stratum; the offset was the log of the stratum-specific population. We applied the linear combination of regression coefficients from pre-COVID to calculate the expected log rates in the COVID period, and computed the ratio of observed to expected rates in the COVID period by exponentiating the difference between the observed and expected log rates and 95% confidence intervals (CI). In additional secondary analyses, visit rates were stratified by social determinants of health, age, sex, and mental health diagnostic grouping.

We quantified monthly rate ratios of observed compared with expected mental health visit rates through the peri-COVID period (March 1, 2020 through December 31, 2021), as well as by early-and peri-COVID-19 periods (March 2020–June 2020 and July 2020–December 2021), respectively, as the first 3 months of the pandemic exhibited large decreasing trends in mental health service use due to major system access disruptions.

All analyses were performed using SAS version 9.4 (SAS Institute, Cary, North Carolina, United States). The use of these data

TABLE 1 Baseline demographic characteristics of children and adolescents, ages 3 to 17 years in Ontario, 2017–2021.

Year	2017	2018	2019	2020	2021
Children and adolescents on January 1st, *N*	2,377,289	2,393,927	2,416,427	2,443,606	2,426,171
Age					
Mean ± SD	10.09 ± 4.31	10.08 ± 4.29	10.09 ± 4.29	10.10 ± 4.29	10.11 ± 4.28
Median (IQR)	10 (6–14)	10 (6–14)	10 (6–14)	10 (6–14)	10 (6–14)
Age group n (%)					
3 to 12 years	1,572,135 (66.1)	1,584,983 (66.2)	1,599,073 (66.2)	1,615,946 (66.1)	1,600,090 (66.0)
13 to 17 years	805,154 (33.9)	808,944 (33.8)	817,354 (33.8)	827,660 (33.9)	826,081 (34.0)
Sex, n (%)					
Female	1,157,190 (48.7)	1,165,478 (48.7)	1,176,762 (48.7)	1,189,716 (48.7)	1,181,156 (48.7)
Male	1,220,099 (51.3)	1,228,449 (51.3)	1,239,665 (51.3)	1,253,890 (51.3)	1,245,015 (51.3)
Rurality, n (%)					
Urban	2,139,111 (90.0)	2,154,930 (90.0)	2,175,685 (90.0)	2,200,403 (90.0)	2,184,690 (90.0)
Rural	232,836 (9.8)	233,905 (9.8)	235,667 (9.8)	238,287 (9.8)	236,935 (9.8)
Missing	5,342 (0.2)	5,092 (0.2)	5,075 (0.2)	4,916 (0.2)	4,546 (0.2)
Immigration status, n (%)					
Non-refugee immigrants	142,452 (6.0)	128,019 (5.3)	112,284 (4.6)	98,159 (4.0)	83,656 (3.4)
Refugees or other immigrants	40,334 (1.7)	37,269 (1.6)	33,584 (1.4)	29,984 (1.2)	26,343 (1.1)
Newcomers	0 (0.0)	25,569 (1.1)	67,395 (2.8)	115,871 (4.7)	137,040 (5.6)
Canadian-born	2,194,501 (92.3)	2,203,069 (92.0)	2,203,164 (91.2)	2,199,592 (90.0)	2,179,132 (89.8)
Material deprivation quintile, n (%)					
Q1 (lowest)	554,645 (23.3)	566,171 (23.7)	579,107 (24.0)	590,365 (24.2)	586,023 (24.2)
Q2	510,798 (21.5)	514,656 (21.5)	520,516 (21.5)	526,610 (21.6)	522,021 (21.5)
Q3	437,272 (18.4)	438,782 (18.3)	441,164 (18.3)	445,078 (18.2)	442,487 (18.2)
Q4	398,832 (16.8)	399,339 (16.7)	401,072 (16.6)	403,954 (16.5)	401,487 (16.5)
Q5 (highest)	448,685 (18.9)	447,904 (18.7)	447,166 (18.5)	450,165 (18.4)	447,210 (18.4)
Missing	27,057 (1.1)	27,075 (1.1)	27,402 (1.1)	27,434 (1.1)	26,943 (1.1)

SD, standard deviation; IQR, interquartile range; Q, quintile.

was authorized under section 45 of Ontario's Personal Health Information Protection Act, which does not require review by a Research Ethics Board, and cell sizes <6 were suppressed to meet institutional policy. We used the Reporting of Studies Conducted Using Observational Routinely-Collected Data (RECORD) reporting guideline.

Results

Sociodemographic characteristics were relatively stable over the 3 years baseline period. In 2021, there were 2,426,171 children and adolescents aged 3–17 years living in Ontario (Table 1), with a mean age of 10.1 years (SD 4.28). Almost half were female (48.7%, $n = 1,181,156$). The majority lived in urban centres (90.0%, $n = 2,184,690$) and were Canadian-born (89.8%, $n = 2,179,132$). Approximately one-third (34.9%, $n = 848,697$) were living in the most deprived neighbourhoods (i.e., quintiles 4 or 5).

Changes in new and continuing mental health care visits

Overall, expected monthly rates of pediatric mental health outpatient visits during the pandemic were 1.5/1000 for those new to mental health care and 5.4/1,000 for those already engaged in care. Observed rates during the first 18 months of the pandemic increased above expected to 1.8/1,000 for those new to care and 5.9/1,000 for those already engaged with services (Figure 1). Overall, visits among those new to care increased by 22% [adjusted rate ratio (aRR) 1.22, 95% CI 1.17, 1.27] compared to expected rates, whereas those continuing care increased by 10% (aRR 1.10, 95% CI 1.07, 1.12). Initially following the pandemic onset, mental health visits decreased until July 2020, after which rates began to increase above expected (Figures 1, 2). Examining monthly trends, we observed an increase in visit rates consistently well above expected ranging from 18% in July 2020 (aRR 1.18, 95% CI 1.12, 1.25) and peaking to 42% in March 2021 (aRR 1.42, 95% CI 1.38, 1.46) for those new to mental health care (Figure 1). In contrast, we observed only a modest increase in mental

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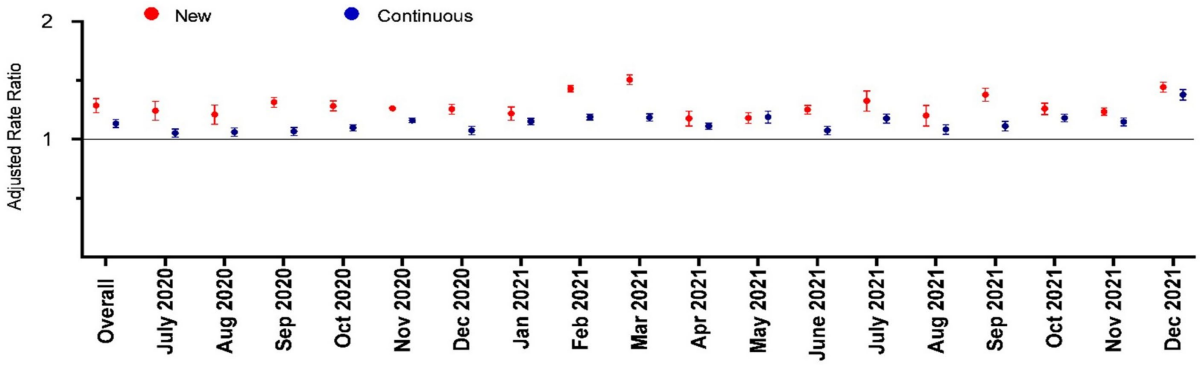

		2020							2021										
		Overall	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
New	Observed Rate	1.84	1.39	1.48	1.76	2.01	2.22	1.51	1.94	2.12	2.34	1.82	1.81	1.67	1.52	1.52	1.9	2.04	2.24	1.77
	Expected Rate	1.51	1.18	1.28	1.42	1.65	1.85	1.26	1.67	1.58	1.65	1.61	1.6	1.41	1.22	1.32	1.46	1.71	1.91	1.3
	Rate Ratio per 1,000 (95% CI)	1.22 (1.17, 1.27)	1.18 (1.12, 1.25)	1.16 (1.09, 1.22)	1.24 (1.21, 1.28)	1.22 (1.18, 1.25)	1.20 (1.18, 1.22)	1.19 (1.16, 1.23)	1.16 (1.12, 1.21)	1.35 (1.32, 1.37)	1.42 (1.38, 1.46)	1.13 (1.08, 1.18)	1.13 (1.10, 1.17)	1.19 (1.16, 1.22)	1.25 (1.18, 1.33)	1.15 (1.08, 1.22)	1.30 (1.25, 1.35)	1.19 (1.16, 1.24)	1.18 (1.15, 1.20)	1.36 (1.32, 1.40)
Continuous	Observed Rate	5.93	4.68	4.75	5.36	6.02	6.65	4.80	6.53	6.5	6.53	6.41	6.62	5.89	5.32	5.04	5.78	6.67	6.87	6.16
	Expected Rate	5.39	4.51	4.56	5.12	5.63	5.95	4.55	5.9	5.71	5.75	5.94	5.81	5.59	4.71	4.76	5.34	5.88	6.21	4.75
	Rate Ratio per 1,000 (95% CI)	1.10 (1.07, 1.12)	1.04 (1.01, 1.06)	1.04 (1.02, 1.07)	1.05 (1.02, 1.07)	1.07 (1.05, 1.09)	1.12 (1.10, 1.13)	1.05 (1.03, 1.08)	1.11 (1.09, 1.13)	1.14 (1.12, 1.16)	1.14 (1.11, 1.16)	1.08 (1.06, 1.10)	1.14 (1.10, 1.18)	1.05 (1.03, 1.08)	1.13 (1.10, 1.16)	1.06 (1.03, 1.09)	1.08 (1.05, 1.11)	1.13 (1.11, 1.16)	1.11 (1.08, 1.13)	1.30 (1.26, 1.34)

FIGURE 1
Adjusted monthly rate ratio of observed mental health-related visit rates following the onset of the COVID-19 pandemic compared to expected rates among children and adolescents with new and continuous care needs in Ontario.

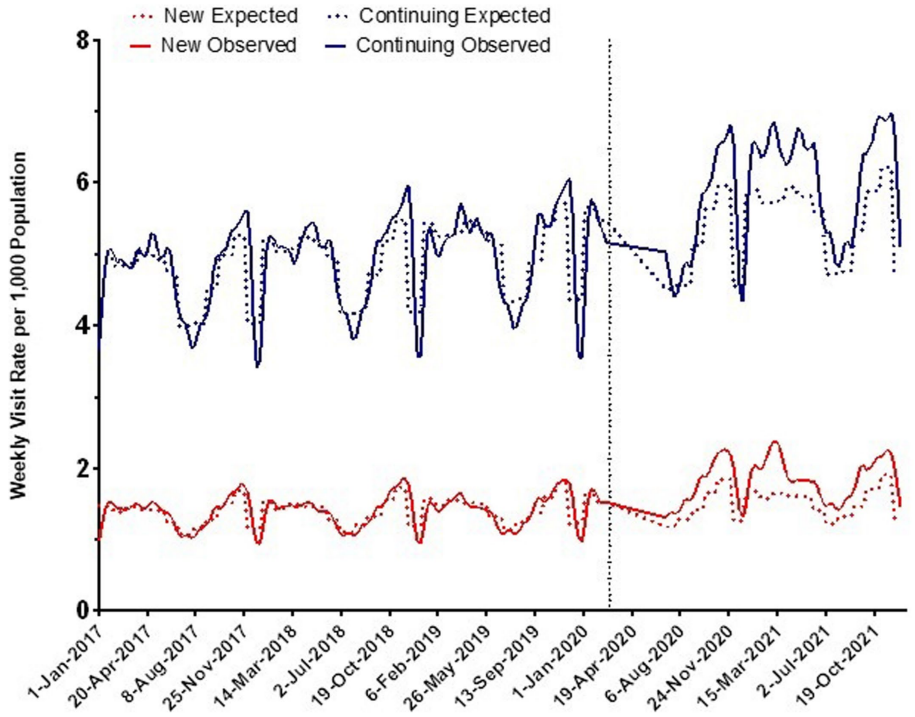

FIGURE 2
Observed and expected rates of outpatient mental health care visits over time in Ontario before and during the COVID-19 pandemic (per 1,000 population).

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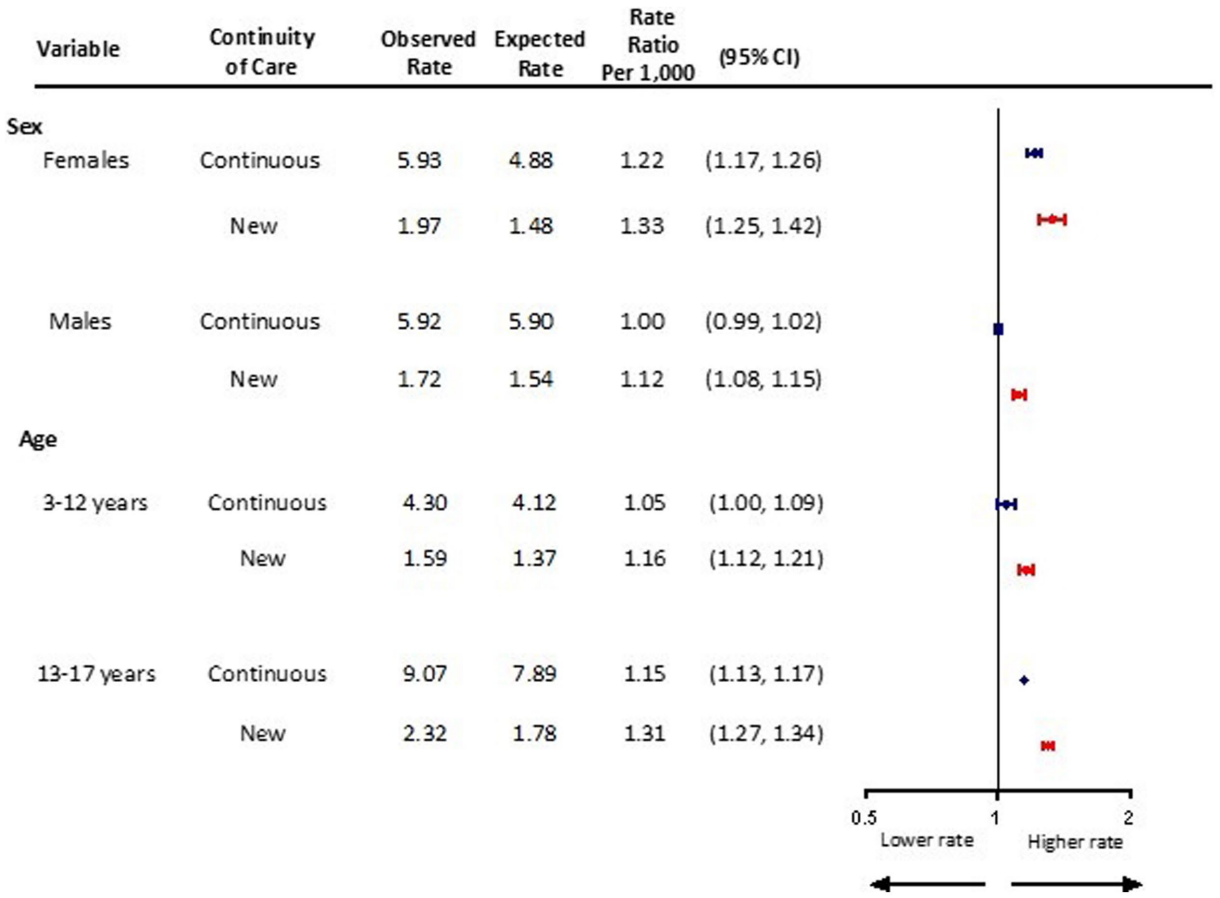

FIGURE 3
Adjusted monthly rate ratio of observed mental health-related visit rates following the onset of the COVID-19 pandemic compared to the expected rates based on 3 years pre-pandemic rates, by sex and age in Ontario.

health visit rates among those continuing to receive mental health care during the pandemic, typically ranging from 4% to 14% above expected levels.

Sex and age

Following the pandemic onset, females new to mental health care had the greatest overall increase in visit rates above expected (new: aRR 1.33, 95% CI 1.25, 1.42; continuing: aRR 1.22 95% CI 1.17, 1.26) (Figure 3). Visit rates among males new to mental health care were also above expected levels (aRR 1.12, 95% CI 1.08, 1.15), however, not for those continuing to receive care during the pandemic (aRR 1.00, 95% CI 0.99, 1.02). A 16% increase in visit rates above expected was observed among children ages 3–12 new to mental health care (aRR 1.16, 95% CI 1.12, 1.21), compared with a 5% increase among those continuing to receive care during the pandemic (aRR 1.05, 95% CI 1.00, 1.09) (Figure 3). Visits rates among adolescents new to mental health care during the pandemic increased 31% above expected (aRR 1.31, 95% CI 1.27, 1.34), compared with a 15% increase among those with continuing care needs (1.15 95% CI 1.13, 1.17).

Social determinants of health

Following the onset of the pandemic, a 15% increase above expected was observed for children and adolescents new to mental health care in rural settings (aRR 1.15, 95% CI 1.11, 1.19), and a 23% increase in urban settings (aRR 1.23, 95% CI 1.18, 1.28) (Figure 4). For those with continuing mental health care needs, visit rates increased by 8% in rural (aRR 1.08, 95% CI 1.05, 1.10) and by 10% in urban regions of residence (aRR 1.10, 95% CI 1.07, 1.13).

Immigrant children and adolescents new to mental health care had a 37% increase in visit rates above expected (aRR 1.37, 95% 1.28, 1.47), whereas those with continuing care needs had an 18% increase (aRR 1.18, 95% 1.12, 1.24) (Figure 4). Refugees new to mental health care also had significantly higher than expected mental health visit rates during the pandemic (aRR 1.20, 95% CI 1.11, 1.28). This pattern was not seen among refugees with continuing mental health care needs (aRR 0.97, 95% 0.88, 1.07).

Similar trends were observed during the pandemic among children and adolescents new to mental health care across material deprivation quintiles with visit rates increasing by 13%–28% above expected (Figure 4). While mental health visits did not increase among children and adolescents with continuing mental care needs

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Variable	Continuity of Care	Observed Rate	Expected Rate	Rate Ratio Per 1,000	(95% CI)
Region of Residence					
Rural	Continuous	5.00	4.65	1.08	(1.05, 1.10)
	New	1.45	1.26	1.15	(1.11, 1.19)
Urban	Continuous	6.02	5.47	1.10	(1.07, 1.13)
	New	1.88	1.53	1.23	(1.18, 1.28)
Immigrant Status					
Immigrant	Continuous	3.38	2.87	1.18	(1.12, 1.24)
	New	1.46	1.07	1.37	(1.28, 1.47)
Refugees	Continuous	2.51	2.60	0.97	(0.88, 1.07)
	New	1.39	1.16	1.20	(1.11, 1.28)
Non-immigrant	Continuous	6.23	5.66	1.10	(1.07, 1.13)
	New	1.86	1.53	1.22	(1.17, 1.27)
Material Deprivation Quintile					
Q1	Continuous	6.40	5.58	1.15	(1.11, 1.18)
	New	2.02	1.57	1.28	(1.23, 1.33)
Q2	Continuous	5.96	5.22	1.14	(1.11, 1.17)
	New	1.90	1.52	1.25	(1.19, 1.31)
Q3	Continuous	5.67	5.14	1.10	(1.06, 1.14)
	New	1.80	1.49	1.21	(1.15, 1.27)
Q4	Continuous	5.65	5.42	1.04	(1.01, 1.07)
	New	1.75	1.45	1.21	(1.16, 1.25)
Q5	Continuous	5.85	5.69	1.03	(0.99, 1.07)
	New	1.68	1.49	1.13	(1.07, 1.19)

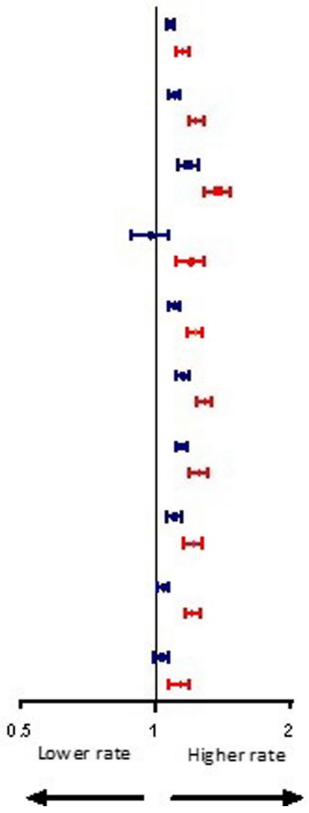

FIGURE 4
Adjusted monthly rate ratio of observed mental health-related visit rates following the onset of the COVID-19 pandemic compared to the expected rates based on 3 years pre-pandemic rates, by rurality, immigration status, and material deprivation in Ontario.

living in the most deprived neighborhoods (i.e., quintiles 5), such visits did increase for those residing in the least deprived areas.

Mental health diagnostic groupings

Children and adolescents with both new and continuing care needs related to mood and anxiety disorders experienced greater than expected mental health visit rates following the pandemic (new: aRR 1.14, 95% CI 1.08, 1.21; continuing: aRR 1.13, 95% CI 1.10, 1.16) (Figure 5). In the first 18 months of the pandemic, observed monthly visit rates were 0.70/1,000 and 2.16/1,000 among those with new and continuing mental health care needs related to mood and anxiety disorders, compared to expected rates of 0.62/1,000 and 1.91/1,000, respectively. For psychotic disorders, observed monthly visit rates increased to 0.11/1,000, representing a 23% increase above an expected rate of 0.09/1,000 among those with continuing care needs (aRR 1.23, 95% CI 1.15, 1.31), but not for those new to care (aRR 1.09, 95% CI 0.95, 1.26). Visit rates for substance use disorders did not differ from expected levels in the 18 months following the pandemic onset (new aRR 0.80, 95% CI 0.68, 0.94 vs. continuing aRR 1.14, 95% CI 0.99, 1.30). Mental health visit rates for social problems and other mental health concerns were at or near expected levels.

Discussion

In the 18 months following onset of the pandemic, physician-based outpatient mental health visit rates were 22% above expected based on pre-pandemic trends for children and adolescents with new-onset mental health concerns, and 10% above expected for those already engaged in mental health services. While the relative increase in visit rates were higher among those new to care, the absolute increases were higher among those with continuing care needs. Their overall monthly visit rates increased from 5.4/1,000 (expected) to 5.9/1,000 (observed), compared to an increase from 1.5/1,000 (expected) to 1.8/1,000 (observed) for those new to care. The greatest increases above expected were among females (34%), adolescents aged 13–17 years (31%) and children and adolescents of immigrant families (37%) new to mental health care. Mood and anxiety disorders were prominent diagnoses among both the new to care and continuing care groups with overall observed monthly visit rates of 0.70/1,000 and 2.16/1,000, respectively.

Findings from this population-based study fill an important gap in the literature on the changing characteristics of children and adolescents seeking outpatient mental health care during the pandemic and magnitude of the impact of cumulative stressors over time. The data signal that relatively more children and adolescents

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Mental Health Disorder	Continuity of Care	Observed Rate	Expected Rate	Rate Ratio Per 1,000	(95% CI)
Psychotic	Continuous Care	0.11	0.09	1.23	(1.15, 1.31)
	New to Care	0.01	0.01	1.09	(0.95 1.26)
Mood/Anxiety	Continuous Care	2.16	1.91	1.13	(1.10, 1.16)
	New to Care	0.70	0.62	1.14	(1.08, 1.21)
Substance	Continuous Care	0.02	0.02	1.14	(0.99, 1.30)
	New to Care	0.00	0.00	0.80	(0.68, 0.94)
Social Problems	Continuous Care	0.47	0.46	1.03	(1.00, 1.07)
	New to Care	0.12	0.13	0.97	(0.93, 1.00)
Other	Continuous Care	3.07	2.91	1.05	(1.02, 1.09)
	New to Care	0.74	0.75	0.99	(0.96, 1.03)

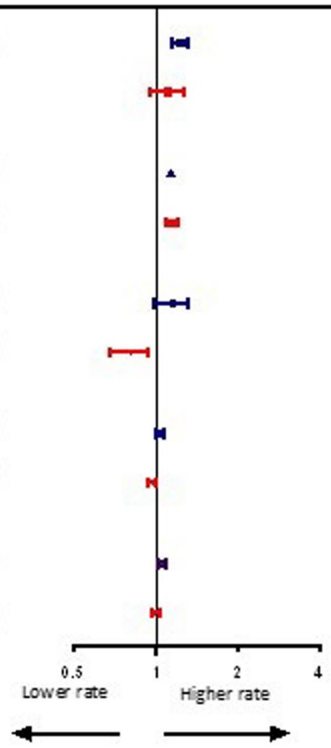

FIGURE 5
Adjusted monthly rate ratio of observed mental health-related visit rates following the onset of the COVID-19 pandemic compared to the expected rates based on 3 years pre-pandemic rates, by mental health disorder in Ontario.

new to mental health care are seeking services to cope with their distress during the pandemic, while at the same time children and adolescents engaged with mental health services pre-pandemic continue to access care at slightly above expected rates. These findings are consistent with a US based study that reported a higher percentage of children and adolescents presenting for emergency psychiatric care during the pandemic with no prior mental health history (21), however, there were no differences observed in the types of new mental health disorders. Furthermore, a large cross-sectional Canadian study examining children and adolescents found a substantial increase in newly diagnosed anorexia nervosa with incidence increasing from 24.5 to 40.6 cases per month and hospitalizations among these patients increasing from 7.5 to 20.0 per month during the first wave of the COVID-19 pandemic (9).

The pandemic disrupted the most important aspects of children's and adolescents' development, especially in areas of skill achievement through school and play that are fundamental to their optimal growth, health, and emotional wellness (33–36). The distinction between new mental health presentations and continuing care is important to our evolving understanding of the pandemic's impact on children and adolescents and the health care system receiving these patients. A critical difference is the additional comprehensive assessment that a new presentation usually entails, adding a substantial and relatively greater burden and cost on patients, their families, and the health care system as compared with those with continuing care needs. While the pandemic may have increased the need for new care or increased the need for more frequent care among those already engaged in care, the nature of need in these two groups may differ. For example, among those already in care, the increased need might translate into more intense care in the form of hospitalizations or emergency department visits. However, the dynamics of access to health care during the pandemic might affect the two groups differently, with the massive shift in outpatient care from in-person to virtual and a likely general reluctance, particularly early in the pandemic, to visit hospital settings and/or reduced services in acute care settings (6, 19). Understanding these differences and changing temporal patterns of both new and continuing mental health care visits during the pandemic is crucial as the scientific community, health system leaders, and decision makers apply research findings in real time to respond to the mental health needs of children and adolescents. Many health care systems, including that in Ontario, lack adequate capacity to manage the growing number of children and adolescents with mental health concerns, especially in the context of increasing demand on systems already stressed by the COVID-19 pandemic. While adequate capacity to meet the growing mental health service demands is important, ensuring continuity of care and clear pathways between primary care and community-based supports will be critical as the pandemic continues to evolve.

Published data remain limited on the changing characteristics of children and adolescents presenting to mental health care following onset of the pandemic. Our findings that female sex, adolescent age group, those living in the least deprived neighborhoods, and immigrants and refugees were disproportionately represented among new-onset mental health presentations following the pandemic builds on our previously published work and that of others (6, 13, 37, 38). The large sex-based and sociodemographic differences in physician-based mental health care visits suggests that the pandemic's cumulative stressors may have had a disproportionately greater impact on adolescent females and certain disadvantaged populations, therefore, warranting closer monitoring and potential intervention. A report from the US Department of Health and Human Services/Centers for Disease Control and Prevention comparing data on mental-health related emergency department visits in 2019 and 2020 indicated that adolescents aged 12–17 years accounted for the largest proportion of visits following the pandemic, with rates increasing by 31% compared with 24% for younger children aged 5–11 years (28). An Ontario-based study of child and youth mental health assessments through multiple pandemic waves found an overall decline in the number of assessments across 53 select mental health agencies during the first wave of the pandemic, with some recovery during the second wave (38). Further, the authors report assessments of younger clients and males declined more than older clients and females. Other studies, however, have suggested little difference in sociodemographic characteristics during the pandemic apart from age (21, 39).

This study has several strengths. Our data encompasses a large population-based sample of almost all children and youth in Ontario, Canada. We utilized multiyear longitudinal pre-COVID data to predict health care utilization patterns 18 months following the pandemic onset. However, our results may not generalize to other health jurisdictions with different models of health care delivery, mental health services, and pandemic-related public health restrictions. Our administrative data are also limited by lags in data transfer, coding accuracy, and reflect mainly physician and hospital-based health care service use. Our data do not tell us the extent of unmet mental health care needs including those that are on waiting lists to be assessed. In addition, the use of neighbourhood-level socioeconomic variables in this study limits the extent to which we can make inferences about individual characteristics (e.g., being economically deprived is different than living in a geographic region that is economically deprived). While our findings signal a population-level increase in visits for new-onset mental health concerns among children and adolescents following onset of the pandemic, there are other equally important but unmeasured indicators not captured by our data that also signify serious distress. For example, many children and adolescents may access mental health supports from health care providers other than physicians including psychologists, social workers, and other therapists. Our databases do not capture services delivered by these other mental health professionals and therefore, we may have under reported the burden of new-onset illness and continuing service needs. Lastly, our data measures physician-based mental health care utilization through to December 2021 and future studies should examine whether and how patterns of new-onset mental illness presentations in children and adolescents following the pandemic change in the long-term.

The COVID-19 pandemic has created a distinct set of risk factors for the development of new mental health disorders and exacerbation of pre-existing illness among children and adolescents. We report significant differences in the number of pediatric patients presenting with new-onset mental health concerns compared with ongoing mental care needs during the pandemic relative to expected levels. Ongoing research is needed to better understand whether the increase in new-onset presentations will persist as the pandemic and recovery plans evolve. Furthermore, certain populations require close surveillance, particularly females, adolescents, marginalized populations and those with mood and anxiety disorders. Our findings have important implications for pandemic recovery planning as well as future pandemics, particularly expanding access to services and new pathways for mental health care across primary care, community, and hospital settings to better support children and adolescents with mental health service needs.

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.

Author contributions

AT conceptualized and designed the study, interpreted the results, drafted the initial manuscript, and revised the manuscript. SV, PK, TS, RS, EC, AG, and NS conceptualized and designed the study, interpreted the results, and revised the manuscript. MCh, CH, KM, WG, MCa, and PS interpreted the results and revised the manuscript. LF and JG had access to and analyzed the data, interpreted the results and revised the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2023.1063203/full#supplementary-material

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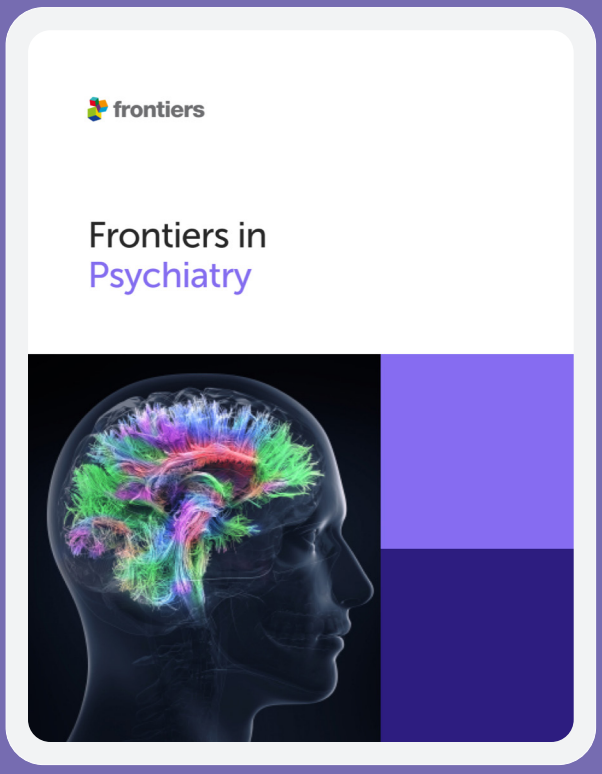

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