

Consequences of the COVID-19 pandemic for evidence-based public health measures fostering child and adolescent mental health

Edited by

Stephan Bender, Ulrike Ravens-Sieberer and Luis Rajmil

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Consequences of the COVID-19 pandemic for evidence-based public health measures fostering child and adolescent mental health

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Table of contents

- 05 **Editorial: Consequences of the COVID-19 pandemic for evidence-based public health measures fostering child and adolescent mental health**
Stephan Bender
- 08 **The relationship between sleep quality and daytime dysfunction among college students in China during COVID-19: a cross-sectional study**
Wei Ji, Liyong Shi, Xinjun Lin, Zhiyong Shen, Qingquan Chen, Duanhong Song, Pengxiang Huang, Zhihuang Zhao, Jimin Fan, Yiming Hu, Mianmian Xie, Jiaohong Yang and Xiaoyang Chen
- 22 **Factors affecting COVID-19's mental health impact on college students in the southeastern United States**
Tiffany Chenneville, Kemesha Gabbidon, Campion Zharima, Stefanie Hornschuh and Janan Janine Dietrich
- 33 **Admission rates and clinical profiles of children and youth with eating disorders treated as inpatients before and during the COVID-19 pandemic in a German university hospital**
Ann-Sophie Silber, Simeon Platte, Afsheen Kumar, Sukhdeep Arora, Dennis Kadioglu, Marvin Schmidt, Holger Storf, Andreas G. Chiocchetti and Christine M. Freitag
- 45 **Mental health and quality of life in children and adolescents during the COVID-19 pandemic: a systematic review of longitudinal studies**
Ester Orban, Lydia Yao Li, Martha Gilbert, Ann-Kathrin Napp, Anne Kaman, Sabine Topf, Maren Boecker, Janine Devine, Franziska Reiß, Flora Wendel, Caroline Jung-Sievers, Vanessa Sophie Ernst, Marco Franze, Eva Möhler, Eva Breitingner, Stephan Bender and Ulrike Ravens-Sieberer
- 58 **Reciprocal effect between non-suicidal self-injury and depressive symptoms in adolescence**
Rui Hu, Li-Li Peng, Yu Du, Yi-Wei Feng, Lin-Shen Xie, Wei Shi, Peng Jia, Li-Hua Jiang and Li Zhao
- 67 **Anxiety disorders among children and adolescents during COVID-19 lockdowns and school closures: a cross-sectional study in Kuwait**
Bibi Alamiri, Moh A. Alkhamis, Ahmed Naguy, Hend F. Alenezi and Muna Al Shekaili
- 80 **Mobile applications in adolescent psychotherapy during the COVID-19 pandemic: a systematic review**
Sarah Wüllner, Katharin Hermenau, Mariya Krutkova, Ira-Katharina Petras, Tobias Hecker and Michael Siniatchkin
- 98 **Anxiety symptoms and coping strategies among high school students in Vietnam after COVID-19 pandemic: a mixed-method evaluation**
Pham Thi Thu Hoa, Do Thi Trang, Nguyen Thi Lien and Ngo Anh Vinh

- 106 **The change of psychosocial stress factors in families with infants and toddlers during the COVID-19 pandemic. A longitudinal perspective on the CoronabaBY study from Germany**
Catherine Buechel, Anna Friedmann, Stefan Eber, Uta Behrends, Volker Mall and Ina Nehring
- 119 **The interrelationship between sleep disturbance symptoms and aggression before and after the campus closure of the COVID-19 pandemic: insight from a cross-lagged panel network model**
Jinhua Zou, Baohua Bian, Min Li and Gang Liu
- 129 **Exploring adolescent mental health during the COVID-19 crisis – strengths and difficulties**
Johanna K. Loy, Janina Klam, Jörg Dötsch, Julia Frank and Stephan Bender
- 142 **Determinants of default from completion of child immunization among children aged 15–23 months in Kacha Bira district, Kembata Tembaro zone, South Ethiopia: a case–control study**
Sitota Tesema Masebo, Eskinder Wolka, Sintayehu Kussa, Muluken Markos Uloro, Selamu Abera Handiso, Dilugeta Mathewos Libabo, Eyosiyas Abreham Anjajo and Efa Ambaw Bogino
- 152 **Mental health symptoms and associated factors among primary healthcare workers in China during the post-pandemic era**
Difei Liu, Yuhe Zhou, Xubowen Tao, Yutong Cheng and Rui Tao
- 162 **Anxiety among children a year after the onset of the COVID-19 pandemic: a Brazilian cross-sectional online survey**
Marla Andréia Garcia de Avila, Tainara de Jesus Amorin, Pedro Tadao Hamamoto Filho, Graziela Maria Ferraz de Almeida, Patricia Olaya-Contreras, Malin Berghammer, Margaretha Jenholt Nolbris and Stefan Nilsson
- 170 **Influence parental- and child-related factors on the acceptance of SARS-CoV-2 test methods in schools and daycare facilities**
Johanna K. Loy, Christian Kimmig, Simon Klos, Heidrun Lioba Wunram, Thorsten Langer, Eva Breitingner and Stephan Bender



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Editorial: Consequences of the COVID-19 pandemic for evidence-based public health measures fostering child and adolescent mental health

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KEYWORDS

child, adolescent, public health, SARS-CoV-2, pandemic, surveillance, psychosomatic, mental health

Editorial on the Research Topic

[Consequences of the COVID-19 pandemic for evidence-based public health measures fostering child and adolescent mental health](#)

The SARS-CoV2 pandemic has had a major impact on infants, children, and adolescents. While children and adolescents are most often only mildly affected by somatic symptoms of a SARS-Cov2 infection, significant challenges in this age group have been identified regarding mental health as a consequence of public health measures to protect adults and elderly people. These challenges were associated with social distancing and public health measures employed to limit infection rates. Different countries adopted various public health strategies concerning the extent of social isolation for children, such as the duration and manner of school closures. Pandemic isolation as a natural experiment allows for assessing the consequences for the psychosocial development and mental health of the next generation. In Germany, this endeavor was undertaken by the project coverCHILD, funded by the Ministry of Education and Science (BMBF), and some results of the project are illustrated in this Research Topic. However, most articles from this Research Topic span the entire world, highlighting the importance of intercultural comparisons and international cooperation during global crises.

In a systematic review, [Orban et al.](#) found that children and adolescents experienced heightened mental health problems, specifically internalizing symptoms like anxiety and depression. Further, there was a decline in their overall health-related quality of life over the course of the pandemic that did not necessarily subside when lockdowns ended. Therefore, the SARS-Cov2 pandemic had a well-documented long-lasting effect on the quality of life and dimensionally assessed mental health symptoms. As [Loy, Klam et al.](#) point out, a combined assessment of reports by caregivers and self-reports of adolescents is needed, as well as country-specific normative values, to obtain a full picture of the mental health status. With respect to the SDQ, subtle differences can be found even between Western European countries. Thus, it is even more important that there is compelling evidence around the globe for the effects of social distancing in various populations: College students in the Southeastern US showed elevated symptoms of anxiety and post-traumatic stress ([Chenneville et al.](#)) and [Hoa et al.](#) report higher rates of anxiety disorder symptoms

in a Vietnamese school student population when the Hanoi government introduced an extended period of social distancing. Comparing data between countries with strict and less strict public health measures seems especially valuable to distinguish general effects (climate change, etc.) from pandemic effects, despite all caveats about country-specific confounding factors. In Kuwait (Alamiri et al.), elevated rates of categorical anxiety disorders were described, with lockdown duration and sex of the child being important predictors for mental disorders. Therefore, both analyses across different countries as well as over different periods in the same country point toward a dose-effect with respect to the social isolation of children. Vulnerable groups were especially affected by pandemic measures, such as families with reduced income during the pandemic, and children with chronic disease or disability (Garcia de Avila et al.), as shown in this Research Topic in a Brazilian sample. These findings fit well into the worldwide literature indicating that more effective targeted support for vulnerable groups will be a challenge for the next pandemic. In adolescents with symptoms of depression, the prevalence of non-suicidal self-injury increased in China compared to pre-pandemic levels, pointing toward increased disease severity in this group (Hu et al.).

Not only did affective and anxiety disorders increase, but also the hospital admission rates for eating disorders went up in Germany (Silber et al.). In line with this finding, psychosomatic complaints such as sleeping problems and disorders have increased. A relationship between pandemic healthcare measures is suggested by the association of sleep quality with gender, limited time spent on outdoor activity, and prolonged electronic entertainment time (Ji et al.). Sleep problems, in turn, can have broader and secondary effects on mental health, as daytime dysfunction is related to sleep problems (Ji et al.). Moreover, Zou et al. show in the Research Topic that hostility mediates the relationship between sleep disturbances and aggression, i.e., sleep disturbances tend to increase aggression, especially in hostile people. Thus, the general effects of social deprivation and lack of sports and outdoor activities can affect circadian rhythms and indirectly a broad spectrum of mental disorders in addition to direct effects on anxiety or mood. In times of digitalization of medical routine care data, ways to rapidly aggregate and evaluate standardized mental health assessments along the lifespan will help to close the empty spaces in our knowledge and to rapidly assess the effects of any crisis as well as the public health measures to face it.

So far, the public health measures and family support applied during the SARS-Cov2 pandemic were not able to sufficiently alleviate parent stress. The most predictive factor for high parenting stress at follow-up in a German (Bavarian) sample of parents of toddlers was high parenting stress at baseline (Buechel et al.). This was also true for parental affective symptoms (depression/anxiety) and child mental health problems. Parents remained burdened. This burden was not limited to parents but also affected professional primary healthcare workers in the post-pandemic era in China (Liu et al.): Female gender, being divorced or widowed, being a nurse, years of working experience, working seniority, monthly income, and experience of workplace violence were identified as associated factors. Targeted interventions are needed in the future to reduce depression and improve primary healthcare workers' wellness and mental health.

At the same time, public health measures to ameliorate the negative consequences of pandemic hygiene measures need to be derived from our data and experience in the past pandemic, despite the scientific need not to infer causality from correlations. Anxiety and post-traumatic stress symptoms were reduced in college students who exercised daily, pointing to the importance of sports and the possibility of being active (Chenneville et al.). On the other hand, the pandemic accelerated the development of telemedical approaches in child and adolescent mental health. Apart from video-conference-administered psychotherapy, Wüllner et al. review the availability of (mobile phone) apps and evidence about their effectiveness. However, they conclude that although the majority of studies favor the intervention relying on or including the app over the control group, most studies have low or very low quality. Further studies are needed to improve both mental health care and low-threshold interventions and recommendations under conditions of social distancing.

It has become clear that timely research is necessary to guide healthcare and welfare policies to provide adequate vaccination and surveillance strategies for children and adolescents to maximize safe social contact in the pandemic context. Therefore, the willingness of parents, as well as children and adolescents, to accept surveillance (testing for infections, e.g., in schools) and/or vaccination is crucial.

In Ethiopia, a lack of antenatal care follow-up, postponement of the vaccination schedule in the past, mothers with parity of greater than four, and poor knowledge of the mothers about immunization were identified as determinants of immunization defaulting (Masebo et al.). This implies that the educational background, psychosocial burden, health literacy, as well as general attitudes toward public health measures and vaccination, affect parents' adherence to recommended vaccination schedules.

In Germany, the acceptance of an easier SARS-Cov2 testing method, a PCR-based "lollipop" test (taking a swab into the mouth so it can soak with saliva), was consistently rated more acceptable than nasal swab antigen rapid tests in school surveillance (Loy, Kimmig et al.). Parents highly appreciated that the test yielded more reliable results than the antigen rapid tests. Children said that it felt less uncomfortable. However, it also became clear that regardless of the test method, subjects who did not favor SARS-Cov2 vaccination also tended to rate school surveillance poorly.

In sum, this Research Topic shows how both the quality of life and the mental and psychosomatic health of children and adolescents have been affected by the SARS-Cov2 pandemic and social distancing measures. It illustrates some psychopathological mechanisms and risk factors for these effects. Some data for future health policies with respect to surveillance measures, vaccination campaigns, physical activity, as well as digitally supported healthcare, are provided. We hope that this research will help the responsible politicians draw adequate conclusions and weigh the positive and negative effects of public health care measures for children in order to maximize their well-being during future crises.

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The relationship between sleep quality and daytime dysfunction among college students in China during COVID-19: a cross-sectional study

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Objective: College Students' sleep quality and daytime dysfunction have become worse since the COVID-19 outbreak, the purpose of this study was to explore the relationship between sleep quality and daytime dysfunction among college students during the COVID-19 (Corona Virus Disease 2019) period.

Methods: This research adopts the form of cluster random sampling of online questionnaires. From April 5 to 16 in 2022, questionnaires are distributed to college students in various universities in Fujian Province, China and the general information questionnaire and PSQI scale are used for investigation. SPSS26.0 was used to conduct an independent sample t-test and variance analysis on the data, multi-factorial analysis was performed using logistic regression analysis. The main outcome variables are the score of subjective sleep quality and daytime dysfunction.

Results: During the COVID-19 period, the average PSQI score of the tested college students was 6.17 ± 3.263 , and the sleep disorder rate was 29.6%, the daytime dysfunction rate was 85%. Being female, study liberal art/science/engineering, irritable (due to limited outdoor), prolong electronic entertainment time were associated with low sleep quality ($p < 0.001$), and the occurrence of daytime dysfunction was higher than other groups ($p < 0.001$). Logistics regression analysis showed that sleep quality and daytime dysfunction were associated with gender, profession, irritable (due to limited outdoor), and prolonged electronic entertainment time ($p < 0.001$).

Conclusion: During the COVID-19 epidemic, the sleep quality of college students was affected, and different degrees of daytime dysfunction have appeared, both are in worse condition than before the COVID-19 outbreak. Sleep quality may be inversely associated with daytime dysfunction.

KEYWORDS

sleep quality, daytime dysfunction, PSQI, college students, COVID-19

1. Introduction

One-third of a person's life is spent in sleep. The quality of sleep often determines the quality of personal life (1, 2). With the accelerating pace of life in contemporary society, different degrees of sleep problems and daytime dysfunction have emerged. Before the outbreak of the COVID-19 epidemic, more than 200 million people in China had varying degrees of sleep quality problems and daytime dysfunction (1). Since the outbreak of the COVID-19 epidemic, according to the Chinese People's Sleep Quality Report (2020), about nearly 300 million people in China have different degrees of sleep quality problems and daytime dysfunction, and nearly two-thirds of them claim that they suffer from insomnia and other symptoms (2, 3). College students who are in the late stage of adolescence and about to enter society are sensitive to changes in the external environment. Sleep problems and daytime dysfunction of this group have become more severe under the influence of changes in study and life patterns, and epidemic prevention policies in the COVID-19 era (4, 5). Recent studies have showed that 36.1–50.1% of college students had different degrees of sleep quality problems and daytime dysfunction (6). In 2022, due to the recurrence of the COVID-19 epidemic, colleges and universities insisted on the general strategy of “external prevention of importation and internal prevention of rebound” (Specific actions include tightening controls on the student movement in COVID-19 epidemic regions and boosting isolation and supervision of people accessing the campus, ensuring that students do not leave campus unless required, and so on. Before the COVID-19 outbreak, these measures had never been implemented.), scientifically formulated the spring back-to-school program, and strengthened the health management of teachers, students, and staff returning to school. Hence, the study and life patterns of college students have changed significantly. The purpose of this study is to understand and evaluate the sleep quality of college students during the COVID-19, to explore its relationship with daytime dysfunction, and to participate in investigating the sleep quality reports of students in each university during COVID-19.

2. Materials and methods

2.1. Study design

This study is a cross-sectional study with a whole random sampling form of an online questionnaire, which was distributed to college students in Fujian Province, China from April 5 to 16, 2022, and filled out by students voluntarily and anonymously. The survey has returned 6,993 questionnaires, covering 33 colleges and universities in Fujian Province. Among them, 5,379 questionnaires were valid, and the recovery efficiency was 76.9%.

2.2. Methodology of the study

2.2.1. Sample size

The sample size was determined according to the formula (7) ($n = \frac{\mu^2 \alpha \pi (1 - \pi)}{\delta^2}$). π is the detection rate of college students' sleep disorders. In order to minimize the error, we set π as 0.3 [Based on the

reference (6)]. δ is the allowable error, it is the maximum error of the sample rate and the overall rate that should be controlled range, we set the allowable error is 0.01π . We set α as 0.05, a confidence interval is taken as 95%, then the corresponding μ is 1.96. Using this method, we determine that n is 4,482 (people), and considering the 20% lost interview rate, 5,379 people need to be surveyed.

2.2.2. Questionnaire development

The questionnaire was first developed in English and then translated into Chinese, and a literature review, clinical expert discussion, and validation were conducted to check the reliability and validity related to the development of the questionnaire. The Pittsburgh Sleep Quality Index scale (8) with high reliability and validity was used, and then the online questionnaire design tool (Sleep Medicine Research Management Platform) was used to form an online questionnaire. After the questionnaire was formed, whole-group random sampling was conducted online, and the questionnaire was distributed to college students in Fujian Province, China from April 5 to 16, 2022. The study was approved by the Ethics Committee of the Second Affiliated Hospital of Fujian Medical University. Prior to completing the survey, participants were informed that participation was voluntary and that their data were anonymous. Study participants consented to their participation in the survey being published. The Questionnaire development process is shown in Figure 1.

2.2.3. Questionnaire quality control

To ensure the quality of the questionnaire itself, we have conducted literature review, clinical expert discussion, and validation. To ensure the quality of respondents filling out the questionnaire, we performed a logical relationship validation of the questionnaire, such that some of the question options are mutually exclusive or inclusive. We set a certain number of questions and screened out the questionnaires with inconsistent answers to these questions. In addition, we measured the response time and screened out the questionnaires where the response time was less than 5 min. In addition, to limit duplication, each IP address and cell phone number can only fill out the questionnaire once. Finally, we conducted manual screening after the questionnaires were collected, and the questionnaires with disorderly or negative answers were invalidated.

2.2.4. General information questionnaire

- 1) General information: It contains basic information such as age, gender, school, and major.
- 2) Study and life situation survey: It contains lifestyle (diet, exercise situation) and study situation (online class study status) during the COVID-19 epidemic.
- 3) Compliance survey: Whether you are willing to accept nighttime sleep quality monitoring? (in the form of wearable devices or smart bracelets); whether you are willing to accept follow-up?

2.2.5. Pittsburgh sleep quality index

The PSQI scale was developed by scholars Buysse (8) and others and then revised by scholars Liu (9) and others. The PSQI scale was used to assess the sleep quality of subjects in the last month, and its Chinese version has good reliability with a retest reliability of 0.81, a sensitivity of 98.3%, and a specificity of 90.2% (10). The Cronbach's α

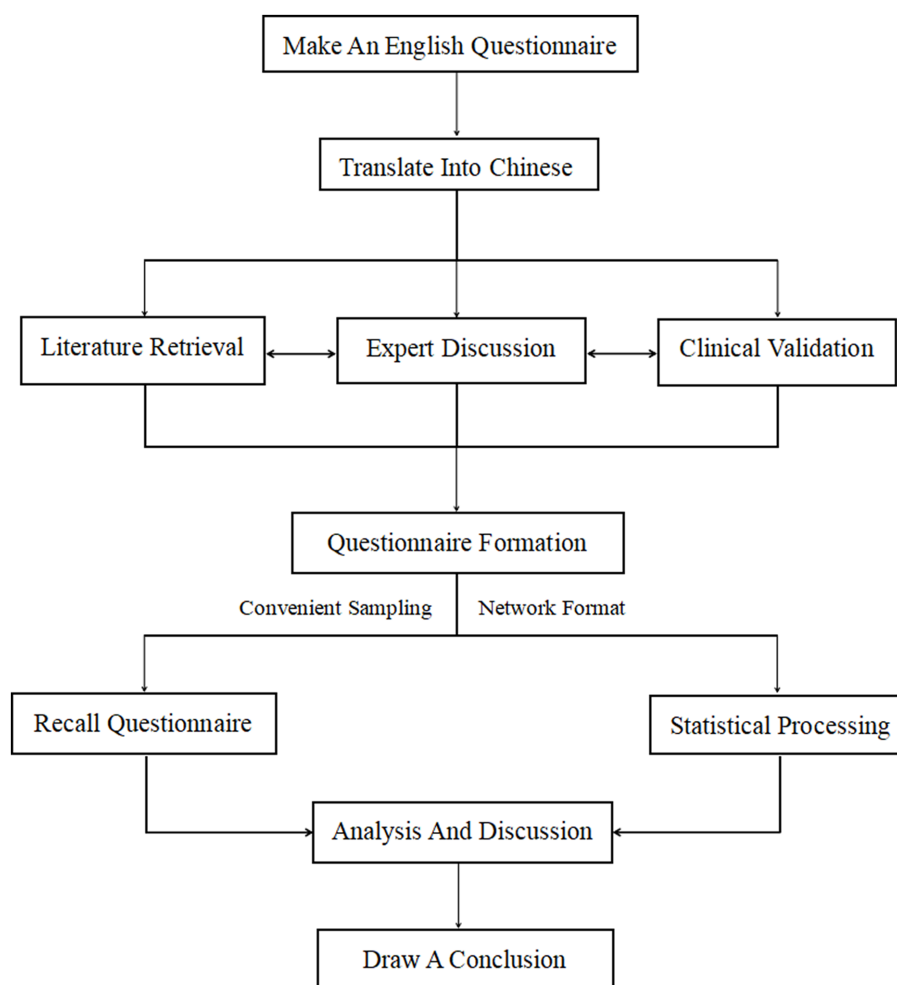


FIGURE 1
The questionnaire development process.

with Chinese version is 0.842 (9). After the survey, the discrete and missing data were removed according to the demographic data indicators, and the relevant items were analyzed with high internal consistency (Cronbach's $\alpha=0.859$). The PSQI scale consists of 18 items, which is divided into 7 components. The components include sleep quality (A), time to fall asleep (B), sleep duration (C), sleep efficiency (D), sleep disturbance (E), hypnotic drug use (F), and daytime dysfunction (G). Each component is scored on a scale of 0–3, and the cumulative score of each component is the total PSQI score, which ranges from 0 to 21, with higher scores indicating poorer sleep quality. 0–5 is considered good sleep quality, 6–10 is fair sleep quality, 11–15 is poor sleep quality, and 16–21 is worse sleep quality. A total PSQI score >7 is the criteria for determining sleep disorders (11). There is one item abnormality in the daytime dysfunction score, which is identified as a daytime dysfunction (Daytime dysfunction score ≥ 1) (12).

2.3. Date analysis

In this study, SPSS26.0 software was used to analyze the data. SPSS26.0 was used to conduct an independent sample t-test and

variance analysis on the data, as well as to determine whether the differences among variables were statistically significant through the significant differences of each component, to test whether there were mediating effects among variables. Multi-factorial analysis was performed using logistic regression analysis. Differences were considered statistically significant at $p < 0.05$. The measurement data conforming to normal distribution were expressed as mean \pm standard deviation, those not conforming to normal distribution were expressed as median (interquartile spacing), and the count data were expressed as rate or composition ratio. In addition, all statistical tests were two-sided ($\alpha = 0.05$).

3. Results

3.1. General status of tested college students

The age range of this sample is 17–25 years old, and the average age is “ 19 ± 1.4 ” years old. There were 1714 (31.9%) males and 3,665 (68.1%) females. There were 2,251 (41.8%) liberal arts majors, 2037 (37.9%) science and engineering majors, and 1,091 (20.3%)

TABLE 1 General status of tested college students (*n*, %).

Variables	Categories	Participants	Constituent ratio
Gender			
	Male	1714	31.9
	Female	3,665	68.1
Major			
	Liberal Arts	2,251	41.8
	Science and Engineering	2037	37.9
	Medical-related	1,091	20.3
Grades			
	Graduation Class	376	7
	Non-graduation Class	5,003	93
BMI			
	<18.5	1,221	22.7
	[18.5,24]	3,295	61.3
	[24,28]	598	11.1
	≥28	265	4.9
Colleges and Universities			
	Project 211/985 Colleges and Universities (National Key Colleges and Universities)	246	4.6
	General Undergraduate of Colleges and Universities	4,229	78.6
	General Vocational Colleges and Universities	904	16.8
Residence			
	FuZhou	1,003	18.6
	XiaMen	109	2
	QuanZhou	1,318	24.5
	LongYan	1772	32.9
	NanPing	238	4.4
	NingDe	128	2.4
	PuTian	37	0.7
	SanMing	595	11.1
	ZhangZhou	179	3.3

medical-related majors. There were 376 students (7.0%) in the graduating class and 5,003 students (93.0%) in the non-graduating class. Other demographic information is shown in [Table 1](#) and [Figure 2](#).

3.2. Comparison of sleep quality and demographic differences among college students

In this study, the mean PSQI total score of college students during the COVID-19 epidemic was 6.17 ± 3.263 . Differences in scores were correlated with gender, major, irritable (due to limited outdoor), and the time spent on electronic devices for entertainment was prolonged, and was not statistically significantly related to district and BMI; The differences in sleep disorder rates among college students were statistically significantly correlated with gender, major, irritable (due to limited outdoor), the time spent on electronic devices for

entertainment was prolonged, and district, and was not statistically significantly related to BMI. Among 5,379 college students, the number of poor sleep quality was 1,594, the rate of sleep disorders was 29.6%, the rate of daytime dysfunction was 85% (The percentage of daytime dysfunction scores 1–2 was 31%, scores 3–4 was 33%, scores 5–6 was 21%). Other information is summarized in [Table 2](#) and [Figure 3](#).

3.3. Binary logistic regression—good and bad sleep quality

The PSQI score was used as the dependent variable (bad sleep quality = 1, good sleep quality = 0), and gender, major, irritable (due to limited outdoor), the time spent on electronic devices for entertainment was prolonged, and the district was used as independent variables in a multi-factorial unconditional logistic regression analysis (inclusion criteria were $p < 0.05$ and exclusion criteria were $p > 0.10$).

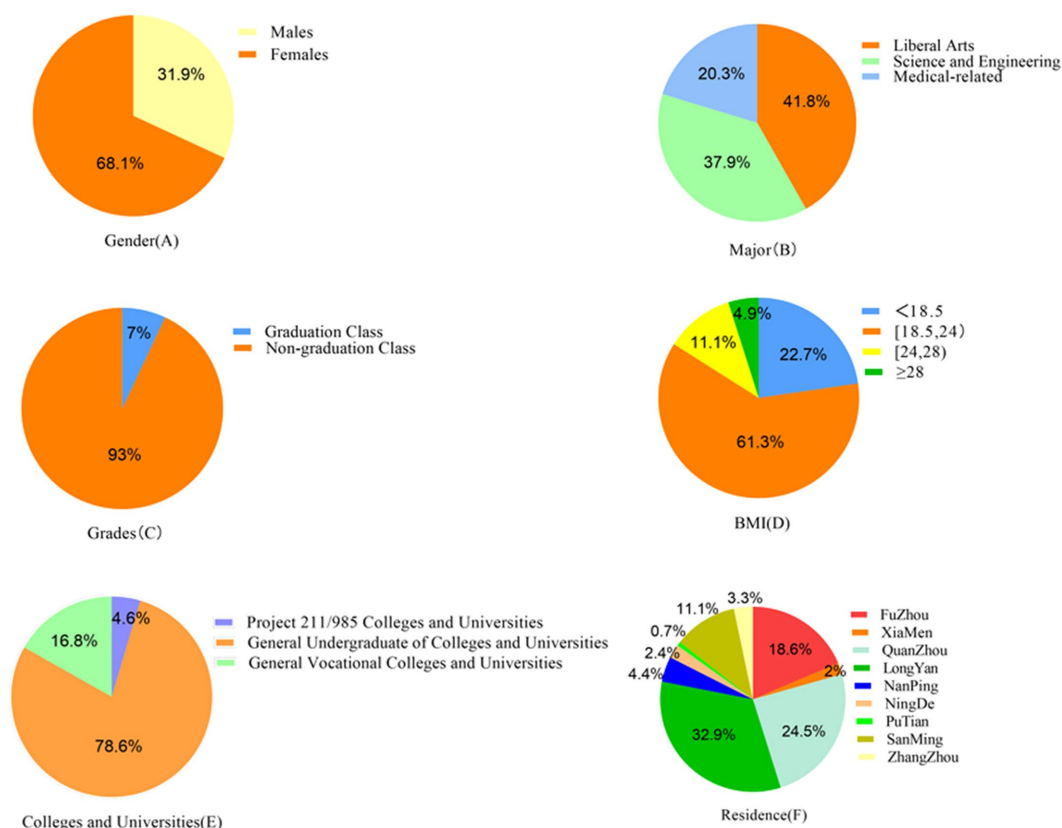


FIGURE 2

Percentage of participants with different demographic characteristics, including gender, major, grades, BMI, colleges and universities, and residence.

The rows with β of 0 and OR of 1 in Table 3 were used as controls. The results of the analysis showed that female, liberal arts and science engineering, irritable (due to limited outdoor), the time spent on electronic devices for entertainment was prolonged, and Quanzhou city, Zhangzhou city, and Longyan city in the district were statistically significantly associated with better or worse sleep quality during the COVID-19 epidemic under the corresponding controls. This is summarized in Table 3 and Figure 4.

3.4. Ordered multi-categorical logistic regression-sleep quality(A)/daytime dysfunction(G)

The outcome variables include sleep quality (A) and daytime dysfunction (G): A/G item score was the dependent variable (very good=0, better=1, worse=2, very bad=3), and gender, major, irritable (due to limited outdoor), the time spent on electronic devices for entertainment was prolonged, and district were the independent variables in an ordered multi-categorical logistic regression (method: Fisher). The rows with β of 0 and OR of 1 in Tables 4, 5 were used as controls.

The results of the analysis (Table 4 and Figure 5) showed that the sleep quality of females was worse than males during the COVID-19 epidemic; The sleep quality of the population of liberal arts and science and engineering was worse than medical-related, especially in the liberal arts; The sleep quality of those who felt irritable with

restricted access to the outside and those with prolonged electronic entertainment time were both worse than the average population. The variables follow a hierarchical order of sometimes conforming, often conforming, and always conforming. There was no statistically significant difference in sleep quality between the study districts.

The other results (Table 5 and Figure 6) showed that the proportion and degree of daytime dysfunction in men were lower than those in women; Daytime dysfunction in medical-related majors was better than that in liberal arts and science and engineering, with liberal arts being more serious than science and engineering; Daytime dysfunction in those who felt irritable when they were restricted from going out and those who spent more time on electronic entertainment showed different degrees of increase compared with the normal population, and the variables that are sometimes conforming, often conforming, and always conforming are progressive step-by-step; The daytime dysfunction of the population in Fuzhou city, Xiamen city, and Longyan city were more severe than that of the normal population, while the population in other district had no statistical significance.

4. Discussion

This is the first study to explore the relationship between sleep quality and daytime dysfunction in Chinese people during the COVID-19 epidemic. We found that Sleep quality and daytime dysfunction among Chinese college students were affected during the COVID-19 epidemic and were more severe than before the

TABLE 2 Comparison of sleep quality among college students in different demographic groups (*n*, %, $\bar{x} \pm S$).

Variables	Categories	The number of poor sleep quality	The rate of sleep disorders	PSQI total score	t/F	<i>p</i>	χ^2	<i>p</i>
Gender					−6.944	<0.001	17.846	<0.001
	Male	442	25.8	5.6 ± 3.397				
	Female	1,152	31.4	6.28 ± 3.195				
Major					23.803	<0.001	40.868	<0.001
	Liberal arts	770	34.2	6.42 ± 3.228				
	Science and engineering	554	27.2	5.86 ± 3.286				
	Medical-related	270	24.7	5.71 ± 3.286				
BMI					0.903	0.856	0.854	0.837
	<18.5	362	29.6	6.10 ± 3.253				
	[18.5,24]	983	29.8	6.07 ± 3.273				
	[24,28]	168	28.1	5.89 ± 3.321				
	≥28	81	30.6	6.25 ± 3.303				
Feel irritable when restricted from going out					156.445	<0.001	261.945	<0.001
	Do not conform	400	19.4	5.03 ± 3.092				
	Sometimes conform	694	30.9	6.34 ± 2.994				
	Often conform	269	44.3	7.10 ± 3.230				
	Always conform	231	50.2	7.93 ± 3.870				
The time spent on electronic devices for entertainment was prolonged					192.764	<0.001	319.122	<0.001
	Do not conform	292	18	4.82 ± 3.138				
	Sometimes conform	631	27.8	6.06 ± 2.958				
	Often conform	409	40.5	7.10 ± 3.181				
	Always conform	262	55.5	8.12 ± 3.574				
Residence					4.972	0.026	48.52	<0.001
	FuZhou	343	34.2	6.37 ± 3.333				
	XiaMen	42	38.5	6.72 ± 3.238				
	QuanZhou	400	30.3	6.10 ± 3.380				
	LongYan	431	24.3	5.77 ± 3.106				
	NanPing	66	27.7	5.71 ± 3.312				
	NingDe	39	30.5	6.26 ± 3.534				
	PuTian	9	24.3	5.54 ± 2.501				
	SanMing	196	32.9	6.14 ± 3.272				
	ZhangZhou	68	38	6.73 ± 3.434				

The first value of *p* corresponds to the t/F test and the second value of *p* corresponds to the chi-square test.

outbreak of COVID-19. We found that the average PSQI score of the tested Chinese college students was 6.17 ± 3.263 , the sleep disorder rate was 29.6% (PSQI score > 7), the daytime dysfunction rate was 85% (Daytime dysfunction score ≥ 1). Among them, The percentage of daytime dysfunction scores 1–2 was 31%, scores 3–4 was 33%, scores 5–6 was 21%). In terms of demographic characteristics, the sleep quality of the group with female, liberal arts and science and engineering was worse than that of other groups, and the occurrence of daytime dysfunction was higher than other groups. Logistics regression analysis showed that sleep quality and daytime dysfunction were associated with gender, profession,

irritable (due to limited outdoor), and prolonged electronic entertainment time.

Due to the rapid development of science and engineering, social life is changing rapidly, and the social pressure faced by each person has increased steeply (4, 13). Sleep problems and daytime dysfunction can often appear under these pressures (Among the daytime dysfunction are the following (14): ①Weakness or overall illness; ②Diminished ability to pay attention, maintain focus, or remember things; ③Diminished capacity for learning, working, or socializing; ④Erratic or irritable moods; ⑤Daytime drowsiness; ⑥Loss of Interest and Energy; ⑦Increased propensity to make mistakes while working

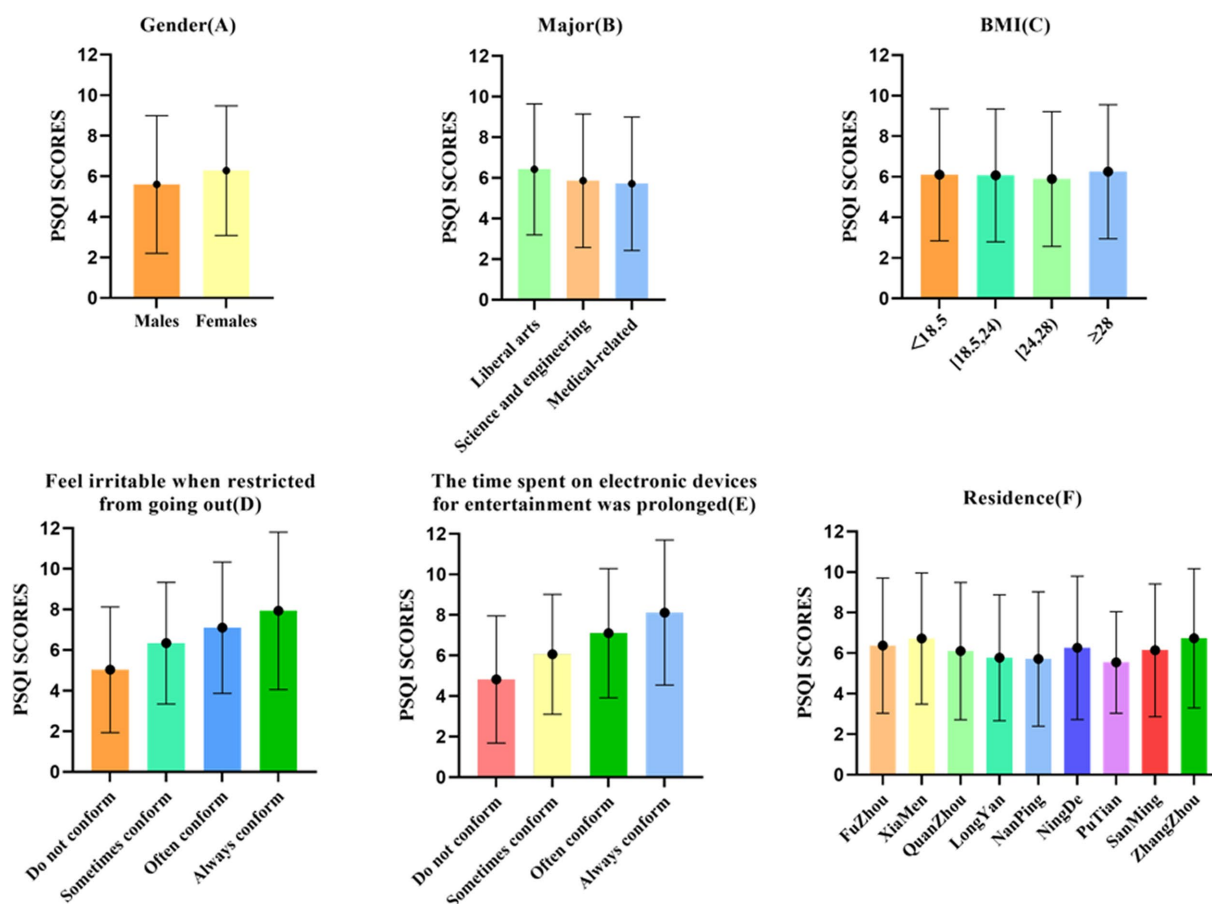


FIGURE 3

Comparison of PSQI scores, including gender, major, grades, BMI, colleges and universities, and residence.

or driving; ⑧Tension, headache, or other somatic symptoms associated with sleep loss; ⑨Excessive worry about sleep.) (6, 12, 15). The number of college students group continues to increase. Employment pressure, academic pressure, interpersonal pressure, and other problems continue to emerge under the influence of the COVID-19 epidemic. In such cases, the sleep problems of this group must be addressed and taken seriously (16). A survey by scholars (6, 17) in 2018 showed that the prevalence of sleep disorders was 18.3%, a survey in 2019 showed that the prevalence of sleep disorders was 33.3%, and a survey in 2020 showed that the prevalence of sleep disorders was 35.1%. The “2021 China Sleep Index Report” released by China in 2021 also showed that sleep problems are becoming more prevalent and severe. Since the COVID-19 epidemic, the sleep quality of college students is gradually decreasing, the rate of sleep disorders continues to increase, and daytime dysfunction is growing.

In the context of the recurrence of the COVID-19 epidemic, this study found that the population of those with very good and better sleep quality in component A of the PSQI scale accounted for 40%, and its proportion was not much different from the proportion of those with very good sleep quality corresponding to the total PSQI score, indicating that the PSQI evaluation has a certain degree of reliability and authenticity (9). In the component BCD, the cumulative score of sleep time was 86% for people with less than 4 points; The sleep time was 84% for people with more than 6 h of sleep, but only 32% of them

had more than 7 h; The sleep efficiency was 82% for people with more than 75%, but only 52% of them had more than 85% efficiency. The difference between the three ratios is not significant, which suggests that because patients have longer sleep time and ordinary sleep efficiency, then the sleep time also decreases to a different extent. This may be due to the fact that during the COVID-19 epidemic period, some college students had large mood swings and failed to regulate their emotions in a timely and reasonable manner, and they passively coped with the changes brought about by the COVID-19 epidemic, which affected sleep time and sleep efficiency in a certain extent, and thus reduced sleep time when the next day's study and living time was scheduled (5, 18). In the accompanying component EG, only 14% of the population had a cumulative score of 0 for a sleep disorder, and the remaining 86% of the population had different degrees of sleep disorder, of which 53% of the population had a cumulative score of 10 or more; At the same time, only 15% of the population had a cumulative score of 0 for daytime dysfunction, 85% of the population had different degrees of daytime dysfunction, and 54% of the population had more serious dysfunction. The percentage of people with different degrees of daytime dysfunction was 85%, and the percentage of people with more serious dysfunction was 54%. This suggests that shortened sleep duration and reduced sleep efficiency can lead to different degrees of sleep disorders and daytime dysfunction compared to before the COVID-19 epidemic (1–3, 19, 20). On the one

TABLE 3 Multi-factor logistic regression analysis of college students' sleep quality (ending with good or bad sleep quality).

Factors	Variables	β	Wald χ^2	OR (95%CI)	p
Constants		-2.179	316.6299976	0.113	<0.001
Gender					
	Male	0.000		1	
	Female	0.107	2.12	1.112(0.964–1.284)	0.145
Major					
	Liberal arts	0.607	35.595	1.834(1.503–2.239)	<0.001
	Science and engineering	0.417	14.734	1.517(1.226–1.876)	<0.001
	Medical-related	0.000	36.648	1	<0.001
Feel irritable when restricted from going out					
	Always conform	1.123	95.103	3.073(2.452–3.851)	<0.001
	Often conform	0.996	92.720	2.709(2.211–3.317)	<0.001
	Sometimes conform	0.487	41.361	1.628(1.403–1.889)	<0.001
	Do not conform	0.000	144.574	1	<0.001
The time spent on electronic devices for entertainment was prolonged					
	Always conform	1.390	138.122	4.016(3.185–5.064)	<0.001
	Often conform	0.870	83.001	2.386(1.979–2.876)	<0.001
	Sometimes conform	0.391	22.144	1.479(1.256–1.741)	<0.001
	Do not conform	0.000	172.152	1	<0.001
Residence					
	FuZhou	0.678	14.063	1.970(1.382–2.807)	<0.001
	XiaMen	-0.047	0.216	0.955(0.785–1.161)	0.642
	QuanZhou	-0.409	18.528	0.664(0.551–0.800)	<0.001
	LongYan	-0.087	0.265	0.916(0.657–1.278)	0.607
	NanPing	-0.059	0.076	0.943(0.621–1.431)	0.783
	NingDe	-0.283	0.492	0.754(0.342–1.662)	0.483
	PuTian	-0.024	0.040	0.976(0.773–1.233)	0.841
	SanMing	0.269	1.554	1.309(0.857–2.000)	0.213
	ZhangZhou	0.000	48.847	1	<0.001

^a β is the regression coefficient of logistic regression analysis, which indicates how many units a dependent variable increases or decreases if the other independent variables are unchanged.

^bWald χ^2 is equal to β divided by its standard error squared, and is used to test whether the partial regression coefficient β of logistic whether is equal to 0 (The rows with β of 0 and OR of 1 in this table were used as controls.). OR, Odds ratio; CI, Confidence interval.

hand, this may be due to the fact that most college students are unable to arrange their studies and lifetime rationally in the context of the recurrent COVID-19 epidemic and failed to actively cope with the adverse effects of the COVID-19 epidemic (21). Thus, on the basis of the shortened sleep time and reduced sleep efficiency, they are unable to regulate their own life rhythm which resulted in the successive emergence of sleep disorders and daytime dysfunction; On the other hand, it either stems from the fear of uncertainty and variability of the COVID-19 epidemic, combined with the failure to relieve it in a timely manner, which in turn causes increased sleep disturbances and daytime dysfunction (22, 23).

It is important to note that the number of people using hypnotic drugs in Component F was only 5%, which indicates that even though the surveyed population had a significant degree of poor sleep quality, they were still reluctant to use hypnotic drugs (such as Estazolam, Zopiclone, Oryzanol Tablets, and so on). But perhaps it was the reluctance to use drugs that led to the worsening of sleep problems

and coupled with the complex environmental impact of the epidemic, which in turn led to a continued decrease in sleep quality (5, 24, 25). On the basis of the total PSQI score, the comparison of PSQI component A and G showed that the proportion of people with very good or better sleep quality and those with no or little daytime dysfunction was similar, which means to some extent that people with good sleep quality tend to be energetic in their daily work and study life and rarely have daytime dysfunction such as sleepiness. This is probably because these people can correctly cope with the adverse impact of the COVID-19 epidemic, timely grasp their own life and learning rhythm, and actively overcome the challenges brought by changes in the surrounding environment to ensure that they are only minimally affected or even not affected by the COVID-19 epidemic in the context of recurrent epidemics (2, 5, 6, 26, 27).

The results of this study showed that women had higher rates of sleep disturbance and poorer sleep quality than men during the COVID-19 epidemic and had a higher proportion and severity of

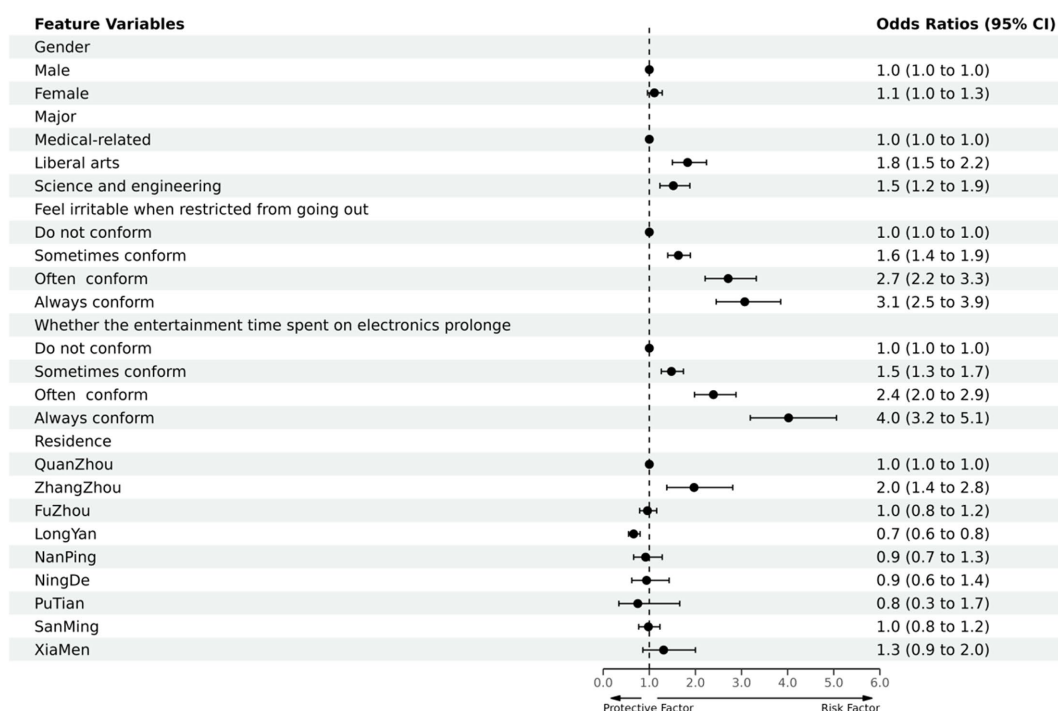


FIGURE 4

Protective and risk factors of multi-factor logistic regression analysis of college students' sleep quality (Ending with good or bad sleep quality).

daytime dysfunction than men, which may be due to the physiological characteristic that women are more sensitive to the external environment and have higher risk perception than men, and this characteristic may be exacerbated in response to environmental changes in the context of recurrent COVID-19 epidemics (5, 28). It is possible that the medical-related population has better sleep quality and less daytime dysfunction than the liberal arts and science and engineering, possibly because the medical-related population has a more comprehensive and specific understanding of the COVID-19 epidemic and can make better judgments and more appropriate adjustments (29). Among them, the poor sleep quality and daytime dysfunction of the liberal arts population are more severe than those of the science and engineering population, probably because the liberal arts population perceives changes more carefully and thus responds to environmental changes in a more complex way, while the science and engineering population is less affected because of a deeper understanding of the inner nature of things (4, 5, 28, 29). Those who feel irritable when they are restricted from going out and those who spend more time on electronic entertainment have poorer sleep quality than other groups, and daytime dysfunction is also more severe than other groups. This is probably due to the fact that the quality of sleep was reduced because of the restriction of going out, irritability, and the reduction of recreational activities (5, 6); Based on this situation, the use of electronic devices is prolonged to relax, but the next day's class time is relatively fixed, thus affecting the quality of sleep, and in a vicious circle, which in turn affects daytime dysfunction (4–6, 29). It is worth mentioning that this phenomenon is more significant in the district where the COVID-19 epidemic is recurrent, such as Fuzhou city and Xiamen city. In these cities, the COVID-19 epidemic is being prevented and controlled with stronger procedures,

such as prohibiting students from leaving school except in life-threatening situations and quarantining and monitoring visitors and departing campus for at least 2 weeks (Before the COVID-19 outbreak, these procedures had never been implemented).

It should be noted that the proportion of those who always and often conformed to the restriction of going out and feeling irritable and the prolongation of electronic entertainment increased significantly compared to those who did not, and the proportion of poor sleep quality and daytime dysfunction that accompanied them also increased significantly, while gender and major had a certain degree of influence on sleep quality and daytime dysfunction, but less than the two. This suggests that it is the main reason for the emergence of poor sleep quality and daytime dysfunction among college students during the COVID-19 epidemic. This may be because the COVID-19 epidemic had a negative impact on the cognitive ability of some college students, which led to their irritability and depression, and the superimposed effect of psychological factors such as irritability and prolonged electronic entertainment time, in which sleep disorders and daytime dysfunction emerged and worsened one after another (19, 21, 26, 29); On the contrary, although factors such as gender and major all had an impact to some extent, the superimposed possibility or superimposed effect due to the epidemic was relatively small (19, 29).

In conclusion, the situation of sleep quality and daytime dysfunction is not optimistic among college students in the context of recurrent epidemics. It is urgent to implement individualized measures to alleviate and improve the physical and mental health of college students, such as correctly guiding college students' cognition of the COVID-19 epidemic, establishing confidence in overcoming the COVID-19 epidemic, providing social support to relieve the stress load, carrying out special lectures and publicity, holding offline fellowship activities on

TABLE 4 Multi-factor logistic regression analysis of sleep quality among college students (Sleep quality/A).

Factors	Variables	β	Wald χ^2	OR(95%CI)	<i>p</i>
Threshold(A)					
	Very good	0.000		1	
	Better	−0.185	4.004	0.831(0.694–0.996)	0.045
	Worse	2.303	543.647	10.003(8.243–12.140)	<0.001
	Very worse	4.618	1471.013	101.251(0.970–1.226)	<0.001
Gender					
	Male	0.000		1	
	Female	0.087	2.113	1.091(0.970–1.226)	0.146
Major					
	Liberal arts	0.403	24.166	1.497(1.274–1.758)	<0.001
	Science and engineering	0.282	10.547	1.326(1.118–1.572)	<0.001
	Medical-related	0.000		1	
Feel irritable when restricted from going out					
	Always conform	1.143	125.496	3.137(2.569–3.832)	<0.001
	Often conform	0.864	90.375	2.372(1.985–2.834)	<0.001
	Sometimes conform	0.587	92.381	1.799(1.596–2.028)	<0.001
	Do not conform	0.000		1	
The time spent on electronic devices for entertainment was prolonged					
	Always conform	1.248	143.040	3.483(2.839–4.273)	<0.001
	Often conform	1.042	166.867	2.835(2.420–3.320)	<0.001
	Sometimes conform	0.620	91.447	1.859(1.637–2.111)	<0.001
	Do not conform	0.000		1	
Residence					
	FuZhou	0.173	1.224	1.189(0.875–1.614)	0.269
	XiaMen	−0.194	5.207	0.823(0.697–0.973)	0.022
	QuanZhou	−0.268	11.647	0.765(0.656–0.892)	0.001
	LongYan	−0.468	10.936	0.626(0.474–0.826)	0.001
	NanPing	0.097	0.294	1.101(0.777–1.562)	0.588
	NingDe	−0.389	1.461	0.678(0.361–1.274)	0.227
	PuTian	−0.398	15.130	0.672(0.550–0.821)	0.000
	SanMing	−0.080	0.176	0.923(0.634–1.343)	0.675
	ZhangZhou	0.000		1	

^a β is the regression coefficient of logistic regression analysis, which indicates how many units a dependent variable increases or decreases if the other independent variables are unchanged.

^bWald χ^2 is equal to β divided by its standard error squared, and is used to test whether the partial regression coefficient β of logistic whether is equal to 0 (The rows with β of 0 and OR of 1 in Table 4 was used as controls.). OR, Odds ratio; CI, Confidence interval.

campus, applying a music therapy, and easing the epidemic control and prevention measures if circumstances permit in order to improve the current situation of poor sleep quality and daytime dysfunction among college students caused by the COVID-19 epidemic (1, 10, 17, 30).

It is noteworthy to mention that colleges and universities worldwide implemented diverse precautionary measures at varying stages of the COVID-19 situation. A number of colleges and universities around the world adopted stringent COVID-19 prevention measures such as mandatory mask-wearing on campus, promoting distance learning, and suspending offline experiments (31–33). While students' sociocultural backgrounds and customs might differ, it was observed that many experienced sleep disturbances due to concerns regarding the epidemic, familial issues, and academic performance (3–6, 32, 33).

5. Strengths and limitations

This study's strength was its substantial sample size, which gave it the power to find significant relationships. A questionnaire is also more practical and economical for a large-scale population survey, although having a potential for lower specificity than laboratory tests.

Some potential limitations of the study merit discussion. First, the causality of the observed relationships in this study could not be established because of the cross-sectional nature of the study. Second, all sleep quality and daytime dysfunction information were collected via self-reporting, and objective measures of sleep quality and daytime dysfunction were not available in the study. Misclassification and recall bias could be introduced. Third, the scope of the clinical

TABLE 5 Multi-factor logistic regression analysis of sleep quality among college students (Daytime dysfunction/G).

Factors	Variables	β	Wald χ^2	OR(95%CI)	<i>p</i>
Threshold(G)					
	Very good	0.000		1	
	Better	0.723	63.658	2.060(1.725–2.461)	<0.001
	Worse	2.255	556.638	9.539(7.909–11.505)	<0.001
	Very worse	4.070	1484.867	58.584(47.628–72.060)	<0.001
Gender					
	Male	0.000		1	
	Female	0.270	22.015	1.311(1.171–1.467)	<0.001
Major					
	Liberal arts	0.413	27.209	1.511(1.294–1.765)	<0.001
	Science and engineering	0.349	22.205	1.483(1.258–1.748)	<0.001
	Medical-related	0.000		1	
Feel irritable when restricted from going out					
	Always conform	1.208	149.631	3.348(2.759–4.063)	<0.001
	Often conform	0.937	115.492	2.553(2.152–3.028)	<0.001
	Sometimes conform	0.648	122.920	1.911(1.704–2.143)	<0.001
	Do not conform	0.000		1	
The time spent on electronic devices for entertainment was prolonged					
	Always conform	1.914	346.763	6.779(5.542–8.291)	<0.001
	Often conform	1.348	299.414	3.851(3.306–4.487)	<0.001
	Sometimes conform	0.727	139.908	2.090(1.849–2.361)	<0.001
	Do not conform	0.000		1	
Residence					
	FuZhou	0.345	5.207	1.412(1.050–1.899)	0.022
	XiaMen	0.293	12.676	1.340(1.141–1.574)	<0.001
	QuanZhou	0.348	21.086	1.416(1.220–1.642)	<0.001
	LongYan	0.311	5.265	1.365(1.046–1.780)	0.022
	NanPing	0.181	1.112	1.199(0.856–1.679)	0.292
	NingDe	0.19	0.383	1.210(0.662–2.211)	0.536
	PuTian	0.258	6.902	1.295(1.068–1.570)	0.009
	SanMing	0.791	18.399	2.207(1.537–3.168)	<0.001
	ZhangZhou	0.000		1	

^a β is the regression coefficient of logistic regression analysis, which indicates how many units a dependent variable increases or decreases if the other independent variables are unchanged.

^bWald χ^2 is equal to β divided by its standard error squared, and is used to test whether the partial regression coefficient β of logistic whether is equal to 0 (The rows with β of 0 and OR of 1 in Table 5 was used as controls.). OR, Odds ratio; CI, Confidence interval.

implications of our findings were constrained by the subjective global evaluation of sleep quality and daytime dysfunction in this investigation. Fourth, worse sleep quality and daytime dysfunction may be related not only to home isolation and offline learning due to the epidemic, but it is also possible that it is related to poor lifestyle habits of the subject population, such as smoking, drinking, staying up late, and irregular work and rest (34, 35). In addition, it should be noted that the COVID-19 epidemic also exacerbates these poor habits. Since women are more susceptible to environmental influences than men, and the recurrence of epidemics brings about enormous environmental changes, the large and substantial depression in sleep quality does not exclude the reason for the predominance of women in the subject population (36).

6. Conclusion

During the COVID-19 epidemic, college students' sleep quality has been affected, with varying degrees of daytime dysfunction, both are in worse condition than before the COVID-19 outbreak. Sleep quality may have been negatively associated with daytime dysfunction.

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.

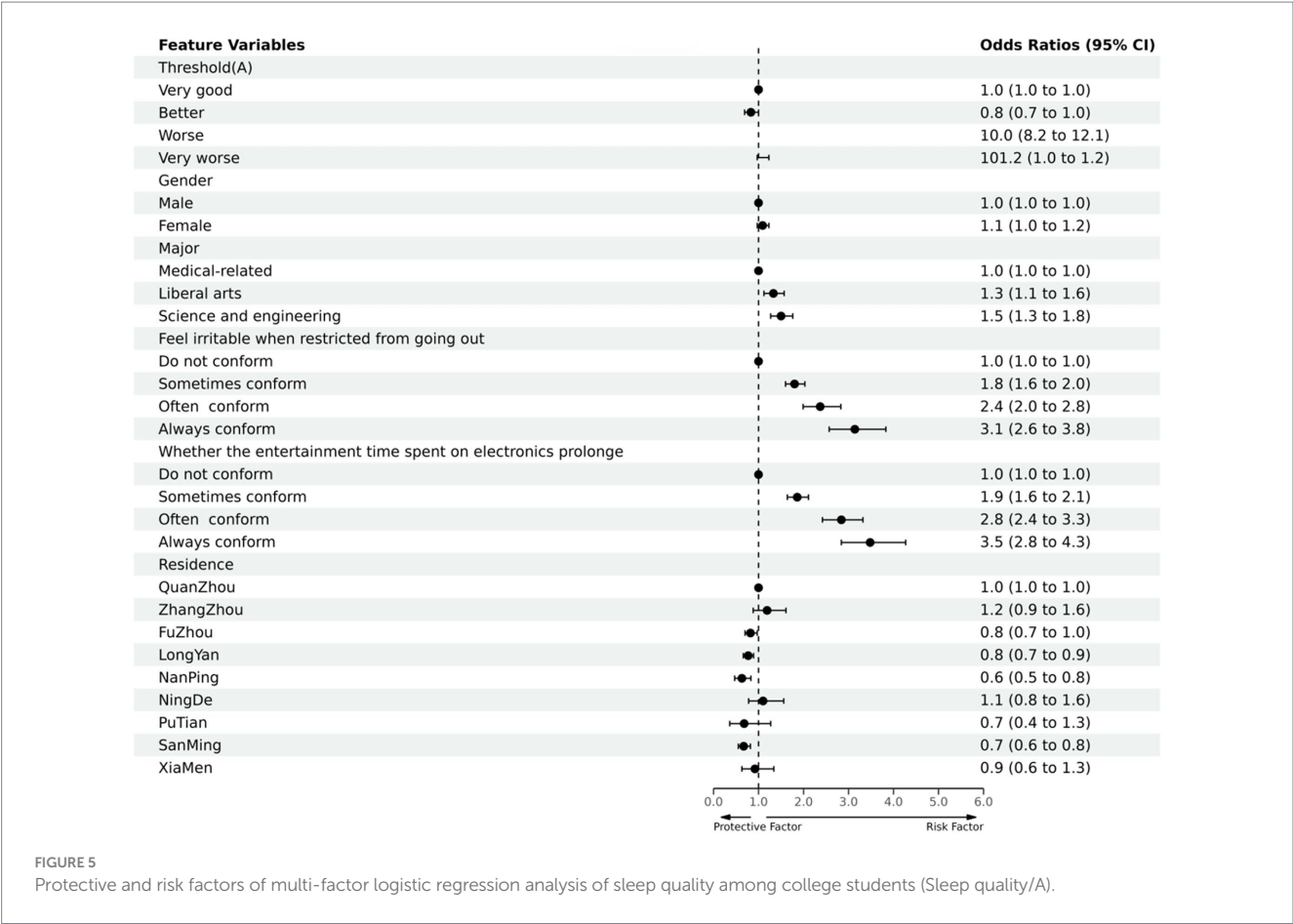


FIGURE 5 Protective and risk factors of multi-factor logistic regression analysis of sleep quality among college students (Sleep quality/A).

Ethics statement

The studies involving humans were approved by the Second Affiliated Hospital of Fujian Medical University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

WJ: Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Writing – original draft. LS: Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Writing – original draft. XL: Formal analysis, Investigation, Writing – original draft. ZS: Investigation, Writing – original draft. QC: Formal analysis, Writing – original draft. DS: Methodology, Writing – original draft. PH: Formal analysis, Investigation, Writing – original draft. ZZ: Data curation, Investigation, Writing – original draft. JF: Investigation, Writing – original draft. YH: Investigation, Writing – original draft. MX: Investigation, Writing – original draft. JY: Methodology, Writing – original draft. XC: Formal analysis, Funding acquisition, Project administration, Supervision, Validation, Writing – review & editing.

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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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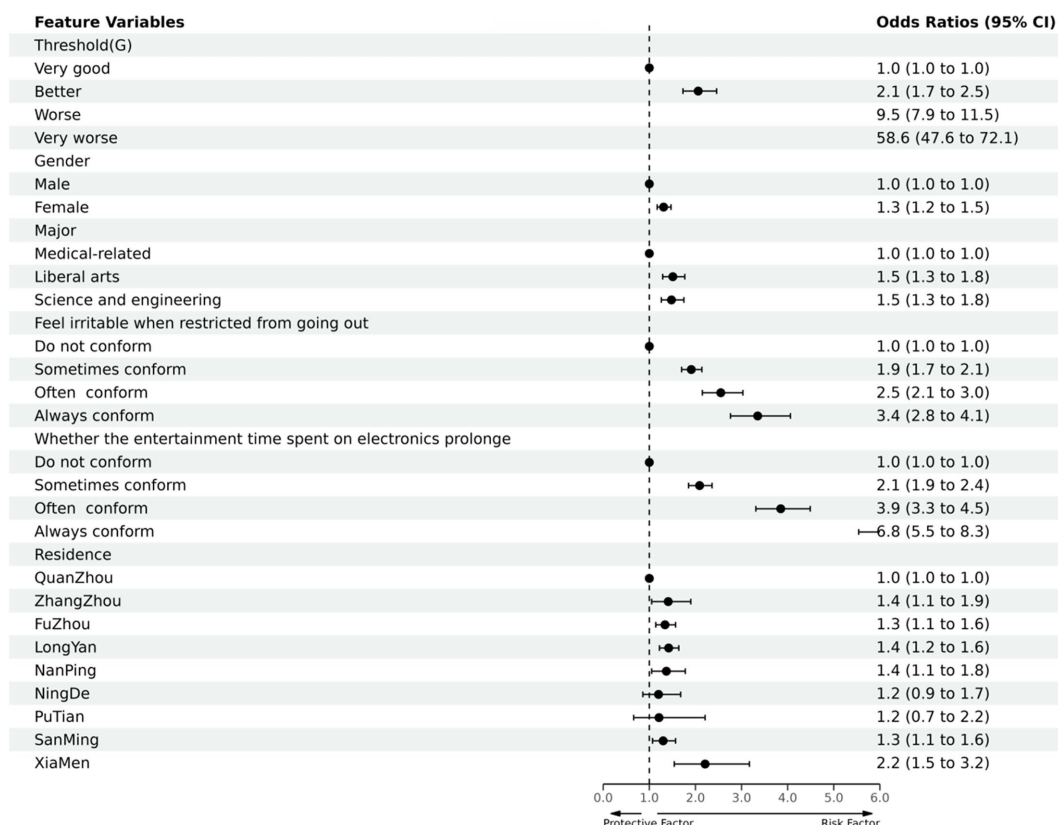


FIGURE 6

Protective and risk factors of multi-factor logistic regression analysis of sleep quality among college students (Daytime dysfunction/G).

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Factors affecting COVID-19's mental health impact on college students in the southeastern United States

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Emerging evidence confirms COVID-19's negative impact on college students' mental health; however, more research is needed to identify factors that promoted or hindered college students' mental health early in the pandemic. This exploratory study addressed this need. Participants were 697 students attending a large, state, urban university in the southeastern United States. Using a cross-sectional survey design, participants completed an anonymous, online survey assessing socio-demographic variables, mental health issues, and activities during the lockdown period in 2020. Findings suggest college students in the southeastern US who were women or transgender men and had pre-existing mental health conditions, fewer routine activities, and high exposure to COVID-19 news reported more mental health problems early in the pandemic. Students who exercised daily had fewer symptoms of anxiety and post-traumatic stress than students who exercised monthly, but there were no differences in emotional responses to COVID-19 based on exercise frequency. Tailored strategies to address college students' needs in response to the current or future pandemics are needed and should take into consideration factors that promote or hinder mental health. Patient or Public Contribution: College students were participants in this study. College students who were not participants in this study assisted with the implementation of this study.

KEYWORDS

COVID-19, mental health, college students, southeastern, United States

1 Introduction

Like other pandemics, Coronavirus Disease 2019 (COVID-19) has threatened mental health around the world (1–5). The high prevalence of deep traumas in societies overwhelmed by natural disasters and global pandemic diseases, such as COVID-19, and the resulting increase in psychological stress and psychiatric disorders has been documented (6–8). An estimated 16% of the world's population was affected by mental health disorders before the COVID-19 pandemic including high rates of depression, anxiety, and post-traumatic stress (9). Although it is still too early to accurately estimate the lasting mental health impact of COVID-19, its threat

to global mental health is well established (10). Shigemura et al. (10) and Hossain et al. (11) described COVID-19's potential effects on physical and mental health in terms of extreme fear of illness and anxiety driven by risk perceptions and poor health. However, the indirect effects of COVID-19 also have negatively affected mental health (e.g., job loss, financial issues, increased caregiving) (12–15). Further, a systematic review of studies addressing the mental health consequences of COVID-19 provides evidence of decreased psychological well-being among the general population in response to the pandemic (3). Of note, most studies included in the review were conducted in China.

Young people are likely to be susceptible to mental health problems associated with the COVID-19 pandemic including anxiety, depression, and stress symptoms (16). This may be especially true for college students (17), a population already at risk for mental health and substance use issues due to academic stress, family separation, and the need to juggle multiple responsibilities (e.g., work, school, family, and friends) (18).

Indeed, COVID-19's mental health impact on college students has been studied in countries across the world. Findings from a global systematic review and meta-analysis of studies published through September 2020 documented COVID-19's negative impact on college students' mental health early in the pandemic (5). In another systematic review, Wang et al. (4) found symptoms of anxiety, stress, and depression were higher among non-Chinese students than Chinese students. In a cross-sectional survey study, Wang et al. (19) found most students attending a university in the southwestern United States reported pandemic-related increases in, and difficulty coping with, stress and anxiety. Son et al. (20) reported similar findings in the same region. In a comparison of pre-pandemic to pandemic time points, Frazier et al. (21) found college students at a midwestern university in the US had higher depression and stress rates during the pandemic than they did several years before the pandemic's onset. Studies in Bangladesh (22) and Italy (23, 24) showed similar findings.

Fewer studies have examined specific factors associated with COVID-19's mental health impact on college students, although the literature in this area is growing. Among a French sample of college students, Wathélet et al. (25) identified multiple factors affecting COVID-19's mental health impact including gender, income, housing, psychiatric history, social isolation, low quality COVID-19 information, and COVID-19 symptoms. Using survey data from students attending large, public, research universities across eight US regions, Soria and Horgos (26) found some marginalized groups were at increased risk for depression and anxiety symptoms during COVID-19 as were students who were disabled or caretakers. Financial stress, food insecurity, housing issues, and academic stressors also affected mental health issues among students in Soria and Horgos' study (26).

The impact of COVID-19 on college student mental health in the southeastern US is understudied despite this region being considered especially vulnerable to the pandemic's negative impact. Americans living in the south are more likely to live in poverty and be uninsured, which contributes to poor health outcomes (27). Health disparities and systemic racism also contribute to COVID-19's negative impact in this region given that many racial and ethnic minorities live in what is often called the Deep South. These factors, combined with the political climate in this region, negatively affect healthcare access,

including mental health treatment (28). According to the Centers for Disease Control (CDC) (29), 13 of 16 southern states were ranked in the highest 50% of COVID-related deaths in the US. It is difficult to compare COVID-19 rates and outcomes in the southeastern US to the rest of the world, in part, because of problems with tracking in the southern states. For example, tracking of up-to-date vaccinations among state residents designated as southern states by the US census bureau (30) are among some of the lowest in the nation (31). However, World Health Organization (32) data suggests that, globally, the US is responsible for 16% of all COVID-related deaths and 13% of infections, though the vaccination rate of the US closely compares with global vaccine rates.

As demonstrated above, emerging evidence confirms COVID-19's negative impact on college students' mental health. Information about the circumstances associated with COVID-19's mental health impact also is increasing. However, more research is needed to better understand what factors promote or hinder college students' mental health so that prevention strategies and interventions can be tailored to meet students' needs and inform planning for future pandemics. This kind of research is particularly important in the southeastern US given this region's vulnerability to the negative outcomes related to the pandemic, as described above. To address this need, this exploratory study's primary purpose was to assess factors associated with COVID-19's mental health impact early in the pandemic on college students at a large university in the southeastern US. Specifically, this study aimed to examine the relationship between socio-demographic variables, activities during the COVID-19 lockdown, and mental health symptoms (e.g., depression, anxiety, and post-traumatic stress).

2 Materials and methods

2.1 Study design

We used a cross-sectional survey design.

2.2 Participants and setting

Participants were 697 students enrolled in a summer course in 2020 at one of three campuses that are part of a large, research intensive, public university in the southeastern US. Only students 18 and older could participate. Minors were excluded.

Only a few days before data collection, the university consolidated, prior to which the campus where data was collected was a separately accredited institution within the larger university system. This context is important for explaining procedures and understanding response rate (see below). The student population is approximately 50,000 across the three campuses, but approximately 4,000 on the campus where data was collected. The demographic makeup of students is predominantly white (63.6%), non-Hispanic (82.7), women (63.4%) aged 18–24 (64.8%) (33), which is representative of the larger population of college students in the US (34). The university offers student mental health services, including counseling, through wellness centers located on each campus. Services were offered virtually during the pandemic. Of note, in the state where data was collected, a state-wide stay-at-home mandate

was issued on April 4, 2020, and lifted on April 30, 2020. City and county stay-at-home mandates within the state varied but had ended prior to data collection.

2.3 Procedures

This study was reviewed by the University of South Florida Institutional Review Board and determined exempt given its use of anonymous data. Following university approvals, the campus registrar sent an invitation email to 3,791 students on July 5, 2020, to complete an online survey administered through Qualtrics survey software. As a quality control measure, Qualtrics survey options were set to prevent multiple submissions by the same respondent, thus ensuring each participant completed the survey only once. The survey was closed on August 7, 2020. Due to consolidation issues beyond the investigators' control, a reminder email was never sent, which may have negatively affected response rate. Although measures were not taken to mitigate this issue, the response rate was approximately 17%, which falls within a typical range for online survey response rates.

Participation was completely voluntary. Responses were anonymous. After an introduction to the study, participants were notified that by completing the survey they were agreeing to participate. Participants were told they could discontinue the survey at any time. At the survey's end, participants received information about how to access mental health services, if needed, through the university wellness centers. Using a systematic or quasi-random selection procedure, every 10th participant who completed the survey received a \$10 Amazon gift card up to 500 participants. To limit sampling bias, participants were blind to survey completion numbering. Contact information for incentives was gathered after the survey was completed and was not linked to survey data.

2.4 Measures

The measures used to assess socio-demographic variables, mental health, and activities during lockdown early in the pandemic are described below.

2.4.1 Socio-demographics

A socio-demographic questionnaire gathered data on age, gender identity, race, ethnicity, degree program (undergraduate versus graduate level), monthly income, mental health history (including diagnoses), daily cell phone use (in hours), COVID-19 testing, food security, and living situation (including any housing disruptions) during the height of the pandemic. Race and ethnic categories were determined by the US Census Bureau's characterization (35); however, authors recognize understanding of racial and ethnic identity varies among cultural groups, see [Table 1](#).

2.4.2 Mental health

Mental health was assessed using: (1) the General Health Questionnaire-12; (2) the Primary Care Post Traumatic Stress Disorder Screen; and (3) four items assessing emotional responses to the COVID-19 pandemic.

TABLE 1 Sociodemographic characteristics of study participants, $N = 697$.

	<i>n</i>	%
Age		
18–19 years	169	24.2
20–29 years	429	61.5
30–39 years	63	9.0
40–49 years	19	2.7
50–59 years	11	1.6
60 or older	6	0.9
Gender ^a		
Men	147	14.7
Women	526	75.5
Transgender men	5	0.7
Transgender women	0	0
Prefer not to say	4	0.6
Prefer to self-identify	12	1.7
Missing	3	0.4
Race ^b		
Black/African American	70	10.0
White	554	79.5
Asian	50	7.2
American Indian/Alaskan Natives	7	1.0
Native Hawaiian and Pacific Islander	6	0.9
Other	57	8.1
Ethnicity		
Hispanic	122	17.5
Non-Hispanic	572	82.1
Missing	3	0.4
Degree program		
Undergraduate certificate	105	15.1
Graduate certificate	17	2.4
Bachelor's degree	448	64.3
Master's degree	75	10.8
Doctoral degree	20	2.9
Other	4	0.6
Non-degree seeking	11	1.6
Missing	17	2.4
Monthly income		
\$0–\$500	286	41.0
\$501–\$1,000	145	20.8
\$1,001–\$1,500	88	12.6
\$1,501–\$2,000	46	6.6
\$2,001–\$2,500	35	5
\$2,501–\$3,000	16	2.3
\$3,000+	55	7.9
Missing	26	3.7

(Continued)

TABLE 1 (Continued)

	<i>n</i>	%
Previously diagnosed with emotional difficulty or mental illness		
Yes	268	38.5
No	388	55.7
Missing	41	5.9
Phone use in hours		
0–2 h	49	7.0
2–4 h	158	22.7
4–6 h	195	28.0
6–8	114	16.4
Always	103	14.8
Tested for COVID		
Yes	19	2.9
No	646	92.7
Missing	32	4.6
Did you have to move out of the residence halls?		
Yes	96	13.8
No	80	11.5
I do not live in the halls	493	70.7
Missing	28	4.0

^aAmong the 12 participants who opted to self-identify gender, five reported being non-binary while others reported concerns about categorizing gender.

^bSeveral participants skipped the question on race and chose to identify as other in the “racial” category and Hispanic in the ethnic category rather than indicating whether they were White Hispanic, Black Hispanic, or other racial and ethnic combinations.

2.4.3 General Health Questionnaire-12

The 12-item General Health Questionnaire (GHQ-12) (36) was used to assess mental health during the pandemic. The GHQ-12 includes items such as *Have you recently been feeling unhappy and depressed?* Participants responded to items using a four-point Likert scale. Response options varied by question. For some items (e.g., *Have you recently been able to face up to your problems?*), response options were 0 = *more than usual*, 1 = *same as usual*, 2 = *less than usual*, and 3 = *much less than usual*. For other items (e.g., *Have you recently been losing confidence in yourself?*), response options were 0 = *not at all*, 1 = *no more than usual*, 2 = *more than usual*, and 3 = *much more than usual*. Scores ranged from 0 to 36, with higher scores indicating more severe psychological distress. Cronbach’s alpha in our sample was 0.899. Total scores under 16 indicate no stress, scores 16–20 indicate stress, and scores >20 indicate great psychological distress (36).

2.4.4 Primary care post traumatic stress disorder screen

Symptoms of posttraumatic stress disorder (PTSD) were assessed using six questions adapted from the Primary Care PTSD Screen (PC-PTSD). The PC-PTSD is considered a valid, reliable instrument and is recommended by the American Psychiatric Association (37). A Cronbach’s alpha of 0.76 was reported for the original sample (37). The original PC-PTSD survey has general questions on frightening or traumatic events. Items were adapted to make the instrument more specific to the COVID-19 pandemic. For example, participants were asked *Do you have intrusive thoughts about the COVID-19 pandemic*

that cause repeated, distressing memories, or dreams? As another example, a question on self-blame and guilt in the original survey was replaced with a question on experiences of negative thoughts or moods associated with the pandemic. In addition to the five questions from the scale, an additional question assessed if the pandemic had caused any fear, helplessness, or horror among participants. Response choices were yes (1 point) or no (0 points). Scores ranged from 0 to 5 with scores greater than 4 signifying a positive PTSD screen. Cronbach’s alpha for our sample was 0.696.

2.4.5 Emotional response to COVID-19

To further assess mental health associated with the pandemic, four items gathered information about feelings of anxiety, worry, upset, and coping. These items were adapted from an online survey developed by the South African Depression and Anxiety Group (SADAG).¹ An example item is *Because of the COVID-19 pandemic, I feel anxious*. Participants responded to items using a three-point Likert scale where 0 = *more than usual*, 1 = *less than usual*, and 2 = *the same*. Scores ranged from 1 to 4 with lower scores indicating more frequent negative mental health symptoms during the pandemic compared to pre-pandemic experiences. Cronbach’s alpha for our sample was 0.699.

2.4.6 Activities during lockdown

Participants’ activities during the lockdown – routine activities, exercise, and COVID-19 news exposure – were assessed using seven items adapted from the SADAG online survey of COVID-19 and mental health (SADAG). One item asked participants to indicate whether they engaged in the following activities during lockdown *never, daily, weekly, or monthly*: kept to a routine; exercised; changed clothes; spoke with someone outside the home via telephone or virtually; watched television or movies for entertainment; read/watched updates for COVID-19; and tried a new activity (e.g., online course, baking, and reading). Other items assessed respondents’ perception that they needed mental health assistance (*yes/no*); if so, why (*stress, anxiety, depression, substance use, other*) and to whom they reached out for mental health support (*a trusted friend/family member, free online support, paid counseling services, other*); how often they considered seeking assistance (*never, occasionally, frequently*); whether they sought assistance (*yes/no*); and, if so, if they sought assistance from a registered mental health professional (*yes/no*). Cronbach’s alpha for our sample was 0.510. Although relatively low, the use of these items is justified given the small number of items; the fact that the items assess different activities, which may not be correlated with one another; and the exploratory nature of this study.

2.5 Data analysis

Data were analyzed using the IBM Statistical Package for the Social Sciences version 26. Descriptive analyses were used to describe

1 This study was part of a larger cross-cultural study designed to examine differences in student mental health in response to the COVID-19 pandemic between the US and South Africa. Because the original project was designed by South African authors, some of the measures used in this study originated in South Africa.

the sample and variables of interest (e.g., mental health, activities during lockdown). Authors conducted normality testing of the data. Results of the Kolmogorov–Smirnov and Shapiro–Wilk tests suggested that the data was not normally distributed, thus we conducted nonparametric testing to determine relationships between variables. The Mann Whitney U Test and Kruskal–Wallis Test were used in place of Independent Samples T-tests and One-way ANOVA. To address small subsamples (e.g., students identifying as transgender), the Kruskal–Wallis test was used. *Post hoc* tests (Dunn's) were used to determine the direction of significant differences seen across groups. Correlation between mental health variables was assessed using Kendall's tau-b. Given the low number of missing data values, all missing data were excluded from analysis.

3 Results

3.1 Participant demographics

Most participants (61.5%, $n=429$) were aged 20–29 years. Most were women (75.8%, $n=526$) and identified as White (79.5%, $n=554$) followed by Black/African American (10% $n=70$) and Asian (7.2%, $n=50$). Most identified as non-Hispanic (82.1%, $n=572$). Most participants were completing a Bachelor's degree (64.3%, $n=448$) across a wide variety of majors and reported a monthly income of \$1,000 or less (61.8%, $n=431$).

Most participants (83.4%, $n=581$) did not report food insecurity as a result of the pandemic. Further, most participants (70.7%, $n=493$) did not live in the residence halls and experienced no disruption in housing. However, among the 176 respondents who lived in the residence halls, 54% ($n=96$) reported having to relocate during the COVID-19 pandemic.

Nearly 40% ($n=268$) of participants had previously been diagnosed with a mental illness. Commonly cited diagnoses were General and Social Anxiety Disorder, Major Depressive Disorder, Attention Deficit Hyperactivity Disorder, Panic Disorder, Post-Traumatic Stress Disorder, Obsessive Compulsive Disorder, and Bipolar Disorder. The vast majority of participants (92.7%, $n=646$) had not received COVID-19 testing at the time of data collection. See [Table 1](#).

3.2 Mental health during the COVID-19 pandemic

3.2.1 General health

Given the non-parametric nature of our data, we report median (MDN) and interquartile ranges (IQR) as comparison points. The median total score on the GHQ was 16.00, IQR = 10.00. A significant portion (46.6%, $n=297$) of participants scored below the threshold for stress (<16); 132 (20.7%) scored between 16–20, indicating stress; and 208 (32.7%) scored >20 , demonstrating severe psychological distress. Using the Kruskal–Wallis Test, significant differences were noted between GHQ scores and gender, $H(2) = 16.41$, $p < 0.001$. Pairwise comparisons using Dunn's *post hoc* test indicated that cis gender men, MDN = 13.00, IQR = 10.00 had better outcomes than women MDN = 17.00, IQR = 10.00, $p = 0.002$ and transgender men, MDN = 25, IQR = 6.50, $p = 0.02$. To ensure the small number of transgender men

in our sample did not distort findings, we re-ran the analyses without transgender men and found similar results. Specifically, results from the Mann Whitney U test showed that women had significantly worse general health (higher GHQ scores) compared to men, $z = -3.245$, $p = 0.001$. There were no significant differences by age groups, $p = 0.33$ or by race (p values ranged from 0.35–0.77) or ethnicity, $p = 0.99$. There were also no differences based on a previous mental health diagnosis, $p = 0.56$.

3.2.2 Primary care post traumatic stress disorder screen (PC-PTSD)

The median score on the PC-PTSD was 2.00 and approximately one fourth of participants (25.7%, $n=167$) had a score greater than 4, which is the threshold for a positive PTSD screen, as noted above. There was a significant difference in scores based on gender $H(2) = 23.20$, $p < 0.001$. Dunn's *post hoc* results showed both women, MDN = 2.00, IQR = 3.00, $p < 0.0001$ and transgender men, MDN = 5, IQR = 2.00, $p = 0.002$ had higher PTSD scores than cis gender men, MDN = 1.00, IQR = 3. To ensure the small number of transgender men in our sample did not distort findings, we re-ran the analyses without transgender men and found similar results. Specifically, results from the Mann Whitney U test showed that women had significantly worse PTSD scores compared to men, $z = -3.898$, $p < 0.001$. There were no significant differences in scores based on age groups, $p = 0.17$ or by race (p -values ranged from 0.18–0.53) or ethnicity, $p = 0.86$. There was a significant difference based on previous mental health diagnosis. Participants with a previous mental health diagnosis reported worse PTSD scores, MDN = 3.00, IQR = 2.00 compared to participants without a history, MDN = 2.00, IQR = 3.00, $p < 0.001$.

3.2.3 Emotional response to COVID-19

There was a significant difference in mental symptoms based on gender, $H(2) = 16.126$, $p < 0.001$. Dunn's *post hoc* results showed cis gender men, MDN = 2.00, IQR = 1.19 reported better mental health experiences than women, MDN = 1.75, IQR = 1.00, $p = 0.005$ and transgender men, MDN = 1.00, IQR = 0.25, $p = 0.008$. To ensure the small number of transgender men in our sample did not distort findings, we re-ran the analyses without transgender men and found similar results. Specifically, results from the Mann Whitney U test showed that men had better emotional responses to COVID-19 compared to women, $z = -3.413$, $p = 0.002$. There were no significant differences in scores based on age, $p = 0.13$ or by race (p -values ranged from 0.44–0.90) or ethnicity, $p = 0.49$. However, there was a significant difference based on previous mental health diagnosis. Participants without a previous mental health diagnosis reported a more positive emotional response to COVID, MDN = 2.00, IQR = 1.00 compared to participants with a history of mental health issues, MDN = 1.5, IQR = 1.00, $p < 0.001$.

Over one-third of respondents (37%, $n=258$) reported needing mental health support because of the pandemic, including the lockdown. The most cited reasons for needing mental health support were anxiety (34%, $n=237$), stress (32.9%, $n=229$), and depression (27.7%, $n=193$). The most frequently reported source of support (44%, $n=307$) was a trusted friend/family member. Over half of participants (54.6%, $n=381$) considered seeking professional mental health care on occasion (38.7%, $n=270$) or frequently (15.9%, $n=111$). However, only 22.7% of respondents sought assistance. Among these,

56.9% ($n=90$) sought care from a professional mental health provider or hotline.

3.3 Relationship between mental health variables

Results showed a significant, moderate inverse correlation between general health and participants' emotional response to COVID-19 ($tb = -0.49, p < 0.001$). Poor general health reports were correlated with a more negative emotional response to COVID-19 including feeling anxious or worried. There also was a significant correlation between general health and PTSD symptoms ($tb = 0.55, p < 0.001$). Specifically, worse GHQ scores. Mirrored worse PTSD scores. See Table 2.

3.4 Activities during COVID-19 lockdown

Most participants reported maintaining a daily or weekly routine (67.0%, $n=467$), changing their clothes daily (74.2%, $n=517$), speaking with others outside the home by telephone or other virtual methods (e.g., Skype or Zoom) daily or weekly (74.5%, $n=519$), watching television or movies for entertainment daily (61.4%, $n=428$), and reading or watching updates on COVID-19 daily or weekly (73.6%, $n=513$). Approximately half of participants (50.9%, $n=355$) exercised daily or weekly. Less than half of participants (40.8%, $n=284$) reported trying a new activity daily or weekly. See Table 3.

3.5 Impact of activities during COVID-19 lockdown on mental health

Authors also examined the relationship between lockdown activities during the COVID-19 pandemic and mental health outcomes. There were differences in mental health outcomes based on

the extent to which participants had a routine, exercised, and were exposed to COVID-related information.

3.5.1 Routine activities and mental health

According to findings of the Kruskal-Wallis Test, there was a significant difference in GHQ-12 scores based on routine frequency at the $p < 0.05$ level, $H(3) = 46.76, p < 0.001$. Dunn's *post hoc* test showed that participants with a daily routine, $MDN = 15.00, IQR = 9.00$ had better outcomes compared to participants with a weekly routine, $MDN = 17.00, IQR = 9.00, p = 0.009$, monthly routine, $MDN = 18.00, IQR = 9.00, p = 0.026$, or no routine, $MDN = 22.50, IQR = 12.25, p < 0.0001$. Those with a weekly routine also fared better than those without a routine, $p < 0.0001$.

There was a significant difference in PTSD scores based on routine frequency at the $p < 0.05$ level, $H(3) = 19.89, p < 0.001$. Participants with a daily routine, $MDN = 2.00, IQR = 2.00$ had better outcomes than participants without a routine, $MDN = 3.00, IQR = 2.00, p < 0.0001$.

There was a significant difference in emotional response scores based on routine frequency at the $p < 0.05$ level, $H(3) = 19.67, p < 0.001$. Participants with a daily routine, $MDN = 2.00, IQR = 1.00$ had better emotional responses than participants with a weekly $MDN = 2.00, IQR = 1.25, p = 0.048$, monthly $MDN = 1.50, IQR = 1.00, p = 0.006$, or no routine, $MDN = 1.50, IQR = 1.25, p = 0.004$.

3.5.2 Exercise and mental health

There were significant differences in GHQ-12 scores based on having an exercise habit at the $p < 0.05$ level, $H(3) = 18.958, p < 0.003$. Participants who exercised daily, $MDN = 14.00, IQR = 11.00$ had better outcomes than participants who exercised monthly, $MDN = 17.00, IQR = 9.00, p = 0.005$, or not at all, $MDN = 18.5, IQR = 11.25, p = 0.0001$.

There were significant differences in PTSD scores based on exercise habits at the $p < 0.05$ level, $H(3) = 10.380, p = 0.018$. Participants who exercised monthly, $MDN = 3.00, IQR = 3.00$ had worse PTSD scores compared to participants who exercised daily, $MDN = 2.00, IQR = 2.00, p = 0.04$.

There were no significant differences in emotional response to COVID-19 based on exercise frequency, $p = 0.10$.

3.5.3 COVID-19 news exposure and mental health

There was a significant difference in GHQ-12 scores based on frequency of watching/reading COVID updates at the $p = 0.05$ level, $H(3) = 11.5423, p = 0.010$. Participants who viewed daily content on COVID-19 had poorer general health outcomes, $MDN = 17.00$,

TABLE 2 Correlations between variables.

Measure	1	2
1. General health		
2. COVID-emotional response	−0.604***	
3. PTSD	0.668***	−0.618***

*** $p < 0.001$.

TABLE 3 Lockdown activities in percentages.

Measure	Daily	Weekly	Monthly	Never
Kept a routine	31.6% (220)	35.4% (247)	4.7% (32)	12.9% (90)
Exercised	19.8% (138)	31.1% (217)	17.6% (123)	16.1% (112)
Changed clothes	74.2% (517)	9.2% (64)	0.4% (3)	0.9% (6)
Spoke with someone outside the home through telephone, Skype, etc.	46.1% (321)	28.4% (198)	8.0% (38)	2.2% (14)
Watched TV, movies for entertainment	61.4% (428)	18.2% (127)	3.3% (22)	1.7% (11)
Reading, watching updates on COVID	43.0% (300)	30.6% (213)	6.2% (39)	4.9% (33)
Tried a new activity	14.8% (103)	26.0% (181)	22.5% (157)	21.4% (149)

$IQR=10.00$ compared to participants who never viewed any such content, $MDN=14$, $IQR=8.50$ $p=0.03$. There was a significant difference in PTSD scores based on frequency of watching/reading COVID updates at the $p<0.05$ level, $H(3) = 22.242$, $p<0.009$. Participants who watched media content on COVID daily had worse outcomes, $MDN=3.00$, $IQR=3.00$ compared to participants who watched weekly, $MDN=2.00$, $IQR=2.00$, $p=0.002$, monthly, $MDN=2.00$, $IQR=3.00$, $p=0.010$, or never, $MDN=2.00$, $IQR=3.00$, $p=0.04$.

There was a significant difference in emotional response scores based on frequency of watching/reading COVID updates at the $p<0.05$ level, $H(3) = 31.626$; $p<0.001$. Participants who watched/read daily updates, $MDN=1.50$, $IQR=1.00$ had poorer emotional responses compared to participants who watched weekly, $MDN=2.00$, $IQR=1.00$, $p<0.0001$, or never, $MDN=2.5$, $IQR=1.00$, $p<0.0001$. Other behaviors such as changing clothes, speaking to someone outside the home, and watching tv or movies did not show any relationship with changes in PTSD, GHQ or emotional response.

4 Discussion

Current findings provide data on COVID-19's mental health impact among college students in the southeastern US, a setting considered particularly vulnerable to COVID-19 (27) and where access to mental health treatment is limited compared to other US regions (28). Several factors were associated with students' mental health early in the pandemic. Being a woman or a transgender man, pre-existing mental health conditions, low engagement in routine activities, and COVID-19 news exposure were associated with college student mental health. These findings, and others, are described in more detail below.

4.1 Gender and mental health during COVID-19

In this study, more women reported adverse mental health outcomes associated with the pandemic followed by transgender men. The finding that women were more negatively affected by COVID-19 is consistent with findings from a systematic review and meta-analysis, which revealed higher levels of COVID-related psychological distress among women compared to men in the general population (5). However, while findings from some individual studies examining COVID-19's impact on college students, specifically, provide evidence of more negative mental health outcomes for women students [e.g., Xu et al. (38)], a systematic review and meta-analysis of studies focused on COVID's mental health impact on college students revealed no gender differences in anxiety or depression (2). In another systematic review focused on the mental health impact of COVID-19 on college students, gender differences were not examined (4).

Despite mixed findings regarding gender differences in mental health impact related to COVID-19, the finding that women were more negatively affected than men in the current study is not surprising given that gender differences in mental health are well established (39). Less data exists on the differential mental health impact of COVID-19 on students based on sexual orientation and gender identity, thus current findings contribute something important

to the existing literature. However, current results support findings from Gonzales et al.'s study (40), which described the mental health needs of students who identify as LGBTQ+. Indeed, the mental health needs of people who identify as transgender has been documented (41). Combined, findings suggest gender is an important mental health determinant, thus prompting a need for interventions in the college setting that target women and gender minorities.

4.2 Race/ethnicity and mental health during COVID-19

Inconsistent with other studies, current findings did not provide evidence of a differential impact of COVID-19 on mental health based on race or ethnicity. Xu et al. (38) found COVID-19's mental health impact on college students was greater for Hispanic students compared to other ethnic groups. Molock and Percham (42) described symptoms of stress, anxiety, and depression associated with COVID-19 among students of color as well as other negative effects (e.g., disruptions in living situation, finances, academic performance, educational plans, and career goals). Students in Molock and Percham's study (42) also described difficulties managing feelings surrounding racial injustice, noting that George Floyd's killing early in the pandemic heightened awareness of racism in the US, thus compounding mental health challenges during COVID-19. Molock and Percham (42) did not compare the mental health of students of color to White students' mental health so conclusions cannot be drawn about the differential impact of COVID-19 on mental health between these groups. The absence of mental health differences based on race or ethnicity in this study may be attributed, at least in part, to the student body at the university where data was collected being ranked in the top 15% for racial/ethnic diversity among the 3,790 universities included in the rankings (43).

4.3 Pre-existing conditions and mental health during COVID-19

Nearly 40 percent of students in this study reported a pre-existing mental health condition. Participants reporting previous diagnoses also reported worse mental health outcomes, which is not surprising. Asmundson et al. (44) showed pre-existing mental health problems affect coping and general response to stress. This finding was more the case for individuals who self-reported anxiety related disorders than those who self-reported mood disorders (44). While the current study does not show such distinctions, findings do demonstrate COVID-19 had a worse impact on students with pre-existing mental illness(es) compared to students with no history of mental illness, thus highlighting the need for specialized services in the college setting for students living with diagnosed mental health conditions.

Despite the significant mental health challenges posed by the pandemic on students and the high number of students who had pre-existing conditions, a little over one third of participants reported needing mental health support. From that third, only about half considered seeking help and just 27% sought assistance. This finding demonstrates a pattern of underreporting and poor health seeking behavior among college students despite high levels of need. These results are consistent with the literature on decreased health seeking

behavior during the COVID-19 pandemic (45, 46). Identifying ways to increase mental health service uptake among college students is therefore important.

4.4 Routine activities and mental health during COVID-19

Students reported creating new, or maintaining old, routines such as exercising or leisure activities like reading books and watching television, which may have been a means of coping during the pandemic. Results showed students who engaged in activities such as exercising more frequently had better mental health outcomes than students who engaged in such activities less frequently or not at all. These findings are consistent with Rogowska *et al.*'s report of a relationship (47), albeit weak, between physical activity and symptoms of anxiety and depression among a large sample of Ukrainian university students. However, other research in this area is mixed. Findings from a longitudinal cohort study in the United Kingdom (48) demonstrated a relationship, albeit weak, between perceived stress and sedentary behavior among college students. However, Savage *et al.* (48) did not find a relationship between mental health and moderate to vigorous physical activity although both decreased during the pandemic. Similarly, Talapko *et al.* (49) did not find a relationship between decreased physical activity and mental health symptoms of Croatian university students, nor did Wilson *et al.* (50) find physical activity served as a protective factor against COVID-19 related mental health issues among college students at a northeastern university in the US. Given mixed findings in this area, more research is needed to explore the impact of exercise on mental health among college students during COVID-19.

Beyond exercise, current findings suggest leisure activities may be beneficial for mental health. Some research has demonstrated that the relationship between leisure activities and mental health depends on the type of leisure activity. For example, reading may have mental health benefits whereas online activities may not. Research indicates that resilience may mediate the relationship between leisure activities and mental health, which is consistent with the broaden-and-build theory that suggests positive emotions associated with leisure activities may increase the mental resources needed to cope with stressful events (51).

4.5 Exposure to COVID-19 news and mental health

Exposure to COVID-19 information presented a coping challenge for students. Students who were less active on social media during the pandemic had a better chance of avoiding misinformation that might cause anxiety. Studies have shown COVID-19 information disseminated through social media increased levels of panic and general anxiety especially among younger people (52, 53). With young people more likely to get information from social media than from other verifiable or official government sources, discerning between true and false information becomes difficult. Media coverage has been extensive during the COVID-19 pandemic, which has been vital to informing the public about prevention measures. However, such coverage can easily raise fear and panic. Although little research exists

on the mental health impact of news exposure on college students, specifically, a growing body of literature supports the negative impact of news exposure on the mental health among the general population (54–56).

5 Limitations

This study had several limitations. Although the exploratory nature of this study and the use of a cross-sectional design were justified given that little data on COVID-19 existed at the time of data collection and randomization was not possible, the cross-sectional design limits the ability to make causal inferences and to account for confounding variables. Also, although this study intentionally focused on the southeastern region of the US, data was limited to one large public university and may not generalize to other universities in this region. Further, data are based on self-report, thus introducing response bias as a potential issue although the use of an anonymous online survey should mitigate this concern. The sample was over-represented by women, which may affect the applicability of findings to people with other gender identities. Nonetheless, given that women outnumber men on college campuses (57), understanding the experiences of women college students is prudent. Related to the issue of sampling, the small number of transgender men in our sample may be viewed as a weakness. Although we re-ran our analyses without transgender men to confirm the small number did not distort our findings (see results section above), the small number of transgender men in our sample may limit the generalizability of findings to other college students who identify as transgender men. Despite these concerns, the inclusion of transgender men in our analyses is justified by the need to better understand the unique experiences of people who identify as transgender. Additionally, excluding people who identify as transgender from research perpetuates their invisibility and promotes marginalization, which are contrary to the promotion of equitable and inclusive research practices. Finally, the measures used in this study pose limitations. There is considerable item overlap between the GHQ-12 and the SADAG, which likely contributes to the strong correlation between scores on those measures. Also, the adaptation of scales assessing the effect of COVID-19 may limit findings. Specifically, the low internal consistency of some measures raises questions about construct validity and the possibility of measuring more than one latent variable. However, lower alphas in our sample for some measures may be a function of a small number of items or the lack of unidimensionality (e.g., the items assessing activities during lockdown assessed several different dimensions). Therefore, a lower alpha should not render a measure unreliable in our sample.

6 Conclusion and future directions

In conclusion, this exploratory study provides valuable insights into the mental health impact of COVID-19 among college students in the southeastern US, a region considered vulnerable to COVID-19 and with limited access to mental health treatment compared to other regions. Several factors were associated with students' mental health during the early stages of

the pandemic, including gender, pre-existing mental health conditions, engagement in routine activities, and exposure to COVID-19 news. Women and transgender men were more adversely affected by the pandemic, highlighting the importance of gender-specific interventions in the college setting. While the study did not find significant differences in mental health impact based on race or ethnicity, the need for specialized services for students with pre-existing mental health conditions was evident. Engaging in routine activities, especially exercise and leisure activities, appeared to have a positive impact on mental health outcomes. However, exposure to COVID-19 news posed a coping challenge, with those less active on social media experiencing less anxiety. This study underscores the importance of addressing mental health needs of students during the pandemic and highlights the need for further research to inform effective interventions. It also emphasizes the significance of accurate information dissemination and health-seeking behavior among college students to promote their well-being.

Although other research has documented similar findings with regard to factors affecting college students' mental health during COVID-19, this study's focus on the southeastern U.S. contributes to our understanding of regional similarities and differences. Further, findings provide some emerging insights into the stress and coping response of transgender students during the pandemic.

As research in this area continues to emerge, colleges and universities are encouraged to adapt mental health programming to better meet students' needs including targeting at-risk students for prevention and intervention programs. Based on findings from a study of factors associated with depression, anxiety, and PTSD among young adults in the US, Liu et al. (58) emphasized the importance of family support and suggested mental health programming for young people should focus on decreasing loneliness and improving distress tolerance. Although ensuring family support may be difficult for higher education institutions, developing programs to promote social support and build resilience are within their purview. Building upon Roksa and Kinsley's (59) suggestions for fostering family support for low income students, two specific recommendations are offered to administrators in higher education for promoting family support, especially for students at risk for negative mental health outcomes: (1) engage in dialogue with parents from diverse backgrounds (e.g., based on socioeconomic status, country or region of origin) and with diverse identities (e.g., based on gender identity, sexual orientation, race, ethnicity, age) about the social-emotional and academic needs of their college-aged children; and (2) educate faculty, advisors, and staff about the importance of family support for student success.

In a longitudinal study with timepoints before, during, and after the COVID-19 lockdown, Li et al. (60) found novelty seeking, defined as behaviors related to the pursuit of new experiences, was associated with decreased symptoms of anxiety, stress, and depression among Chinese university students. As Li et al. (60) noted, novelty underlies creativity and novelty seeking may mitigate the negative mental health impact of crises such as the COVID-19 pandemic. Findings such as these also may be useful when developing strategies to support college students' mental health needs. For example, An et al. (61) recommend interventions that

teach and promote the use of active coping strategies in order to reduce student stress.

Future research should further explore COVID-19's impact on college students, particularly long-term mental health effects as well as academic progress and career trajectories. Also needed is research examining the effectiveness of interventions designed to treat college students experiencing mental health problems associated with COVID-19. Finally, research is needed on the long-term impact of COVID-19 on educational practices in higher education and how enduring changes prompted by COVID-19 (e.g., virtual learning) will affect college students' mental health long past this pandemic's end. Research designs that allow for the control of confounding variables, such as randomized controlled trials, will be important when possible.

Ethics statement

This study involved humans and was approved by the University of South Florida Institutional Review Board (TC). The study was conducted in accordance with local legislation and institutional requirements. The ethics committee/institutional review board waived the requirement of written informed consent for participation from the participants because the study used an online anonymous survey. No identifying information was collected. Participants were notified that by entering the online survey they were consenting to participate in the study.

Author contributions

TC was responsible for study design, investigation, interpreting data, and wrote first and subsequent drafts. KG analysed and interpreted data, assisted in original draft writing, and draft review and editing. CZ contributed to draft writing and review and editing. SH reviewed first and subsequent drafts. JD was responsible for study design and conceptualization, investigation, and review of drafts and editing. All authors contributed to the article and approved the submitted version.

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Admission rates and clinical profiles of children and youth with eating disorders treated as inpatients before and during the COVID-19 pandemic in a German university hospital

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Introduction: Children and youth at risk for mental health disorders, such as eating disorders (ED), were particularly affected by the COVID-19 pandemic, yet evidence for the most seriously affected and thus hospitalized youth in Germany is scarce.

Methods: This crosssectional study investigated anonymized routine hospital data (demographic information, diagnoses, treatment modalities) of patients admitted ($n=2,849$) to the Department of Child and Adolescence Psychiatry, Psychosomatics and Psychotherapy (DCAPPP) of a German University Hospital between 01/2016 and 02/2022. Absolute and relative number of inpatients with or without ED prior to (01/2016–02/2020) and during the COVID-19 pandemic (03/2020–02/2022) were compared. The effect of school closures as part of social lockdown measures for COVID-19 mitigation on inpatient admission rate was explored as it has been discussed as a potential risk factor for mental health problems in youth.

Results: During the COVID-19 pandemic, ED inpatient admission rate increased from 10.5 to 16.7%, primarily driven by Anorexia Nervosa (AN). In contrast to previous reports, we found no change in somatic and mental disorder comorbidity, age or sexratio for hospitalized youth with ED. However, we did observe a shortened length of hospital stay (LOS) for hospitalized youth with and without ED. In addition, non-ED admissions presented with an increased number of mental disorder comorbidities. In contrast to our hypothesis, school closures were not related to the observed increase in ED.

Discussion: In summary, the COVID-19 pandemic was associated with an increased rate of inpatient treatment for youth suffering from AN, and of youth affected by multiple mental disorders. Accordingly, we assume that inpatient admission was prioritized for individuals with a higher burden of disease during the COVID-19 pandemic. Our findings pinpoint the need for adequate inpatient mental health treatment capacities during environmental crises, and a further strengthening of child and adolescence psychiatry services in Germany.

KEYWORDS

anorexia nervosa, COVID-19 pandemic, child, adolescent, youth

1 Introduction

The COVID-19 pandemic, declared by the World Health Organization on March 11th, 2020, and associated public health strategies of mitigation, such as lockdown orders and school closures, have been proposed as negative environmental factors on the mental health of children and youth (1–3), with long-term consequences still surfacing. Cumulating studies indicate a corresponding increase in depressive and anxious symptoms (4, 5), a rise in emergency consultations due to mental health problems (6), and a reduction in perceived quality of life (7, 8) in children and youth. Next to the impacts on physical health and changes in work and family life, proposed mediators especially affecting children and youth include the disruption of daily routines, loneliness due to social distancing orders, increased use of virtual communication and social media, as well as reduced availability of extracurricular activities (8, 9).

ED, and especially AN, often lead to extensive medical and mental health consequences, thus constituting a profound individual and public health burden. AN carries a high risk for cachexia-induced organ failure, repetitive hospitalizations, a more than six-fold mortality rate, and increased suicide risk. The recovery rate is less than 50%, indicating a high risk for chronicity, leading to a high personal disease burden and related impairment (10, 11). Meta-analyses (12, 13) and systematic reviews (14–16) reported a rise in ED incidence during the COVID-19 pandemic along with increases in ED symptom severity and comorbid mental disorders. Still, only a small portion of the included studies reported data on children and youth. Restrictive ED regularly emerge in early adolescence, with an onset in childhood resulting in an even poorer prognosis (17, 18). This underlines the necessity for further research on ED in children and youth in the context of the COVID-19 pandemic. Local studies found increases in pediatric hospital admissions for ED in Canada (19–21), North America (22–24), Australia (25), Israel (26), Italy (27, 28), Norway (29), and the Netherlands (30) following the onset of the COVID-19 pandemic. Findings concerning symptom severity or clinical characteristics of children and youth admitted for ED treatment during the COVID-19 pandemic have been diverse: North-American, Canadian and Italian pediatric departments at tertiary care hospitals with special ED-treatment programs registered more critical somato-medical problems (19, 20, 23, 24, 28), whereas similar medical facilities in Australia (25) and Israel (26) found clinical characteristics to be unchanged to pre-COVID-19 samples. Shortened length of stay (LOS) was found at pediatric hospitals in Israel and Italy (26, 27), yet prolonged LOS was observed at a large pediatric hospital with a specialized ED-treatment program in North America and at some Departments of Child and Adolescent Psychiatry in European Countries (31). Most of the few available studies found an increase in co-occurring mental health disorders in children and youth with ED (28, 32, 33). German studies investigating the impact of the COVID-19 pandemic on ED, and especially AN, in children and youth are scarce, but mostly concur with international data, indicating an increase of youth hospitalized for ED during the COVID-19 pandemic (18, 34, 35). The COVID-19 pandemic thus seems to be an environmental risk factor in the Western world, influencing the development and exacerbation of ED in adults and probably children and youth, as well. However, it remains unclear which definitive factors drove this development, especially in the vulnerable adolescent age group, and how it evolved longitudinally during the COVID-19 pandemic.

The primary objective of this study is to retrospectively analyze admission rates of children and youth with ED in a German, university-hospital based DCAPPP. Building on previous research, we specifically tested the hypothesis that the COVID-19 pandemic increased the relative admission rates of children and youth with ED and especially AN. We further tested if the increase was accompanied by a younger average age, a higher rate of co-occurring somatic and mental health disorders including depressive and anxiety disorders, a prolonged LOS and/or a higher rate of early re-admissions, all possibly indicating a higher burden of disease. Additionally, we explored the longitudinal correlation between local school closures as part of German lockdown orders and ED admission rates. This study thus also addresses the paucity of research on the effect of school closures on youth with ED during the COVID-19 pandemic in Germany.

2 Materials and methods

The ethical conduct of this study is based on the current version of the Declaration of Helsinki. The medical faculty's Ethics Board of Goethe University Frankfurt granted ethics approval for this investigation of anonymized routine hospital data (13/06/2022, number 2022–804). Due to anonymization and aggregate analysis of routinely collected hospital data (as stated below), patient consent was not required for this study. The university-hospital's department of data protection granted the respective data protection approval (31/08/2022).

2.1 Study population, data source, and variables

This retrospective hospital-based, cross-sectional study was conducted at the Department of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy of the University Hospital Frankfurt, Goethe University, Frankfurt am Main, Germany. We investigated children and youth aged 5;0 to 17;11 years hospitalized for emergency or elective psychiatric treatment between January 2016 and February 2022. Our DCAPPP serves all children and youth resident in Frankfurt for emergent and elective inpatient mental health care as well as children and youth living close to Frankfurt for elective mental health care, thus serving around 150.000 children and youth. Retrospective data on the study population was obtained from respective electronic medical records (software: Orbis by Dedalus) including sociodemographic information, routine health care information, diagnoses and treatment modalities, all routinely gathered throughout inpatient treatment, originally for the purpose of health insurance reimbursement. With the core data set covering inpatients only, outpatients in ambulatory treatment at our DCAPPP could not be analyzed in this study. All data was pseudonymized; patient identification numbers (stable over recurring treatment intervals) and case identification numbers (singular to each treatment interval) were generated, respectively, (patient volume < case volume) to distinguish between a first-time admission and a re-admission. Treatment intervals interrupted by temporary

discharges due to mandatory COVID-19 mitigation regulations followed by a consecutive re-admission within 3 weeks were considered cumulatively as a single case. Consequently, 2,849 cases, i.e., treatment intervals, of 2,188 individuals, i.e., patients, were investigated. In total, 61% had female sex assigned at birth, and the average age at admission was 14.1 years (SD 2.7). Relative to the onset of the COVID-19 pandemic, the total study period (01/2016 to 02/2022) was divided into a “pre-pandemic” interval from January 1st, 2016, to February 28th, 2020, and a “pandemic” interval from March 1st, 2020, to February 28th, 2022. By date of admission, patients were either allocated to the pre-pandemic or the pandemic interval, the COVID-19 pandemic serving as the main independent variable.

The data source investigated in this study did not yield information on the details of individual admission indications other than the diagnoses. Admission decisions for inpatient treatment at our DCAPPP are based on current German clinical guidelines and the judgment of board-certified child and adolescent psychiatrists or psychotherapists. The intervention of admission itself may serve as a marker for severity of the primary diagnosis and comorbidity load. For ED/AN specifically, respective youth in this study should be considered severely affected. As advised by the German S3 guideline (AWMF), admissions for AN occurred in case of rapid weight loss ($> 20\%$) in less than 6 months independent of BMI percentile, severe kachexia (< 3 BMI percentile), insufficient weight restoration during outpatient treatment, insufficient prospect of stabilisation or treatment success in an outpatient setting due to other factors (e.g., comorbidities, problematic family structure, decompensation of family resources), acute endangerment of self or others (e.g., acute suicidality).

Disorders were diagnosed according to the International Statistical Classification of Diseases, German Modification (“ICD-10”) via a team-based, iterative procedure. For each case, the following clinical aspects and treatment modalities served as dependent variables:

- Age at admission (years)
- Sex assigned at birth (% female)
- Length of stay (LOS; number of treatment days from admission to discharge)
- Re-admission (new case, same patient) within 6 months of discharge (% of all admissions)
- First admission (new case, new patient) within 2 years (% of all admissions)
- Total number of all diagnoses at discharge (ICD-10, excluding chapters U, V, X, and Z)
- Number of co-occurring diagnoses regarding mental health (ICD-10, chapter 5: F00-F99: Mental and behavioral disorders) other than the primary diagnosis (total number of mental health diagnoses minus primary diagnosis)
- Number of diagnoses regarding somatic health (ICD-10, chapters other than 5: F00-F99, excluding chapters U, V, X, and Z)
- Proportional case volume (n_{cases} , %) of respective diagnostic groups, as specified below

Based on their particular discharge diagnoses, one or more diagnostic groups were assigned to each case:

- ED group: F50 subchapter (i.e., F50.00, F50.01, F50.1, F50.2, F50.3, F50.4, F50.5, F50.8, F50.9) and F98.2/3. Cases lacking such ED-diagnoses were considered within the “non-ED” group.
- ED subgroups: AN (ICD-10: F50.00, F50.01, F50.1), Bulimia Nervosa (BN; ICD-10: F50.2, F50.3), and other ED (ICD-10: F50.4, F50.5, F50.8, F50.9, F98.2, F98.3).
- Depressive Disorders (DD) group: F32.0–9, F33.0–9, F34.1, F34.8/9, F41.2, F48.0, F92.0. Cases lacking any of these diagnoses were classified in the “non-DD” group.
- Anxiety or fear-related Disorders (AD) group: F40.0–9, F41.1–9, F93.0–9, F94.0. Cases lacking any of these diagnoses were classified in the “non-AD” group.

2.2 Exploratory investigation of COVID-19 mitigation strategies

For the pandemic interval, changes in non-ED and ED admission rates relative to the pre-pandemic baseline were exploratively correlated with school closures as part of the comprehensive lockdown orders in Germany. We also explored differences in the degree of changes in non-ED and ED admission rates between the two periods of school closures within the pandemic study interval. Duration and timing of school constraints were obtained from (36) and published government directives. School constraints for the average age group in this study were categorized as either (1) schools fully closed (including school holidays, if adjacent or enclosed by a period of school closure) or hybrid teaching (i.e., virtual teaching alternating with in-classroom teaching, or not otherwise specified) OR (2) schools full open.

2.3 Statistical analysis

Descriptive statistical analysis was performed with the open-source Software R (version 4.2.2). Dichotomized or categorical variables were summarized by frequencies and percentages (i.e., in reference to the maximum occupancy possible at the respective time interval). Dimensional variables were summarized by means and standard deviation (SD). p -values less than 0.05 were considered statistically significant with the null-hypothesis assuming proportional ED admission rates and associated clinical aspects being independent of the COVID-19 pandemic overall and associated school closures in particular. We modeled an average “pre-pandemic baseline” of 1 year on the averaged basis of pre-pandemic admission rates and clinical characteristics, specified per calendar week/month. The respective deviations during the pandemic interval in total and per month of each year were compared by χ^2 , ANOVA and/or Wilcoxon tests to test whether diagnostic frequencies and clinical aspects as specified above differed significantly between the two study intervals. In general, the available cohort had a power > 0.8 to detect group differences with an effect size $d > 0.16$ (t -test) or $w > 0.08$ (χ^2 -test) at an alpha of 0.05 corrected for 39 tests (alpha = 0.0013). A Granger-causality testing was performed to examine the time-lagged causal relationship between school closure severity (schools fully open $<$ hybrid teaching $<$ schools fully closed) and monthly admission rates of AN, allowing for a lag of up to 6 months.

3 Results

During the pre-pandemic study interval from January 2016 to February 2020, 1887 hospitalizations ($n_{\text{cases [pre-pandemic]}}$) of 1,426 children and adolescents ($n_{\text{individuals [pre-pandemic]}}$) were registered with 3.91 ED inpatient admissions per month (198 ED inpatient admissions in total) and 33.34 non-ED inpatient admissions per month (1,689 non-ED inpatient admissions in total), 58.1% with female sex assigned at birth, with an average age at admission of 14.1 years, SD 2.8. During the pandemic study interval from March 2020 to February 2022, inpatient treatment capacities had to be intermittently reduced in compliance with hospital regulations for COVID-19 mitigation. During this interval, 962 hospitalizations ($n_{\text{cases [pandemic]}}$) of 762 children and adolescents ($n_{\text{individuals [pandemic]}} = 749$) were registered with 6.64 ED inpatient admissions per month (161 ED inpatient admissions in total) and 33.02 non-ED inpatient admissions per month (801 non-ED inpatient admissions in total), 66.8% of with female sex assigned at birth and an average age at admission of 14.2 years, SD 2.5 (for complete descriptive statistics, see Table 1). Across all cases, independent of diagnostic groups, we found a significant increase in the percentage of female inpatients during the pandemic (58.1% vs. 66.8%, $\text{FDR} = 3.68 \times 10^{-5}$), a significant decrease in LOS (61.9 days vs. 46.4 days, $\text{FDR} = 2.51 \times 10^{-14}$), a significant increase in the total number of diagnoses with a significant increase in DD, but not AD (58.9% vs. 69.1%, $\text{FDR}_{\text{DD}} = 1.05 \times 10^{-6}$), and no change in the burden of disease regarding somatic health.

For ED cases, the ratio of treated patients increased significantly from 10.5% during the pre-pandemic interval to 16.7% during the pandemic interval ($\text{FDR} = 1.34 \times 10^{-5}$). This was mainly driven by patients with AN (Figures 1A,B), increasing from 5.1 to 10.0% ($\text{FDR} = 6.59 \times 10^{-6}$), whereas changes in BN ($\text{FDR} = 0.739$) or other ED ($\text{FDR} = 0.401$) did not reach statistical significance. Compared to the pre-pandemic baseline (Table 1), ED cases did not differ in age at admission ($\text{FDR} = 0.979$) or female preponderance ($\text{FDR} = 0.925$). There was, however, a significant reduction in LOS of *circa* 20 days ($\text{FDR} = 0.008$). There were no significant changes in the total number of diagnoses, the number of co-occurring diagnoses related to somatic or mental health and no significant change in the proportional co-occurrence of either DD or AD in addition to ED during the COVID-19 pandemic compared to the pre-pandemic baseline. There was no change in the ratio of ED cases receiving psychopharmacological intervention. We found no significant changes in the ratio of *de novo* presentations (cases lacking previous admissions two years from index-admission) or the ratio of early re-admissions within six months of the index-admission compared to pre-pandemic times. There was a significant increase from 4.6 to 7.6% in the proportion of hospitalized youth presenting with the three mental disorders ED, DD and AD simultaneously ($\text{FDR} = 0.003$) during the COVID-19 pandemic, also with a significantly shortened LOS (97.5 days vs. 67.6 days, $\text{FDR} = 0.016$).

For non-ED cases (Table 1), there was no significant change in average age at admission ($\text{FDR} = 0.446$), but there was a significant relative increase in females (54.6% vs. 62.4%, $\text{FDR} = 0.001$). There was a significantly shortened LOS (59.0 days vs. 42.3 days; $\text{FDR} = 4.06 \times 10^{-16}$) and a significant increase in the total number of diagnoses (3.2 vs. 3.4 diagnoses; $\text{FDR} = 0.026$). The increase in numbers of diagnoses was not caused by changes in diagnoses related to somatic health, but by more comorbid diagnoses related to mental

health (1.8 vs. 2.1 diagnoses; $\text{FDR} = 0.024$). Also, relatively more patients with DD were treated during the COVID-19 pandemic (57.3% vs. 68.5%; $\text{FDR} = 1.05 \times 10^{-6}$) whereas the percentage of AD diagnoses remained the same. Similar to ED cases, there were no significant changes in the proportion of *de novo* admissions or inpatients receiving psychopharmacological intervention in non-ED cases, but there was a significant increase in the ratio of early re-admissions within six months for all 3 years of the COVID-19 pandemic (38.8% vs. 44.1%; $\text{FDR} = 0.032$; Figures 2A,B).

We explored the impact of school closures during the two episodes of governmentally mandated lockdown on the ratio of ED admissions (Table 2; Figures 3A,B). There was no influence of school constraints or re-openings on the ratio of ED cases ($\text{FDR} = 0.572$) within a timelag of 6 months. On a descriptive basis, the ratio of ED cases (17.7%) treated at our DCAPP during episodes with no school constraints within the pandemic interval was larger than the ratio of ED cases during episodes of (partial) school closures (partial closures: 15.5%, full closures: 14.3%). The reopening of schools after the second lockdown episode coincided with the largest increase in the ratio of ED cases (20.3%) and the highest ratio of AN cases (11.0%).

4 Discussion

In this study, we investigated the change in absolute and relative admission rates as well as clinical profiles of children and youth with ED following the COVID-19 pandemic at a German, university-hospital based DCAPP. Based on predominantly Northern American studies, we assumed an increase of AN, accompanied by a younger average age, a higher number of co-occurring mental and somatic disorders, a prolonged LOS and an increase of early re-admissions, all supposedly indicating a higher burden of disease. Additionally, we explored the longitudinal correlation between local school constraints as part of the governmentally mandated lockdown orders and admission rates. We found a significant increase in relative admission rates of children and youth admitted for ED during the COVID-19 pandemic, agreeing with German mandatory health insurance data on out- and inpatients for 2021 (18, 37). In our study, the proportional increase of ED was, however, already apparent at the beginning of the COVID-19 pandemic during the first lockdown in 2020 and persisted well into 2022, also reported by Vyver et al. (21). The separate analysis for ED subgroups proved the relative ED increase to be specifically driven by AN rather than by BN or other ED. Taking our results and internationally available data on incidence, prevalence and hospitalization rates into account (14, 15, 19, 21, 25), it may be concluded, that AN incidence seems to have strongly increased during the COVID-19 pandemic in Western societies. The exact underlying mechanisms have to be determined. Studies addressing possible factors associated with AN incidence increase during the COVID-19 pandemic have found a more intense preoccupation with own's body image resulting from an increase in social media use and screen time during lockdown episodes while filling the growing amounts of spare time (38, 39).

Looking at the demographic profile of our study population, i.e., age at admission or sex distribution, we found no change during the pandemic, in line with most international studies (33, 40). Whereas the multifaceted psychosocial impact of the COVID-19 pandemic added to the well-specified vulnerabilities and risk factors to develop

TABLE 1 Statistical analysis of admissions for inpatient treatment to the Frankfurt DCAPP during the pre-pandemic and pandemic intervals.

	Prepandemic interval	Pandemic interval	<i>p</i> value	FDR
Admissions total	N = 1,887	N = 962		
Individuals total	N = 1,426	N = 762		
Time period (months)	50.66	24.26		
Admissions per month	Npm = 37.25	Npm = 39.65		
Individuals per month	Npm = 28.15	Npm = 31.41		
ED cases	10.49% (N = 198, Npm = 3.91)	16.74% (N = 161, Npm = 6.64)	2.056E-06 ^a	1.336E-05
non-ED cases	89.51% (N = 1,689, Npm = 33.34)	83.26% (N = 801, Npm = 33.02)		
AN	5.09% (N = 96, Npm = 1.89)	9.98% (N = 96, Npm = 3.96)	8.457E-07 ^a	6.597E-06
BN	2.65% (N = 50, Npm = 0.99)	3.12% (N = 30, Npm = 1.24)	4.739E-01 ^a	7.393E-01
Other ED	2.76% (N = 52, Npm = 1.03)	3.64% (N = 35, Npm = 1.44)	1.955E-01 ^a	4.012E-01
Age on admission	14.07 (SD = 2.76)	14.23 (SD = 2.52)	1.110E-01 ^b	2.406E-01
ED cases	14.74 (SD = 2.13)	14.77 (SD = 1.86)	8.954E-01 ^b	9.799E-01
non-ED cases	13.99 (SD = 2.81)	14.12 (SD = 2.62)	2.403E-01 ^b	4.468E-01
Female	58.13% (N = 1,097, Npm = 21.65)	66.84% (N = 643, Npm = 26.5)	6.607E-06 ^a	3.681E-05
ED cases	87.88% (N = 174, Npm = 3.43)	88.82% (N = 143, Npm = 5.89)	7.829E-01 ^a	9.253E-01
non-ED cases	54.65% (N = 923, Npm = 18.22)	62.42% (N = 500, Npm = 20.61)	2.511E-04 ^a	1.224E-03
N diagnoses	3.28 (SD = 1.74)	3.46 (SD = 1.73)	7.560E-03 ^b	2.106E-02
ED cases	3.87 (SD = 1.94)	3.78 (SD = 1.67)	6.096E-01 ^b	8.358E-01
non-ED cases	3.21 (SD = 1.7)	3.4 (SD = 1.74)	1.023E-02 ^b	2.659E-02
N somatic diagnoses	0.38 (SD = 0.81)	0.36 (SD = 0.73)	4.129E-01 ^b	7.002E-01
in ED cases	0.50 (SD = 0.93)	0.4 (SD = 0.72)	2.406E-01 ^b	4.468E-01
in non-ED cases	0.37 (SD = 0.79)	0.35 (SD = 0.73)	5.626E-01 ^b	8.126E-01
N co-occurring mental health diag. ¹	1.90 (SD = 1.42)	2.1 (SD = 1.49)	3.404E-04 ^b	1.475E-03
in ED cases	2.37 (SD = 1.51)	2.38 (SD = 1.5)	9.744E-01 ^b	1.000E+00
in non-ED cases	1.84 (SD = 1.4)	2.05 (SD = 1.48)	8.156E-04 ^b	3.055E-03
DD diagnoses	58.93% (N = 1,112, Npm = 21.95)	69.13% (N = 665, Npm = 27.41)	1.082E-07 ^a	1.055E-06
in ED cases	72.73% (N = 144, Npm = 2.84)	72.05% (N = 116, Npm = 4.78)	8.865E-01 ^a	9.799E-01
in non-ED cases	57.31% (N = 968, Npm = 19.11)	68.54% (N = 549, Npm = 22.63)	8.206E-08 ^a	1.055E-06
AD diagnoses	45.89% (N = 866, Npm = 17.09)	47.92% (N = 461, Npm = 19)	3.049E-01 ^a	5.404E-01
in ED cases	51.01% (N = 101, Npm = 1.99)	52.8% (N = 85, Npm = 3.5)	7.368E-01 ^a	9.253E-01
in non-ED cases	45.29% (N = 765, Npm = 15.1)	46.94% (N = 376, Npm = 15.5)	4.407E-01 ^a	7.162E-01
ED + DD + AD cases	4.56% (N = 86, Npm = 1.7)	7.59% (N = 73, Npm = 3.01)	8.615E-04 ^a	3.055E-03
Length of stay (days)	61.95 (SD = 56.65)	46.41 (SD = 44.17)	1.288E-15 ^b	2.512E-14
ED cases	87.07 (SD = 68.8)	66.8 (SD = 57.21)	2.477E-03 ^b	8.050E-03
non-ED cases	59.01 (SD = 54.32)	42.31 (SD = 39.85)	1.043E-17 ^b	4.066E-16
cases with ED + DD + AD	97.47 (SD = 78.7)	67.59 (SD = 54.03)	5.405E-03 ^b	1.622E-02
W/o previous admission	70.36% (N = 629, Npm = 12.42)	70.06% (N = 674, Npm = 27.78)	9.296E-01 ^b	9.799E-01
ED cases	58.06% (N = 54, Npm = 1.07)	60.87% (N = 98, Npm = 4.04)	7.592E-01 ^a	9.253E-01
non-ED cases	71.79% (N = 575, Npm = 11.35)	71.91% (N = 576, Npm = 23.74)	1.000E+00 ^a	1.000E+00
Readmission within 6 months	39.27% (N = 741, Npm = 14.63)	43.97% (N = 423, Npm = 17.43)	1.577E-02 ^a	3.618E-02
ED cases	42.93% (N = 85, Npm = 1.68)	43.48% (N = 70, Npm = 2.89)	9.169E-01 ^a	9.799E-01
non-ED cases	38.84% (N = 656, Npm = 12.95)	44.07% (N = 353, Npm = 14.55)	1.303E-02 ^a	3.177E-02
Psychopharmaco. treatment	74.88% (N = 313, Npm = 6.18)	76.54% (N = 372, Npm = 15.33)	5.609E-01 ^a	8.126E-01
ED cases	70.37% (N = 38, Npm = 0.75)	74.32% (N = 55, Npm = 2.27)	6.215E-01 ^a	8.358E-01
non-ED cases	75.55% (N = 275, Npm = 5.43)	76.94% (N = 317, Npm = 13.07)	6.493E-01 ^a	8.440E-01

1: The primary diagnosis, which is always a mental health diagnosis, is not included here (N diag. = N somatic diag. + N co-occurring mental health diag. + 1 primary diag.); a: Chi-Square-test comparing absolute numbers between phases. b: *t*-test comparing average numbers per individual months across phases. diag: diagnosis; N: absolute number; Npm: number per 30 days. SD: standard deviation.

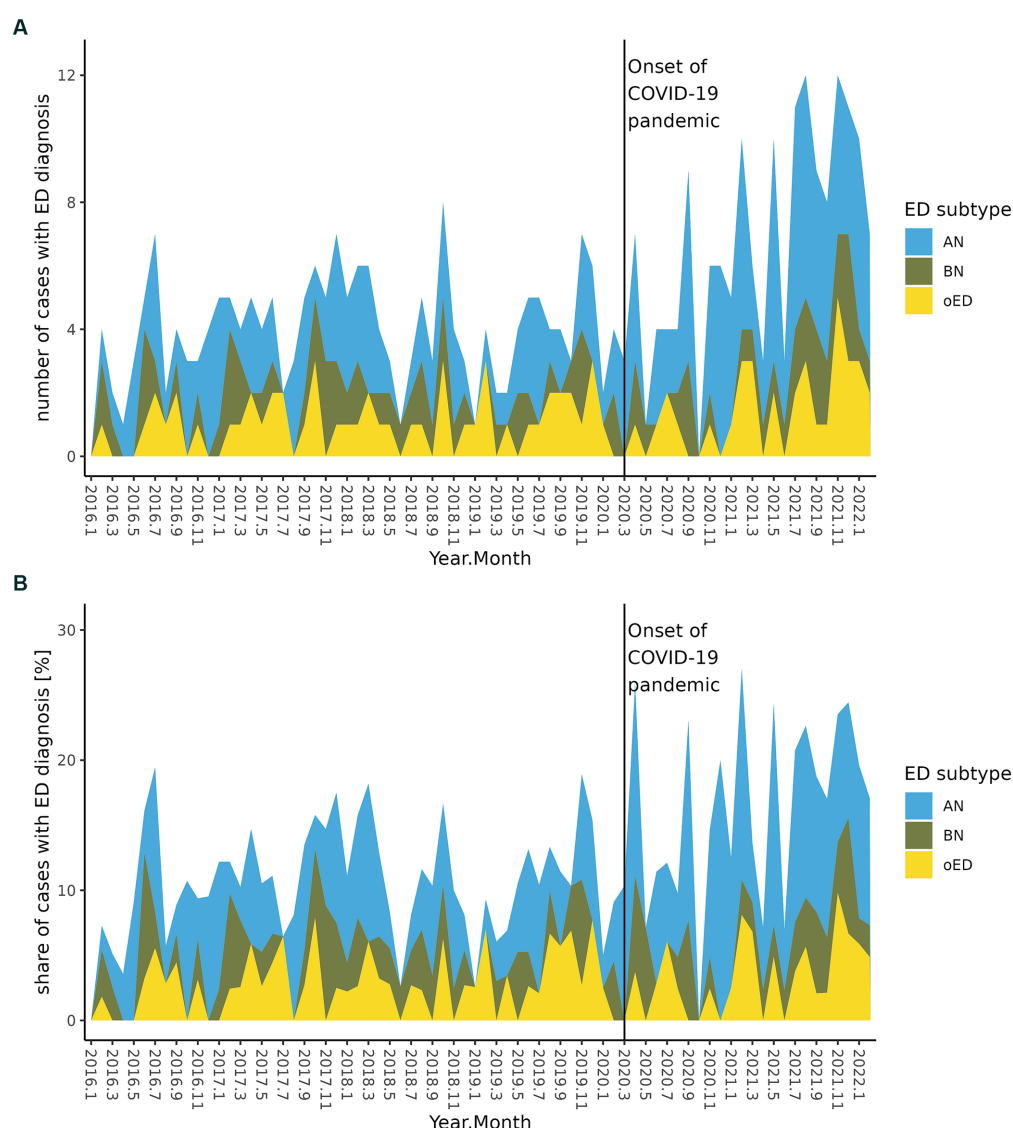


FIGURE 1

Development of ED inpatient admissions per month, separately depicted by ED subgroup, before and during the COVID-19 pandemic. (A) Absolute number of ED inpatient admissions. (B) ED inpatient admissions as percentage of all inpatient admissions.

severe AN, the primary demographic profile did not change, with adolescents still remaining the most vulnerable age group to develop AN. Higher parental supervision of younger children, and intensity of family and peer social interaction may thus be investigated as protective factors in times of environmental stress (1, 41, 42). Considering the relative increase in females regarding ED and non-ED patients, an increased vulnerability of female adolescents to develop or exacerbate mental health disorders in response to environmental stressors can be postulated based on our data, agreeing with international reports (9, 40, 43, 44).

The profile of co-occurring diagnoses of patients with ED in our study population did not change in response to the COVID-19 pandemic with unchanged numbers of co-occurring mental or somatic disorders as well as unchanged rates of co-occurring DD or AD. Accordingly, we did not find an increased need for psychopharmacotherapy in ED patients. Still, we found a significant increase in the admission rate of trifold-affected youth showing ED,

DD, and AD, indicating a small group of patients with ED with strongly increased severe mental health problems during COVID-19. Other studies reported a generally increased DD comorbidity in ED inpatients (25, 28) but, similar to our results, no changes in AD comorbidity rates (28, 43, 45).

Whereas our data did not allow for the evaluation of somato-medical information (e.g., BMI-percentiles at admission, laboratory results, cardiac parameters, necessity of tube feeding), the number of co-occurring diagnoses related to somatic health was considered a surrogate for general physical health for the purpose of this study. Contrary to our hypothesis, we did not find an increase in the number of diagnoses related to somatic health in ED patients (COVID-19 related diagnoses excluded), suggesting an unchanged severity of physical deterioration in ED/AN cases. This finding agrees with previous reports (25, 26), where no change in ED symptom severity was found during the first wave of the COVID-19 pandemic. Preexisting or secondary somatic comorbidity did thus not seem to

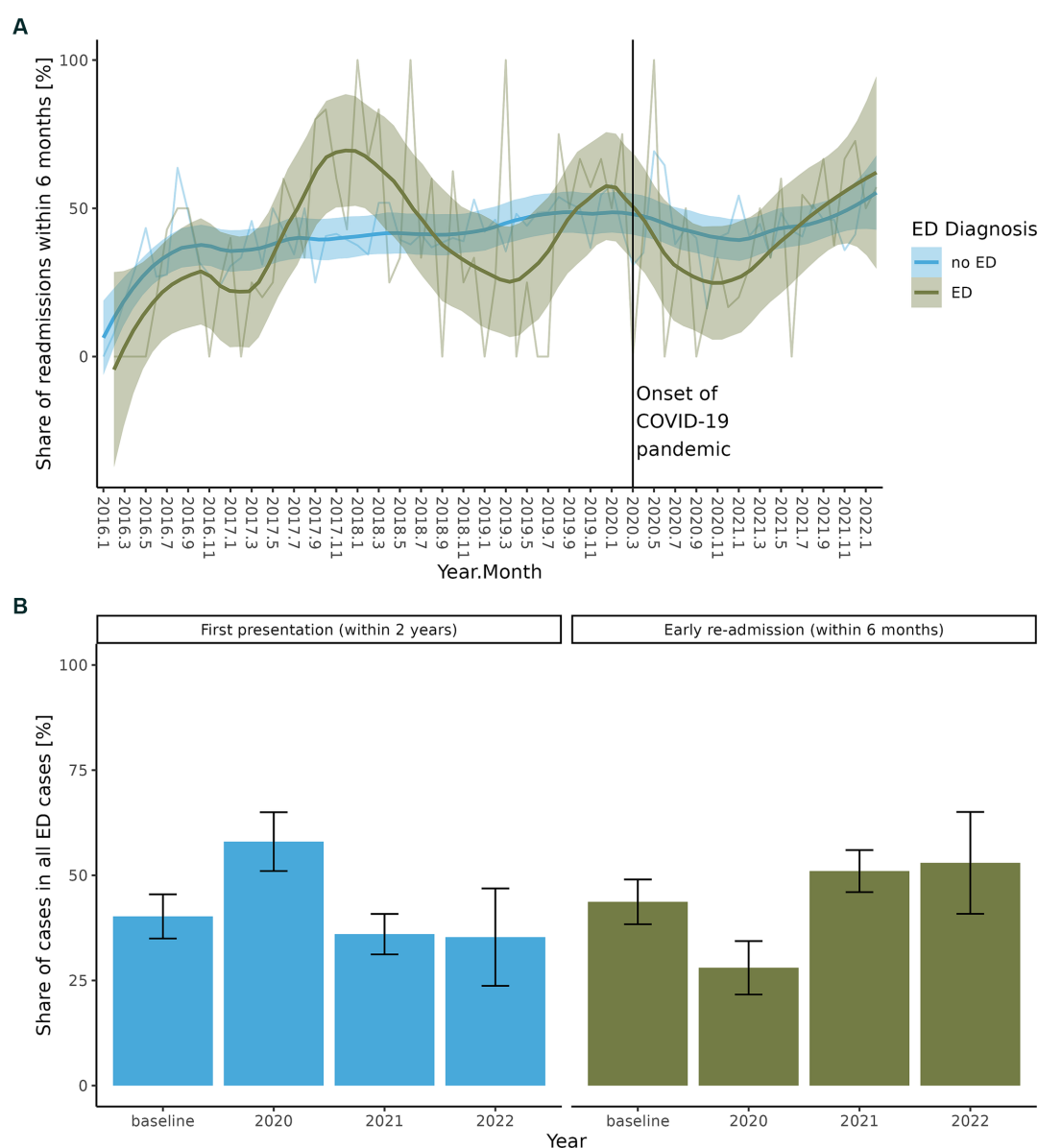


FIGURE 2

(A) Early re-admissions within six months after discharge from inpatient treatment for cases with and without ED during the total study interval 2016–2022. (B) Share of de-novo presentations in ED cases and early readmissions in ED cases during each year of the COVID-19 pandemic relative to a pre-pandemic baseline.

mediate the increase in ED/AN hospitalization rates of youth in response to the COVID-19 pandemic. In addition, the unchanged ED somatic comorbidity seen at our DCAPPP population during COVID-19 indicates an ongoing and prioritized inpatient treatment for children and youth with ED over children and youth with other severe mental disorders, as can also be concluded from the relative decrease in non-ED admission rates during the pandemic. This conclusion is also supported by the increased mental comorbidity rates of children and youth with non-ED diagnoses, and the higher re-admission rate of the non-ED group. International studies investigating patients at pediatric wards found more serious somato-medical outcomes (higher risk for medical instability, higher need for invasive supplementation, more rapid weight loss and ED development, more adverse cardiac parameters) in young ED

patients during the COVID-19 pandemic (19, 20, 23, 28). The respective countries are characterized by smaller CAPPP inpatient capacities compared to Germany; thus, within their health care system, an effective triage of ED above other mental disorders may not have been possible, resulting in more chronic and more severely affected ED inpatients and necessitating more emergency admissions to pediatric wards. Still, to rule out selection bias in terms of study setting, analog pandemic data from pediatric wards in Germany might be evaluated. AN cases presenting with greater physical impairment may have been treated more often within the pediatric setting compared to pre-pandemic times. To this end, Kölch et al. (35) recently reported trends of rising AN admissions and an increased LOS of youth with AN in pediatric departments in Germany.

TABLE 2 Statistical analysis of children and youth admitted for inpatient treatment to the Frankfurt DCAPPP during the pandemic interval.

	0th open period	1st school closure	1st open period	2nd school closure	2nd open period	p value	FDR
Addmissions total	N = 18	N = 95	N = 199	N = 251	N = 399		
Individuals total	N = 18	N = 94	N = 189	N = 232	N = 347		
Time period (months)	0.39	3.83	5.47	6.33	8.23		
Admissions per month	Npm = 45.00	Npm = 24.79	Npm = 36.39	Npm = 39.64	Npm = 48.488		
Individuals per month	Npm = 45.00	Npm = 24.53	Npm = 34.56	Npm = 36.63	Npm = 42.16		
non-ED cases	88.89% (N = 16, Npm = 40)	84.21% (N = 80, Npm = 20.88)	86.93% (N = 173, Npm = 31.64)	85.26% (N = 214, Npm = 33.8)	79.7% (N = 318, Npm = 38.64)	0.021 ^a	0.103
ED cases	11.11% (N = 2, Npm = 5)	15.79% (N = 15, Npm = 3.91)	13.07% (N = 26, Npm = 4.75)	14.74% (N = 37, Npm = 5.84)	20.3% (N = 81, Npm = 9.84)		
AN	11.11% (N = 2, Npm = 5)	8.42% (N = 8, Npm = 2.09)	9.55% (N = 19, Npm = 3.47)	9.16% (N = 23, Npm = 3.63)	11.03% (N = 44, Npm = 5.35)	0.411 ^a	1
BN	0% (N = 0, Npm = 0)	3.16% (N = 3, Npm = 0.78)	2.51% (N = 5, Npm = 0.91)	1.99% (N = 5, Npm = 0.79)	4.26% (N = 17, Npm = 2.07)	0.164 ^a	0.804
Other ED	0% (N = 0, Npm = 0)	4.21% (N = 4, Npm = 1.04)	1.01% (N = 2, Npm = 0.37)	3.59% (N = 9, Npm = 1.42)	5.01% (N = 20, Npm = 2.43)	0.047 ^a	0.231
cases with ED + DD + AD	0% (N = 0, Npm = 0)	7.37% (N = 7, Npm = 1.83)	5.53% (N = 11, Npm = 2.01)	6.77% (N = 17, Npm = 2.68)	9.52% (N = 38, Npm = 4.62)	0.058 ^a	0.287

a: Spearman-correlation test comparing admissions per month across time bins; N: absolute number; Npm: number per 30 days; SD: standard deviation; ED: Eating disorder; DD: Depressive disorders; AD: Anxiety disorders.

For the Frankfurt DCAPPP we found a significant reduction in LOS for both ED and non-ED cases during the pandemic, in line with Kölch et al. (35) analyzing a similar data set. In contrast, data from two German DCAPPPs from 2020 found LOS unchanged during the early phase of the COVID-19 pandemic (46). The reduction of LOS during the full length of the pandemic at the Frankfurt DCAPPP might at least partly be attributed to opportunity costs of the necessary COVID-19 mitigation measures. Due to intermittently reduced treatment capacity and an increasing ED caseload, triage had to be intensified which may have resulted in shorter LOS. Families' wishes and/or physicians' endorsement for a timelier discharge, fearing COVID-19 contagion in a hospital setting especially when little was known about the morbidity of COVID-19 in possibly immunocompromised AN patients, might also have contributed to a shortened LOS. Neither the rate of early re-admissions within 6 months (conceptualized as a surrogate for first time treatment failure), nor the proportion of *de novo* admissions for ED treatment increased during the COVID-19 pandemic. Consequently, the LOS reduction was not associated with a worse treatment outcome for youth suffering from AN, i.e., significant post-hospitalization weight loss leading to early rehospitalization, during the pandemic. Effective acute and intermediate medical and mental health care for relatively more youth suffering from ED/AN compared to pre-pandemic sites was continuously provided by the Frankfurt DCAPPP during the COVID-19 pandemic. Specific characteristics of the German mental health care system for children and youth may have supported this effective care for youth with ED/AN, such as the usual provision of inpatient, day-care, and outpatient care by the same DCAPPP. Due to the overarching structure with one responsible medical director, the

system allows flexible triage and specific support for severely affected individuals on an inpatient as well as outpatient basis.

Regarding the comparison group of non-ED cases, we observed an increase in the ratio of females being treated as inpatients. This may indicate a higher vulnerability of female youth to the individual and social stressors induced by the COVID-19 pandemic. This group also suffered from an increased rate of mental health comorbidities and a higher rate of co-occurring depressive disorder. Our results mirror previous reports, suggesting a near doubling of depressive symptoms and a reduction in quality of life in German youth during the COVID-19 pandemic (47, 48). Regarding AD, we found no change in diagnosis rates in the non-ED group. Symptoms of anxiety were found to increase in a general population of youth during the COVID-19 pandemic (8, 48), meta-analytic evidence encompassing primarily adult populations showed an increase in anxiety disorders in 2020 (49). An unchanged ratio of AD in our study may be due to reduced social and academic demands during lockdown-associated remote schooling and more interaction with caregivers during times of increased parental home office.

With regard to the underlying mechanisms, especially of the increased ED and DD inpatient admission rates, it remains unclear as to how specific circumstances during the COVID-19 pandemic impacted on the mental state of vulnerable children and youth, and which specific risk and resilience factors were involved. A growing body of evidence suggests that COVID-19 mitigation strategies showed general and individual effects on vulnerable youth. For example, youth with ED were reported to have suffered higher levels of stress compared to healthy controls during the first episode of social lockdown and school closures (50). We also found an increased AN admission rate already surfacing in the early phases of the COVID-19

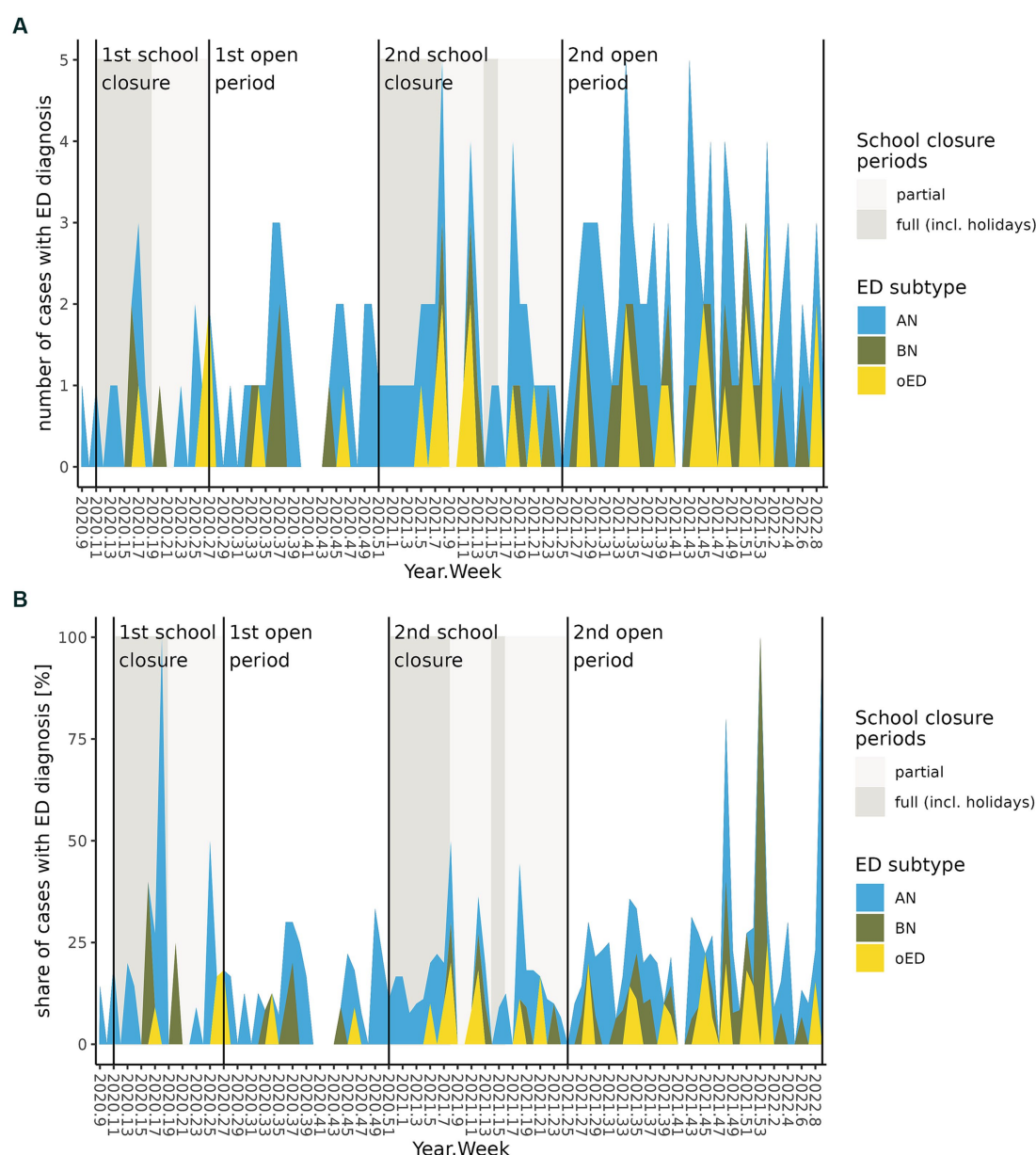


FIGURE 3

Development of ED inpatient admissions per week during the COVID-19 pandemic interval in combination with Lockdown associated school closures and re-openings. (A) Absolute number of ED inpatient admissions. (B) ED inpatient admissions as percentage of all inpatient admissions.

pandemic. Regarding general youth mental health, a stronger impact of the COVID-19 pandemic was found during episodes of remote schooling than during episodes of in-classroom-teaching especially on DD and depressive symptoms (1, 2). In our study, in contrast, school closures or re-openings were not longitudinally predictive of an increase in ED or non-ED admission rates, with the relative increase in ED remaining stable throughout the investigated pandemic interval. We thus propose a multifaceted explanation for the heterogenous changes in mental symptoms and admission rates of youth during the COVID-19 pandemic. Given that social media use increased significantly in German youth during the COVID-19 pandemic (51), this secondary effect should be considered in context of changes in youth mental health. Especially for youth with a genetic risk for AN, symptoms may have been triggered by an increase in use

of social media during the COVID-19 pandemic (38, 39) and other stressors combined with reduced availability of early professional intervention in some health care systems. Some studies reported a time-lagged increase in ED admission rates during the second year of the COVID-19 pandemic compared to the first year, which we did not observe (50). We are in the process of planning a multicenter study across a number of University Hospital based DCAPPPs in Germany, also including data until 2023, to clarify, if the locally observed increase in ED admission rates occurred nationwide and if such data reflects the clinically observed attenuation of ED admission rates with the subsiding of the COVID-19 pandemic. As the data structure used for this investigation is equally available at other DCAPPPs, this study may serve as a use-case for a multicenter study. To evaluate the impact of the COVID-19 pandemic on youth suffering from ED with lower

clinical severity or just emerging symptoms, the study population should be extended to include children and youth with ED in outpatient treatment settings, e.g., patients at outpatient clinics of DCAPPPs, to evaluate the need for early interventions during the COVID-19 pandemic.

Limitations

Our study comes with a few limitations: Including data from only one urban DCAPPP, sample size and statistical power are limited. A multicenter replication including other DCAPPPs will allow for a larger sample size with increased power to find smaller effects, and investigation of regional differences. Furthermore, biometrical data, such as weight or laboratory results, were not available in our dataset, limiting the analysis of physical illness severity to surrogates, i.e., the number of diagnoses regarding somatic health, without differentiating the etiology of the respective somatic disorders in more detail. Also, the dataset did not include detailed or quantified clinical information on psychiatric symptom severity, (e.g., individual symptom descriptions; psychopathological findings; results from questionnaires), other than expressed by the ICD-10 diagnoses. Thus, our results do not offer insight into severity changes of discrete diagnoses in our inpatient population as a result of the COVID-19 pandemic. Due to the retrospective nature of this study, we could not differentiate whether the increase in DD and AD in ED patients preceded or resulted from ED symptomology or whether this group is characterized by high vulnerability to develop these disorders simultaneously. International studies often reported DSM-5 rather than ICD-10 diagnoses, which might explain some discrepancies of our findings compared to North American studies in particular. We did not include data of pediatric hospitals in this study, thus possibly underreporting emergency admissions of ED youth due to somatic complications. Still, in the German system, the vast majority of youth with ED is treated in DCAPPPs, where both, physical needs and complications of AN as well as psychiatric care can be delivered simultaneously. Thus, our study likely covered the majority of ED youth living in Frankfurt.

Conclusion

To our knowledge, this study is the first to analyze routine hospital data of admission rates and clinical profiles of children and youth suffering from severe ED, including ED-subgroups, and compare these with non-ED patients from a large German city, studying the effect of the COVID-19 pandemic and its mitigation measure, i.e., all school closure episodes, until spring 2022. Throughout the COVID-19 pandemic but independent of both episodes of school closures, we found a higher burden of mental disorders in youth hospitalized for reasons other than ED, and an increased ratio of youth hospitalized for ED treatment, mainly driven by female youth suffering from AN, prompting a shortened LOS as well as a stricter triage necessity for other non-ED admissions. These findings pinpoint the need for adequate mental health treatment capacities during environmental crises, and continuous strengthening of DCAPP services in Germany.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The data presented in this study underly local policies and are not available on request from the corresponding author. The respective data can be requested through the “Forschungsdatenportal für Gesundheit” (FDPG): <https://www.forschen-fuer-gesundheit.de/>. The analysis code is available as git-repository: https://github.com/KJPMolgenLab/coverCHILD_ED_UKF_2308. Requests to access these datasets should be directed to ann-sophieluise.silber@kgu.de.

Ethics statement

The studies involving humans were approved by the medical faculty's Ethics Board of Goethe University Frankfurt (13/06/2022, number 2022-804). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements.

Author contributions

A-SS: Writing – original draft. SP: Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – review & editing. AK: Formal analysis, Writing – review & editing. SA: Methodology, Writing – review & editing. DK: Data curation, Writing – review & editing. MS: Data curation, Writing – review & editing. HS: Data curation, Writing – review & editing. AC: Formal analysis, Methodology, Project administration, Supervision, Visualization, Writing – review & editing. CF: Conceptualization, Project administration, Supervision, Writing – review & editing.

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Conflict of interest

CF receives royalties for books on ASD, ADHD, and MDD. She has served as scientific advisor on the board of Servier in 2021. CF and AC have received speakers honoraria on talks on ASD.

The remaining 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 and quality of life in children and adolescents during the COVID-19 pandemic: a systematic review of longitudinal studies

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Background: The COVID-19 pandemic has significantly impacted the mental health of children and families, i.e., due to measures like social distancing and remote schooling. While previous research has shown negative effects on mental health and health-related quality of life (HRQoL), most studies have focused on pre-post comparisons in the early pandemic stages. This systematic review aims to examine longitudinal studies to understand the long-term impacts of the pandemic on children and adolescents.

Methods: This systematic review adhered to the PRISMA guidelines and was preregistered in the international prospective register of systematic reviews (Record ID: CRD42022336930). We systematically searched PubMed/MEDLINE, Web of Science, PsycINFO, PSYINDEX, and the WHO-COVID-19 database and included studies published up to August 30, 2022. Based on pre-defined eligibility criteria, longitudinal and prospective studies that assessed the mental health or quality of life of children or adolescents (0–19 years) in the general population over a longer time span (at two or more measurement points) during the COVID-19 pandemic were included in the review. The methodological quality of the included studies was assessed using an adapted version of the Effective Public Health Practice Project (EPHPP) checklist. Narrative data synthesis was used to summarize the findings.

Results: A total of 5,099 results were obtained from literature searches, with 4,935 excluded during title/abstract screening. After reviewing 163 full-text articles, 24 publications were included in the review. Sample sizes ranged between $n = 86$ and $n = 34,038$. The length of the investigated time periods and the number of assessment points, as well as outcomes, varied. The majority of studies were of moderate methodological quality. Mental health outcomes were more frequently

studied compared to measures of HRQoL. The findings from these studies mostly suggest that children and adolescents experienced heightened mental health problems, specifically internalizing symptoms like anxiety and depression. Further, there was a decline in their overall HRQoL over the course of the COVID-19 pandemic that did not necessarily subside when lockdowns ended.

Conclusion: It is crucial to continue monitoring the mental health and well-being of children and adolescents following the pandemic to identify groups at risks and plan interventions. This should ideally be conducted by large systematic studies, using validated instruments, and encompassing representative samples to obtain reliable and comprehensive insights with the aim of improving youth mental health care.

KEYWORDS

systematic review, children, adolescents, mental health, quality of life, COVID-19, prospective studies

Introduction

The COVID-19 pandemic has significantly interfered with the daily lives of children and families. Although the direct physical health effects of the coronavirus infection appear to be minor in the young population (1, 2), children and adolescents may suffer severely from the indirect effects of the pandemic on mental health. Pandemic containment measures such as social distancing and restrictions on social gatherings, lockdowns, and phases of complete or partial home and online schooling have limited children's and adolescents' possibility of socializing and engaging in physical activity or play. Peer interaction, which is an important aspect of development, has been limited (3). Various studies have shown that the mental health and well-being of children and adolescents have been negatively affected during the pandemic. For instance, symptoms of depression and anxiety have increased compared to the pre-pandemic state (4, 5). This has been observed in adults as well, but the younger population appears to be particularly vulnerable (6). Studies have noted an initial reduction in provision and use of child and adolescent psychiatric services in the early phase of the pandemic (7, 8), while providers signaled a substantial increase in the number of referrals and requests for assessments 1 year after the start of the pandemic (9). The initial reductions in youth psychiatric service provision indicate delays or unmet needs early in the pandemic, and alarmingly some evidence points at increased suicide rates in the second wave of the pandemic (July to October 2020) (8). This is obviously of serious public health concern, also because mental health issues in childhood are associated with an elevated risk of adult mental disorders (10).

A vast amount of research on child mental health has been published since the beginning of the COVID-19 pandemic and the body of evidence is constantly evolving. Several reviews on mental health and quality of life in children and adolescents have predominantly identified evidence of a negative impact of the pandemic (4, 11–22).

The majority of reviewed original studies however relied on cross-sectional data. The need for longitudinal mental health research in the young population was identified early in the pandemic (23). Systematic reviews and meta-analyses of longitudinal studies on the psychological impact of the COVID-19

lockdown have been published, but predominantly included studies on adults (24, 25). Further, most longitudinal research has focused on comparing pre-pandemic outcomes with outcomes measured after the start of the pandemic (26), mostly at a single pandemic time point. In their recent systematic review on this type of pre-post COVID-19 studies, Kauhanen et al. (22) found a predominantly negative impact on mental health in adolescents and young people, particularly increased depression, anxiety and psychological distress. Studies with pre-pandemic and pandemic data were also analyzed in a meta-analysis by Ludwig-Balz et al. (27), focusing on depressive symptoms in young Europeans. The review reported an increase in depressive symptoms, while evidence for clinically relevant depression was of low certainty (27). The same authors found in another recent meta-analysis an increase of anxiety symptoms during school closures in Europe (28). Another systematic review and meta-analysis with a similar focus was published by Newlove-Delgado et al. (21). The studies included in these reviews mainly refer to the early phases of the pandemic in the first half of 2020.

Now, over 3 years since the pandemic began, we wonder how children have been faring throughout this period. In this context, longitudinal studies aiming to assess COVID-19-related mental health trajectories have started to emerge. However, to the best of our knowledge, a systematic synthesis of evidence from longitudinal studies, focusing on children's long-term mental health or quality of life trajectories during the pandemic using at least two pandemic assessment points, has not been published to date.

Therefore, our objective is to focus beyond pre-post comparisons and conduct a systematic review of longitudinal studies on mental health and quality of life outcomes in children and adolescents during the COVID-19 pandemic, specifically focusing on general population studies with multiple data assessment points covering longer periods during the pandemic. The review aims to address the key question of how the mental health and quality of life of children and adolescents in the general population have developed over the course of the COVID-19-pandemic. It is important on a public health scale to assess whether long-term consequences for children's mental health and well-being persist, also considering the management of future similar crises that might emerge.

Methods

The procedure and reporting of this systematic review are in line with the recommendations of the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines (29). The review protocol was published *a priori* in the international prospective register of systematic reviews (PROSPERO) on June 6, 2022 (Record ID: CRD42022336930, https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=336930).

Eligibility criteria

Inclusion and exclusion criteria are based on the PECO scheme (population–exposure–comparison–outcome) (30) and were determined *a priori*.

Population

Original studies on children and adolescents aged 0–19 years were included in this review. We refer to the definition of adolescents (10–19 years) by the World Health Organization (WHO) for the upper age limit (31). We excluded studies that focused on older individuals, studies that did not report the age of the included subjects, or studies on a broader age group including ages 0–19, but not reporting subgroup results for ages 0–19.

Population, community or school-based studies were included. We excluded studies with a focus on clinical populations or participants that were sampled or studied for specific health conditions, as our aim was to study the general population.

Exposure

To be included, studies must have measured a relevant outcome on at least two occasions *during the COVID-19 pandemic*. We defined the start of the pandemic as after March 11, 2020 (i.e., the date the WHO declared the pandemic), and for Chinese studies after January 23, 2020, when substantial contact restrictions were put in place by the Chinese government.

Comparison

Included studies needed to report a comparison of at least two outcome assessments during the COVID-19 pandemic (i.e., after the start of the pandemic). “Comparison” refers to a statistical analysis difference/change in outcome between assessment points, including a reported estimate and/or value of *p*. We included any kind of effect measure reported for these comparisons. Reports of descriptive data without statistical testing were excluded.

Outcomes

The outcomes of interest are self- or proxy-reported measures of mental health or (health-related) quality of life in children/adolescents. These primarily comprise results from screening tools and rating scales like the Strengths and Difficulties Questionnaire (SDQ), Center for Epidemiologic Studies Depression Scale (CES-D), the KIDSCREEN, etc. The same instrument had to be applied at all compared assessment points. Examples of mental health outcomes include depressive symptoms, symptoms of anxiety, internalizing/externalizing symptoms, behavioral problems, and stress.

Study design

This systematic review included any type of longitudinal/prospective studies that used surveys or interviews to determine the mental health or quality of life of children or adolescents at multiple assessment points. These included cohort, repeated cross-sectional, panel, time series, and time trend studies. We also included studies that compared samples from different surveys if they demonstrated that the populations were comparable. We excluded cross-sectional studies without follow-up, experimental studies, and intervention studies which mainly focused on intervention effects.

As this review focuses on long-term trajectories of mental health beyond the initial phase of the pandemic, we only included studies that cover a period of at least 6 months during the pandemic, meaning the time between the first and last outcome assessment after the above-mentioned start dates. Studies covering a pandemic time period of <6 months and studies that only compare outcomes before and after the beginning of the pandemic (with only one time point after) were excluded.

We further excluded duplicate publications of results from the same study/population. In this case, we included the study that provided the most information regarding our research questions.

Publication type

Studies were eligible for inclusion if they were peer-reviewed publications reporting original study results; other publication types, such as reviews, letters to the editor, opinion papers, conference abstracts and preprints, were excluded. We only included studies published after 03/2020. We did not limit the publication language; however, our search terms were in English.

Data sources and search strategy

The first two authors (EO, LL) searched PubMed/MEDLINE, Web of Science, PsycINFO, PSYINDEX, and the WHO-COVID-19 database on August 30, 2022. Based on the pre-defined eligibility criteria and the PICO framework, we used a combination of search terms referring to the population (“child* OR adolescent* OR youth OR pediatric* OR infant*”), COVID-19 pandemic (“COVID-19 OR coronavirus OR sars-cov-2 OR pandemic OR lockdown OR school closure”), outcomes (“mental health OR well-being OR depressi* OR anxi* OR psycholog* OR stress OR mental distress OR PTSD OR loneliness OR internalizing OR quality of life OR QoL OR HRQoL”), and study type (“longitudinal or prospective or cohort or trajector*”), which were then adapted to the respective database. The full search strategy can be found in the Appendix 1. We also searched Google Scholar, checking the first 200 results. As we aimed to identify studies conducted in the context of the COVID-19 pandemic, searches were limited to studies published after the beginning of 2020.

Study selection

After deduplication, titles and available abstracts of the retrieved records were screened for eligibility by the reviewers (EO, LL, MG, A-KN, VE, MF, and EB). We piloted the title/abstract screening

process on 50 records that were each screened by two reviewers independently. Given the very high degree of agreement between the two reviewers, it was decided that double screening of all the records was not necessary at this stage.

In the second step, two reviewers each (EO, LL, MG, A-KN, FW, VE, MF, and EB) independently screened the full texts of the included records. Disagreements between reviewers were discussed until consensus was reached, involving a third party if necessary. Reference lists of included studies and identified relevant reviews were screened for further potentially eligible publications (MG, A-KN).

EndNote was used to collect and de-duplicate the records. For the screening of titles and abstracts, we used the web-based application Rayyan.¹ At the full text screening stage of the screening process, we documented the reasons for exclusion using a Microsoft Excel spreadsheet. Reasons of exclusion were documented in hierarchical order, meaning that in case of multiple reasons for exclusion the first reason (publication type > population > outcome > study design > comparison/pandemic time points) was documented.

Data extraction process and synthesis method

Study characteristics and study data were extracted independently by teams of two reviewers (EO, LL, FW, MF, VE, and EB) using a standardized spreadsheet. The following information was extracted: First author and year, country, research question, study design, times of data collection, sample size, age of participants, information on sample and setting (e.g., from which study, general or other population, gender and distribution), caregiver age and gender (if applicable), outcomes, instruments used to measure outcomes, statistical methods, and results (see Table 1).

A meta-analysis was not conducted since the included longitudinal studies applied especially heterogeneous outcome assessments and statistical methods. Therefore, the reported effect measures varied highly. Furthermore, the assessed time periods and variety in pandemic protection measures imply different circumstances during the pandemic. The study results were thus narratively synthesized. The following main aspects were considered to organize and synthesize the study results systematically: type of outcome (i.e., internalizing symptoms, externalizing symptoms, and quality of life), gender differences, study size, covered time periods, and whether there was a pre-pandemic outcome measurement. The study periods and number of time points were summarized visually in the results section.

Risk of bias assessment

The methodological quality (risk of bias) was assessed in all included studies using an adapted version of the Effective Public Health Practice Project (EPHPP) checklist (32, 33) (see Appendix 2). Summarizing five subdomains (selection bias, study design, detection bias, attrition bias, and statistical methods), studies received an overall rating of low, moderate or high quality. Risk of bias in studies was

assessed independently by teams of two reviewers (rating reviewers: EO, MG, and A-KN). Reporting bias was assessed indirectly through the EPHPP checklist, which considered whether relevant information was reported.

Results

Figure 1 shows the PRISMA flow chart of study identification and selection. The literature searches generated a total of 5,099 results after removal of duplicates, of which 4,936 were excluded at the title/abstract screening stage. After screening the remaining 163 full-text articles, 24 articles were included in the review, covering a total of $n = 24$ studies. Notably, two of the included articles reported results from the same study population (but different outcomes) (34, 35), and one article reported relevant results from two different study populations separately (36).

Important study characteristics are summarized in Table 1. The 24 included studies comprised populations from 16 different countries, with sample sizes ranging from $n = 84$ to $n = 34,038$. Thirteen (54%) of the studies included >1,000 participants. The majority of the studies were conducted in Europe ($n = 12$) (5, 34–44). Some studies were from East Asia ($n = 5$) (45–49) and very few from the United States/Canada ($n = 3$) (50–52). One study included both United States and United Kingdom populations (53), and there were single studies conducted in Israel (54), Brazil (55), and Australia (56).

Most studies focused on school-aged children or adolescents (~7–19 years) and relied on self-reported outcomes, only four studies focused on children younger than 7 years and all of them used caregiver-reported outcomes (38, 44, 46, 54). All studies included both male and female participants, with the proportion of girls ranging from 43.7 to 67.5%.

The majority of studies were of longitudinal design ($n = 18$) (5, 34, 35, 37, 40–43, 45–48, 50–56); six were repeated cross-sectional studies with completely or largely different study subjects (36, 38, 39, 44, 49). Length of investigated time periods and number of assessments varied (see Figure 2). Most studies had two assessment points during the pandemic (range 2–14); one study reported measuring every 2 weeks for about 12 months (55). Eight studies additionally included a comparable pre-pandemic outcome measure (5, 36–39, 43, 45). The pandemic time periods covered by the studies ranged from 6 to 21 months (mean = 10.2 months) and the data was from 2020 and 2021 (Figure 2).

Considering the outcome domains of interest, mental health outcomes ($n = 23$ studies) were more frequently studied (5, 35–40, 42–56) than HRQoL ($n = 4$), which was measured using the KIDSCREEN in all identified studies (5, 34, 37, 41). The most frequently investigated mental health outcomes were depressive symptoms ($n = 12$) and anxiety symptoms ($n = 10$). The assessment instruments varied between studies, depressive symptoms were measured using the Patient Health Questionnaire (PHQ), Revised Child Anxiety and Depression Scale (RCADS), or the Child Depression Inventory (CDI); anxiety symptoms were, e.g., measured by the Generalized Anxiety Disorder Scale (GAD-7) or by the Screen for Child Anxiety Related Disorders (SCARED), to give a few examples. Further investigated mental health outcomes mainly comprised broader constructs of internalizing and/or externalizing

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TABLE 1 Rating of methodological quality (risk of bias) of the included studies, in alphabetical order.

First author, year	Selection bias	Study design	Detection bias	Attrition bias	Statistical methods	Overall quality
Adachi et al. (45)	M	H	H	H	H	H
Albrecht et al. (37)	L	M	H	L	H	L
Cimino et al. (38)	L	H	H	L	H	L
Fischer et al. (36) (KLIK)	M	M	H	L	M	M
Fischer et al. (36) (NTR)	L	M	H	L	M	L
Gordon-Hacker et al. (54)	L	H	H	M	H	M
Hafstad et al. (39)	H	M	H	L	H	M
Hagihara et al. (46)	M	H	H	L	H	M
Lehmann et al. (34)	L	H	H	L	H	L
Lehmann et al. (35)	L	H	H	L	H	L
Lengua et al. (50)	L	H	H	M	H	M
Martinsone et al. (40)	L	H	H	M	H	M
Nikolaidis et al. (53)	M	H	L	L	H	L
Poulain et al. (41)	L	H	H	M	H	M
Ravens-Sieberer et al. (5)	M	H	H	M	H	H
Raymond et al. (51)	L	H	H	M	H	M
Theuring et al. (42)	M	H	H	H	H	H
van der Laan et al. (43)	M	H	H	L	H	M
Weissman et al. (52)	L	H	H	H	H	M
Wenter et al. (44)	L	M	H	L	H	L
Westrupp et al. (56)	H	H	H	M	M	M
Xie et al. (47)	M	H	H	H	M	H
Zhang et al. (48)	L	H	H	H	M	M
Zhou et al. (49)	M	M	H	L	M	M
Zuccolo et al. (55)	M	H	H	L	M	M

L, Low; M, Moderate; and H, High quality rating.

symptoms, mostly measured through the SDQ ($n=7$). Many of the studies investigated multiple outcomes (see Table 1).

Based on the criteria of our risk of bias assessment tool (Appendix 2), we identified studies of high ($n=4$), moderate ($n=14$), and low ($n=7$) quality (see Table 1).

Mental health—internalizing symptoms

Depression

The studies investigating measures of depressive symptoms ($n=12$) covered a median of 9 months (range: 7–19 months) pandemic study time (see Figure 2). Five of the studies also included a pre-pandemic measure of depressive symptoms (5, 36, 38, 39, 45). Of these studies, four showed increased depressive symptoms during the pandemic compared to before (5, 36, 38, 39). In two of the studies, the pre-post increase in depressive symptoms was observed only later during the pandemic, namely in July 2021 in Norway (UEVO study) with no increase observed initially in June 2020 (39), and during the second lockdown in Germany (December 2020, COPS study) (5). Only one study found decreased depressive symptoms during compared to before the pandemic (between Sept

2019 and Jul 2020). However, this was only observed in a group of children without smartphones; there was no change in the other group (45).

Considering the trajectories of depressive symptoms during the pandemic, the study results are mixed. Most studies ($n=7$) found that depressive symptoms increased (or remained elevated compared to pre-pandemic levels) during the pandemic in the studied populations (36–39, 47, 51, 55). In a smaller study in Italy on children aged 5–6 years, Cimino et al. (38) surprisingly only found an increase in the group of children with mothers not at risk of psychological problems, while there was no change in depressive symptoms in the at-risk group.

Other studies observed fluctuating trajectories, with peaks related to periods of high infections and lockdowns (5, 56). A large Australian study included mothers of children aged 0–18 and applied a unique design with 14 assessment points, comparing a state with strict second wave lockdown in Victoria to states with no lockdown (56). They found no state differences during the first national lockdown (Apr/May 2020), but another peak in Victoria during their second lockdown (Jul–Oct 2020), that later subsided and was not observed in the states with looser restrictions. The German COPS study (5) examined a large representative

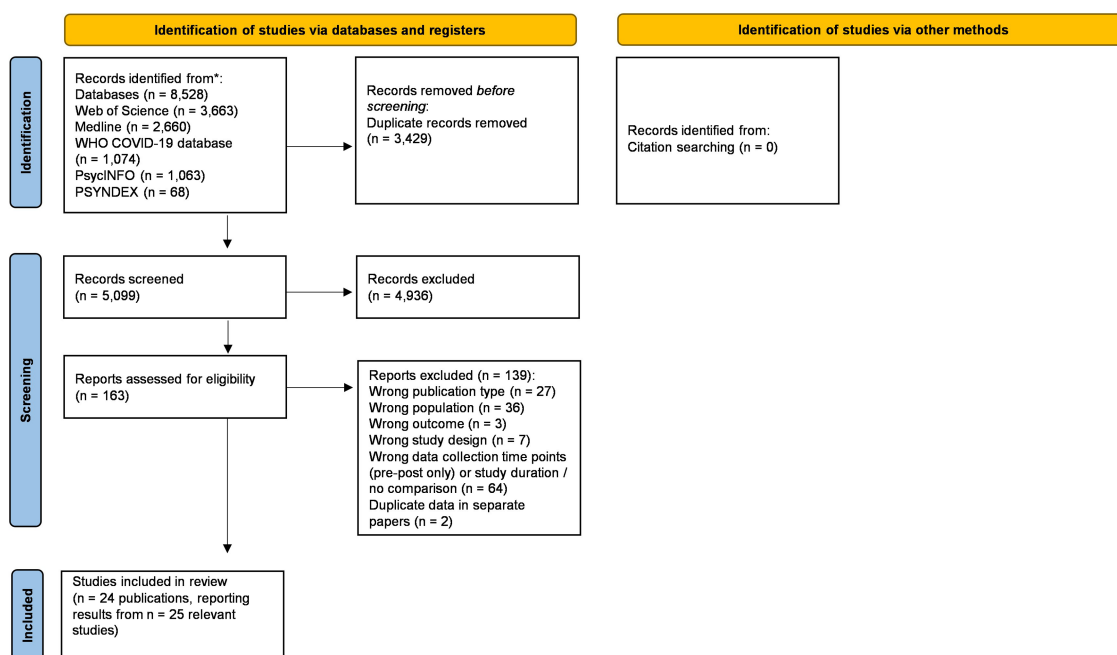


FIGURE 1
PRISMA flow chart of the systematic review process (57).

community sample of children aged 7–17 years in a longitudinal design, including pre-pandemic data and comparing this with three pandemic assessment points. They similarly observed an increase in depressive symptoms during the second infection wave/lockdown (Dec 2020/Jan 2021), which returned to pre-pandemic levels after restrictions were loosened (5).

Four of the studies noted a decline of depression symptoms throughout the pandemic (36, 45, 48, 49). A big study of Japanese children 9–12 years of age noted a decrease over three pandemic assessment points between July 2020 and March 2021, with higher symptoms before the pandemic, however only in the group of children without smartphones. They also found that depressive symptoms were higher in smartphone-owning children compared to non-owners (45). The Dutch KLIK study including 8–18-year-old also found that depressive symptoms decreased after lockdown (Nov/Dec 2020) compared to during lockdown (Apr 2020), but it is important to note that symptoms were higher than pre-COVID at both assessment points during the pandemic (36). Two Chinese studies noted a decrease in depression symptoms by May/June 2021 compared to earlier phases of the pandemic (48, 49). One study was conducted on a big sample with a mean age of 16.4 years (49), the other was a smaller study with children aged 9–11 years (48); neither of them included a pre-pandemic comparison. The study by Zhang et al. (48) did not cover the early pandemic period, as the first assessment was in November 2020.

In summary, study results were mixed, but a strong majority of the evidence points toward a continued increase in depressive symptoms after the beginning of the pandemic and a correlation of higher symptoms during times of higher infections rates and/or pandemic restrictions such as lockdowns. Further, where pre-pandemic data were available, all studies except one noted an increase in depressive symptoms after the beginning of the pandemic.

Anxiety

Nine of the 12 studies that investigated depressive symptoms also measured anxiety symptoms (5, 36, 39, 47–49, 51, 55, 56). One additional longitudinal study addressed anxiety but not depression in children and adolescents aged 8–18 years in Germany (42).

Three studies included a pre-pandemic comparison measure of anxiety (5, 36, 39), and found that symptoms increased at the first assessment after onset of the COVID-19 pandemic in spring/summer 2020 (5, 36), or remained stable early in the pandemic and increased later on, i.e., in June 2021 (39).

Trends found for children's anxiety symptoms were largely similar to what was observed for depression. The majority of studies ($n=7$ studies set in the Netherlands, Norway, Germany, Canada, and China) indicated an increasing trend during the pandemic (5, 39, 42, 47, 51) or found that levels of anxiety symptoms were higher than before the pandemic both early on and later in the pandemic, though they slightly decreased between early and late measurement points (36). Several studies also found that anxiety levels peaked during times of high infection rates/lockdowns (5, 36, 42, 51, 56).

Zuccolo et al. (55) measured mental health outcomes 14 times in a large sample of children (ages 5–17 years) in Brazil between June 2020 and June 2021. They found an increase of anxiety in July 2020, followed by a decrease from October 2020 to February 2021, which coincided with a reduction in social distancing requirements in Brazil in late 2020, followed by another decrease from April to May 2021. They reported no pre-pandemic data (55).

In agreement with what they found for depressive symptoms, two of the Chinese studies noted a decrease in anxiety symptoms (48, 49).

Study (1st author, year)	Country	pre-COVID 19	2020												2021												2022	
			Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb		
Adachi, 2022	Japan	Sep 2019					X					X																
Albrecht, 2022	Switzerland	Spring 2017		X													X											
Cimino, 2022	Italy	Oct 2019	X																							X		
Fischer, 2022 (KLIK)	Netherlands	1995-2019		X								X																
Fischer, 2022 (NTR)	Netherlands	2018		X								X																
Gordon-Hacker, 2022	Israel							X	X					X	X													
Hafstad, 2022	Norway	Jan 2019					X														X							
Hagihara, 2022	Japan			X								X																
Lehmann, Haug, 2022	Norway			X								X																
Lehmann, Skogen, 2022	Norway			X								X																
Lengua, 2022	USA			X								X																
Martinsone, 2022	Latvia/ Italy/ Portugal								X													X						
Nikolaidis, 2022	USA & UK			X	X							X																
Poulain, 2022	Germany	2019	X												X													
Ravens-Sieberer, 2022	Germany	2014-2017; 2017-2018			X								X												X			
Raymond, 2022	Canada				X					X	X	X							X									
Theuring, 2022	Germany				X						X								X	X								
van der Laan, 2022	Netherlands	Mar 2019			X		X					X								X								
Weissman, 2021	USA				X							X																
Wenter, 2022	Austria/Italy		X												X												X	
Westrupp, 2022	Australia			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X										
Xie, 2022	China		X												X													
Zhang, 2022	Hong Kong, China										X								X									
Zhou, 2021	China			X																				X				
Zuccolo, 2022	Brazil				X	X	X	X	X	X	X	X	X	X	X	X	X	X										




X = measurement time
 = mental health outcome
 = HRQoL outcome
 = mental health & HRQoL outcome

FIGURE 2
Overview of the timelines of the included studies, in alphabetical order.

Other internalizing symptoms

Ten studies reported results for internalizing symptoms assessed with instruments not specifically targeting depression or anxiety, but using most commonly the SDQ.

Lehmann et al. (35) analyzed data from the large Norwegian COVID-19 Young study including participants aged 11–19 years. They noted a significant increase in internalizing problems between the lockdown in April/May 2020 and 9 months later in Dec 2020/Jan 2021 (35). In a smaller sample of US children with data from the same study period (T1: April/May 2020, T2: Nov 2020–Jan 2020), the investigators also found that internalizing problems (SDQ) increased significantly during the pandemic (52). Another small United States study following participants with a mean age of 14.1 years came to the same conclusion and additionally noted that adolescent mental health was closely linked to maternal mental health (50). Similarly, the German COPSy study found that internalizing symptoms (peer and emotional problems) steadily increased in children and

adolescents during the pandemic's high infection and lockdown phases (T1: May/Jun 2020 to T2: Dec 2020/Jan 2021, also compared to pre-pandemic) and plateaued at the last assessment (T3: Sep/Oct 2021), where restrictions had been lifted again (5). A small sample of Israeli mothers provided information about young children's conduct and emotional problems at four time points during the pandemic, namely September 2020 (lockdown), October 2020 (post-lockdown) and in January 2021 (lockdown) and March 2021 (post-lockdown) (54). They similarly found that emotional problems in the 2–5-year-old children were the highest during the first lockdown period (T1) and significantly decreased in the post-lockdown periods. Contrary to these studies, the PROMEHS study on adolescents aged 11–16 years in Italy, Latvia, and Portugal found no significant changes in adolescents' internalizing (and externalizing) symptoms between October 2020 and May 2021 (40), and a Japanese study in preschoolers and school-aged children also noted no significant change in SDQ scores over time (46).

The large Dutch NTR (Netherlands Twin Register) study assessed internalizing symptoms in 8–18-year-olds before and at two time points during the pandemic (Apr–May 2020, strict lockdown; Nov–Dec 2020, partial lockdown) (36). They found significantly higher levels of internalizing symptoms during the COVID-19 pandemic than before, but more so during the strict lockdown, with a decrease during the following partial lockdown (36). The WHISTLER study (Wheezing Illnesses Study Leidsche Rijn), also conducted in the Netherlands, and followed a small sample of adolescents from March 2019 (T0) to February 2021 (T4) (43). They found increased internalizing symptoms only during the second full lockdown at T4 (43). The large Tyrolean COVID-19 Children's Study examined the effects of the pandemic and factors influencing the mental health and quality of life of children aged 3–13 in North Tyrol (Austria) and South Tyrol (Italy) at four different time points [Mar 2020 (lockdown), Dec 2020, Jun 2021, and Dec 2021]. The study found that mental health outcomes, including internalizing problems and posttraumatic stress symptoms, gradually increased and were worse in December 2021 compared to during lockdown in March 2020 in all age groups (44). Lastly, the aforementioned study in Brazil examined emotional problems in a large sample of children and adolescents aged 5–17 years and found that the total emotional problems increased in July and September 2020, decreased from December 2020 to February 2021, and then increased again in May 2021, compared to June 2020 (55). Despite these fluctuations, the authors reported no sustained increase.

Studies on internalizing symptoms, be it depression, anxiety or a broader mental health construct, mostly conclude that symptom levels in children and adolescents increased or remained high during the pandemic not only compared to before, but also many months or even over a year after the onset of the pandemic, oftentimes in relation to periods with pandemic restrictions such as lockdowns or school closures.

Mental health—externalizing symptoms

Externalizing disorders include Attention-Deficit/Hyperactivity Disorder (ADHD), Conduct Disorder (CD), Oppositional Defiant Disorder (ODD), and Antisocial Personality Disorder (ASPD). Eight studies assessed externalizing symptoms during the pandemic (5, 35, 38, 40, 44, 46, 50, 54), oftentimes considering maternal mental health as well. Gordon-Hacker et al. (54) report that children's conduct problems were highest during the second lockdown (September 2020) in Israel and dropped in the post-lockdown periods. A similar trend was found by Cimino et al. (38), who examined mother–child dyads in Italy (children ages 5–6), with pre-pandemic data from Oct 2019 and two pandemic follow-ups in Mar 2020 (lockdown) and Oct 2021 (post-lockdown). They compared children of mothers with a high risk of psychopathology and those with a low risk. Interestingly, the authors found that in the no-risk group, symptoms of aggression in the children increased significantly between 2019 and 2020, but significantly decreased again by the assessment in 2021, when there was no more lockdown, reaching even lower levels than in 2019. In the high-risk group however, aggression decreased from 2019 to 2020 and again in 2021 (38). Another study assessed the relation between adolescent and maternal mental health early in the pandemic (April 2020) compared to 6 months later in a small sample of US adolescents.

While studying adolescents' mental health trajectories was not the main objective, the results indicated an increase in externalizing problems over time, which was strongly predicted by maternal mental health (50).

Martinsone et al. (40) describe a sample of adolescents from the PROMEHS study (Latvia, Italy, and Portugal), assessed in October 2020 and May 2021, and their caregivers. This study found no changes in externalizing difficulties scores between these time points, during a period characterized by strict COVID restrictions and high mortality rates (40). Another longitudinal study in Japanese parents of children aged 0–9 years also found no significant changes in externalizing symptoms throughout different stages of the pandemic between lockdown in March 2020 and February 2021, in the investigated group of children aged 4–9 years (46). While the Norwegian COVID-19 Young study found an overall increase in internalizing difficulties, there was no significant change in the level of externalizing symptoms, with conduct problems as well as hyperactivity remaining stable between April/May 2020 and December 2020/January 2021 (35).

The aforementioned COPS study describes a significant increase in externalizing symptoms, specifically from pre-pandemic levels to May/June 2020 (first lockdown in Germany). The percentage of children with abnormal symptoms significantly increased from a pre-pandemic 13% to approximately 18% for conduct and 22% for hyperactivity problems during the first lockdown. These rates remained elevated throughout December 2020/January 2021 and September/October 2021 (5). Similar results have been reported by an Austrian group finding a significant pandemic-related increase in aggressive behavior according to longitudinal data collected from a large sample of parents (44).

Studies on externalizing symptoms paint a more heterogeneous picture than the results found for internalizing symptoms. While two studies found an increase in externalizing symptoms during the pandemic (44, 50), three studies found no change (35, 40, 46). Another study also noted no change during the pandemic, but had pre-pandemic data suggesting higher levels at all times during the pandemic (5). Lastly, two studies noted a decrease during the pandemic, after lockdown, but had pre-pandemic data suggesting that levels of externalizing symptoms had initially increased during lockdown (38, 54).

Health-related quality of life

Three large ($n > 1,000$) studies (5, 34, 37) and one smaller study (41) investigated changes in HRQoL during the pandemic. All of these studies used data from 2020 to 2021, three of them included pre-pandemic data as well (5, 37, 41). The studies were set in Germany ($n = 2$), Switzerland, and Norway. They all used a version of the KIDSCREEN to assess HRQoL, and the current pandemic restriction measures such as lockdowns were considered in the interpretation of the results.

The German LIFE Child study investigated changes in KIDSCREEN scores in the domains of physical well-being, psychological well-being, and peers and social support in 9–16-year-old German children, covering a 10-month-follow-up period during the pandemic (41). Compared to before the pandemic, all domains decreased during the first lockdown, and physical well-being had further decreased by the second lockdown, while there was no change

in the domains peers and social support (41). The German COPSy study found similar trends in a general population sample of children and adolescents (5). The percentage of participants with poor HRQoL increased significantly from 15% pre-pandemic to 40% in T1 (May/Jun 2020, end first lockdown 2020) and 48% in T2 (Dec 2020/Jan 2021, second lockdown 2020), and improved slightly to 35% in T3 (Sep/Oct 2021, loosened restrictions)—though this rate is still more than double the pre-pandemic percentage (5). Albrecht et al. (37) investigated overall HRQoL in a large sample of Swiss high school students at two times during the pandemic (during school closure in April 2020 and 12 months later, post-closure) and compared this data with a pre-pandemic control group. HRQoL was significantly better in the closure group and lower in the post-closure group compared to the control group.

The Norwegian COVID-19 Young study (34) investigated HRQoL during (Apr/May 2020) and 9 months after the national lockdown (Dec 2020/Jan 2021) and, consistent with the findings of Poulain et al. (41), found a significant decline of physical and psychological well-being between these time points. Peer and social support, however, increased over time while the other domains of HRQoL (autonomy and parent relations; school environment) showed no change.

In summary, the three studies with pre-pandemic data observed a decrease in HRQoL that coincided with the first lockdown in Germany and Switzerland (5, 37, 41). The longitudinal evidence of the identified studies suggests that decreases in HRQoL of children and adolescents persist months, or even over a year, after the start of the pandemic and related lockdown measures, and persist further even when restrictions are no longer in place.

Gender differences

Fifteen of the studies analyzed gender differences in mental health and/or HRQoL during the COVID-19 pandemic, with mixed results. Three studies found no gender differences in mental health outcomes (38, 48) and no differential change in symptoms between boys and girls (54). One study found no differential change in symptoms, but a higher mental health symptom load in girls (43). In another study, male gender predicted aggressive behavior, but there was no significant association of gender with internalizing symptoms and PTSD symptoms (44). Altogether, 10 studies indicated that girls had higher levels of internalizing symptoms (5, 40, 42, 43, 47, 49, 51, 55, 56) and/or a more pronounced increase in internalizing symptoms than boys (39, 47).

Regarding HRQoL, one study found that girls had lower initial HRQoL and a steeper decline in HRQoL over time than boys (34), and similarly, a second study found higher proportions of girls with low HRQoL, and high anxiety and depressive symptoms both before and during the pandemic (5).

Discussion

This systematic review investigated the development of child and adolescent mental health and HRQoL throughout the COVID-19 pandemic based on published literature identified in a thorough systematic search. To our knowledge, this is the first systematic review to collect empirical evidence on COVID-19-related trajectories of

mental health and quality of life in children and adolescents, focusing on population-based studies that cover at least 6 months of pandemic time and at least two pandemic assessment points. Building on recent evidence comparing pre-pandemic and pandemic data that has shown a decrease in young people's mental health during the COVID-19 pandemic, such as the systematic review by Kauhanen et al. (22) or the scoping review by Wolf and Schmitz (26), this study addresses the question of how children's and adolescents' mental health and HRQoL has developed over the course of the pandemic, and especially beyond the first lockdowns.

In total, 24 prospective studies were included in the final review. Most of the studies investigated mental health outcomes, with a strong focus on internalizing symptoms such as anxiety and depression. Fewer studies ($n=4$) investigated children's HRQoL during the pandemic. Overall, the quality of evidence we found was predominantly moderate or low according to risk of bias assessment (Table 1) and notably, only few studies included large and representative samples (5, 36, 39, 56).

The core result of this synthesis is that, despite some heterogeneity in the results, most of the evidence suggests an increase in young people's mental health problems and poor quality of life during the pandemic, also beyond the initial phase of lockdowns.

Since this comparison was not the focus of this review, not all included studies had pre-pandemic outcome data. However, the comparison with pre-pandemic data has been covered by previous reviews showing substantial evidence that mental health in young people has decreased compared to before the pandemic (15, 22). Results of a meta-analysis showed that pooled prevalence estimates of clinically-elevated depression and anxiety symptoms in children and adolescents during the first year of the pandemic were 25.2 and 20.5%, respectively, which implies that the respective prevalence has doubled compared to pre-pandemic estimates (4).

The results of this review indicate that the burden of mental health problems and decreased HRQoL has further increased, or at the very least remained elevated, throughout the pandemic years 2020 and 2021 in many countries. Fluctuations in symptom levels were often attributed to phases with strict restriction measures. In particular, the strength of the restriction measures varied greatly not only between the 16 countries examined in this study but also within each country, making a comparison difficult. Some studies, however, noted no changes or even noticed an improvement in mental health outcomes over time. Inconsistencies in findings among the reviewed studies may be due to the variability in study samples, such as different assessment times, contexts and country/region. These variations are connected to differences in infection rates, (strength of) health protection measures, and the duration and intensity of exposure to the pandemic at the time of assessment. The timing of assessments might be a significant factor when studying changes in symptoms throughout the pandemic.

Interestingly, the studies covering 12 or more months of the pandemic and using large, representative samples, such as the COPSy study (5), the Tyrolean COVID-19 Children's Study (44), and the UEVO study (39), found that mental health symptoms and decreased HRQoL persisted or continued to increase, even when strict restrictions or lockdowns were no longer in place. The results of this review suggest that having experienced the COVID-19 crisis with all its implications for public and family life might have long-term effects on the mental health and well-being of the young population, and we might consequently face an accumulated need for youth mental

health services and support after the pandemic. It is possible that the reason some studies did not observe a decrease in symptoms after lifting restrictions is that recovery takes time and may not be immediately noticeable in assessments. Even without restrictions, certain stressors like the unpredictability of the situation and fear of infection have likely continued to impact mental health.

The reviewed literature shows that externalizing symptoms and HRQoL were far less frequently studied in a longitudinal design than internalizing symptoms such as depression and anxiety. Externalizing symptoms also appear to be impacted by the pandemic to a lesser degree. There might be several hypothetical explanations for this finding. One important factor could be that a strong majority of the studies focused on older children and adolescents, where externalizing symptoms are less common than in children of preschool age or younger, while internalizing symptoms increase in adolescence (58). The results of the studies in this review might indicate that externalizing symptoms are not as strongly affected by social isolation, in fact, in some studies they even decreased, underpinning the fact that these symptoms are of a highly heterogeneous origin and also have a strong genetic component (59).

For the internalizing symptoms, the observed results, mainly indicating an increase during the pandemic and peaks during phases of high restrictions, appear plausible. Decreased peer contacts, school closures, fear of infection, and the disruption of family life are known exacerbators of anxiety and depression symptoms that have been previously discussed in the literature (18). In terms of risk factors and pathways to mental health and well-being, the included studies described a variety of environmental and also pandemic-related factors that also played a role in the level of mental health symptoms and HRQoL during the pandemic. Among these were peer and family conflict, parenting practices, previous psychiatric diagnosis, parental psychopathology, socioeconomic disadvantages, and reduced social contact. However, analyzing these risk factors in detail is beyond the scope of this review. Though, we did examine and summarize whether studies reported gender differences. We found that 12/15 studies examining gender reported poorer mental health and well-being and/or steeper declines during the pandemic for girls particularly for internalizing symptoms. This is consistent with the current state of evidence, which has demonstrated that girls tend to have a higher load of internalizing symptoms than boys (60) and that girls' and women's mental health and well-being appear to have been affected more by the pandemic (6). Concerning risk and protective factors (other than gender) for mental health problems during the COVID-19 pandemic, the recent scoping review by Wolf and Schmitz provides an excellent overview (26). Their synthesis suggests that low socioeconomic status, financial worries, material hardship, lack of space, negative home-schooling experience, poor physical health, and pre-existing neurodevelopmental disorders represent key risk factors for experiencing more pronounced negative mental health effects during the pandemic (26).

Even though the pandemic has evidently affected children's and adolescents' mental health and well-being, research shows there are several resilience factors in young people and families (26) that could be strengthened through interventions in the future, particularly targeting the most vulnerable groups of children. One example is the promotion of physical activity, which can mitigate

the negative effects of the COVID-19 pandemic by improving young people's moods (61, 62). A recent meta-analysis has also demonstrated that psychosocial interventions that enable personal interaction and include a physical activity component showed greater effectiveness in improving children's and adolescents' mental health outcomes (63). Future research should also focus on monitoring other health outcomes relevant to the young demographic, such as eating disorders. According to an analysis of administrative data from the largest German statutory health insurance, there has been a significant increase in hospital admissions for anorexia nervosa among children and adolescents during the pandemic, particularly among girls (64). This suggests that crises like the pandemic, which involve social isolation and school closures, can aggravate eating disorders in young people, possibly due to increased social media activity. Thus, even though many children and adolescents show resilience in times of crisis, this vulnerable group should not be forgotten.

Strengths and limitations

A primary strength of this systematic review is that it encompassed 24 studies, collectively examining a substantial number of children and adolescents across 16 countries. These papers provided valuable longitudinal data regarding the development of various mental health issues and measures of HRQoL throughout the pandemic. Synthesizing these findings, this study is addressing an important research gap.

However, this review also has certain limitations. Due to the nature of the study question, the heterogeneous study designs, the different assessment points, and the diverse outcomes assessed by the reviewed studies, a quantitative synthesis using meta-analysis was deemed inappropriate. Instead, data was extracted, visualized, and narratively synthesized to a very detailed extent (see Table 1 and Figure 2). However, the presence and strength of the restriction measures between and within the included countries could not be addressed in detail due to the large number of countries and high variations. Furthermore, the inclusion criteria were restricted to peer-reviewed papers, potentially resulting in the omission of relevant information published at pre-print stage or grey literature like governmental reports or reports from insurance providers. We only included peer-reviewed publications to ensure the methodological quality of the studies. Despite the inclusion of 24 studies, many of them were small or based on non-representative data, thereby limiting the generalizability of the findings. Further, studies from African countries were missing, limiting our conclusions mainly to a European context, and there was a dearth of studies examining children below school age, which limited the interpretability of findings for this specific age group. As for the outcome measures, it can be positively noted that most studies used validated instruments. However, it needs to be emphasized that such instruments commonly used to screen for mental health symptoms such as anxiety or depression are not suited to (categorically) diagnose any mental disorders but rather to assess population-level trends in symptom load. Lastly, as with any systematic review, there is the risk of publication bias, which could for example lead to an overestimation of effects if non-results were systematically less frequently published.

Conclusion

The results of this systematic review point toward a sustained increase in mental health problems, particularly internalizing symptoms such as anxiety and depression, and a reduced quality of life in children and adolescents during the first 2 years of the COVID-19 pandemic. The identified studies were heterogeneous regarding the studied populations and methods applied, and high-quality evidence from large, representative population samples was scarce.

From a public health point of view, these results point toward the importance of preventing mental health problems in children and adolescents. Promoting mental health and well-being, especially in times of crisis and especially in particularly vulnerable groups, is important in order to prevent symptoms of, for example, anxiety and depression from becoming manifest disorders that might persist into adulthood.

It is critical to continue monitoring children and adolescents to learn about their mental health and well-being after the pandemic, preferably on a broad, collaborative scale, in representative samples, and using validated instruments. This requires a systematic approach, such as national research networks, and, ideally, the use of the same instruments, which would facilitate a comparison between countries.

As the results demonstrate long-term consequences of the COVID-19 pandemic, the mental health and well-being of children and adolescents requires a stronger consideration in the future context of pandemic management, especially when considering the implementation of strict measures such as school closures and lockdowns.

Author contributions

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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/fpubh.2023.1275917/full#supplementary-material>

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Reciprocal effect between non-suicidal self-injury and depressive symptoms in adolescence

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Background: Non-suicidal self-injury (NSSI) is a common psychological and behavioral problem among adolescents. The COVID-19 pandemic has had a significant impact on people's mental health. To date, few studies have documented the temporal changes in adolescents' psychological status during the pandemic, as well as the impact of large-scale public health intervention strategies. This study contributes to the existing evidence on the subject.

Methods: Participants were 6,023 adolescents aged 10 years and older, with data from two waves of longitudinal surveys, including data for a 7-month interval before and during the pandemic. A cross-lagged model was used to test the bidirectional relationship between NSSI and depressive symptoms in adolescents; logistic regression analysis was used to explore the predictors of NSSI implementation in adolescents with depressive symptoms.

Results: In this study, 32.69% participants reported depressive symptoms at baseline and 34.27% at follow-up; 44.34% participants with depressive symptoms reported NSSI at baseline and 53.44% at follow-up. The duration of the online class, depressed affect, and somatic and related activity were the risk factors for NSSI; sleep duration and positive mood were the protective factors. The lag effect of depression symptoms on NSSI is significant, and so is NSSI on depressive symptoms.

Conclusion: During the COVID-19 pandemic, adolescents' mental health has worsened, resulting in an increase in the prevalence of NSSI among those with depressive symptoms compared to pre-pandemic levels. Early screening for depression is crucial in preventing or decreasing NSSI in adolescents.

KEYWORDS

non-suicidal self-injury, depressive symptoms, adolescence, follow-up study, COVID-19

1 Introduction

The outbreak of the COVID-19 pandemic has presented significant challenges to people's mental well-being (1). After the outbreak, countries, including China, implemented lockdown or semi-lockdown measures, disrupting the normal routines of daily life. The uncertainty and concerns surrounding contracting the virus have intensified the psychological health crisis (2, 3). A systematic review of studies on COVID-19-related psychological distress in countries such as China, Italy, and the United States revealed high prevalence rates of anxiety (6.3 to 50.9%), depression (14.6 to 48.3%), post-traumatic stress disorder (7 to 53.8%), psychological distress (34.4 to 38%), and stress (8.1 to 81.9%) among the general population (4).

The global mental crisis coronavirus disease 2019 (COVID-19) had created a challenging situation for all, especially adolescents. Adolescence is characterized by prominent relationships with peers. Research suggests that friends provide companionship and social and emotional support as adolescents pursue independent development (5). However, home isolation, maintaining social distancing, and closing schools hindered peer interactions, especially school closures, and reduced students' accessibility to external psychosocial protective resources during COVID-19. Therefore, it is necessary to study the influence of the COVID-19 pandemic on adolescent mental health. Adolescence is a time when the incidence of psychological problems is high, with approximately 50% of psychological disorders, including anxiety, depression, and other negative feelings, appearing before the age of 14 years (6, 7). Data on adolescents before the COVID-19 pandemic in China suggest that 19.9% of adolescents had already experienced depressive symptoms, and 13.99% had experienced anxiety disorders (8). A systematic review and meta-analysis revealed that 28.6 and 25.5% of adolescents experienced symptoms of depression and anxiety, respectively, during the COVID-19 pandemic (9). The COVID-19 pandemic has affected the mental health of adolescents.

Adolescence is also a critical period for mental health issues and risky behaviors such as non-suicidal self-injury (NSSI), which refers to the direct intentional destruction of one's body without suicidal intent, including cutting, scratching, burns, stabbing, and biting, but is not life-threatening (10, 11). Adolescents are at a high risk of NSSI, with a lifetime prevalence of 17.2% (12). Adolescents are at a high risk of NSSI, with a lifetime prevalence of 17.2% (13) and 27.4% among middle school students (14). Some data show that the prevalence of NSSI among Chinese adolescents has been on the rise in recent years (15). NSSI not only causes harm to one's body, but also adversely affects family and interpersonal relationships, and NSSI is also a risk factor for subsequent suicidal behavior (16). There is evidence that NSSI is associated with a range of psychological difficulties, including depression, anxiety, and post-traumatic stress disorder (17). A meta-analysis of factors related to NSSI among Chinese adolescents showed that adolescents with mental health problems were more than 1.5 times more likely to develop NSSI than those without mental health

problems (18). A meta-analysis of factors related to NSSI among Chinese adolescents showed that adolescents with mental health problems were more than 1.5 times more likely to develop NSSI than those without mental health problems (19). A longitudinal study with a sample of 813 Chinese adolescents also showed that higher levels of depressive symptoms were associated with an increase in NSSI one year later (20). However, the long-term effects of depressive symptoms on NSSI in adolescents remain unknown in the context of COVID-19.

The WHO emphasized the need for people to study the psychological impact COVID-19 has caused (21). Thus far, there is a relatively small record of longitudinal change in adolescents' psychological status during the COVID-19 pandemic as well as with the implementation of large-scale public health intervention methods (22–24). To investigate the influence of depressive symptoms on NSSI among adolescents and the occurrence rate of NSSI among adolescents with depressive symptoms, we performed this follow-up study. Furthermore, to assess the bidirectional association between depressive symptoms and NSSI to provide more evidence for a follow-up study of NSSI in Chinese adolescents. Therefore, we hypothesized that during COVID-19, there will be an increase in NSSI behaviors and the incidence of depressive symptoms. In addition, psychological health among adolescents deteriorated, and the prevalence of NSSI among adolescents with depressive symptoms increased compared with that before the pandemic.

2 Methods

2.1 Design and participants

Five schools in Chengdu were selected for this study using multi-stage stratified cluster sampling. Stage 1: The city of Chengdu was divided into high, medium, and low levels according to the level of economic development, with one district randomly selected from each level; Stage 2: One school was randomly selected in each district (county); and Stage 3: all students in the school were included in the study. In this way, we selected one school in the center of Chengdu City and two schools in each of the two suburban counties to the north and south. Among these schools, two schools included both primary and secondary students, two were primary school and one was middle school. All students in the selected schools were included in the survey. Before conducting the targeted school surveys, the researchers coded all students in all schools individually and created survey manuals to train classroom teachers and quality controllers (QC). Then the school was organized to conduct the questionnaire survey and all respondents were grouped into classes, each class was assigned a classroom teacher and a QC. The class teacher led the students to fill in the questionnaire and explained the content of the questionnaire according to the student's cognitive ability. When the classroom teacher encounters a student question that cannot be answered, the QC will explain.

There are two waves of data collection. The Wave 1 survey was carried out between December 23, 2019, and January 13, 2020 (before the pandemic, at baseline). We did an on-site survey and distributed questionnaires from December 23, 2019 until the end of December. We collected questionnaires and processed data from the beginning of January through January 13, 2020. This was before the outbreak of COVID-19 in Wuhan, China, and the school closure. A year following

Abbreviations: NSSI, Non-suicidal self-injury; CPCD, Chengdu Positive Child Development; DSHI, Deliberate Self-Harm Inventory; CES-DC, Center for Epidemiologic Studies Depression Scale for Children; M, Mean; SD, Standard deviation; CFI, Comparative fit index; RMSEA, Root Mean Square Error of Approximation; TLI, Tucker-Lewis Index.

the baseline survey, a wave 2 survey was planned. It was, however, carried out 6 months ahead of schedule to record the immediate impact of the COVID-19 pandemic. So, from June 16 to July 8, 2020 (during the pandemic, at follow-up), wave 2 data was obtained when schools reopened following the COVID-19 outbreak.

We received 6,190 and 6,654 completed questionnaires in Wave 1 and Wave 2 surveys, respectively, from adolescents aged 10 and up. Finally, 6,023 valid respondents were included after excluding questionnaires with more missing (variable missing more than 20%), not answering attentively, and inconsistent personal information in the two surveys.

2.2 Ethics approval and consent to participate

The study was conducted by the Declaration of Helsinki. The schools, students, and parents participating in the survey provided written informed consent, whereas the children provided parental informed consent before inclusion in the study. The study protocol was approved by the Medical Ethics Committee of Sichuan University (Ethics No. K2020025).

2.3 Measuring tools

2.3.1 Deliberate self-harm inventory, DSHI

The Deliberate Self-Harm Inventory (DSHI) was used to measure the NSSI. Gratz (2) created and verified a scale that Lundh et al. (25, 26) reduced and shortened. The Chinese version of the DSHI has also been proven to have high reliability and validity when applied to Chinese children and adolescents (27, 28). Adolescents were asked if they had ever experienced self-injury, including cuts, burns, scratches, bites, stabbing, or other types of NSSI. To measure the existence or absence of NSSI behaviors, a scoring system was employed, and the frequency of each NSSI was designed as 0 points for “never,” 1 point for “1 time,” 2 points for “2 times,” and 3 points for “3 times or more.” The NSSI scores were categorized into dichotomous “yes” and “no” variables. “Without” refers to a cumulative total score of 0, and “with” refers to a cumulative score of ≥ 1 for each of the 8 NSSI modalities. Cronbach's α for the surveyed sample was 0.875.

2.3.2 Center for epidemiologic studies depression scale for children, CES-DC

The Center for Epidemiological Studies for Children (CES-DC) (29) was used to assess depressive symptoms in participants during the past week. Dimensionality and factorial invariance were also investigated (30). Radloff (31) designed the scale. In addition to being widely used worldwide, the CES-DC has been applied to Chinese adolescents with good reliability and validity (32). The CES-DC includes four dimensions: depressed affect (8 items), positive affect (4 items), somatic symptoms and related activity (6 items), and interpersonal (2 items). Each item is answered on a four-point scale (0 = very little or no time, 1 = some or a little time, 2 = moderate or most of the time, and 3 = most or all of the time). A total score of 15 shows no depression symptoms, a total score of 16 to 27 suggests the possibility of depressed symptoms, and a total score greater than 27 indicates confirmed depressive symptoms. Participants who had both

the likelihood of and definite depression symptoms were deemed to have depressive symptoms (33). The Cronbach's α of this study is 0.84.

2.3.3 Demographics and COVID-19 infection history

The demographic data consists of nine items: age (year), gender (boy or girl), self-evaluation of caregiver relationship (Do you have a good relationship with your caregivers? “1 “means very bad,” 10 “means very good”), place of residence (urban and rural), sleep duration, exercise time, and duration of online classes during the pandemic (From the COVID-19 Pandemic to the Back-to-School Period, how long were your daily sleep/exercise time and duration of online classes respectively?), history of COVID-19 infection (Have you or your family members been infected by COVID-19?).

2.4 Data analysis

SPSS (version 22.0) and Mplus (version 7.3) were used to analyze the data. Descriptive statistics include mean and standard deviation (SD) for continuous variables, whereas categorical variables include frequency and percentage. *T*-test, Chi-square, and logistic regression models were used to analyze the connection between depression symptoms and NSSI. Data that do not follow a normal distribution are represented by the median and quartile, replace the *t*-test with the Wilcoxon signed rank sum test. Cross-lagged analysis was utilized to explore the bidirectional relationship between depressive symptoms and NSSI. To assess overall model quality and path significance, a variety of fit indices were used, including χ^2/df (degrees of freedom), Root Mean Square Error of Approximation (RMSEA), CFI (Comparative Fit Indices), and TLI (Tucker Lewis Index). When χ^2/df is less than 5.0, the CFI and TLI are all greater than 0.95 and the RMSEA is less than 0.05, as a good fit, the longitudinal cross-lagged route model is supported (34). Furthermore, the model demonstrates that the proposed model can accurately reproduce the observed longitudinal data. All statistical tests used were two-sided, and a *p* value of less than 0.05 was considered statistically significant.

3 Results

3.1 Demographic profile of study participants

The study used two waves of data-complete samples, with 6,023 adolescents aged 10 years and older included in the survey. The oldest was 17 (Mean age = 11.63, SD = 1.54, at Wave 1). 3,121 boys (51.82%) and 2,902 girls (48.18%) were included. 5,048 adolescents (89.78%) assessed their relationship with caregivers as good (≥ 5 points), and 615 adolescents (10.21%) assessed such relationship as bad (< 5 points). 3,679 (61.08%) of all adolescents included resided in urban areas, while the rest 2,344 (38.92%) lived in rural regions. During the pandemic, adolescents' average daily sleep duration was 8.64 (1.50) hours, their average physical exercise duration was 1.55 (1.41) hours, and their average online class duration was 5.64 (2.92) hours. COVID-19 infected 111 people (1.84%) and 732 households (12.15%) lost their jobs.

TABLE 1 Occurrence of NSSI in adolescents with different demographic characteristics ($N = 6,023$).

Demographic characteristics	Number of people		Number of NSSI occurrences (Incidence%)		χ^2/T		p	
	W1	W2	W1	W2	W1	W2	W1	W2
Age	6,023							
Gender					10.54	45.49	<0.01	<0.01
Boy	3,121		924 (29.61)	863 (27.65)				
Girl	2,902		972 (33.49)	1,037 (35.73)				
Depressive symptoms					568.61	697.03	<0.001	<0.01
Yes	1969	2064	1,023 (44.34)	1,103 (53.44)				
No	4,054	3,959	873 (21.53)	797 (20.13)				
Self-perception of relationship with caregivers					0.05	267.35	>0.05	<0.01
≥5points	5,452	5,407	1714 (31.44)	1,527 (28.04)				
<5points	571	616	182 (31.87)	373 (60.55)				
Place of residence					6.30	26.53	<0.01	<0.01
City or town	3,679	1,114 (30.28)	1,070 (29.08)					
Rural area	2,344	782 (33.36)	830 (35.41)					
COVID-19 infection history				/		0.38	/	>0.05
Yes	/	111	/	38 (34.23)				
No	/	5,912	/	1862 (31.50)				
Unemployed due to COVID-19				/		6.09	/	<0.01
Yes	/	732	/	260 (35.52)				
No	/	5,291	/	1,640 (31.00)				

W1 = At baseline; W2 = At follow-up.

TABLE 2 The alteration of NSSI and depressive symptoms at baseline and follow-up ($N = 6,023$).

Grouping	At baseline	At follow-up	Wilcoxon signed the rank sum test	
	M ± SD/ Median (Quartile)	M ± SD/ Median (Quartile)	T	p
NSSI	0 (0, 1.26)	0 (0, 2)	4.43	<0.01
Depressive symptoms	14.15 ± 10.34	14.55 ± 10.90	−3.09	<0.01

M, Mean; SD, Standard Deviation.

After performing a normality test, we found that the NSSI data did not meet the requirements. Therefore, logarithmic transformation was performed on the NSSI data. At baseline, 29.61% of boys and 27.65% of girls reported NSSIs; at follow-up, the statistics were 33.49 and 35.73%, respectively. Among students with depressive symptoms, the occurrence rate of NSSI was 44.34 and 53.44%, respectively, and the occurrence rate of NSSI increased in both surveys. The occurrence of NSSI decreased among students without depressive symptoms (Table 1).

3.2 The alteration of NSSI and depressive symptoms at baseline and follow-up

A paired t-test of depressive symptoms was conducted to assess the differences between baseline and follow-up. The Wilcoxon signed-rank sum test was used for NSSI. The NSSI scores showed a statistically significant difference between the baseline and follow-up periods, and the same was observed for depression symptoms, with an increase in scores compared to the previous period ($p < 0.01$) (Table 2).

McNemar et al. suggested an increase in the incidence of NSSI in adolescents (37.71 to 38.32%); however, the difference was not statistically significant ($p > 0.05$). The occurrence rate of depressive symptoms among adolescents was higher than that at baseline (32.69–34.27%, $p < 0.01$) (Table 3).

3.3 The alteration of depression symptoms scores in different dimensions at baseline and follow-up

The test of normality for the four dimensions of depressive symptoms showed that the vast majority of points could be distributed on a straight line with a clear linear trend, and the continuous data could be considered as obeying a normal distribution. Data analysis using independent samples T-test. According to the analysis from the

TABLE 3 The alteration of the occurrence rate of depression in adolescents at baseline and follow-up.

W2	W1		Total number(%)	χ^2	<i>p</i>
	NSSI/Depressive symptoms	Non-NSSI/Non-depressive symptoms			
NSSI	1,609	699	2,308 (38.32)	0.94/5.53	0.33/<0.05
Non-NSSI	662	3,053	3,752 (62.29)		
Depressive symptoms	1,201	863	2064 (34.27)		
Non-depressive symptoms	768	3,191	3,959 (65.73)		
Total number(%)	2,271 (37.71)/1969 (32.69)	3,715 (61.68)/4,054 (67.31)	6,023		

TABLE 4 The alteration of depression symptoms scores in different dimensions at baseline and follow-up.

variables	Group	W1				W2			
		Mean	SD	<i>T</i>	<i>p</i>	Mean	SD	<i>T</i>	<i>p</i>
Depressed affect	Non-NSSI group	2.67	3.64	−32.04	<0.001	2.62	3.82	−34.29	<0.01
	NSSI group	6.62	5.82			7.02	6.04		
Positive affect	Non-NSSI group	5.74	3.76	−11.44	<0.001	5.93	3.86	−12.65	<0.01
	NSSI group	6.90	3.35			7.22	3.22		
Somatic and related activity	Non-NSSI group	2.41	2.87	−29.16	<0.001	2.38	3.06	−31.56	<0.01
	NSSI group	5.11	4.16			5.44	4.29		
Interpersonal	Non-NSSI group	0.59	1.18	−22.44	<0.001	0.56	1.18	−24.85	<0.01
	NSSI group	1.46	1.77			1.53	1.82		

independent sample test, differences exist in the scores of depressed affect, positive affect, somatic and related activity, and interpersonal relationships between the depressive group and the non-depressive group ($p < 0.01$) (Table 4).

3.4 Binary logistic regression analysis revealing effect on NSSI

Taking whether adolescents commit NSSI as a dependent variable while considering gender, age, depression measurement factors, duration of sleep, duration of exercise, duration of online class, self-perception of relationship with caregivers, residence, and whether unemployed due to COVID-19 as the independent variables, a binary logistic regression analysis (forward: LR method) was conducted. The introduction level was 0.05 and the exclusion level was 0.1. The statistical results showed that among adolescents, females, age, duration of the online class, self-perceived poor relationship with caregivers, depression mood, somatic and related activity were the risk factors for NSSI (or > 1 , $\beta > 0$), living in rural area, sleep duration and positive mood was the protective factor (or < 1 , $\beta < 0$) (Table 5).

3.5 Longitudinal, bilateral relations between NSSI and depressive symptoms

A cross-lagged model was used to explore the longitudinal relationship between depressive symptoms and self-injury, with gender and age as control variables. Variables were non-normal data and parameter estimation was performed using the MLM, provided a good fit ($\chi^2/df = 2.74/3$, CFI = 0.996 > 0.95 , TLI = 0.993 > 0.95 , RMSEA = 0.017 < 0.05).

Figure 1 illustrates the normalized coefficients for all model paths. At seven-month intervals, NSSI and depression symptoms were associated, with correlation coefficients of 0.77 ($p < 0.05$) and 0.27 ($p < 0.01$), respectively. A steady association was found between pre-pandemic NSSI and post-pandemic NSSI, implying that pre-existing NSSI can predict subsequent ($\beta = 0.53$, $p < 0.05$). The same was true for depression symptoms ($\beta = 0.43$, $p < 0.05$). There was a significant lag effect of adolescents' depressive symptoms on NSSI, meaning that the deeper the adolescents were depressed, the more frequent their NSSI was, controlling for the adolescents' baseline NSSI ($\beta = 0.26$, $p < 0.01$). There was also a lag effect of NSSI on depressive symptoms ($\beta = 0.02$, $p < 0.01$). However, depressive symptoms were more predictive.

TABLE 5 Results of binary Logistic regression analysis revealing effect on NSSI.

Factors	B	S.E.	Wald	Significance	Exp (B)	95% C. I	
						Lower	Upper
Constant	−3.49	0.40	76.37	<0.01	0.03		
Gender = female	0.34	0.07	26.73	<0.01	1.41	1.24	1.60
Age	0.05	0.02	5.66	0.017	1.06	1.01	1.10
sleep duration	−0.09	0.02	14.68	<0.01	0.92	0.87	0.96
Duration of online classes	0.27	0.01	515.23	<0.01	1.31	1.28	1.35
Place of residence = rural area	−0.30	0.07	20.18	<0.01	0.74	0.65	0.84
Self-perception of relationship with caregivers = Bad	0.53	0.11	23.76	<0.01	1.70	1.37	2.10
Depression mood	0.11	0.001	87.95	<0.01	1.12	1.09	1.15
Positive mood	−0.06	0.01	37.23	<0.01	0.94	0.93	0.96
Somatic and related activity	0.07	0.02	21.13	<0.01	1.08	1.04	1.11

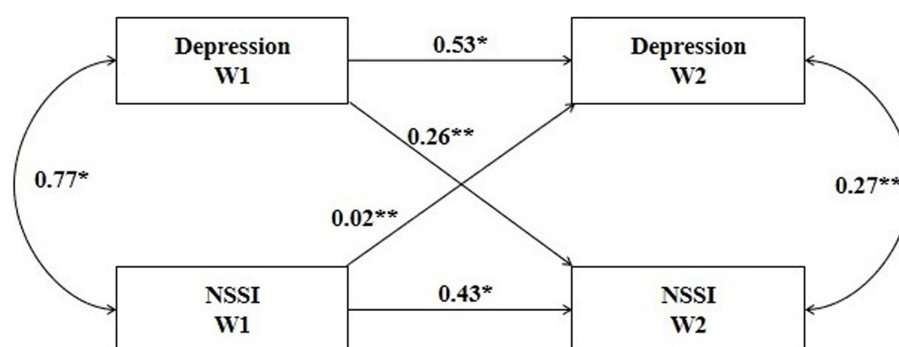


FIGURE 1

The cross-lagged model between NSSI and depressive symptoms. Using sex and age as control variables, the two-way arrow in the chart indicates the result of correlation analysis, with the data of correlation coefficient; the one-way arrow indicates the result of path analysis, with the data of standardized regression coefficient (β). * $p < 0.05$. ** $p < 0.01$. Depression W1: depressive symptoms at baseline; Depression W2: depressive symptoms at follow-up; NSSI W1: NSSI behavior at baseline; NSSI W2: NSSI behavior at follow-up.

4 Discussion

To our knowledge, the hypothesis that “an increase in the prevalence of depressive symptoms and prevalence of NSSI with depressive symptoms” was confirmed. Adolescents had relatively high rates of depressive symptoms (32.69 to 34.27%) and NSSI with depressive symptoms (44.34 to 53.44%). These findings enrich theoretical research on teenage mental health and NSSI in the context of the COVID-19 pandemic. First, this study did not find an increased incidence of NSSI during the COVID-19 pandemic. Nevertheless, the NSSI scores showed statistically significant differences between baseline and follow-up. Prolonged exposure to the uncertainty of infection may trigger vulnerability in adolescents and lead to changes in NSSI from the pre-pandemic period to several months later. There was an increased incidence of NSSI among adolescents with depressive symptoms. This suggests that adolescents with preexisting mental

distress perceived the negative events that occurred during COVID-19 as more stressful, which may have contributed to their increased likelihood of participating in NSSI (6, 35). Specifically, adolescents with prior depressive symptoms, relatively high rates of internalizing problem behaviors, and poorer emotional regulation experienced more COVID-19-related stress and were at a higher risk of engaging in NSSI.

NSSI and depressive symptoms in adolescents before COVID-19 predicted these issues after COVID-19. Studies have shown that underlying psychological and psychiatric problems usually occur after disasters, the most common being depression (36, 37). If this theory were applied to the pandemic, we could infer that adolescents who had never experienced mental illness before COVID-19 may experience psychiatric symptoms such as depression, distress, stress, and anxiety. Groups that had previously suffered psychological distress may have exacerbated

preexisting mental and emotional distress (38, 39). However, adolescents are emotionally vulnerable and easily stimulated by negative life events to experience emotional outbursts, which, in turn, produce several negative emotions. When there is an inability to regulate negative emotions, they may resort to NSSI to transfer them. According to the experiential avoidance model proposed by Chapman et al., NSSI can provide temporary relief from adolescents' negative emotions. Nevertheless, when adolescents are again exposed to negative emotional stimuli, they tend to use NSSI for relief, which continuously facilitates the occurrence of NSSI (40). Based on this theory, adolescents with pre-existing vulnerabilities may be more stressed in the face of the COVID-19 pandemic and are at a higher risk of engaging in NSSI. This study also found that NSSI was a predictor of depressive symptoms. NSSIs such as cuts or burns may be a coping mechanism for those experiencing emotional distress or mental health problems. These behaviors may provide temporary relief; nonetheless, they do not address the root cause of distress and can instead lead to feelings of guilt, shame, or despair—common symptoms of depression. Thus, adolescents participating in NSSI are more likely to experience depressive symptoms.

Data from this study found that adolescents who had engaged in the NSSI scored higher on all dimensions of depressive symptoms than those who had not participated in the NSSI; the highest and lowest scores were for depressed affect and interpersonal, respectively. Depression symptoms are primarily defined as emotional problems characterized by a predominantly depressed state of mind, ranging from mildly negative emotional experiences to severe mood disorders (41). In turn, depressive symptoms are associated with chronic dopamine downregulation, which can be accompanied by psychomotor inhibition, and may have a synergistic effect on clinical deficits in adolescents' affective, cognitive, and motor behaviors, leading to unresponsiveness, reduced speech and movement, reluctance to communicate with others, and enjoyment of solitude, all of which are harmful to adolescents' interpersonal development (42, 43). Regression analyses revealed that depressed mood and somatic and related activities were risk factors for NSSI. Adverse life events that are usually capable of directly causing negative emotional experiences are risk factors for prompting and maintaining NSSI in adolescents (44).

Adolescents' self-perceptions of their relationship with their caregivers are predictors of NSSI, and adolescents who perceive themselves as having a poor relationship with their caregivers are more likely to engage in NSSI. Studies have shown that dysfunctional family environments increase the risk of NSSI and that parental conflict and parent-child conflict are associated with a range of psychological problems in adolescents (45, 46). The duration of online classes during the pandemic was also a predictor of NSSI, and the fact that parents had to support their children's homeschooling while working at home may have increased the risk of parent-child conflict. Past theories on the psychological effects of an approaching disaster have predicted how the place of residence will affect mental health, namely "psychological typhoon eye" (47). The results of this study support the psychological typhoon-eye effect, as adolescents living in rural areas have a lower risk of developing NSSI than those living in urban areas, regardless of whether or not these adolescents have depressive symptoms. The potential explanation was a decrease in

social contact. During the pandemic, adolescents have been forced to reduce their social contacts, and involuntary reductions in social contact may cause more suffering among socially active urban adolescents than among rural adolescents. NSSI may also increase as a result of limited social contact, especially among those who are mentally vulnerable. Gender was one of the predictors of adolescent NSSI during the pandemic, consistent with previous findings (48).

Positive emotions were also found to be positive predictors. Evidence from previous studies suggests that disasters and pandemics can stimulate social cohesion and solidarity (49, 50). For example, after the outbreak of severe acute respiratory syndrome in Hong Kong in 2003, residents' sense of belonging to friends and family increased (51, 52). Therefore, we believe that, in the context of the pandemic, the widely shared experience of combating the pandemic may enhance social cohesion and intimacy, which may change adolescents' views on death and health. Adolescents who develop psychological disorders may experience a climate of social support during difficult pandemic prevention. During the COVID-19 pandemic, people supported the government's strategies and measures to prevent and control the pandemic, the community provided help for survival and medical supplies for the sealed control area, and healthcare workers stood firm on the frontline of the fight against the pandemic. Such positive feedback may promote adolescents' psychological functioning and lead to positive psychological changes. This study also found that sleep duration has an important protective effect against NSSI. Previous studies have identified poor sleep quality and frequent nightmares as important risk factors for NSSI. A study of 223 adolescents with self-harming behaviors found that 2% had serious sleep problems (53). However, adolescents with sleep disorders usually experience NSSI mediated by mood disorders. Shorter sleep duration is directly related to depression (54). Lack of sleep can lead to decreased mood regulation, and chronic sleep deprivation may increase the risk of depression and trigger NSSI.

To conclude, adolescents with NSSI have worse depressive symptoms, and adolescents with depressive symptoms are at higher risk for NSSI; they should be the primary group for attention and intervention. Timely attention should be paid to the negative emotions of adolescents, and screening for depression, as well as their assessment and treatment, should be conducted. For adolescents with NSSI, it is important to intervene as early as possible and provide effective psychological support from schools, families, and society to help them realize the value of life. Finally, it is necessary to develop the mental toughness of young people and improve their abilities to withstand stress and adversity.

5 Limitations

This study had several limitations. To begin, the duration of the follow-up research was 7 months, which is short but fair because we collected data before and after the school shutdown in Chengdu. Furthermore, the Center for Epidemiological Studies for Children (CES-DC) instrument is a self-report screening scale rather than a diagnostic tool, which may be a major limitation. It assesses the intensity of depressive symptoms over the previous week, which is also

a short timeframe for making a diagnosis. Finally, as this study collected data using a self-administered questionnaire, there may be some confounding issues, such as remembrance bias and report bias, which could have affected the stability of our study's longitudinal connection. Further advancements are required in future research. Additionally, the sampling technique for this study was divided geographically, while the discussion was held in urban and rural areas. The use of sample data is insufficient, and there may be conflicting data.

6 Conclusion

Reciprocal effects between depression symptoms and NSSI among Chinese adolescents were found in our study. The increasing trend in the incidence of depressive symptoms and NSSI with depressive symptoms before and during the pandemic, demonstrates that COVID-19 may have had some impact on the mental health of adolescents. The current study also reveals that sleep duration and positive emotions are protective factors for NSSI. Sleep duration is essentially a modifiable influence on depressive symptoms and can also alter the NSSI. Positive emotion, as an intrinsic psychological trait, suggests that future research could already be conducted from a positive psychology perspective, focusing on the positive traits of adolescents.

Data availability statement

The datasets generated and/or analyzed during the study are not publicly available due to reasons of sensitivity e.g. human data. Anonymized data can be made available from the corresponding author on reasonable request.

Ethics statement

The studies involving humans were approved by The study protocol was approved by the Medical Ethics Committee of Sichuan University (Ethics No. K2020025). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

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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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Anxiety disorders among children and adolescents during COVID-19 lockdowns and school closures: a cross-sectional study in Kuwait

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Introduction: Investigating the epidemiology of mental health disorders resulting from COVID-19 intervention measures, primary school closures, and social isolation in children and adolescents needs to be prioritized over adults at the post-pandemic stage. Most preliminary psychosocial studies conducted during the pandemic have demonstrated that younger age groups are the most vulnerable to such implications. Thus, this study aims to estimate the probable prevalence of specific anxiety disorders in children and quantify their relationships with relevant demographic risk factors.

Methods: We used a cross-sectional study comprising 430 children aged between 8- and 18 years old living in Kuwait during the period of school closures as well as full and partial lockdowns. The survey included questions about participants' characteristics, children's anxiety using the Screen for Child Anxiety Related Emotional Disorders Questionnaire (SCARED) scale, and children's emotions and behaviours using the Strengths and Difficulties Questionnaire (SDQ). Univariate and multivariate logistic regression analyses were used to summarize the demographic and characteristics of the participants and their association with general, social, and generalized anxieties, as well as behavioural and emotional difficulties.

Results: We inferred that 24.83% of our participants had at least one anxiety disorder, while 20.19% were classified as abnormal on the SDQ scale. Our multivariate analysis revealed that lockdown duration and sex of the child were consistently significant predictors (p -values < 0.05) of the broad spectrum of selected mental disorders. Additionally, we inferred notable increases in the likelihood of mental disorders associated with the increased duration of lockdowns.

Conclusions: Our findings revealed preliminary insights into the vulnerability of young populations to the indirect negative impacts of strict public health measures during pandemic emergencies. Thus, authorities should consider such implications when planning and implementing similar interventions in future pandemics.

KEYWORDS

anxiety, mental health, pandemic, children, COVID-19, lockdowns, school closures

1 Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has posed an unparalleled threat to public health and the economy on a global scale. In addition to the physical health implications of COVID-19, past studies showed that non-pharmaceutical interventions such as lockdowns, social distancing, school closures, and self-isolation were also detrimental to the mental health of the general population, particularly adolescents and children (1, 2). This is not surprising since the COVID-19 pandemic has already been characterized as a mass trauma event by the international communities for trauma research. This is reflected by the fact that it suddenly forced populations to change the fundamental features of their conventional anthropological nature (3, 4). Additionally, the prolonged enforcement of public health interventions (*i.e.*, for approximately two years) demanded remarkable changes in behavioral and cognitive aspects of daily life, resulting in a noteworthy increase in mental health illnesses surpassing the direct physical effects of COVID-19 infections (4, 5).

Stressors leading to mental disorders such as anxiety and depression resulting from the prolonged implementation of intervention measures may include a fear of being infected, frustration, boredom, inadequate supplies, lack of information and uncertainty, financial loss, and stigma (6, 7). However, studies have shown that while anxiety and depression rates were highest at the beginning of the implementation of lockdown measures, they both showed a stable decline over time, particularly among adolescents (5, 8). That said, identifying high-risk groups is critical in understanding the epidemiology of anxiety and depression in susceptible populations. For example, it was found that females reported notably higher rates of psychological distress during the early phase of the pandemic than males (3, 8). Additionally, depression and anxiety rates were higher among young adults aged less than 35 compared to older age groups in the United Kingdom (9, 10). Other risk factors identified during the pandemic included preexisting mental health conditions, socioeconomic status, employment status and self-reported loneliness (8–10).

Despite the remarkably lower hospitalization and death rates from COVID-19 among children (11, 12) due to the developing physiology of their immune system (13), they were the most vulnerable to the devastating psychological implications of the pandemic and intervention measures (14). Children start to be preceptive of the changes occurring in their environment by age two (15). Furthermore, children who stay at home away from their distant family members, friends, and school can experience fear, anxiety, distress, and social isolation due to the fear of infection and the uncertainties surrounding the pandemic status (14, 16). Additionally, the parents' stress during the quarantine and social isolation at home can amplify the adverse psychological effects on children and lead to an abusive environment (17). This can lead to short or long-term effects that are detrimental to their brains' growth and development (18). Common changes observed in children's behavior include excessive crying, increased sadness, difficulties with concentration, and changes in activities they enjoyed in the past (19). Thus, pandemics can negatively influence children's psychological health (20), leading to more significant percentages of anxiety and depression (21). In fact, a remarkable 81% increase in children and young people's referrals to mental health services was observed in 2021 compared to 2019 (22). In addition, a global survey by the United Nations International Children's Emergency Fund (UNICEF) revealed that 1 in 5 young people reported depression symptoms in 2021 (23). This high prevalence of anxiety and depression among children and young people has led to an estimated net loss to the global economy of approximately \$390 billion a year since the start of the Pandemic (23).

While the role of school closures in reducing the community transmission of COVID-19 remains inconclusive (24), many studies suggested that such an intervention measure was a fundamental cause of mental illness among children and adolescents (25–29). In addition to the direct effect of interruptions in the education cycle, international educational organizations have highlighted their concerns about the long-term harmful effects of COVID-19 school closures on generations of students worldwide regarding mental health and economic implications (30, 31). This is not surprising since school environments are the cradles of social interaction between and among children and adolescents. Social

exposure, particularly in school environments, is essential for the healthy development of children and youths' mental and cognitive functions (29, 32). For example, it is known that anxiety-provoking and fear situations are critical components of the anxiety treatment (32), which were substantially limited to children and youths during the implementation of social restriction measures. Further, such measures also limited access to school services such as meals, physical activities, social consultation, and surveillance of children for neglect or abuse (28).

Despite the notable global drops in deaths and hospitalizations, the number of epidemiological studies investigating the short-term physical impacts of COVID-19 infection remains considerably more significant than its psychological impacts. Thus, local and regional observational studies on the short- and long-term adverse effects of COVID-19 intervention measures on the mental health of children and youths need to be prioritized over adults at the post-pandemic stage. This is because children's symptoms of mental illness are often not observed or notably expressed like adults, and they have fewer experiences and resources to cope with stressful environments like the pandemic situation. In addition, it was shown that public health measures like quarantine and social isolation were significant predictors of future mental illness in children and adolescents (33). The few regional studies conducted in the Middle Eastern countries revealed a notable prevalence of anxiety and depression among children and young adolescents (34–37). These prevalences were either slightly higher or similar to what has been estimated elsewhere (38, 39) within few decades before the pandemic in the region. Here, we used a cross-sectional study to investigate the prevalence of anxiety disorders during the peak implementation of the pandemic intervention measures among children in the State of Kuwait. More explicitly, we estimated the prevalence of specific anxiety disorders in children and quantified their relationships with relevant demographic risk factors and the implemented public health measures. Here, we present the first epidemiological picture of different anxiety disorders in Kuwait. Thus, the findings of our study are critical for guiding the development and implementation of targeted post-pandemic psychological disorders intervention programs for high-risk groups.

2 Methods

2.1 Participants

We used an observational cross-sectional study comprising children aged between 8- and 18-years old living in the state of Kuwait between April 2020 and July 2020, covering the period of school closures and full and partial lockdowns screening for anxiety disorders. We selected our age group based on the requirements of the data collection instruments described below. The COVID-19 lockdowns in Kuwait started as partial lockdowns (or curfews) for 12 hours daily on March 22nd 2020 (*i.e.*, between 5 pm and 4 am). Then, on May 10th, 2020, the partial curfew was transitioned to a full curfew until May 31st 2020. The full curfew was followed again by partial curfew till April 2021. During the pandemic, schools in Kuwait were closed for in-person learning from the 1st to 12th

grades between February 2020 and October 2021 (*i.e.*, approximately 18 months). Online schooling was implemented in August 2020, and it was a mixture of full and customized schedules depending on the type of school (*e.g.*, private or public/primary or secondary).

We could not use, for example, a cluster sampling strategy through random selection of the schools due to COVID-19 closures and the limited availability of their electronic resources and contact information that may have facilitated the distribution of the questionnaires. We collected the data through an anonymous structured survey disseminated nationwide through local social media platforms (*i.e.*, WhatsApp and Instagram) using convenience and snowball sampling involving no contact with responders. Our final inclusion criteria included children between 8- and 18- years old, with a literate guardian (*i.e.*, the person who is legally responsible for the child's care and filled out the questionnaire), living in Kuwait during the implementation of covid-19 measures, and having internet access. At the end of the survey period, we collected a total of 520 complete responses, of which 430 participants fulfilled the inclusion criteria. Thus, our final sample size has an estimated power of, approximately, greater than 90%, assuming that the prevalence of psychological disorders is 10% and the margin of error is 5%.

2.2 Ethical approval and consent

This study was approved by the Kuwait Ministry of Health (MoH) ethics committee (approval number 2020/1470), and all related research activities were performed in accordance with the committee's guidelines. Parents of the participants received an online information/consent form to read and approve before starting the survey. Parents who signed the consent were allowed to access the study questionnaire. Thus, we confirm that an informed consent from the parent and/or legal guardian for study participation has been obtained from all participants.

2.3 Data collection and evaluation tools

We used a structured questionnaire (see [Supplementary Files 1, 2](#)) comprising three major domains, including questions about participants' characteristics, child anxiety using the psychometric properties of the Screen for Child Anxiety Related Emotional Disorders Questionnaire (SCARED; parent version), and child emotions and behaviors using the Strengths and Difficulties Questionnaire (SDQ; parent version). We used a certified academic translator to translate the questionnaire from English to Arabic and made it available to participants in both languages (see [Supplementary Files 1, 2](#)). The consistency, comprehensiveness, and clarity of the questionnaire were evaluated by a panel of experts consisting of university faculty, schoolteachers, and child psychiatrists. The Arabic versions of the questionnaires of the SCARED and SDQ rating scales and their morbidity cut-offs have been validated elsewhere (40, 41). The SCARED parent rating scale had an estimated Cronbach alpha reliability coefficient (α) = 0.91,

representing a robust internal consistency. Furthermore, the SDQ had an acceptable estimated value for the area under the curve (AUC = 0.84 for the total impact and 0.81 for the total difficulties), representing the ability to distinguish between community and clinical samples. Moreover, we piloted both language versions of the questionnaire to 20 members of the general community to evaluate its length, clarity and consistency. Arabic SCARED and SDQ demonstrated satisfactory psychometric properties in our piloted sample. The participants' characteristics domain included 25 questions divided into two sections. The first section covered the socio-demographic information for the parents and the child (e.g., age, sex, income, and education). At the same time, the second section consisted of questions related to the status of covid-19 intervention measures (i.e., lockdown status and duration), guardians' and the child's past diagnoses of mental illnesses, job status during the pandemic, the child's screen time behavior, and their coping strategies.

The SCARED rating scale (42) is a child and parent self-report instrument explicitly used to screen for anxiety disorders in children aged between 8 and 18 years old, including general anxiety disorder, separation anxiety disorder, panic disorder and social phobia. In addition, it assesses symptoms related to school phobia. The SCARED consisted of 41 items and 5 factors that parallel the Diagnostic and Statistical Manual of Mental Disorder IV (DSM-IV) classification of anxiety disorders. Each item is rated on a 3-point scale coded as 0 points for hardly ever true, 1 point for somewhat true or sometimes true, and 2 points for very true or often true. The rating scale of all items sums between a minimum of 0 and a maximum of 82 points. In this study, we selected general anxiety disorder as the primary outcome while generalized and social anxieties as the secondary outcomes, based on the relevance of these outcomes to the implemented intervention measures, such as lockdowns and school closures. It is worth noting that general anxiety disorder is defined as the child having any of the broad spectrum of disorders described above, in addition to the normal anxiety that results from everyday stressors. In contrast, generalized anxiety disorder is more specific and defined as a child having excessive paranoia, fear, and tension from any stressors and may require psychiatric intervention (42). However, social anxiety disorder is defined as a child feeling excessively uncomfortable in everyday social situations and may also require an intervention.

We calculated the for each outcome to evaluate their internal consistency. An estimated α between 0.74 and 0.93 for the general scale and the subscale is considered a good internal consistency (42). In this study, we estimated an $\alpha = 0.92$ for the general scale, while α s = 0.85, and 0.86 for the generalized and social anxieties subscales, respectively. Furthermore, the score of each outcome was dichotomized into 0 and 1 based on the indicated cut-offs of the general scale (i.e., a total score of ≥ 25 indicates the presence of an anxiety disorder) and subscales (i.e., a cutoff of 9 and 8 indicates generalized and social disorders, respectively) for the subsequent statistical analysis.

We used the SDQ rating scale to screen different aspects of the child's behavioral and emotional aspects developed during the pandemic and associated with anxiety disorders (43). SDQ was designed to detect psychological disorders in children between 3

and 16 years old by assessing subscales related to emotional symptoms, prosocial behaviors, conduct problems, hyperactivity/inattention, and peer relationship problems (44). SDQ has a total of 25 items, in which each subscale is evaluated by 5 items. Like the SCARED rating scale described above, each item is rated on a 3-point scale, generating 10 points for each of the five subscales. Because we aimed to estimate the total difficulties score, we excluded the prosocial subscale, resulting in a total score of 40 and an estimated $\alpha = 0.80$. Then we used the original three-band categorization scheme, which classifies a score between 0-13 as normal (coded as 0), 14-16 as borderline (coded as 1), and 17-40 as abnormal (coded as 2).

2.4 Statistical analysis

We conducted all statistical analyses using Stata version 16.0 (45). Our final four outcome variables included the categorical forms of general, social, and generalized anxiety disorders extracted from the SCARED scales and the three-band categorical form converted from the SDQ total difficulties scale, as described above. At the same time, our predictors comprised participants' demographics and status before and during the pandemic. Thus, we summarized our variables using frequencies and relative frequencies and assessed their univariate relationships with each outcome using Chi-square tests (and Fisher's exact tests when a variable has a cell count less than 5). We used logistic regression analysis for each of the three selected anxiety disorders and ordinal regression analysis for the SDQ-generated outcome to model our multivariate relationships. We used a backward elimination strategy to choose our final models and assessed the statistical significance of all two-way interactions between the predictors in each model. Also, we evaluated the confounding effect of non-significant variables using the classical 10% change in the estimate method (46). Briefly, the backward elimination procedure starts with a model that includes all the variables (formerly known as the saturated model) and gradually removes the predictor with the least statistical significance (i.e., the largest P-values). Our strategy was based on keeping statistically significant predictors (P-values < 0.05) while maintaining the smallest Akaike Information Criterion (AIC) and accounting for confounding variables in the final model (46). Thus, when removing a nonsignificant variable changes the inferred Odds ratios (ORs) of other significant variables by more than 10%, that variable will be considered a confounder and kept in the model regardless of its statistical significance. Finally, the goodness of the fit of the final logistic regression models was evaluated using the Hosmer-Lemeshow statistic testing (HL test). HL test is commonly used in epidemiology to evaluate how well the data fits the final selected risk model. The null hypothesis of the HL test is that the selected model appropriately fits the observed data, while the alternative hypothesis indicates the model does not appropriately fit the data. Therefore, an inferred p-value greater than 0.05 concludes that the model fits well. Similarly, we used the approximate likelihood-ratio method to validate the proportionality of odds across response categories for the SDQ ordinal regression model. More explicitly, the method evaluates

TABLE 1 Baseline characteristics of enrolled participants and their univariate statistical relationships with the study outcomes (N = 430).

Characteristic	n (%)	Anxiety Disorder (n = 107; 24.83%)	Generalized Anxiety (n = 69; 16.00%)	Social Anxiety (n = 78; 18.09%)	SDQ ^a Abnormal (n = 87; 20.19%)
Demographics					
Guardian of the child					
Father	97 (22.51)	0.025*	0.038*	0.111	0.017*
Mother	315 (73.09)				
Other	19 (4.41)				
Number of children		0.267	0.025*	0.348	0.062
1 - 3	283 (65.66)				
4 - 6	124 (28.77)				
> 6	24 (5.57)				
Marital status		0.197	0.273	0.526	0.005*
Married	369 (85.61)				
Single	62 (14.39)				
Age of the guardian		0.380	0.360	0.196	0.554
16 - 34	11 (2.54)				
35 - 44	235 (54.52)				
45 - 54	144 (33.41)				
> 55	41 (0.93)				
Age of the child		0.831	0.597	0.589	0.119
8 - 11	64 (15.55)				
12 - 15	116 (26.91)				
16 - 18	248 (57.54)				
Sex of the child		0.001*	< 0.001*	0.018*	0.435
Female	202 (46.87)				
Male	229 (53.13)				
Father's education		0.004*	0.280	0.042*	< 0.001*
High school or less	58 (13.46)				
Collage	252 (58.47)				
Post-graduate	121 (28.07)				
Mother's education		0.033*	0.203	0.021	0.009*
High school or less	23 (5.34)				
Collage	260 (60.32)				
Post-graduate	148 (34.34)				
Monthly income (in USD)		0.463	0.004*	0.868	0.041*
< 2000	14 (3.25)				
2000 - 3000	74 (17.17)				
4000 - 5000	124 (28.77)				
> 6000	219 (50.81)				
Nationality		0.252	0.017*	0.445	0.120
Citizen	324 (75.17)				
Resident	107 (24.83)				
Participants and their children's characteristics during the pandemic					
Type of lockdown		0.147	0.131	0.801	0.045*
Partial	84 (19.49)				
Full	347 (80.51)				
Lockdown duration		0.001*	0.001*	0.002*	0.019*
< 28 days	159 (36.89)				
4 - 8 weeks	100 (23.20)				
8 - 12 weeks	69 (16.01)				
> 12 weeks	103 (23.90)				
Job status during the pandemic		0.060	< 0.001*	0.002*	< 0.05*
Less hours	97 (22.51)				
Paid leave	244 (56.61)				
Regular hour	29 (6.73)				
Unpaid leave	25 (5.80)				

(Continued)

TABLE 1 Continued

Characteristic	n (%)	Anxiety Disorder (n = 107; 24.83%)	Generalized Anxiety (n = 69; 16.00%)	Social Anxiety (n = 78; 18.09%)	SDQ ^a Abnormal (n = 87; 20.19%)
More hours Lost a job	20 (4.64) 16 (3.71)				
Child stress at home during the pandemic		< 0.001*	< 0.001*	0.005*	< 0.001*
Yes	248 (57.54)				
No	183 (42.46)				
Child mixing with covid-19 cases		0.353	0.097	0.706	0.454
Yes	14 (3.25)				
No	417 (96.75)				
Practiced coping strategies during the pandemic		0.065	0.245	0.060	0.011*
Yes	414 (96.06)				
No	17 (3.94)				
Child's screen hour prior to pandemic		0.806	0.595	0.182	0.002*
< 2 hours	159 (36.89)				
2 - 3 hours	141 (32.71)				
4 - 5 hours	76 (17.63)				
6 - 8 hours	25 (5.80)				
> 8 hours	30 (6.96)				
Child's screen hours during to pandemic		0.083	0.011*	0.332	0.275
< 2 hours	38 (8.82)				
2 - 3 hours	66 (15.31)				
4 - 5 hours	107 (24.83)				
6 - 8 hours	102 (23.67)				
> 8 hours	118 (27.38)				

*Significant p-value at 0.05; *Strengths and Difficulties Questionnaire
Significant p-values are boldfaced.

whether the inferred ORs between each pair of outcomes across two responses are the same. Non-significant P-values inferred by the approximate likelihood-ratio test indicate that the proportionality assumption is not violated.

3 Results

3.1 Participants' demographics and prevalence of the study outcomes

Table 1 summarizes the demographic data and their statistical relationships with the study outcomes. We found that participants (*i.e.*, guardians who filled out the questionnaire) were primarily mothers (73.1%) aged between 35 to 44 years old (54.5%) and have 1 to 3 children (65.7%). The participants' children were mostly aged between 16 and 18 (57.5%), while the proportion of males to females was almost similar (Table 1). Additionally, most of the participants had a college education (60%), Kuwaiti citizenship (75.2%), and a monthly income of over \$6000 (50.8%). During the lockdowns and when filling out the questionnaire, most participants were on paid leave (56.6%), experienced the full curfew measure (80.5%) and a lockdown duration of less than 28 days (36.9%).

Our median SCARED score was equal to 16 and ranging between 0 and 62 (Figure 1A), while the median for the SDQ scores was equal to 11 and ranging between 0 and 29 (Figure 1B). We inferred that 24.83% had at least one anxiety disorder. Additionally, results indicate that 16.0% and 18.1% of the children have generalized and social anxiety disorders, respectively (Table 1). We found that 20.2% of our participants were classified as abnormal on the SDQ total difficulties scale. Notably, results illustrate that approximately 8% and 15% of the participants either reported no past mental illness or didn't answer the related question, respectively, whilst their children were diagnosed with an anxiety disorder based on our SCARED rating scale (Figure 2A). Similarly, 5% and 15% of the parents either reported no past mental illness or didn't answer the related question, respectively, but their children were classified as abnormal on the SDQ scale (Figure 2B). It is worth noting that 57.5% of the parents reported that their children suffered from stress symptoms during the lockdowns. However, approximately 96% of the children did not mix with active COVID-19 cases, and their parents practiced coping strategies during the lockdowns. Moreover, we found a remarkable increase in the child's screen time during the lockdowns (*i.e.*, from 7.0% to 27.4% for greater than 8 hours of screen time; Table 1) compared to before the pandemic.

3.2 Univariate statistical relationships with the probable prevalences of study outcomes

Overall, our results suggest significant statistical relationships, inferred using Chi-square tests, between the presence of anxiety disorders (including generalized and social anxieties, as well as behavioral and emotional difficulties) and participants' demographics, such as the type of child's guardian, number of children, sex of the child, parents' education, monthly income, and nationality (p-values < 0.05; Table 1). Similarly, we found

statistically significant relationships (p-values < 0.05) between the probable prevalence of the study outcomes and children's characteristics under the pandemic restrictions, including lockdown type and duration, guardian's job status, child's stress symptoms, practicing coping strategies, and child's screen time before the pandemic. Nevertheless, our analysis highlighted the importance of family socioeconomic status and intensity of public health restrictions with the broad-spectrum prevalence of anxiety disorders (Table 1). This notion has been reflected through the strongly inferred statistical relationships (P-values < 0.01) with the characteristics of the participants under pandemic restriction

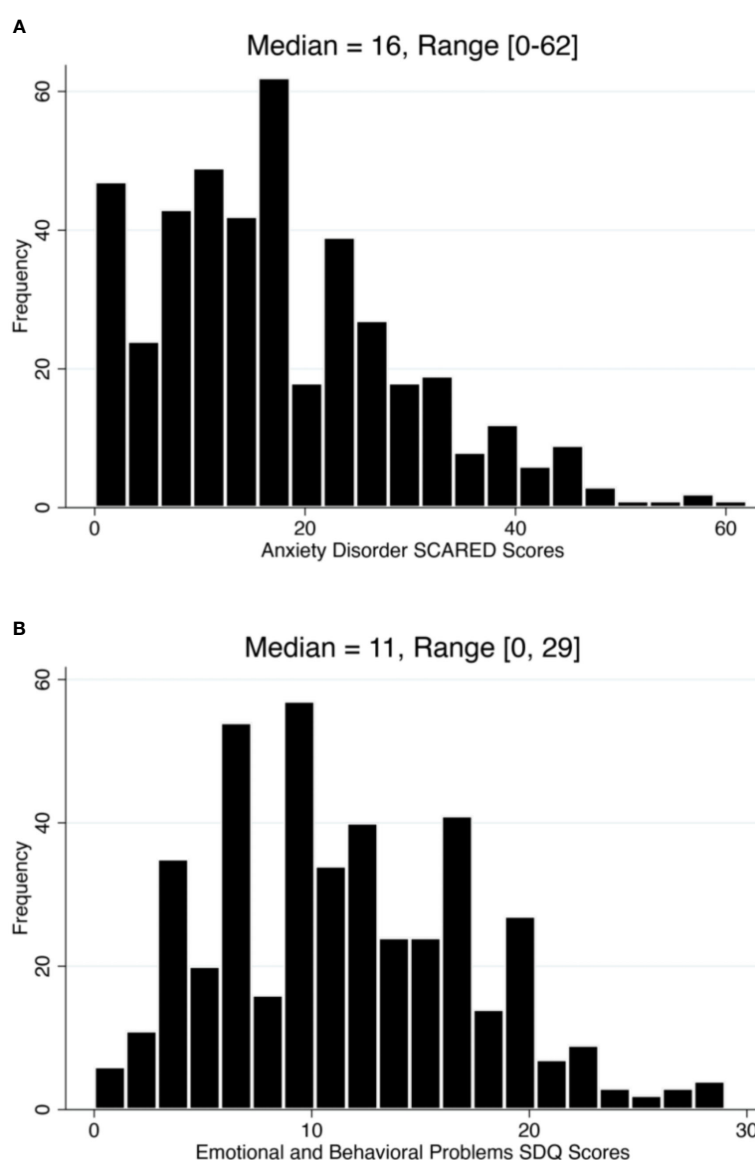


FIGURE 1

Distribution of anxiety disorders and psychosocial behavioral problems scores among children in the state of Kuwait between April and July 2020. (A) histogram showing the score distribution of general anxiety based on the Screen for Child Anxiety-Related Disorders (SCARED) rating scale. (B) histogram showing the score distribution of psychosocial behavioral problems based on the Strengths and Difficulties Questionnaire (SDQ) rating scale.

including lockdown duration, parents' job status, and observed symptoms of child stress.

3.3 Multivariate associations with child's anxiety disorders and behavioral and emotional difficulties

Our multivariate analysis (Table 2) suggests that the sex of the child (being female) and lockdown durations (increased durations) were consistently significant predictors (ORs > 1; p-values < 0.05) of all anxiety disorders. Further, we found that the sex of the primary guardian (*i.e.*, mainly when the guardian is the mother) was significantly associated with general anxiety disorders in children (OR = 1.90). In Addition, results indicate that guardians' job status, particularly those who worked for more extended hours or lost their job (OR = 6.0), and children exhibiting apparent signs of stress at home significantly increased the likelihood (ORs > 1; p-values < 0.05) of generalized and social anxieties.

Similarly, our ordinal regression results suggest that the guardian of the child, lockdown duration and the guardian's job status during the pandemic were significant predictors of SDQ three-band categories (Table 3). We inferred a remarkable increase in the likelihood of abnormal behavioral and emotional difficulties (OR = 2.25) when the child's guardian is the mother, as well as when the lockdown duration exceeds 8 weeks (ORs > 2.0). Also, we found notably high associations with abnormal behavioral and emotional difficulties (ORs > 4) when the guardian lost their job or worked for longer hours during the restrictions (Table 3).

4 Discussion

We used a cross-sectional study with two popular psychometric assessment tools to uncover the impacts of strict public health measures on children's mental health, such as lockdowns and school closures. To the authors' knowledge, this is the first study investigating the prevalence of different anxiety disorders and behavioral and emotional problems among children and young adults in Kuwait during COVID-19 lockdown measures. Here, we found notably significant associations between the prevalence of anxiety disorders, socioeconomic factors, and lockdown duration. These findings are not only critical for shedding epidemiological insights into children's psychological status during COVID-19 restrictions but also assist with the establishment of intervention programs against the long-term implications of such measures on the children's mental and physical health.

Our results revealed a remarkably high probable prevalence of anxiety disorders and psychosocial behavioral problems among children aged between 8 and 18 in Kuwait ($\geq 20\%$; Table 1). Our inferred prevalence of mental disorders was similar to past studies with larger samples from different populations (4, 47, 48). This is not surprising since social isolation and negative information from mainstream media, particularly during emergencies, were significantly associated with psychological disorders (49–51). However, our estimates did not substantially surpass what was

estimated before the pandemic in the region, which ranged between approximately 5% and 20% (39, 52). Yet, the Middle East continues to suffer from regional political conflicts and wars before and after the pandemic. Therefore, a comparative epidemiological analysis between the two periods is difficult to achieve, mainly when the

TABLE 2 Multivariate logistic regression model for the risk factors associated with different anxiety disorders.

Risk factor	Odds ratio	95% confidence interval	P-value
Anxiety disorder^a			
Guardian of the child	Reference = 1		
Father	1.90	(1.02, 3.57)	0.045
Mother	0.94	(0.23, 3.81)	0.933
Other			
Sex of the child	Reference = 1		
Male	3.01	(1.89, 4.75)	0.001
Female			
Lockdown duration	Reference = 1		
< 28 days			
4 - 8 weeks	1.49	(0.77, 2.86)	0.230
8 - 12 weeks	3.02	(1.54, 5.90)	0.001
> 12 weeks	3.24	(1.76, 5.97)	< 0.001
Generalized Anxiety disorder^b			
Sex of the child	Reference = 1		
Male	2.5	(1.4, 5.47)	< 0.001
Female			
Lockdown duration	Reference = 1		
< 28 days			
4 - 8 weeks	2.63	(1.10, 6.30)	0.029
8 - 12 weeks	3.32	(1.32, 8.31)	0.010
> 12 weeks	7.14	(3.15, 16.21)	< 0.001
Job status during the pandemic	Reference = 1		
Less hours	0.85	(0.41, 1.78)	0.678
Paid leave	0.11	(0.01, 0.90)	0.040
Regular hour	1.09	(0.32, 3.73)	0.884
Unpaid leave	4.04	(1.21, 13.45)	0.023
More hours	6.00	(1.71, 21.08)	0.005
Lost a job			
Child stress at home during the pandemic	Reference = 1		
No	2.98	(1.52, 5.81)	0.001
Yes			
Social Anxiety disorder^c			
Sex of the child	Reference = 1		
Male	2.11	(1.26, 7.98)	0.021
Female			
Lockdown duration	Reference = 1		
< 28 days			
4 - 8 weeks	3.67	(1.70, 7.94)	0.001
8 - 12 weeks	3.46	(1.50, 7.96)	0.003
> 12 weeks	4.33	(2.04, 9.18)	< 0.001
Job status during the pandemic	Reference = 1		
Less hours	2.95	(1.31, 6.64)	0.009
Paid leave			

(Continued)

TABLE 2 Continued

Risk factor	Odds ratio	95% confidence interval	P-value
Regular hour	1.28	(0.34, 4.81)	0.713
Unpaid leave	3.58	(1.05, 12.15)	0.041
More hours	2.60	(0.66, 10.30)	0.173
Lost a job	1.75	(3.21, 42.98)	< 0.001
Child stress at home during the pandemic			
No	Reference = 1		
Yes	1.99	(1.13, 3.54)	0.018

Hosmer – Lemeshow goodness-of-fit p-values = 0.14^a, 0.17^b, 0.16^c

Significant ORs (95% CI) and P-values are boldfaced.

population is consistently susceptible to environmental stressors and mental trauma (36, 38). That said, our estimated prevalence of anxieties in Kuwait is considered high and was significantly associated with the pandemic's characteristics, as described earlier.

Like past studies (16, 53–55), the sex of the child was a significant predictor of anxiety disorders (Table 2), in which their prevalence was substantially high in females. In fact, we found that female children are more likely to develop anxiety disorders than males (ORs > 2; Table 2). This aggravated prevalence of female anxieties during the pandemic has been attributed to the Middle Eastern sociocultural norms, school closures which led to their

social isolation, and exacerbated fear of losing their loved ones (53, 56). In fact, Middle Eastern sociocultural norms have been found to be a major cause of stigma toward mentally ill individuals and have acted as a barrier to seeking care or medical intervention (57). Indeed a remarkable percentage of the participants in this study either claimed no history of mental illness or did not answer the question, while their children were diagnosed with anxiety disorders using our rating scales (Figure 2). Thus, our result affirms the importance of increasing public mental health awareness and psychoeducation programs in the region, particularly during emergencies (58).

Nevertheless, it is worth noting that in this study, mothers reported substantially higher anxieties and behavioral problems in their children during lockdowns (Tables 1, 3). Furthermore, our results inferred that mothers are significantly more likely (ORs > 1; p-values < 0.05) to report mental disorders in their children than other guardians (Tables 2, 3). These findings are consistent with the notion that mothers' parenting distress could mediate additional mental disorders in their children, especially during emergencies (59). This might be attributed to maternal protective instincts, associated recall biases, and the additional burden of homeschooling. In fact, we found that most of these mothers had a college degree, which was significantly associated with them reporting mental disorders in their children (Table 1). Such participants are more likely to be working mothers, which adds an additional burden and distress to their parenting role during lockdowns (60).

While most of the guardians were on paid leave during the period of the study, we found significant relationships between children's mental disorders and their job status (Tables 1, 3). Also, job status was a significant predictor of generalized and social anxiety, psychosocial, and behavioral problems (Tables 2, 3). However, our multivariate analysis revealed that guardians who worked regular hours, their children are less likely to have generalized anxiety (OR = 0.11; p-value = 0.040; Table 2). This result might be attributed to the fact that the interaction between parents and children during the day is on a normal basis, and therefore, children are less likely to experience stressful negative encounters with their parents. In contrast, we found that guardians with paid leave and their children are more likely to have social anxiety (OR = 2.95; p-value = 0.009; Table 2). This can be either attributed to the parent being very protective of their children to keep them safe, hindering the development of their social skills, or the indirect impacts of school closures (56, 61). Despite the small number of guardians who lost their jobs due to the pandemic restrictions (Table 1), our multivariate analysis consistently showed that such economic implications substantially increase the likelihood (ORs > 1; p-value < 0.05; Tables 2, 3) of children having psychological disorders. Indeed, job loss, in addition to pandemic stress, was shown to have devastating impacts on the parent's mental health, which subsequently reflects on their children (62). Further, children with guardians working extra hours during the pandemic were more likely to have generalized anxiety and psychosocial behavioral problems due to the abnormal lack of parenting activities (Tables 2, 3). Also, one would consider the notion that the age of the child is potentially a significant

TABLE 3 Multivariate ordinal logistic regression model for potential risk factors associated with SDQ original categories.

Risk factor	Proportional ORs	95% confidence interval	P-value
Guardian of the child			
Father	Reference = 1		
Mother	2.25	(1.34, 3.78)	0.002
Other	1.58	(0.52, 4.77)	0.412
Lockdown duration			
< 28 days	Reference = 1		
4 - 8 weeks	1.65	(0.98, 2.79)	0.057
8 - 12 weeks	2.33	(1.35, 4.27)	0.003
> 12 weeks	2.40	(1.40, 4.27)	0.001
Job status during the pandemic			
Less hours	Reference = 1		
Paid leave	1.37	(0.83, 2.28)	0.214
Regular hour	1.18	(0.50, 2.76)	0.702
Unpaid leave	1.22	(0.48, 3.08)	0.664
More hours	4.15	(1.64, 10.47)	0.003
Lost a job	4.85	(1.66, 14.20)	0.004
Model Intercepts			
Normal vs. Borderline	1.81	(1.15, 2.46)	
Borderline vs. Abnormal	2.87	(2.18, 3.56)	

Approximate likelihood-ratio test of proportionality of odds across response categories, p-value = 0.6. Significant ORs (95% CI) and p-values are boldfaced

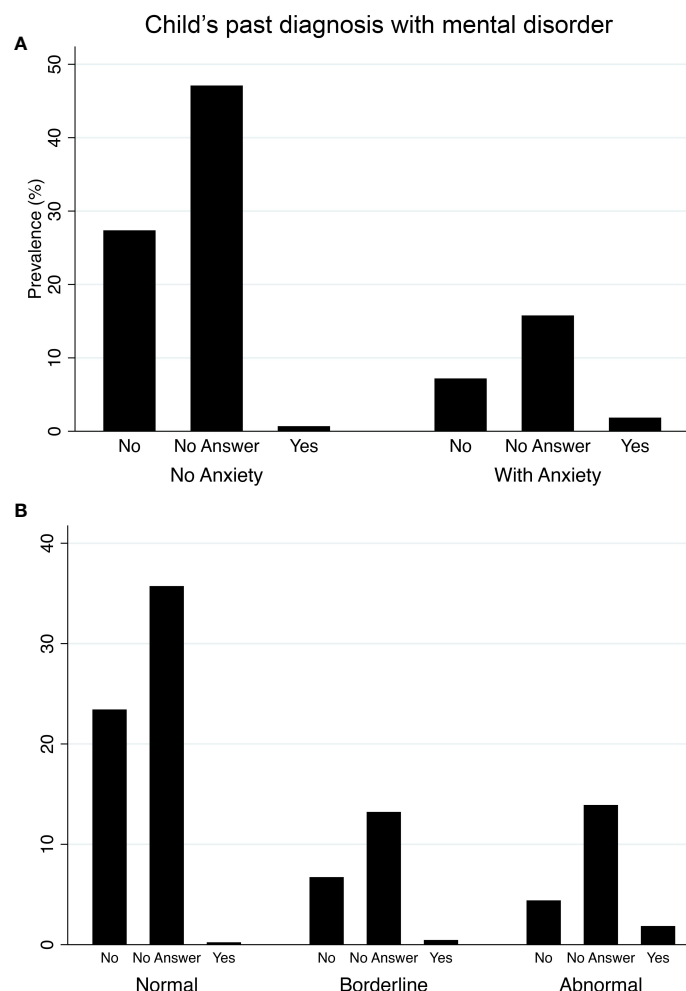


FIGURE 2

Prevalence of anxiety disorders and psychosocial behavioral problems among children in the state of Kuwait between April and July 2020 in relation to their past diagnosis prior to the pandemic. (A) bar chart showing the prevalence of general anxiety based on the Screen for Child Anxiety-Related Disorders (SCARED) rating scale. (B) bar chart showing the prevalence of psychosocial behavioral problems based on the Strengths and Difficulties Questionnaire (SDQ) rating scale.

predictor or a confounder over this relationship between child anxiety and the duration of parental social interactions due to job status. However, the result of our study consistently inferred that the age of the child has neither a significant statistical relationship (Table 1) nor a predictor (Tables 2, 3) with the study outcomes, as suggested elsewhere (59). This might be attributed to the fact that the age range (*i.e.*, between 8 and 18 years) does not sufficiently confound individual susceptibility to mental health disorders by being within that age group.

We found that the type of lockdown (*i.e.*, full or partial) was not a significant predictor of psychological disorders in children. Yet, the lockdown duration was consistently a significant predictor of anxiety and psychosocial, behavioral disorders (Tables 2, 3). Additionally, we inferred notable positive correlations in the ORs as the duration of the lockdowns increased, resembling a dose-response relationship (Tables 2, 3). Kuwait imposed a full lockdown on the 10th of May 2020 for three weeks, followed by prolonged irregular partial lockdowns till the 22nd of April 2021. These findings are consistent with past studies on estimating the

increased longitudinal trajectories of the prevalence of anxiety and depression among children and adults from such prolonged public health restrictions (8, 63). These studies also showed various outcomes among affected individuals from different risk groups (*e.g.*, the autistic population), including the worsening of their existing psychological disorders and the development of additional new mental disorders (5, 9).

Our study inferred a significantly high probable prevalence of psychological disorders among children from low-income families (Table 1). This indicates that the additive combination of prolonged school closures and low socioeconomic status constitute the highest risk factors for observing an increased prevalence of mental disorders among children during emergencies. This is because schools generally provide appropriate environments for childcare and enrichment activities, which are lacking in most low-income families (64). Additionally, such implications might also affect poorly performing students from all socioeconomic strata, primarily due to the prolonged school closures and the limitations of online education (53, 65). Although many families

in our sample practiced coping strategies (Table 1), we could not show consistent positive or protective effects that lower the prevalence of psychological disorders. This is expected since this is a cross-sectional study, and there were no public health awareness campaigns or education programs for coping with such emergencies, particularly during the first year of the pandemic. Yet, such circumstances and related consequences on children's mental health were similar elsewhere, on the levels of the Middle East (34, 36, 53) and the worldwide (4, 5). Finally, while children's screen hours during the pandemic were not a significant predictor of mental disorders, we could infer significantly fewer hours prior to the pandemic in relation to psychosocial problems (Table 2). Also, our results suggested significantly more screen hours during the pandemic in relation to generalized anxiety (Table 1). These findings are another indication of the potential negative implications of school closures that, in particular, exacerbate the use of social media, leading to the further progression of children's mental disorders (28). Therefore, an intervention is needed to mitigate such behavioral problems on the level of the parents as well as the educational and public health authorities.

The first limitation of the present study is that our findings were based on a cross-sectional study in which causal relationships cannot be inferred. Yet, our conclusions regarding the significant associations between the prevalence of mental disorders in children and lockdowns were psychologically plausible and strongly agreed with the published literature described above. Second, the use of convenience sampling through social media platforms may hinder the generalizability of the results to the target population due to selection bias. However, our sample was able to cover an acceptable proportionality in terms of sex and age of the children, as well as, socioeconomic strata in the state of Kuwait (Table 1). Therefore, in addition to the plausibility of the inferred results, our results may have some representativeness to the target population. Moreover, our data were derived from a self-reported survey by the guardians rather than a face-to-face interview, which might have had more validity. Additionally, self-reporting questionnaires suffer from high rates of recall bias. Finally, the present study does not sufficiently explore the relationship between parental bonding (*e.g.*, reflected by equally sharing the responsibility of the childcare) and the development of anxiety disorders in children. As past studies found, poor quality bonding between the parents, as well as with their children, are strongly significant predictors of short and long-term development of anxiety and other mental disorders in children up to their late adulthood (66, 67). Although we attempted this by assessing the statistical significance of the interaction between the type of child guardian and marital status, we could not detect such significance. This might be attributed to most mothers and fathers being married (*i.e.*, 86.0% and 94%, respectively), while a small proportion (*i.e.*, 14.0% and 5.2%, respectively) are single. Furthermore, a more in-depth section in the questionnaire investigating parenthood quality was needed, as described elsewhere (66, 67). Thus, future studies should consider avoiding these limitations and estimating mental disorder incidences and trends, especially after school re-openings.

5 Conclusions

The study represents the first attempt to assess the epidemiological status of mental health disorders in children during the first year of the pandemic when school closures and lockdowns were implemented in Kuwait. We found a remarkably high probable prevalence of anxiety disorders and psychosocial, behavioral problems among children aged between 8 and 18, especially among females. Our most important finding was that lockdown duration was consistently a significant predictor of the broad spectrum of selected mental disorders. Additionally, we inferred notable increases in the likelihood of mental disorders as the duration of the lockdowns increased. Moreover, lockdowns, in combination with school closures, might be associated with the increased prevalence of such disorders, particularly in children belonging to families with lower socioeconomic statuses. Our findings revealed preliminary insights into the vulnerability of young populations to the indirect negative impacts of strict public health measures during pandemic emergencies. Thus, authorities should consider such implications when planning and implementing similar interventions in future pandemics. Also, targeted mental-health surveillance programs for high risk-groups must be initiated to assess and prevent the long-term implications associated with post-pandemic psychological trauma. Therefore, massive and innovative resources must be invested in improving children's coping abilities, particularly during school re-openings.

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 humans were approved by Kuwait Ministry of Health (MoH) ethics committee. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

BA: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. MAA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. AN: Data curation, Investigation, Writing – review & editing. HA: Data curation,

Investigation, Writing – review & editing. MAS: Investigation, Validation, Writing – original draft, Writing – review & editing.

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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/fpsy.2024.1322745/full#supplementary-material>

SUPPLEMENTARY FILE 1

contains the English version of the questionnaire.

SUPPLEMENTARY FILE 2

contains the Arabic version of the questionnaire.

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Mobile applications in adolescent psychotherapy during the COVID-19 pandemic: a systematic review

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Background: To bridge the gap in adolescent psychotherapy created by the increasing need for mental health interventions and the limited possibilities of in-person treatment during the pandemic, many health care providers opted to offer online mental health care programs. As a result, the number of mental health apps available in app stores experienced a sharp increase during the COVID-19 pandemic.

Objective: The aim of the current review is to provide an overview of feasibility and effectiveness studies testing mobile applications in adolescent psychotherapy during the peak phase of the COVID-19 pandemic.

Methods: We conducted a literature search in Pubmed, PsychInfo, Google Scholar, OpenSIGLE and OpenGREY for papers published from June 2020 to June 2023. Studies were included if they evaluated app-based interventions intended for psychotherapeutic treatment and targeted adolescents between 12 and 27 years of age with symptoms of psychological disorders. The quality of each study was assessed using the Systematic Assessment of Quality in Observational Research (SAQOR). Effectiveness outcomes were analyzed by vote counting and calculating a binomial probability test.

Results: The search yielded 31 relevant studies that examined 27 different apps with a total of 1,578 adolescent participants. Nine articles were primary effectiveness studies and 22 focused on feasibility measures as primary outcome. There was evidence that mental health apps influenced adolescents' psychotherapy, with 83% of the studies with effectiveness outcomes favoring the intervention ($p = 0.002$). Sixty-one percent of the included studies were rated at low or very low quality.

Conclusions: The pandemic has given apps a firm and important role in healthcare that will probably continue to expand in the future. To ensure that mental health apps are truly effective and beneficial for adolescents' psychotherapy, we need a standardized measurement of quality features of mental health apps and higher quality app evaluation studies.

Systematic review registration: https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=406455, PROSPERO International Prospective Register of Systematic Reviews [CRD42023406455].

KEYWORDS

mental health, app, adolescent, youth, psychotherapy, mHealth, feasibility, effectiveness

1 Introduction

Due to the Coronavirus Disease 2019 (COVID-19) pandemic mental health problems increased dramatically, especially among adolescents (1–7). Additionally, our health care system experienced rapid digitalization. Many organizations developed mobile applications to maintain their treatment offers under the conditions of social distancing (8, 9). This resulted in a sharp increase of available mental Health apps (10, 11) as well as published evaluation studies (9). Most of the published studies and reviews of evaluated mental health apps focus on the adult population. Research on app-based interventions specifically for adolescents is still scarce. Nevertheless, Ellis et al. (9) reported that children and adolescents were identified as one of the most frequently targeted specific populations in published app evaluation studies during the pandemic. Comparing the number of mental health apps available in app stores and published app evaluation studies, a high discrepancy can be found (9–11). The majority of available mental health apps failed to demonstrate their effectiveness (12, 13). However, evaluation studies are an important quality feature. Without evaluation studies it is difficult to determine whether mental health apps are truly beneficial or potentially harmful for the mental health of users (14, 15). Previous research found that several non-evaluated mental health apps provided incorrect psychoeducation information, inappropriate treatment strategies or wrong contact details of emergency services (16, 17). Given the importance of evaluated mental health apps, as well as the greater focus on app-based psychotherapeutic treatment options for adolescents, there is an urgent need for an updated review of evaluation studies of mental health apps in the context of adolescent psychotherapy during the COVID-19 pandemic.

1.1 Challenges for psychotherapeutic care during the COVID-19 pandemic

In Germany, Ravens-Sieberer et al. (18) reported an increase of overall mental health problems in adolescents from 18 to 28%. The most common disorders were anxiety disorders and depression, which is comparable to data before the pandemic (18). Studies from other countries found an increase in self-harm, suicidal ideation and attempted suicide (5, 19). Madigan et al. (5) showed in their review that emergency department visits due to self-harm, suicidal ideation or suicidal attempts increased in the beginning of the pandemic despite a reduction in total emergency department visits for mental-illness concerns. In times of social distancing and school

closures, adolescents lost important resources for their wellbeing, resulting in negative consequences for their mental health (7, 20, 21). Additionally, most of the treatment services were curtailed or completely discontinued during the phases of social distancing (7). As a result, the youth was exposed to greater stressors during the pandemic, while less support was available. In Germany, we can see the consequences of this in a significant increase of emergency admissions since 2021, especially in child and adolescent psychiatry (22). To address the divergence between the increasing need for mental health treatments and the discontinuation of treatment offers in times of the pandemic, health care providers tried to find new ways to reach adolescents, including offering online mental health care programs (8, 9).

1.2 Chances of mental health apps in adolescent psychotherapy

The use of mental health apps with adolescents is promising. Digital media are an integral part of adolescent everyday lives. In Germany, 96% of 12–19-year-olds own a smartphone and use it daily (23). In 2022, adolescents spent on average 204 min per day on the internet. During the pandemic the online usage times were significantly elevated, averaging 244–258 min per day (23). Furthermore, younger people show greater affinity for online mental health care. They are more likely to use the internet to gather information about their mental health than older people (24, 25). Rauschenberg et al. (26) pointed out that a large proportion of young people with psychological distress and pandemic related anxiety would like to use mobile applications to overcome negative consequences of the COVID-19 pandemic. In addition to permanent availability, mental health apps have further advantages, such as allowing adolescents to have more autonomy. They can use apps flexibly and decide when and where to get involved with the app without having to go to a fixed treatment appointment as one would in case of face-to-face therapy (27, 28). Accessibility is one of the most important arguments for using mental health interventions when it comes to adolescents. Therefore, smartphone-based interventions are more attractive to them than interventions where a laptop or other digital device is needed (27). Furthermore, apps can offer immediate support in critical situations and crises, like acute cases of suicidal ideation or self-harm (29). Due to increased affordability of mental health care through apps, it is possible to reach a higher number of help-seeking adolescents. Access to mental health apps is given independent of the available health care infrastructure or severity

of symptoms. As such, persons with low to moderate symptoms of mental health conditions can be treated to prevent the development of more severe symptomatology (30). In addition, adolescents perceive the use of mental health apps as less conspicuous and bulky, which may lead to increased adherence to psychotherapy. Feeling of connectedness is also an important factor for adolescents and a further advantage of mental health apps. Mental health apps can offer an opportunity to share own experiences with peers in an appropriate manner and mitigate the fear of stigmatization (27, 28). Finally, considering previous effectiveness research on mental health apps, several studies show comparable efficacy and cost-effectiveness between smartphone-based interventions and face-to-face therapy (26, 31–33).

1.3 Areas of application of mental health apps

Just as versatile as the reasons for app usage are their areas of application. Apps can be used as stand-alone or therapy-accompanying treatments. As a stand-alone treatment, apps offer interventions for self-help. For example, they can be used during waiting periods for psychotherapy or as early interventions to prevent the development of severe symptomatology (29, 30, 34–36). Therapy-accompanying apps are used as adjunction to psychotherapy (29). These apps can support adolescents between outpatient sessions. They can increase adherence to therapeutic homework, support application of skills acquired in therapy to everyday life or offer management plans for acute crises (34, 35). Most of the available apps focus on specific disorders rather than a transdiagnostic therapy approach covering the eight common disorders: psychosis, eating disorders, depression, autism, self-harm, anxiety, substance abuse, and suicidal behavior (35). Lui et al. (34) reported in their review of evidence-based mobile applications in a psychotherapy context that none of the 21 included apps focused on symptoms that may be transdiagnostic. Four years later, Ellis et al. (9) reported that during the COVID-19 pandemic the transdiagnostic approach increased in mental health app literature: they found that 38% of the included studies were about COVID-19-related transdiagnostic symptoms like stress, loneliness or general wellbeing.

1.4 Evaluation of mental health apps

As mentioned above, there is a large discrepancy between available mental health apps and published evaluation studies of mental health apps. In the first quarter 2021, 53,979 mental health apps were available in Apple App Store and 53,054 in Google Play Store (10, 11). In contrast, Ellis et al. (9) reported in their review that between January 2020 and March 2021 356 app evaluation articles were published, with 63% of these being non-empirical publication types like commentaries or opinions. In another review, Alyami et al. (12) pointed out that none of the 1,154 identified social anxiety apps for adults had published studies of their effectiveness. Three years later, Qu et al. (13) presented in their review that of 482 investigated depression apps

for adults only seven percent had a sound evidence base. Other reviews of evidence-based mental health apps for adults highlighted an insufficient scientific evaluation of app-based interventions and a lack of standardized methods for assessing effectiveness of mental health apps (15, 33, 34, 37). One reason for the low rates of effectiveness studies is attributed to the high costs involved. Effectiveness studies require a great deal of effort and usually result in long study periods, which does not meet the requirements of the fast-moving app market (14, 38). Another reason for the high rates of non-evaluated mental health apps is that providers of health care apps are not required to provide information in the app stores about the effectiveness of their digital therapeutic tools (39, 40). Most providers still do not hesitate to claim effectiveness of their applications by means of non-empirical scientific explanations, field reports or technical expertise. If an evaluation of a mental health app is available, it is mostly an evaluation of feasibility (41). Feasibility is an important aspect of an overall assessment of interventions, but it does not provide information about the usefulness or effectiveness of mental health apps. To give a comprehensive overview it is important to include various kinds of evaluation studies, from feasibility to effectiveness.

1.5 Objectives

The aim of the current review is to provide an overview of feasibility and effectiveness studies testing mobile applications in adolescent psychotherapy during the COVID-19 pandemic. Furthermore, we investigate how effectiveness of mobile applications is measured. Additionally, we examine whether effects of mobile applications differ according to specific psychological disorders as well as between stand-alone psychotherapy apps and therapy-accompanying apps.

2 Methods

A protocol for reviewing the literature was developed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (42). The review was registered on PROSPERO (CRD42023406455).

2.1 Search strategy

A literature search was conducted in Pubmed, PsychInfo and Google Scholar for papers published from June 2020 to June 2023. Search parameters consisted of numerous combinations of keywords related to adolescents, apps and psychotherapy and included “adolescent*,” “youth,” “young,” “app,” “mobile,” “smartphone,” “mental health,” “digital,” “psychotherapy,” “disorder,” “psychological,” “psychiatry,” “treatment,” “therapy,” and “intervention.” For eligible gray literature, we searched OpenSIGLE and OpenGREY. Furthermore, authors of study protocols were contacted to check for recently published studies or preliminary study results. References of reviews, meta-analyses, review protocols

and included studies were scanned to identify any potentially relevant literature.

2.2 Eligibility criteria

Studies were included if they evaluated app-based interventions intended for psychotherapeutic treatment and targeted adolescents between 12 and 27 years of age with symptoms of psychological disorders. Studies addressing smoking were excluded because smoking is not a clinically relevant and psychiatrically or psychotherapeutically treated addictive disease. In addition, studies with only a subset of eligible participants were excluded if it was not possible to consider the subsample separately. Studies exclusively examining adults 18 years of age or older were likewise excluded. We included any mobile app-based intervention in a psychotherapy context for adolescents. The app had to be used as a supplement to or replacement of psychotherapy. It could focus on specific psychological disorders or transdiagnostic treatment. Solely psychoeducational or diagnostic mobile applications were excluded. We included all published, unpublished, or ongoing experimental and quasi-experimental trials in English and German that compared mobile applications in a psychotherapy context with usual psychotherapy or non-psychological mobile applications (e.g., gaming applications); non-experimental studies with repeated measurements design that included at least pre- and post-measurement; and non-experimental studies based on qualitative research methods. Trials described in Editorials, Comments or Letters to the editor were excluded. Due to the COVID-19 pandemic, only studies published from June 2020 to June 2023 were included.

2.3 Study selection process

The search yielded 31 studies fulfilling all inclusion criteria (see Figure 1 for the number of papers included at each stage of the review). Four reviewers were involved in the study selection process and applied eligibility criteria for sample identification. Studies were identified in two steps. First, one reviewer screened titles and abstracts of each of the chosen databases for eligibility. Articles that did not meet the inclusion criteria were excluded. Second, two reviewers screened the full texts of potentially eligible articles. If the two reviewers' assessment of an article was discordant, the disagreement was discussed until a consensus was reached, involving a third party if necessary. The data collection and selection process was managed using the free software rayyan.ai (43) and specifically developed Excel spreadsheets for documentation. We contacted authors of study protocols or studies with samples that were not completely within the age range with a maximum of three email attempts to ask for data provision of sub-samples. Included studies were transferred to a table that presented all key information of the studies (data items): bibliographical data (e.g., authors, contact details of the corresponding author, publication year), app information (name of the app, short description of the app), sample characteristics, trial methods (e.g., study design, type of comparison group),

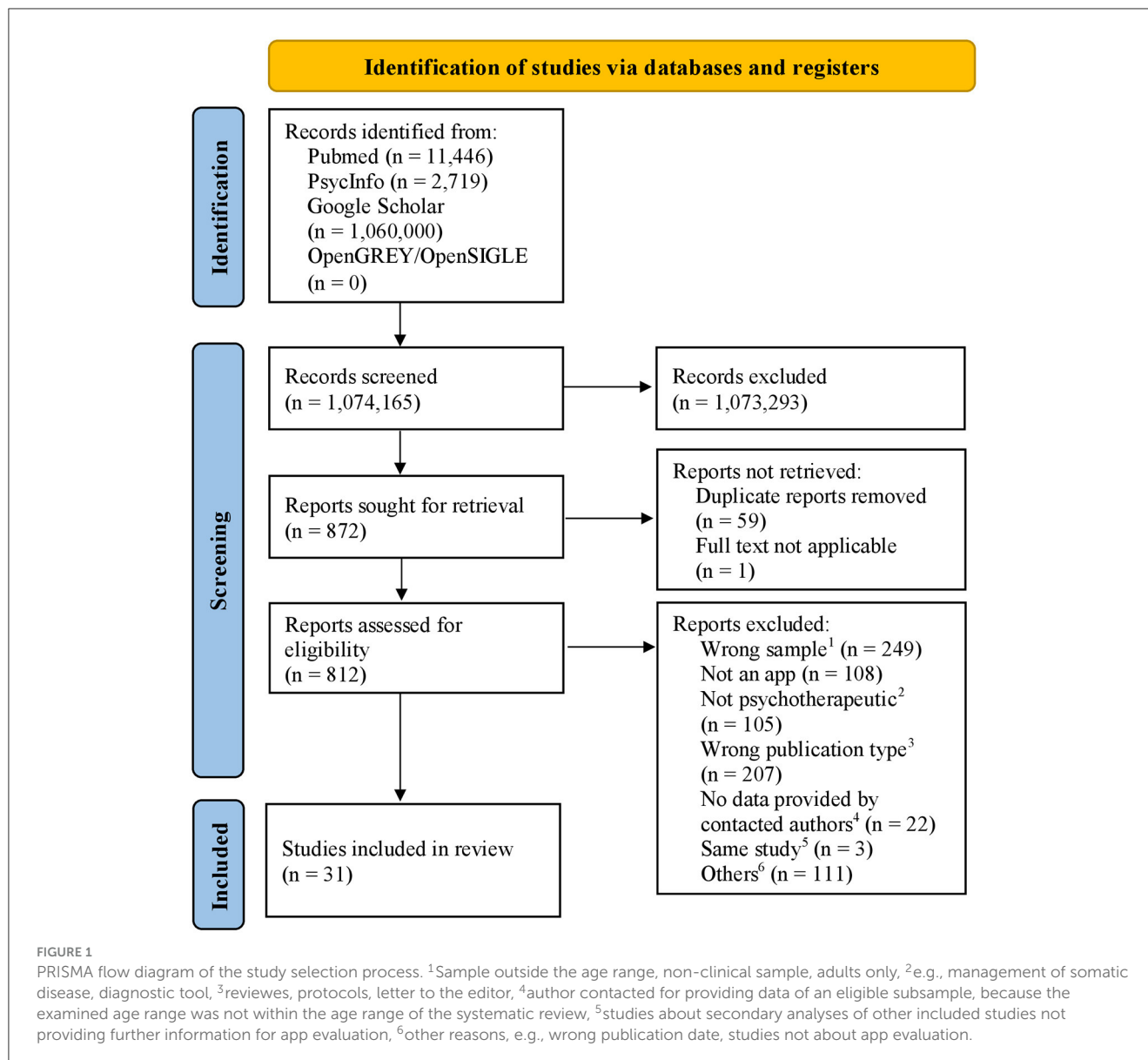
evaluation methods, and outcome data. Finally, two reviewers assessed the quality of each study and their ratings were compared and discussed.

2.4 Quality assessment

To assess the quality of each study, the Systematic Assessment of Quality in Observational Research [SAQOR; (44)] was used. The assessment tool enables a differentiated evaluation of the heterogeneous study designs and methods without being limited to randomized controlled trials (RCT). It rates the quality of studies in six categories: sample, control/comparison group, quality of measurement(s) and outcome(s), follow-up, distorting influences, and reporting data. Each category consists of three to five items. Each category is rated as "adequate," "inadequate," "unclear," or "not applicable" according to the ratings of each item. A final quality rating (high, moderate, low, very low) is determined based on the assessment of the six categories. Adapting the tool to the psychotherapeutic context, the items of the category "distorting influences" were summarized in one item asking for potential confounders in general instead of differentiating between two potential key confounders and additional possible confounders mentioned in the article. Two independent researchers carried out the quality assessment. Disagreements in the category ratings were discussed, involving a third party. Interrater reliability between the two reviewers was calculated using Cohen's Kappa (45).

2.5 Data extraction and synthesis

To synthesize data of included studies we followed the Synthesis Without Meta-analysis (SWiM) guidelines (46). First, in order to address the high degree of heterogeneity in the methodology and data of evaluation studies, we grouped the included studies by potential outcome measures: (1) qualitative measures only, (2) feasibility measures, (3) measures of app quality, or (4) measures of effectiveness. For studies that only include qualitative outcome measures or examine feasibility or app quality, data were synthesized in the form of a narrative summary. Such studies were grouped under the category "feasibility studies". Results of studies including effectiveness measures were analyzed separately in two subcategories: effectiveness studies and feasibility studies with (preliminary) effectiveness outcomes. The reported effect estimates were categorized as indicating benefit or harm based on the observed direction of effect of the main effectiveness outcome. Studies that reported no effect of the app intervention were also rated as harmful. For synthesis, votes based on the direction of effects were counted to report the percentage of studies favoring app-based interventions for adolescent psychotherapy context (47). To test if the vote counting results are a statistically significant indicator of app-based intervention being truly effective, a binomial probability test was calculated (48). Differences in effectiveness according to different disorders or areas of application were reported in a narrative synthesis.



3 Results

The search identified 31 relevant studies in which 27 different apps were examined. Four of these apps were each addressed in two separate studies. Nine articles were primary effectiveness studies and 19 focused on feasibility measures as primary outcome, of which 14 studies also examined preliminary effectiveness outcomes. Three studies reported qualitative data only. None of the included studies focused on app quality as a primary outcome, but one study examined app quality as a secondary outcome (49). Following the World Bank's definition of high-income economy (50), studies were predominantly conducted in high-income countries (30/31, 97%), with the United States having the highest number of studies (10/31, 32%). Only one study was conducted in a lower-middle income country (India). Most of the evaluated apps focused on specific symptoms or disorders ($n = 23$), with only four acting as transdiagnostic interventions. Overall, 15 apps were based on

cognitive behavioral therapy (CBT). Of the 27 apps, 17 were used as stand-alone interventions, seven as therapy-accompanying and three apps were community-network apps, focusing on peer-to-peer treatment or parent-child interactions. Tables 1–3 provide detailed descriptions of the included studies. An overview of the app characteristics is presented in Table 4.

3.1 Results of quality appraisal

Of the 31 studies, four were rated as “high” quality, eight as “moderate” quality, thirteen as “low” quality and six as “very low” quality. The two independent raters showed a moderate interrater reliability of $\kappa = 0.59$. Ratings of studies examining effectiveness as primary outcome ranged from high to low quality, with three studies rated as “high”, two as “moderate” and four as “low” quality. The results of the quality appraisal

TABLE 1 Study characteristics of each study with primary effectiveness outcomes.

References, country	App	Study design	Study registration	Sample		Primary outcome (effectiveness)					Quality assessment (SAQOR)
				Size	Age in years (mean)	Measured effectiveness outcome	Standardized questionnaires	Analysis	Vote count	Effect estimates	
Badesha et al. (51), UK	Sanvello	Mixed-methods, single-case experimental design	No	5	15–17 (16.2)	Psychological distress	K-10	Visual analysis on single case level	0	n.a.	3
Dubad et al. (52), UK	Catch It	Mixed-methods, quasi-experimental cohort study	No	47	16–24 (20.7)	Difficulties in emotion regulation	DERS-SF	Mixed Analysis of Variance (ANOVA)	0	n.s.	3
Hilt et al. (53), USA	CARE ^a	RCT	Yes	152	12–15 (13.7)	Trait rumination	CRSQ	Multi-level models	1	$d = 0.24–0.43$	1
Kruzan et al. (54), USA	TalkLife	RCT	Yes	131	16–25 (20.3)	Non-suicidal self-injury	NSSI-AT	Linear mixed models	1	$\eta^2 = 0.02$	1
Li et al. (55), Australia	SleepNinja	Quasi-experimental cohort study	No	49	12–16 (14.1)	Insomnia symptom severity	ISI, PSQI	Hierarchical linear mixed models	1	n.a.	2
Werner-Seidler et al. (56), Australia	SleepNinja	RCT	Yes	264	12–16 (14.7)	Insomnia and depression symptoms	ISI, PHQ-A	Mixed-model repeated measures	1	$d = 0.28–0.39$	1
Rempel et al. (57), Germany	7mind	RCT	No	56	12–19 (15.7)	Obsessive compulsive disorder symptom severity	CY-BOCS	Mixed-effects repeated measures ANOVAS	0	n.s.	3
Schaeffer et al. (58), USA	iKinnect	RCT	Yes	72	13–18 (14.7)	Externalizing behaviors	GAIN-Q3, SRD, CBCL, YSR, ASEBA	Latent growth curve modeling	1	$d = 0.54–0.84$	2
Yang et al. (59), Korea	HARU ASD	RCT	No	26	15–27 (19.3)	Anxiety level	STAI	Mann-Whitney- <i>U</i> -Test	1	$r = 0.52$	3

^aSame app as Hilt et al. (60). Vote count: 1 = beneficial/0 = harmful or no change. K-10, Kessler Psychological Distress Scale; n.a., not applicable; DERS-SF, Difficulties in Emotion Regulation Scale—Short Form; ns, results were not significant; CRSQ, Children's Response Styles Questionnaire; NSSI, Nonsuicidal Self-Injury Assessment Tool; ISI, Insomnia Severity Index; PSQI, Pittsburgh Sleep Quality Index; PHQ-A, Patient-Health Questionnaire-Adolescent Version; CY-BOCS, German Children's Yale-Brown Obsessive Compulsive Scale; GAIN-Q3, Global Appraisal of Individual Needs; SRD, Self-Report of Delinquency; CBCL, Externalizing behavior scale of the Child Behavior Checklist; YSR, Externalizing behavior scale of the Youth Self Report; ASEBA, Achenbach System of Empirically Based Assessment; STAI, State-Trait Anxiety Inventory.

TABLE 2 Study characteristics of each study with primary feasibility outcomes and secondary preliminary effectiveness outcomes.

References, Country	App	Study design	Study registration	Sample		Primary outcome (feasibility)		Secondary outcome (preliminary effectiveness)				Quality assessment (SAQOR)
				Size	Age in years (mean)	Assessment	Qual. int. ^a	Measured preliminary effectiveness outcome	Standardized questionnaires	Vote count	Effect estimates	
Carmona et al. (61), Canada	Doze	Mixed-methods, observational one-group cohort study	No	83	15–24 (n.a.)	TEM, usage data, self-developed	Yes	Sleep Parameters	ISI, CSM, FSS, CESDR-10, STICSA, SF-36	1	$d = 0.19–0.90$	2
Coughlin et al. (62), USA	MiSARA	Mixed-methods, observational one-group cohort study	No	39	16–24 (n.a.)	Self-developed	No	Substance use	AUDIT-C	1	n.a.	3
Geirhos et al. (63), Germany	YouthCoach _{CD}	RCT	Yes	30	12–21 (16.1)	INEP-On, IUES, WAI-SR CSQ-I, usage data, self-developed	Yes	Depressive and anxiety symptom severity	PHQ-ADS	0	$d = 0.30$	2
Gonsalves et al. (64), India	POD Adventures	Mixed-methods, observational one-group cohort study	No	248	13–19 (15.6)	CSQ, usage data,	Yes	Mental health symptoms, prioritized problems, stress, wellbeing	YTP, SDQ, PSS, SWEMWBS	1	$d = 0.31–1.47$	3
Grasaas et al. (65), Norway	iCanCope with Pain TM	RCT	Yes	73	16–19 (14.4)	Usage data	No	Pain, HRQOL, self-efficacy, anxiety and depression	LPQ, KIDSCREEN-52, GSE, HADS	1	n.s.	1
Hilt et al. (60), USA	CARE ^b	Observational one-group cohort-study	No	80	12–15 (14.0)	Usage data, self-developed	No	Repetitive negative thinking, internalizing symptoms	CRSQ, PWSQ-C, CDI, MASC, PSC.	1	$\eta_p^2 = 0.00–0.33$	2
Jeong et al. (66), South Korea	Brake of my Mind (BoMM)	Observational one-group cohort-study	No	3	15–19 (n.a.)	Self-developed	No	Attitudes toward suicide attempts, subjective norms, perceived behavioral control, suicide intentions	n.a.	1	n.a.	3
Miklowitz et al. (67), USA	No name	Observational one-group cohort-study	No	22	13–19 (15.4)	Perceived Ease of Use Scale, usage data, self-developed	No	Depression or mania severity	PSR, YMRS, CDRS-R	1	$d = 1.58^c$	3

(Continued)

TABLE 2 (Continued)

References, Country	App	Study design	Study registration	Sample		Primary outcome (feasibility)		Secondary outcome (preliminary effectiveness)				Quality assessment (SAQOR)
				Size	Age in years (mean)	Assessment	Qual. int. ^a	Measured preliminary effectiveness outcome	Standardized questionnaires	Vote count	Effect estimates	
Weintraub et al. (68), USA	No name ^d	Mixed-methods, Observational one-group cohort-study	No	31	13–17 (15.1)	Usage data	No	Mood symptoms & psychosocial functioning	CDRS-R, PQ-B	1	$\eta_p^2 = 0.17–0.36$	3
Muscara et al. (69), Australia	BeyondNow & BlueIce	Observational one-group cohort-study	No	20	13–18 (15.5)	Usage data	No	Suicide resilience, self-harm	SRI-25	1	$d = 0.71$	3
Nicol et al. (70), USA	W-GenZ	RCT	No	17	13–17 (14.7)	SUS, usage data, self-developed	No	Depression severity	PHQ-A	1	$d = 0.98$	2
Rauschenberg et al. (71), Germany	EMicompass	Observational one-group cohort-study	No	10	14–24 (20.3)	Usage data, self-developed	No	General psycho-pathology, depression, anxiety and psychotic symptoms	BSI, GSI, GPTS	1	$r = 0.30–0.65$	2
Reininghaus et al. (72), Germany	EMicompass	RCT	Yes	92	14–25 (21.7)	Self-developed	No	Psychological distress, stress reactivity	K-10	1	n.s.	2
Thabrew et al. (49), New Zealand	Village	Mixed-methods, observational one-group cohort-study	No	26	16–25 (17.7)	uMARS, usage data, self-developed	Yes	Depression symptoms, suicidal ideation, level of functioning	PHQ-A, SIQ, WHODAS(-CY)	1	$d = 0.40–0.90$	3

^aQualitative Interview was done; ^bsame app as Hilt et al. (53); ^ceffect estimate of the PSR (effect estimates of the other measurements were not applicable); ^dan adapted version of the app from Miklowitz et al. (67).

n.a., information was not applicable; TEM, Treatment Evaluation Questionnaire; ISI, Insomnia Severity Index; CSM, Composite Scale of Morningness; FSS, Fatigue Severity Scale; CESDR-10, Center for Epidemiologic Studies Depression Scale—revised 10 item version for adolescents; STICSA, State-Trait Inventory for Cognitive and Somatic Anxiety; SF-36, RAND 36-item short form health survey; AUDIT-C, Alcohol Use Disorder Identification Test—Consumption; INEP-On, Inventory for Recording Negative Effects of Online Interventions; IUES, Internet-Use Expectancies Scale; WAI-SR, Working Alliance Inventory-Short Revised; CSQ-I, Client Satisfaction Questionnaire adapted to Internet-based Interventions; PHQ-ADS, Patient Health Questionnaire Anxiety and Depression Scale [combined version of the Patient Health Questionnaire (PHQ-9) and the General Anxiety Disorder Scale-7 (GAD-7)]; CSQ, Client Satisfaction Questionnaire; YTP, Youth Top Problems; SDQ, Strength and Difficulties Questionnaire; PSS, Perceived Stress Scale; SWEMWBS, Short Warwick-Edinburgh Mental Wellbeing Scale; HRQOL, Health related quality of life; LPQ, Lübeck Pain-Screening Questionnaire; GSE, General Perceived Self-Efficacy Scale short form; HADS, Hospital Anxiety and Depression Scale Questionnaire; ns, results were not significant; CRSQ, Children's Response Styles Questionnaire; PWSQ-C, Penn State Worry Questionnaire for Children; CDI, Children's Depression Inventory; MASC, Multidimensional Anxiety Scale for Children; PSC, Pediatric Symptom Checklist; PSR, Psychiatric Status Rating; YMRS, Young Mania Rating Scale; CDRS-R, Children's Depression Rating Scale, revised; PQ-B, Prodromal Questionnaire—Brief; SRI-25, The adapted Suicide Resilience Inventory-25; SUS, System Usability Scale; PHQ-A, Patient Health Questionnaire for adolescents; BSI, Brief Symptom Inventory; GSI, Global Severity Index; GPTS, Paranoid Thoughts Scale; K-10, Kessler Psychological Distress Scale; uMARS, User Version of the Mobile App Rating Scale; SIQ, Suicidal Ideation Questionnaire; WHODAS(-CY), World Health Organization Disability Assessment Schedule (WHODAS was used for patients aged > 18 years and WHODAS-CY was used for children and adolescents aged < 18 years).

TABLE 3 Study characteristics of each study with primary feasibility outcomes (without outcomes on preliminary effectiveness).

References, Country	App	Study design	Study registration	Sample		Primary outcome (feasibility)		Quality assessment (SAQOR)
				Size	Age in years (mean)	Assessment	Qual. int.	
Adams et al. (73), USA	Bright Path	Descriptive cross-sectional study	No	20	14–17 (15.6)	Self-developed	Yes	3
Gómez-Restrepo et al. (74), Colombia	DIALOG+	Descriptive cross-sectional study	No	13	15–17 (16.0)	Self-developed	Yes	4
Li et al. (75), Australia	ClearlyMe	Descriptive cross-sectional study	No	36	12–16 (14.9)	Self-developed	Yes	4
Naccache et al. (76), France	No Name	Descriptive cross-sectional study	No	8	12–18 (15.5)	UEQ, self-developed	Yes	4
Newton et al. (77), Canada	MindClimb	Observational 1-group cohort study	No	8	13–18 (14.0)	Adaptation of CSQ, self = developed	Yes	3
O’Grady et al. (78), Ireland	SafePlan	Descriptive cross-sectional study	No	18	14–16 (n.a.)	SUS, self-developed	Yes	4
Patterson Silver Wolf et al. (79), USA	Bridges To Sobriety	Observational case-control study	No	12	13–19 (n.a.)	Usage data, self-developed	Yes	4
Sharma et al. (80), UK	C.A.L.M BD	Observational 1-group cross-sectional study	No	13	14.5–24.4 (n.a.)	SUS, usage data	n.a.	4

QI, Qualitative Interview; UEQ, User Experience Questionnaire; CSQ, Client Satisfaction Questionnaire for adolescents; SUS, System Usability Survey.

for each study are displayed in the summary of findings Tables 1–3.

3.2 App intervention concepts

The evaluated mental health apps showed high variety in their areas of application. Most apps were intended as stand-alone, psychological self-help programs. One app was specifically designed to support adolescents during the waiting period for psychotherapy (70). Three out of 27 apps were used as additional treatment to therapy, with two apps designed for specific manualized treatments (67, 68, 74). One app could be used in all standard treatments (52). Furthermore, four apps worked as interrelated apps that connected adolescents with their therapist and primary caregivers (58, 67, 68, 74) or self-selected family members and friends (49). As previously mentioned, four apps were transdiagnostic programs, while 23 apps focused on specific disorders or symptoms. Six out of the 23 apps addressed symptoms across disorders like suicidality and self-harm ($n = 5$) or rumination ($n = 1$). Apps about depressive disorders ($n = 6$) were most common. An overview of disorders addressed by included mental health apps is presented in Figure 2.

3.3 App features

Overall, included mental health apps showed a wide range in established features and methods. Five out of the 27 apps followed a defined CBT manual with fixed modules that patients progressed through sequentially (51, 55, 57, 59, 63). Three apps used just-in-time adaptive interventions to treat adolescents (53, 60, 62, 71). All other apps did not specify how the app should be used. Thirty-three percent of apps used gamification elements to motivate patients to use the app (55, 58, 62, 64, 73, 76, 77, 79). Two apps used chatbots in their program to provide patients with personalized treatment (55, 70). Nevertheless, there were also many commonalities between the mental health apps. Fifty-six percent of the mental health apps used mood monitoring as one feature. In total, 63% of apps provided psychoeducational content, with 77% of these apps also providing specific exercises based on the presented psychoeducation. Almost half of the apps aimed to support adolescents in specific behavior changes, with three apps focusing on setting goals (51, 61, 65) and three apps focusing on problem-solving strategies (59, 64, 74). Another frequently used feature was a toolbox with useful skills for difficult situations ($n = 9$). Four out of these nine apps provided a safety plan for suicidal or self-harm crisis management (66, 69, 78, 80). Furthermore, three apps provided a diary feature for app users (59, 61, 78) and four apps had a community forum that

TABLE 4 Characteristics of each app.

App	References, Country	Stand-alone vs. therapy-accompanying	App content			Duration & frequency of app use during the evaluation study	Primary outcome of the evaluation study
			Specific symptom/disorder or transdiagnostic	Overview	Based on ^a		
BeyondNow & BlueIce	Muscara et al. (69), Australia	Therapy-accompanying	Self-harm, suicidal ideation/behavior	Crisis management: safety plan and skill box for NSSI and suicidal ideation	n.a.	6 weeks, self-selected frequency of use	Feasibility
Brake of My Mind (BoMM)	Jeong et al. (66), South Korea	Stand-Alone	Suicidality	Crisis management: safety plan for suicidal ideation	n.a.	n.a.	Feasibility
Bridges to Sobriety	Patterson Silver Wolf et al. (79), USA	Therapy-accompanying	Substance use disorder	Toolbox and serious games for substance use disorder treatment	n.a.	n.a.	Feasibility
Bright Path	Adams et al. (73), USA	Therapy-accompanying	Substance use disorders and mental health comorbidities	Psychoeducational content and serious games and activities focused on substance use and mental health comorbidities for outpatient health treatment	CBT	Presentation of the app without independent app use	Feasibility
C.A.L.M. BD	Sharma et al. (80), UK	Stand-Alone	Bipolar disorder	Self-management for mood regulation	n.a.	90 days, self-selected frequency of use	Feasibility
CARE	Hilt et al. (60), USA	Stand-Alone	Rumination	Mood monitoring and mindfulness exercises	n.a.	3 weeks, using the app 3 times per day	Feasibility
	Hilt et al. (53), USA	Stand-Alone	Rumination	Mood monitoring and mindfulness exercises	n.a.	3 weeks, using the app at least three times per day	Effectiveness
Catch-It	Dubad et al. (52), UK	Stand-Alone	Transdiagnostic	Mood monitoring and cognitive restructuring of thoughts	n.a.	3 weeks, using the app at least two times per day	Effectiveness
ClearlyMe	Li et al. (75), Australia	Stand-Alone	Depression and anxiety	CBT app intervention for anxiety and depressive symptoms	CBT	n.a	Feasibility
DIALOG+	Gómez-Restrepo et al. (74), Colombia	Therapy-accompanying	Anxiety and depression	Accompanying app for the Dialog+ intervention that structures communication between clinician and patient	n.a.	n.a	Feasibility
DOZE	Carmona et al. (61), Canada	Stand-Alone	Sleep problems (e.g. insomnia, daytime sleepiness, delayed phase circadian rhythms; ranging from subclinical to clinical in terms of their severity)	CBT app intervention for sleep problems	CBT	4 weeks, self-selected frequency of use	Feasibility
EMIcompass	Rauschenberg et al. (71), Germany	Therapy-accompanying	Help-seeking individuals with psychotic, depressive or anxiety symptoms	Ecological Momentary Assessment and supply of training exercises according to in-person intervention sessions	CBT	3-weeks, self-selected frequency of use	Feasibility
	Reininghaus et al. (72), Germany	Therapy-accompanying	Transdiagnostic	Ecological Momentary Assessment and supply of training exercises according to in-person intervention sessions	CBT	6 weeks, self-selected frequency of use	Feasibility

(Continued)

TABLE 4 (Continued)

App	References, Country	Stand-alone vs. therapy-accompanying	App content			Duration & frequency of app use during the evaluation study	Primary outcome of the evaluation study
			Specific symptom/disorder or transdiagnostic	Overview	Based on ^a		
HARU ASD	Yang and Chung (59), Korea	Stand-Alone	Anxiety of ASD patients	CBT app intervention to reduce anxiety in persons with ASD	CBT	66 days, using the app once a day	Effectiveness
iCanCope with Pain™	Graasas et al. (65), Norway	Stand-Alone	Persistent pain	Mood and symptom monitoring, goal setting, self-management strategies, and social support	n.a.	8 weeks, self-selected frequency of use	Feasibility
iKinnect	Schaeffer et al. (58), USA	Community-Network	Conduct problems	Support for caregivers in parenting and dealing with the conduct problems of their children	MST	12 weeks, self-selected frequency of use	Effectiveness
MindClimb	Newton et al. (77), Canada	Therapy-accompanying	Anxiety	Ecological momentary interventions	CBT	Using the app over 6–7 group therapy sessions with a self-selected frequency of app use	Feasibility
MiSARA	Coughlin et al. (62), USA	Stand-Alone	Risky drinking behavior	Daily symptom and mood monitoring and just in time adaptive interventions to prevent alcohol use	JTAI	30 days, using the app at least once a day	Feasibility
No name ^b	Miklowitz et al. (67), USA	Therapy-accompanying	Mood disorders	Interrelated app for adolescents, parents and clinicians for family-focused therapy	CBT	Using the app during the family focused therapy with a self-selected frequency of app use	Feasibility
	Weintraub et al. (68), USA ^c	Therapy-accompanying	Mood disorders, psychotic spectrum disorders	Interrelated app for adolescents, parents and clinicians for family-focused therapy	CBT	9 weeks, self-selected frequency of use	Feasibility
No name ^b	Naccache et al. (76), France	Stand-Alone	Anorexia nervosa	Self-help app for managing emotions and behaviors with a focus on weight loss	CBT	n.a	Feasibility
POD Adventures	Gonsalves et al. (64), India	Stand-Alone	Perceived stress	Lay counselor-guided problem-solving intervention	n.a.	2–3 weeks, using the app at least twice per week	Feasibility
SafePlan	O’Grady et al. (78), Ireland	Stand-Alone	Suicidality	Crisis management: safety plan for suicidal ideation	CBT	Presentation of the app without independent app use	Feasibility
Sanvello	Badesha et al. (51), UK	Stand-Alone	Transdiagnostic	Mental health promotion	CBT	5 weeks, using the app at least once a day	Effectiveness
SleepNinja	Li et al. (55), Australia	Stand-Alone	Insomnia	CBT app intervention for sleep problems	CBT	6 weeks, self-selected frequency of use	Feasibility
	Werner-Seidler et al. (56), Australia	Stand-Alone	Insomnia & depression	CBT app intervention for sleep problems	CBT	6 weeks, self-selected frequency of use	Effectiveness

(Continued)

TABLE 4 (Continued)

App	References, Country	Stand-Alone vs. Therapy-accompanying	App content			Duration & frequency of app use during the evaluation study	Primary outcome of the evaluation study
			Specific symptom/disorder or transdiagnostic	Overview	Based on ^a		
TalkLife	Kruzan et al. (54), USA	Community-Network	NSSI	Peer support app with psychoeducational elements	n.a.	8 weeks, using the app at least 3 times per week	Effectiveness
Village	Thabrew et al. (49), New Zealand	Stand-Alone	Suicidality and NSSI	Communication app for family/friends support in difficult situations	CBT	4 weeks, self-selected frequency of use	Feasibility
W-GenZ	Nicol et al. (70), USA	Stand-Alone	Depression	Chatbot-delivered CBT for emotion regulation skills	CBT	12 weeks, self-selected frequency of use	Feasibility
YouthCoachCD	Geirhos et al. (63), Germany	Stand-Alone	Symptoms of anxiety and depression in AYA with chronic medical conditions (CF, JIA, T1D)	CBT app intervention for anxiety and depressive symptoms	CBT	7 weeks, doing one module per week	Feasibility
7mind	Rempel et al. (57), Germany	Stand-Alone	Obsessive-compulsive disorder	Meditation app	CBT	8 weeks, using the app two times per day	Effectiveness

^aTheoretical framework on which the app is based.

^bAuthors did not mention an app name.

^cAdapted version of the app of Mikdowitz et al. (67).

NSSI, non-suicidal self-injury; n.a., information not applicable; ASD, autism spectrum disorder; JTAI, just-in-time adaptive interventions; AYA, adolescent and young adult; CF, cystic fibrosis; JIA, juvenile idiopathic arthritis; T1D: type 1 diabetes.

enabled app users to communicate with other affected adolescents (49, 54, 65, 75).

3.4 Study designs of app evaluations

3.4.1 Studies of effectiveness

Six out of nine effectiveness studies were randomized controlled trials. Two studies were quasi-experimental cohort studies with a pre-post treatment assessment (52, 55) and one study used a single-case experimental design to examine effectiveness of the app intervention (51). Sample sizes ranged from five to 264, with a total of 802 participants across the nine studies. Fifty-six percent of the effectiveness studies examined adolescents under the age of 18 years. Most of the effectiveness studies included a comparison group, except for two studies that did not include any comparison group (51, 55). Five studies used an active control group, of which two studies compared their app-intervention with groups using other similar apps (53, 58) and three studies had a control group in which health related input was provided through other digital technologies (54, 56, 57). Intervention period of app usage lasted between three and 12 weeks with different frequencies of required app usage per day. Most of the apps prescribed daily use (*n* = 7), while two studies required using the app at least three times per day (53, 54). Overall, merely four studies registered their clinical trial and none of the studies published a study protocol.

3.4.2 Feasibility studies with preliminary effectiveness outcomes

As for feasibility studies that also examined (preliminary) effectiveness, 71% of these used an observational one-group cohort study design without a control group. The other four studies conducted a randomized controlled trial, with two studies comparing results with a wait list control group (63, 70), one study using treatment as usual (72) and one study including an attention control group (65). Sample sizes ranged from three to 248, with a total of 774 participants across the 14 studies. Twenty-nine percent of these studies examined adolescents under the age of 18 years. Two studies involved primary caregivers in intervention and assessment, in addition to the adolescent sample (67, 68), and one study involved friends of the participants (49). Intervention periods lasted between 2 and 12 weeks, with two studies requiring daily app usage (60, 62) and three studies requiring app use frequency of at least once a week (63, 64, 68). Of the 14 included feasibility studies with preliminary effectiveness outcomes, three studies registered their clinical trial (63, 65, 72) and one also published a study protocol (72).

3.4.3 Feasibility studies

Five out of eight studies used a descriptive cross-sectional study design to examine feasibility and usability of the apps (73–76, 78). None of the five studies included an intervention period to test the app in real life. For the evaluation component, the app was shown to participants in a single evaluation and assessment session. The other three studies were observational studies, with two studies using the app in regular psychotherapy (77, 79) and one including

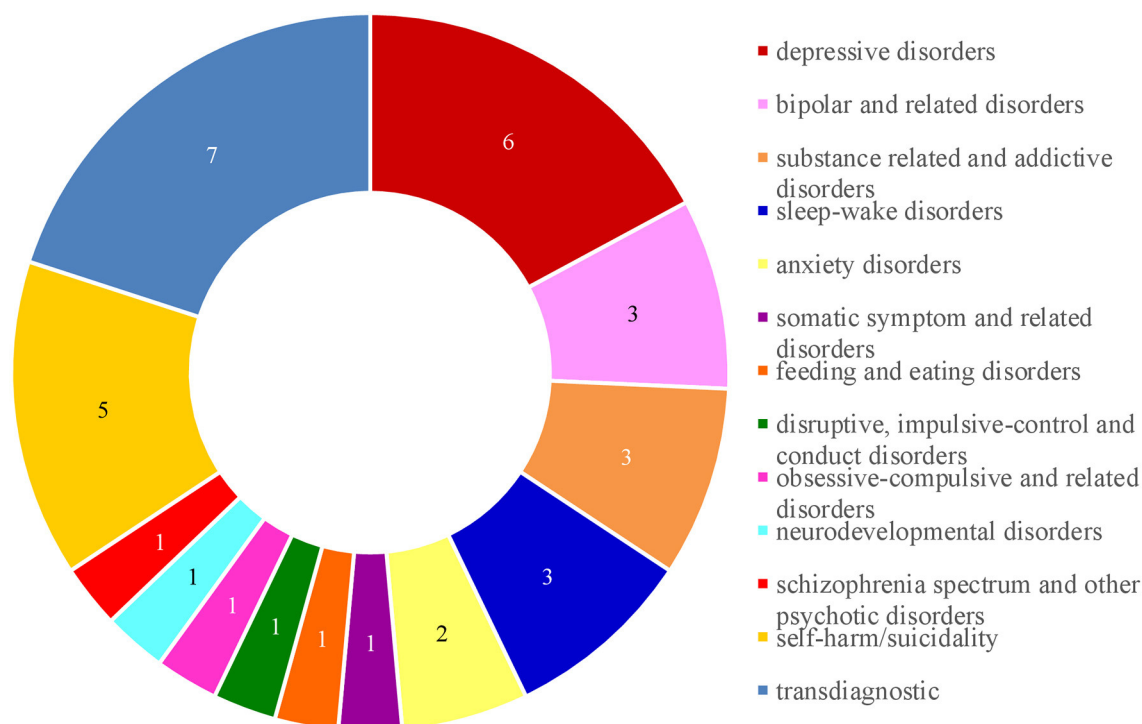


FIGURE 2
Number of mental health disorder grouped into DSM-5 categories that were addressed in the included apps.

an intervention period of 90 days as a stand-alone treatment (80). Of the three qualitative studies one included a control group (79). Sample sizes of feasibility studies without effectiveness outcomes and qualitative outcome measures ranged from eight to 36 participants with a mean sample size of 16 adolescents. Moreover, 63% of the studies included mental health professionals or primary caregivers in app evaluation, in addition to the adolescent sample. Overall, a study protocol was published for only one study (74).

3.5 Outcomes

3.5.1 Effectiveness outcomes

Considering altogether studies with primary effectiveness outcomes and feasibility studies that examined preliminary effectiveness, 23 studies reported data about effectiveness outcomes, with all studies measuring effectiveness as a reduction of symptoms. Therefore, most studies used standardized questionnaires of symptoms or disorders addressed by the evaluated app. Only one study developed a new questionnaire to measure suicidality (66). An overview of the used outcome measures of each study is presented in Tables 1, 2. There was evidence that mental health apps influenced adolescent psychotherapy, with 19 out of 23 studies favoring the intervention (83%, $p = 0.002$). Four out of 23 studies were judged to be high quality, and all four favored the intervention. Overall, 11 studies were rated low quality, with 73% favoring the intervention. However, looking only at the

studies that recorded effectiveness as the primary outcome ($n = 9$), no significant evidence could be found, with six out of nine studies favoring the intervention (67%; $p = 0.508$). Results of vote counting and available effect estimates are presented in the summary of findings tables (Tables 1, 2). Due to the small sample size of the included studies, it was not possible to evaluate effects of mental health apps according to different disorders or areas of application.

3.5.2 Feasibility outcomes

Feasibility was measured with a high heterogeneity in definition and methodology. There was no consistent definition of feasibility aspects across the included studies. Thirteen out of 14 studies used non-validated, self-developed questions about feasibility and acceptability to evaluate their apps. Similarities to standardized questionnaires for feasibility assessment were only found in a few studies: the Client Satisfaction Questionnaire [CSQ; (81)] was used in three app evaluation studies (63, 64, 77), and the System Usability Scale [SUS; (82)] was also used in three app evaluation studies (70, 78, 80). Other validated questionnaires were only used in single studies. As an objective measure, twelve studies presented app usage data as an indicator of feasibility, again showing no consistency in the data categories examined. Furthermore, 11 studies collected qualitative interview data about users' perspectives on the mental health app, with three studies collecting data using solely qualitative methods (74, 75, 79).

4 Discussion

4.1 Principal findings

The present review gives an overview of studies testing mobile applications in the context of adolescent psychotherapy during the COVID-19 pandemic. In the past 3 years, from June 2020 to June 2023, 31 studies on 27 mental health apps for adolescents between ages 12 and 27 years were published. Table 4 presents an overview of all included mental health apps. Across all studies, effectiveness was defined as a reduction of symptoms and was mostly surveyed with standardized questionnaires about symptoms or disorders. The results of the included studies measuring effectiveness as a primary or secondary outcome indicate that mental health apps are effective for adolescent psychotherapy, with 83% of mental health app studies favoring app-based interventions and the other 17% showing no effect on symptom reduction. No published study showing negative effects on adolescents' wellbeing was found. Nevertheless, these results cannot be presented as evidence of the overall effectiveness of mental health apps for adolescents. Focusing on effectiveness as primary outcome only, we did not find significant evidence that mental health apps are truly effective for adolescents. These findings are consistent with the results of previous research, which also reported promising but inconclusive results of the overall effectiveness of mental health apps (33, 83, 84).

4.2 Quality of evaluation studies

One possible reason for the inconclusive results of effectiveness outcomes is the high heterogeneity of study methodology and quality appraisal. Among studies that examined effectiveness as the primary outcome, study quality ranged from low to high, with 44% rated low quality. Two thirds of the effectiveness studies were RCTs, with five studies including active control groups. Two of the high-quality studies used another app within their control group. Three studies did not include comparison groups and one effectiveness study made statements about effectiveness of their treatment using visual analysis of symptom reduction in five participants (51). Another indication of poor research quality in mental health application studies is the non-adherence to established standards, such as good clinical practice guidelines, particularly evident in failure to register their respective studies with a clinical trial registry. Out of the nine effectiveness studies, only four were registered. As other researchers have pointed out, most of the available mental health apps do not provide evidence on their effectiveness (12, 13, 32, 37, 41). In line with the above, we rated a high number of the evaluation studies included in the current review at low quality. Therefore, it remains unclear whether the few apps that show some evidence for their effectiveness were evaluated with studies ensuring good clinical practice and quality.

The other 71% of the included studies focused on feasibility as primary outcome. Considering the steep increase in mental health apps released in app stores (10, 11), the predominance of published feasibility studies over effectiveness studies is not

surprising. Following the steps of developing and evaluating new clinical interventions, focusing on feasibility and overall user experience with the new intervention is a common first step before organizing an elaborate effectiveness study. However, Larsen et al. (41) reported that app providers are frequently content with positive results about feasibility and acceptability of mental health apps and do not continue the evaluation of the app further, for example by doing studies on the effectiveness. We also find a high heterogeneity in the quality appraisal and study methodology in the included feasibility studies. Out of the studies measuring feasibility as primary outcome, 68% were rated low or very low quality. Study designs ranged from RCTs to descriptive cross-sectional design studies. Some feasibility studies did not include an intervention period but had single evaluation sessions to rate the developed mental health app. Sample sizes likewise had a wide range from three to 248 included participants. In addition to the high heterogeneity in study design and procedure, measurement of feasibility did not follow a consistent definition. Most of the studies developed own items ranging from questions about having fun using the app or being satisfied with the app, to detailed questions about app functionality or design, to objective usage data like the number of logins or the duration of use. Considering this range of feasibility aspects, it is not possible to make generalized statements about the feasibility of mental health apps for adolescents.

In order to determine the feasibility and effectivity of mental health apps properly, we need researchers to define concepts like app quality and to develop and use corresponding measurements. Future studies should try to apply common scientific standards like study registration, control-group designs, adequate sample size to the field of app evaluation. Multi-method and multi-informant approaches seem promising. However, it is challenging to combine high quality evaluation studies (feasibility studies as well as effectiveness studies) with the fast pace of new developments of mental health apps (14, 38). Nevertheless, this is the only way to expand the knowledge on apps in psychotherapy.

4.3 Overview of evaluated mental health apps for adolescents during the COVID-19 pandemic

The area of application of mental health apps did not change significantly during the COVID-19 pandemic. About 70% of the mental health apps were offered as stand-alone treatments, replacing usual psychotherapy services, or being used as a bridge-over during the waiting period for psychotherapy. These results are comparable with previous research, showing that more stand-alone mental health apps were provided than therapy-accompanying mental health apps (34). Most therapy-accompanying apps included in our review provide interrelated app-versions for adolescents and their therapists. All of them were designed for supporting outpatient psychotherapy. Therefore, app features are designed with the aim of supporting patients in therapy homework, monitoring their mood between outpatient sessions or facilitating communication between patient and therapist. Two therapy-accompanying apps did not connect patients directly with

their therapists. These apps were designed as accompanying tools for specific manualized treatments with fixed therapy modules following the same order. A new development in this area are apps involving the community network of affected youths. Like Diano et al. (29), former research could typically be divided into two subgroups: stand-alone or therapy-accompanying apps. In the current review, community-network apps were discovered as a third subgroup of the app intervention concept. Three out of the 27 apps were used as community-network apps, connecting youth with primary caregivers or peers. These interventions were predominantly based on family-focused therapy that included primary caregivers or peers as lay counselors and main support for the affected youths. What is remarkable is that two out of the three community-network apps supported the mental health of youth by addressing the issue of self-harm and suicidality. The results of the evaluation studies showed evidence of effectiveness and feasibility without showing negative side effects either on the side of the affected youth or the selected peers or caregivers (49, 54). The development of specific community-network mental health apps could potentially be a consequence of the increased mental health concerns and the resulting pressure to treat during the pandemic. Involving the social environment in supporting the affected youth could relieve the burden on the healthcare system (4, 7, 22) and enable more youth to receive support, especially at an early stage (30). In addition, the feeling of connectedness is an important factor for adolescents (27, 28) and could be another reason for having a greater focus on the social environment in treatment development.

Overall, there is still a greater focus on developing mental health apps for specific disorders or symptoms rather than following a transdiagnostic approach. The current review cannot confirm the trend found by Ellis et al. (9) that transdiagnostic approaches were increasing in the mental health app development. In fact, we found a comparable percentage of transdiagnostic approaches as opposed to those for specific disorders. The increased focus on transdiagnostic treatment approaches is in line with the current psychotherapy research. Instead of developing treatment concepts for clearly defined, specific disorders, psychotherapy research is increasingly trying to develop treatment concepts that focus on symptoms and treatment principles that transcend disorders (85, 86). Moreover, the most common app features, also used in the included disorder-specific mental health apps, were not disorder specific features. For example, mood monitoring and features supporting specific behavior changes were used by almost half of the mental health apps, while skill toolboxes were part of one third of the apps. It can therefore be argued that most of the developed applications exhibited the potential to offer support beyond their primary focus on specific mental health concerns, as each of them incorporated fundamentally transdiagnostic features within their respective platforms. Having a look at the reported disorders of youth, we can see that most adolescents had comorbidities and were diagnosed with more than one specific disorder (18, 87, 88). In order to address the complexity of mental health issues affecting young people, it is necessary to offer transdiagnostic mental health apps. It is not feasible to equip an adolescent with several apps at the time, each one for another psychological problem.

4.4 Strengths and limitations

The current review focused on a narrowly defined period from June 2020 to June 2023 in order to examine the pandemic's influence on mental health app development and evaluation. Including only studies published during the COVID-19 pandemic provides a good overview of recently published, studies on mental health apps that possibly take into account the new needs that have arisen in the healthcare sector due to the pandemic. However, the current review did not exclusively include pandemic-related mental health apps, as evaluation studies conducted before the pandemic but published after June 2020 were also included. Another methodological limitation has to be mentioned for the reviewing process. One reviewer for each database, which could introduce selection bias, conducted the initial screening process. Including all kinds of evaluation studies is another strength of the current review. The given overview presents evidence from different evaluation stages and provides a more complete picture of the current developments in the field of mental health apps. However, looking at all types of evaluation studies also weakens the robustness of the results on the effectiveness of mental health apps. When interpreting the results of the included mental health app evaluation studies, we have to consider the overall low quality of study methodology.

4.5 Conclusion

Taken altogether, it is evident that within the spectrum of evaluation studies, there are significant disparities in both quality and methodological approaches. There is an urgent need to improve quality of evaluation studies and to ensure that research on mobile mental health complies with the established scientific standards. At the latest since the pandemic, mental health apps have a firm and important role in our healthcare system and are likely to continue to grow in influence in the future. Clinicians as well as adolescents in need are more likely to use digital mental health support, but actual app development policy aggravates the access to high-qualitative evaluated apps. Only with defined standards and high-quality research can we ensure that feasible and effective apps are implemented in psychotherapy with adolescents.

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

SW: Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Writing—original draft. KH: Conceptualization, Methodology, Writing—review & editing. MK: Investigation, Writing—review & editing. I-KP: Investigation, Writing—review & editing. TH: Supervision, Writing—review

& editing. MS: Funding acquisition, Project administration, Writing—review & editing.

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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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Anxiety symptoms and coping strategies among high school students in Vietnam after COVID-19 pandemic: a mixed-method evaluation

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Introduction: The objective of the current study was to examine the rate of high school students at risk of anxiety disorder during the COVID-19 pandemic in Vietnam, as well as the coping strategies utilized within this demographic.

Methods: An evaluation was conducted through the utilization of mixed methods, consisting of a combination of a cross-sectional study and in-depth interviews. In this study, a sample of 3,910 students from 13 high schools in Hanoi, Vietnam were selected for participation. The measurement of symptoms of anxiety disorder was conducted through the application of the seven-item General Anxiety Disorder (GAD-7) scale. To comprehend the underlying causes of anxiety and the various coping mechanisms employed, in-depth interviews were conducted.

Results: The findings indicate a prevalence rate of anxiety disorder symptoms among students at 40.6%. The prevalence rates of mild, moderate, and severe anxiety symptoms were found to be 23.9%, 10.9%, and 5.8%, respectively. In-depth interviews uncovered multiple sources of anxiety experienced by high school students, namely their academic performance, social interactions, prejudicial attitudes from their social circle, and familial expectations. Numerous coping strategies were then documented.

Discussion: The current investigation ascertained that there exists a moderate level of anxiety amongst high school students in Hanoi, Vietnam during the COVID-19 outbreak. Furthermore, this study configured potential indicators to identify vulnerable individuals and further suggests the development of targeted interventions.

KEYWORDS

anxiety disorder, coping strategies, adolescent, high school, COVID-19 pandemic

1 Introduction

Adolescence is a distinct period of maturation marked by significant physiological, psychological, and social transformations, rendering these individuals potentially more susceptible to deleterious impacts of stressful circumstances (1, 2). According to a meta-analysis comprising 136 studies conducted on diverse populations impacted by the

COVID-19 pandemic, a minimum of 15–16% of the general populace suffered from symptoms related to anxiety or depression (3). During the COVID-19 pandemic, while various feelings such as the fear of contracting an infection, grief over loss, and a sense of overpowering uncertainty were collectively felt by individuals of varying ages, the extensive disruption of education had a significant impact on the mental wellbeing of children and adolescents.

Prior to the emergence of the current pandemic, there were well-documented and significant instances of increased anxiety, depression, substance abuse, and other related mental health challenges experienced by adolescents who faced high academic and societal pressures to succeed (4). The adoption of remote learning, implementation of social gathering limitations, alteration or discontinuation of sports or clubs, and the suspension of in-school activities and events pose significant obstacles to the intellectual and communal development of juveniles. The perturbation in educational processes and the resultant seclusion, coupled with the absence of guidance from instructors and classmates, not only impedes scholarship but may also intensify the apprehension experienced by adolescents about their academic pursuits and professional ambitions (5, 6). A prior study among adolescent students found that students who received virtual education had more mentally unhealthy days, more depressive symptoms, and a tendency to think about suicide compared to peers with different forms of education (7). The offering of social support by peers and educators is considered a crucial element in safeguarding the social-emotional wellbeing of adolescents, especially during periods of stress. Furthermore, the provision of such support could potentially contribute to the sustained academic engagement and motivation of this particular group (8). Students who received virtual instruction reported experiencing a higher number of mentally unhealthy days, more persistent symptoms of depression, and a greater likelihood of contemplating suicide compared to their peers who were instructed through different modalities (7).

In Vietnam, during the phase of adolescence, individuals undergo a challenging transition, rendering them highly susceptible to the negative impacts posed by the COVID-19 pandemic. A previous population-wide study showed that among university students, 16.2% suffered from anxiety during the COVID-19 pandemic (9). In response to the COVID-19 pandemic, educational institutions nationwide implemented temporary closures and directed students to remain in their respective homes. Adolescents may experience significant psychological impacts due to decreased social interaction, academic challenges, fear of illness, substantial alterations in their daily routine, and feelings of boredom. It has been observed that they exhibited heightened vulnerability to the psychological ramifications of the epidemic, with a corresponding lack of efficacy in coping with their psychological distress. Nevertheless, a limited number of investigations have been undertaken to explore the psychological wellbeing challenges encountered by this demographic amidst the COVID-19 outbreak in Vietnam. The objective of the current study was to examine the rate of high school students at risk of anxiety disorder during the COVID-19 pandemic in Vietnam, as well as the coping strategies utilized within this demographic.

2 Materials and methods

2.1 Study settings and participants

A cross-sectional study was undertaken among high school students in Hanoi, Vietnam, from October to November 2021, in response to the lockdown imposed in Hanoi due to the COVID-19 pandemic. During this stage, students are required to engage in remote learning from home. The study required participants to conform in full to the following stipulations: (1) an age range from 14 to 17; (2) residency in Hanoi, Vietnam coupled with enrollment in a high school chosen for its inclusion in the study; and (3) explicit consent to partake in the research. The research methodology employed a multi-stage sampling technique. Initially, a list of high schools in Hanoi was compiled and stratified according to geographical location (rural/urban) and institutional classification (private/public), resulting in four possible groups (rural/private, rural/public, urban/private, and urban/public). Thirteen high schools were chosen at random in order to ensure that each group would have at least three high schools. The selected schools are independent of the school's performance and are typical options for high school students. The entirety of eligible students encompassed within these educational institutions were chosen. A cohort of 3,910 pupils enrolled from 13 secondary educational establishments in Hanoi. This study was approved by the institutional review board of the Vietnam National University.

2.2 Measurement and instrument

The current study employed the Google Form as the framework to construct an electronic survey. This methodology offers various benefits, including cost-effectiveness, expeditiousness, ease of use, and the ability to attain a sample of a wide geographical coverage. Each survey is expected to require approximately 10 to 15 min for completion. The present study gathers sociodemographic data, anxiety disorder data, and related information about the COVID-19 pandemic via the utilization of a structured questionnaire. At the outset, the questionnaire underwent a pilot test with a cohort of five adolescent individuals to substantiate that the ethnically diverse characteristics of the instruments persisted unaltered after their translation into the Vietnamese language. Subsequently, the revised questionnaire was disseminated through the online survey platform. Before the commencement of data collection, the survey system underwent rigorous testing to verify the accuracy of the questions and to ascertain that no technical complications emerged.

The study participants provided data on their socio-demographic characteristics, including gender, educational institution category, level of schooling, and geographic location. In the present study, the Generalized Anxiety Disorder 7-Item (GAD-7) Scale was employed as an assessment tool to quantify the rate of at-risk anxiety disorders among adolescent participants enrolled in high school education (10, 11). The respondents assessed the frequency of their occurrence of symptoms associated with generalized anxiety disorder, such as emotional irritability or annoyance, using a rating scale ranging from 0 to 3 representing the absence of symptoms and daily manifestation over the last

TABLE 1 Demographic characteristics of respondents (n = 3,910).

Characteristics		Freq.	Percent (%)
Gender	Male	1,851	47.3%
	Female	2,009	51.4%
	Others	50	1.3%
Location	Urban	2,052	52.5%
	Rural	1,858	47.5%
Type of schools	Public	2,069	52.9%
	Private	1,841	47.1%
Grade	Grade 10	1,381	35.3%
	Grade 11	1,127	28.8%
	Grade 12	1,402	35.9%

fourteen consecutive days, respectively. A classification framework was employed to delineate the levels of anxiety among the students. Specifically, the classification system comprised four distinct levels, namely: no anxiety, mild anxiety, moderate anxiety and severe anxiety which were based on a scoring range of 0–4, 5–9, 10–14 and 15–21, respectively. The psychometric properties of GAD-7 scores (which have a potential range of 0–21) were found to be satisfactory with adolescent populations. The Cronbach's alpha coefficient attained a value of 0.916.

In qualitative analysis, 20 high school students were selected at random from the available database and approached through telephone communication to obtain informed consent for a recorded interview. A convenient date and time were then scheduled for interviewing telephonic means. Participants were recruited until a point of saturation was achieved about the responses proffered by the participants.

2.3 Statistical analysis

SPSS version 20.0 was used to analyze the data. The significance level was set at 5% which is equivalent to a $p \leq 0.05$. In a typical descriptive statistical study, the mean and standard deviation for quantitative data, as well as frequency and percentage for qualitative variables, were employed. The internal consistency reliability was examined by calculating Cronbach's alpha, with an alpha value of 0.7 or above being considered acceptable.

The analysis and reporting of qualitative data entail the consolidation of all responses obtained from participants into a singular dataset. The present study employed qualitative content analysis to transcribe and analyze the audio-recorded responses provided by students. Initially, the procedure involved a comprehensive review of the responses contained within the scripts, to gain a thorough understanding of their substance. Following this stage, meaningful segments were subsequently identified as discrete units of analysis. The semantic units were subsequently encoded under their subject matter, and these encodings were subsequently aggregated into taxonomic classes. The authors of the study undertook the tasks of data summarization, coding,

and category development through the application of thematic analysis.

3 Results

Table 1 shows that, among 3,910 students, the majority of them were female (51.4%), studying in urban areas (52.5%). Most of the students studied in public schools (52.9%) and grade 12 (35.9%).

Table 2 shows the profile of GAD-7 instrument among high school students. The most common symptom was "Becoming easily annoyed or irritable" (mean score = 1.01), followed by "Worrying too much about different things" (mean score = 0.96) and "Feeling nervous, anxious, or on edge" (mean score = 0.89). Overall, the rate of high school students who were at risk of anxiety disorder was 40.6%. The proportion of mild, moderate and severe anxiety symptoms accounted for 23.9%, 10.9% and 5.8%, respectively.

Table 3 depicts that there were significant differences in the GAD-7 score regarding gender, location and grade ($p < 0.05$).

3.1 Qualitative analysis regarding challenges, causes and coping strategies among high school students during the COVID-19 pandemic lockdown

There were many causes of anxiety disorders among high school students in Hanoi, in which work and study were the leading causes of anxiety disorders among students.

"Last time of COVID-19, I had just entered 10th grade, so I was quite subjective and busy playing, neglecting my studies plus studying online, the school was less tightly managed than going to face-to-face classes, so there were a few subjects that I didn't like. as if it was completely lost. Now I'm in grade 11 and go back to school directly, losing my roots makes it quite difficult for me to study and my study results are very bad compared to the common ground, I have been under a lot of pressure because of this. that. Because of that, my mother often has harsh words that make me more confused" (A male student in a public school).

The second reason was social relationships. Students' social relationships often revolved around friends and teachers in school. Students often feel inferior to their friends and feel anxious when they were better than them. This feeling could be considered as a positive factor to motivate students to strive, try to overcome difficulties and overcome themselves. Instead of utilizing this anxiety as a motivator for self-improvement, some students perceive this anxiety as causing them to lose sleep, consequently leading to this anxiety becoming a pathological condition or a negative factor, rather than a positive one (12). Many students experienced stress and anxiety just because of the standards they set for themselves.

TABLE 2 Profile of general anxiety disorder (GAD-7) instrument.

TT	Items	Level								Mean
		Not at all		Several days		More than half the days		Nearly every day		
		N	%	N	%	N	%	N	%	
1	Feeling nervous, anxious, or on edge	1,574	40.3	1,658	42.9	359	9.2	319	8.2	0.89
2	Not being able to stop or control worrying	2,320	59.3	1,072	27.4	303	7.7	215	5.5	0.85
3	Worrying too much about different things	2,029	51.9	1,117	28.6	416	10.6	348	8.9	0.96
4	Trouble relaxing	2,111	54.0	1,187	30.4	356	9.1	256	6.5	0.89
5	Being so restless that it is hard to sit still	2,729	69.8	833	21.3	205	5.2	143	3.7	0.75
6	Becoming easily annoyed or irritable	1,754	44.9	1,247	31.9	453	11.6	456	11.7	1.01
7	Feeling afraid, as if something awful might happen	2,637	67.4	824	21.1	244	6.2	205	5.2	0.83

TABLE 3 Anxiety disorder scores according to different demographic characteristics.

Characteristics		Freq.	Percent (%)	Mean	SD	p-value
Gender	Male	1,851	47.3%	1.50	0.83	<0.01
	Female	2,009	51.4%	1.74	0.92	
Location	Urban	2,052	52.5%	1.68	0.92	<0.01
	Rural	1,858	47.5%	1.59	0.86	
Type of schools	Public	2,069	52.9%	1.61	0.88	0.08
	Private	1,841	47.1%	1.66	0.91	
Grade	Grade 10	1,381	35.3%	1.53	0.85	<0.01
	Grade 11	1,127	28.8%	1.64	0.87	
	Grade 12	1,402	35.9%	1.72	0.94	

“When I studied online, my relationship with my best friend was really bad. We rarely talk to each other, even for a week we don’t talk to each other. Even after going back to school, I was isolated and slandered by my classmates” (A female student in a rural high school).

In addition, some students had conflicts in their relationship with teachers, even some were very inhibited when it came to a certain teacher’s class time. *“Since switching to online learning, my teacher curses students a lot. That’s why I feel so pressured every time I take her classes.”*

The third reason was family. Conflicts between parents such as parental discord, parents’ divorce or conflict in communication between parents and children were also concerns of children.

“My grandmother is a person who respects men and despises women, so my family often quarrels at the dinner table. I like school more but because of the covid-19 epidemic, the whole

family has to stay at home due to social distancing, so almost every day I see family quarrels. I feel very tired” (A male student in public school).

Parents’ expectations for their children put students under significant pressure. *“I wanted to enter an art school but my parents expected me to take the pedagogical exam. I really didn’t want that. I tried to talk to my parents but they didn’t listen to me. I feel like I have to live my parents’ life, not mine. They never listen to me. Mom always told me to do this and that. I’m 18 years old, but why does my mother have to decide for me? I’m so negative that I don’t want to do anything, even normal things like eating, I don’t want to eat. At school, I don’t want to talk to anyone and I feel that my friends are also gradually shunned because of my negativity. I don’t know who to share it with”* (A male student in private school).

To contain the stress all students employed a coping strategy to avoid a breakdown. From our interactions, several coping strategies for the lockdown-induced stress and anxiety were identified from

the responses of the study participants. Among the ways to cope with anxiety, high school students chose the most effective way to deal with anxiety, which was “Self-motivation” such as enjoying healthy activities to reduce anxiety such as playing sports, journaling, watching movies, and listening to music. Some of them tried to write diaries to express their feelings.

“I used to keep diaries, but my parents randomly rummaged through them and read them and scolded me. Now I’m sad or negative, I just cry and cry, I just want to go out and be alone until I’m okay again” (A female student in public school).

Another solution was playing sports (“when I feel tired, I often invite my friends to play basketball to relax” or “I listen to music or participate in outdoor activities”). In addition to affirming that they could overcome anxiety (the positive side), some students responded to anxiety with negative behaviors such as “getting into the game, the only thing I can do make yourself happy” (A male student in public school).

The second response was “Need to have a reasonable timetable”. Organizing a reasonable timetable helped students reduce anxiety when the exam came. For students who did not know how to organize and used time appropriately, especially those who have difficulty adapting to difficult situations, it could cause anxiety for students.

“Parents care about feelings” was also a solution: “For me, the best way to deal with anxiety is the care of parents for their children. Whenever I feel difficult about something, I often confide in my mother. Mom always listens and helps me overcome those difficulties.”

The final solution was meeting school counselors. This result showed that, although high schools had psychological counseling rooms, high school students still did not know about the school counseling room, and did not know where they could meet the counselors to share their stories. That was why, even though students tried to motivate themselves to reduce anxiety, this situation had not been overcome, especially during the COVID-19 epidemic, when they had to stay at home due to social distancing and perhaps they did not know how to relieve anxiety.

4 Discussion

The study’s results suggest that an investigation into the mental or cognitive health status of high school students was necessary to illuminate the precise psychological repercussions caused by the COVID-19 pandemic. The emergence of the COVID-19 pandemic is believed to engender intense personal stress and have consequential effects on the mental health of individuals. The coping tendencies of students in Vietnam are impacted by some factors, including symptoms of mental health conditions and social stressors related to uncertainty surrounding the COVID-19 pandemic.

Throughout history, the world has experienced several perilous epidemics, including the recent outbreak of COVID-19. It is noteworthy that the non-adoption of coping mechanisms can significantly impact the academic accomplishments of students, owing to the uncertain nature of the COVID-19 pandemic (13).

The findings of this study demonstrate a significant prevalence of anxiety disorder symptoms among students during the COVID-19 lockdown period. This phenomenon has also been observed during various stages of lockdown in Vietnam. Another online survey conducted on a sample of 5,315 students between the ages of 11 and 17 in Hanoi, Vietnam revealed that approximately 7.4% of participants exhibited severe symptoms of anxiety, while 67.9% reported experiencing mild to moderate symptoms. The author posited that the COVID-19 pandemic, subsequent to the closure of schools and implementation of remote learning, exerted a detrimental influence on the psychological maturation of adolescents in middle and high school (14). A study conducted in Thailand demonstrated that students who received traditional classroom (onsite) instruction were 37.8% less likely to report moderate-to-severe anxiety in comparison to those who were engaged in fully online learning (15). Our results show higher percentages compared to other studies, such as 37.4% in China during the first year of COVID-19 (16), 36% in the second year in America (17), and 25% in June 2021 and 16% in September 2021 in Germany (18). Another internet-based study that included 212 adolescents and 662 young adults who filled out surveys in the Fall of 2019 and 2020, both before and after the COVID-19 pandemic began, suggested that rates of adolescents experiencing anxiety symptoms rose from 24.3% to 28.4% following the onset of COVID-19 (19). The lower global research results compared to our study may be attributed to several factors. Our research was conducted during the period when the Hanoi government implemented an extended period of social distancing and lockdown measures (beginning in April 2021), resulting in increased impact of COVID-19 on the economic situation of households and the health of students (20). Extended periods of social distancing, anxiety surrounding contagion, limited understanding, social stigmas, and financial burdens have been posited by researchers as factors contributing to a heightened adverse psychological effect (21). Secondly, the implementation of online learning in Hanoi during this period has not proven to be significantly effective, leading to heightened stress and anxiety among students. A study conducted in Vietnam revealed that among secondary school students, 56.7% reported a preference for online learning, and 62.7% perceived themselves to make progress through online learning (22). The corresponding proportions among high school students are 52.6% and 54.3%, respectively (22). The pressure of online learning on time management must ensure the physical and mental wellbeing of students, as well as concerns about the transition exams that students may not have been able to study for certain subjects. This is a matter of concern, impacting the holistic development of students. Furthermore, the learning activities of students in the process of online learning are quite diverse. However, not all academic activities receive appropriate attention from teachers, especially those with the unique characteristics of online learning (22). This will have a significant impact on the academic quality of students and subsequently lead to implications for students’ mental health.

Vietnam implemented measures of social distancing in certain provinces and urban areas with elevated rates of COVID-19 transmission, while also sustaining the implementation of remote learning and assessments. The transition to online education and examinations has been associated with heightened levels of

depression and anxiety symptoms (23). Numerous nations have opted to either suspend or delay the administration of university entrance examinations as a mitigative measure. The postponement of classes due to challenges with online learning has elicited a positive response from some students, who perceive online learning as ineffective. However, there are also opposing views, with some arguing that such a mode of study may contribute to heightened stress levels (24). A distinct schism within the online public discourse in Vietnam gives rise to inquiries regarding the encompassing nature of distance learning (25). Socioeconomically disadvantaged students encounter challenges in accessing and adhering to online classes, which results in heightened levels of anxiety and psychosocial disturbances (26).

This research has identified specific subpopulations of students that exhibit greater susceptibility to the manifestation of symptomatic indications related to both mental and physical health. In comparison to male participants, female respondents and individuals identifying as non-binary demonstrated an increased tendency to report symptoms of mental health, aligning with the observed prevalence in previous scholarly literature. A notable proportion of individuals within different demographic groups exhibit a markedly higher propensity to experience symptoms of anxiety, with a particular emphasis on those residing in urban areas and students in their twelfth year of education. The heightened levels of pressure originating from parental or peer influence may offer a plausible rationale for the observed phenomenon in comparison to their counterparts.

This study also demonstrates a significant correlation between coping mechanisms and levels of anxiety. In this study, 40.6% of students reported experiencing at risk of anxiety disorder symptoms, ranging from mild to severe levels. The evaluation of students' coping strategies entails the assessment of various factors such as their capacity to actively seek social support, the degree of isolation and mental detachment they experience, as well as their responsiveness to humanitarian concerns (27).

The present study elucidates the diverse coping mechanisms employed by students during qualitative analysis, encompassing a broad spectrum of approaches ranging from seeking social support to engaging in relaxation techniques, and in some instances, avoidance tactics. According to the findings, individuals who present symptoms of anxiety tend to resort to avoidance as a coping mechanism more frequently than they adopt alternative strategies. The present findings are congruent with the research outcomes revealed by other previous studies (28, 29). Both of these studies present findings that were obtained during a period of pronounced COVID-19 outbreak in their respective countries. Accordingly, it can be inferred that students felt compelled to utilize any feasible techniques at their disposal to mitigate their anxiety levels.

The implementation of COVID-19 policies, including social distancing, isolation, and a sedentary lifestyle, has been linked to a negative impact on the mental health of young adults (29). It has been noted in recent research that students may encounter a variety of negative emotional responses, including stress with the cancellation of exams and anticipated events, anxiety spurred by the academic workload, and fear of contracting an infection. The findings of this study indicate that an increased frequency of in-person educational activities, in the absence of interventions aimed at mitigating the root causes of psychological

distress, may not yield a beneficial impact on the mental health of students.

The study has limitations that must be addressed for further exploration of the phenomenon. The survey did not differentiate between compulsory and voluntary remote education, which could introduce confounding factors associated with mental health difficulties, such as having a family member with a high medical risk or expressing reservations about the school's capacity to guarantee safety. The aforementioned factors may have exerted an influence on the selection of schooling modality by children, thereby potentially undermining the conclusiveness of the observed associations. Furthermore, it is important to acknowledge that our research utilized a convenience sampling method via the online survey, thereby imposing limitations on the extent to which the findings can be generalized to all high schools due to the non-random nature of the sample selection process. However, it is important to note that the sample size was substantial and can be considered as a strong representation of a specific group of high school students in a large urban area such as Hanoi. Finally, the GAD-7 is utilized as a screening tool rather than a diagnostic tool, which has led to our inability to assess the actual prevalence of anxiety disorders but only to evaluate the prevalence of symptoms associated with anxiety disorders. Further research is necessary to explore alternative diagnostic methods for assessing anxiety disorders within this particular demographic.

This study indicates a variety of implications for the wider community. Firstly, the administration of the educational institution should possess an understanding of the strategies utilized by students to navigate through adversities and challenges. During the period of the outbreak, it is imperative to ensure that appropriate care and assistance are provided to students who are not living with their parents or other relatives. Secondly, to effectively confront the widespread psychological difficulties faced by students, it may be advantageous for educational institutions to contemplate the implementation of interventions such as an online platform for sharing personal experiences, along with incentivizing engagement through the provision of awards or financial assistance. Thirdly, to facilitate the adoption of adaptive coping strategies and minimize the adverse impact of stress on mental well-being, it is recommended that high schools prioritize the incorporation of approach-coping techniques into their educational curricula. Furthermore, it is imperative to recognize the importance of integrating coping interventions as a fundamental element of high school and other educational programs. No research has examined the temporal evolution of mental health symptoms in relation to the length of school closures. However, it is reasonable to speculate that the detrimental impact on mental health is expected to escalate as school restrictions persist. Additional research is essential to gain a deeper understanding of this correlation.

5 Conclusions

The present investigation demonstrates a noteworthy level of anxiety symptoms among high school students situated in Hanoi, Vietnam amidst the global crisis of COVID-19. Furthermore, this research seeks to identify associated factors that can aid in identifying susceptible groups and formulating targeted

interventions. As the global COVID-19 pandemic persists, our research outcomes may hold significant implications for analogous regions within Vietnam, as well as other countries, on addressing the mental health predicaments of secondary school learners.

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 humans were approved by Institutional Review Board, University of Social Sciences and Humanities. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

Conceptualization: PH and NV. Formal analysis: DT and NV. Investigation: DT and NL. Methodology: PH and DT. Project

administration: NL. Writing—original draft and writing—review and editing: PH, DT, NL, and NV. All authors contributed to the article and approved the submitted version.

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The change of psychosocial stress factors in families with infants and toddlers during the COVID-19 pandemic. A longitudinal perspective on the CoronabaBY study from Germany

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Background: Over nearly three years, the COVID-19 pandemic has had a lasting impact on people's lives and mental health worldwide with its far-reaching restrictions and concerns about infections and other personal consequences. Families were particularly affected and showed increased stress and psychological problems. Long-term effects cannot be ruled out. So far, data on young families are sparse. The present longitudinal analysis ($n = 932$) of the CoronabaBY study investigated the development of parenting stress, parental affective symptoms, and child's mental health in young families with children aged 0–3 years in Germany as well as potential influencing factors.

Methods: The observational study includes two measurement points over the course of the pandemic (baseline and follow-up). Data was collected by app using standardized questionnaires.

Results: $N = 932$ participants, mainly mothers (94.7%) born in Germany (93.1%) with higher education (61.3% with at least high school diploma) and a comfortable financial situation participated in the longitudinal study. Children were on average 14.7 months old at baseline (SD: 12, range: 1–39 months). While the proportion of parents who perceived the pandemic as stressful decreased significantly from baseline (60%) to follow-up (52.3%), the proportion with parenting stress increased significantly (from 40.1% to 45.4%). Both parental and child mental health problems remained constant over time, with infants crying/feeding/sleeping problems ranging above pre-pandemic comparative data. Most predictive for high parenting stress at follow-up was high parenting stress at baseline. This was also true for parental affective symptoms (depression/anxiety) and child mental health problems.

Conclusions: Despite faded pandemic restrictions, parents remained burdened. Support services do not appear to have been sufficient to help families out of their stressful situation. Our results indicate a need for action regarding low-threshold services that effectively reach affected families.

Abbreviations

CFS, questionnaire for crying, feeding and sleeping; EBI, Eltern-Belastungs-Inventar [German version of "parenting stress index (PSI)"]; SDQ, strengths and difficulties questionnaire; STADI, state-trait anxiety-depression inventory.

Trial registration: The study was pre-registered in OSF (<https://osf.io/search/?q=tksh5&page=1>).

KEYWORDS

parent psychosocial functioning, infant mental health, COVID-19 pandemic, early life adversity, parenting stress, depression, anxiety

Introduction

For nearly three years, the COVID-19 pandemic has preoccupied the world, leading to a prolonged state of emergency with far-reaching restrictions and impact on everyone's life (1, 2). Families were particularly affected by additional childcare responsibilities due to the closures of day care centers/schools (3), disruptions in daily routines and limited access to family support services (4). They showed a high level of multiple stress factors and burden due to restriction measures (3, 5–8) which was seen especially in families with very young children (3, 7, 8). Fear and worries as well as social isolation are supposed to have caused acute states of stress at the onset of the pandemic. Long-term, however, a chronification of stressors is likely (8). Even short-term relaxations of high Covid-incidence rates and fading of restriction measures in Germany did not reduce psychosocial burdens in families (8). In accordance with the assumption that chronic stress can have lasting impact on mental health (9, 10), experts predicted a wave of mental illness following the wave of infection (11).

Various studies showed an increase in psychosocial stress factors among parents and children, including increases in parenting stress (12–15), parental mental health symptoms such as depression and anxiety (16–22), and child's psychological problems (13, 20, 22–32). However, most of these studies only reported on the first pandemic year whereas longitudinal studies mainly compared their results to pre-pandemic surveys (33). Moreover, children's age was at least school age (e.g., (23), investigations on early childhood are sparse (33).

Regarding the importance of early childhood for a healthy development, long-term data on infants, toddlers and their parents during the pandemic from a longitudinal perspective are needed to further assess mental health in young families (34–36). Early psychosocial stress in childhood can have a potentially harmful influence on a child's mental health (37–39). In addition, families with young children can be considered as a specific risk group (3) as infants and toddlers are still highly vulnerable to external influences and exclusively dependent on their parents' involvement in care and emotional availability (40, 41). Parenting-related exhaustion was notably higher during lockdown the younger the children were (42) and well-being significantly decreased for parents with young children in times of COVID-19 (3). Understanding young families' psychosocial needs is fundamental for developing and addressing adequate support services.

The CoronabaBY study investigated psychosocial stress factors of families with children aged 0–3 years in Germany (7, 8). While comparing three samples from three pandemic waves in a cross-sectional observation (February 2021–March 2022) (8) the

extent of the perceived pandemic burden followed the waves and their attending restrictions. Parenting stress and crying/sleeping problems of infants, however, constantly increased and were higher in families who were examined later (October 2021–March 2022) than earlier during the pandemic (February–June 2021). At the same time, parental depression and anxiety symptoms were elevated in all three pandemic phases— independent of current infection rates or restrictions. In summary, psychosocial stress factors were highly pronounced regardless of the degree of pandemic restrictions/relaxation of measures (8). However, these findings are based on a comparison of cross-sectional data. Although the participating families in the three waves showed similar sociodemographic characteristics, the results do not provide intra-individual observations of the same sample. Thus, to detect the development of psychosocial stress factors as well as underlying predictors within the sample over the course of the pandemic, we conducted a longitudinal analysis.

The present evaluation aims to extend the previous study findings and to show intraindividual changes and trends during the pandemic, considering two measurement points (baseline and follow-up). This leads to the following research questions:

1. How did the experienced psychosocial stress factors (parenting stress, parental affective symptoms, child mental health symptoms, and perceived pandemic burden) change in the sample over the course of the pandemic (baseline to follow-up)?
2. Which pandemic-related (e.g., increased family conflicts) or sociodemographic factors (e.g., financial situation, education level) influenced the psychosocial stress factors perceived in the families (parenting stress, parental affective symptoms, child mental health symptoms) over the course of the pandemic, i.e., in the follow-up?

Materials and methods

Study design

The CoronabaBY study investigated intermediate and long-term psychosocial stress during the COVID-19 pandemic ("Corona") in families with infants and toddlers ("baby") in Bavaria (Southern Germany) ("BY"). Data has been collected continuously from the 1st of February 2021 until the 2nd of November 2022. Data was evaluated longitudinally, i.e., at two measurement points (baseline and follow-up). The study protocol was approved by the Ethics Committee of the Technical University of Munich (vote no. 322/20 S) and pre-registered in OSF (<https://osf.io/search/?q=tksh5&page=1>).

Participants

All participants (parents with children up to three years) were recruited and surveyed via the smartphone app “Meine pädiatrische Praxis” (“My pediatrician”) (www.monks-aerzte-im-netz.de), which is a well-established communication tool connecting parents with their pediatrician [for detailed recruitment information, see (7)]. Invitations to the study were sent out together with invitation to the next early childhood check-up (“U-Untersuchung”). Therefore, measurement time depended on time of early childhood check-up. At baseline, the first checkup considered was “U4” (child aged around 3–4 months) and the last was “U7a” (child aged around 34–36 months), thus the ages of the children ranged around 3 months and 3 years. Corresponding reminders via app acted as invitations to the in-app-baseline respectively -follow-up-surveys. Due to the varying time intervals between the different checkups, there were individual time intervals between baseline and follow-up for the families. All children up to checkup “U6” (about one year) were classified as “infants” in this study; children from “U7” on (about two years) were considered “toddlers”.

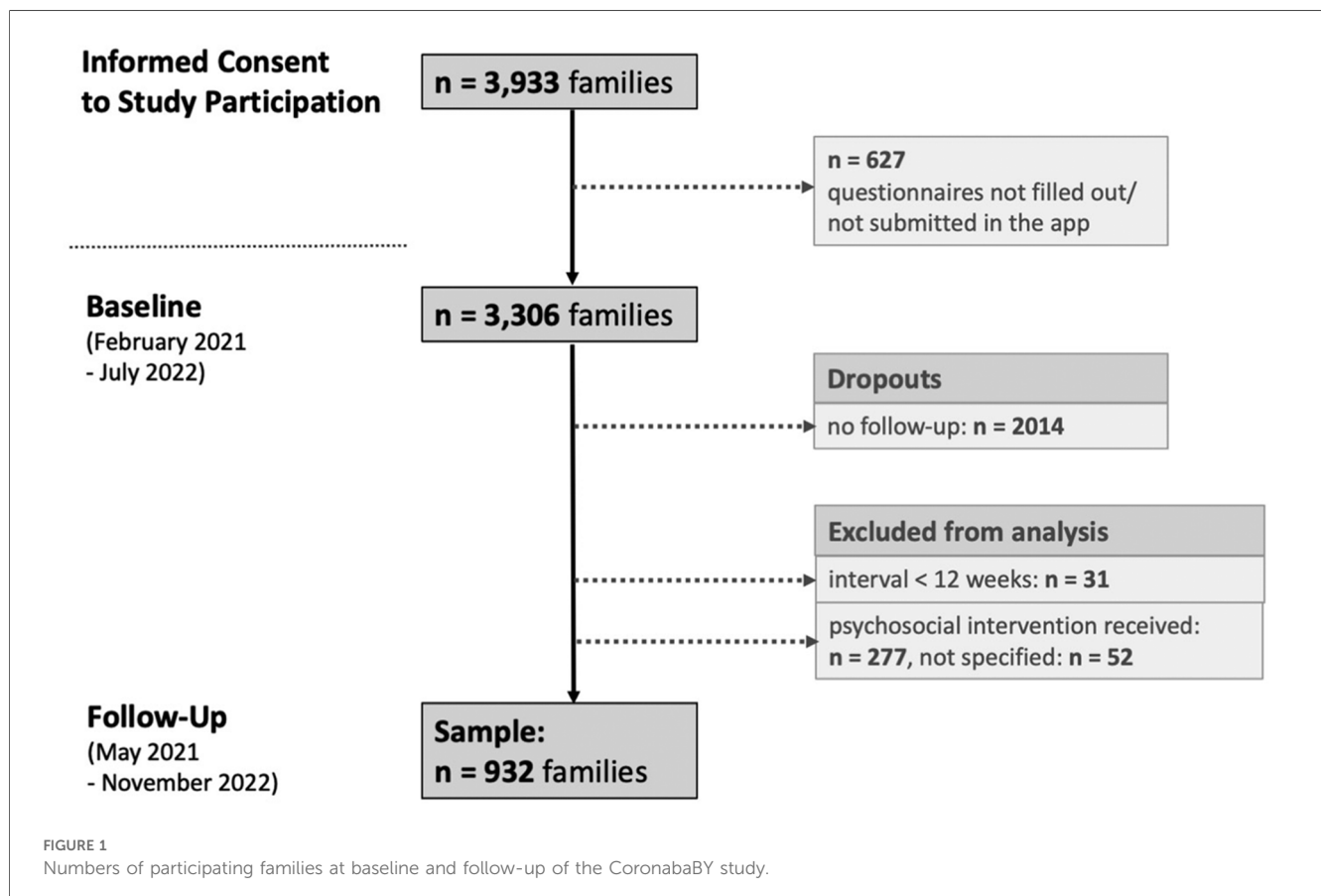
Informed consent was given by nearly 4,000 parents, a total of 3,306 finally attended and completed the in-app-study-questionnaire at baseline. A remaining number of 932 parents (28%) could be included in the follow-up evaluation (see Figure 1).

Measures

All data was collected by standardized questionnaires via app. Participants were asked about general sociodemographic characteristics, perceived pandemic burden, parenting stress, and parent and child mental health outcomes.

Pandemic-related restrictions and perceived pandemic burden

Ten questions were asked about specific restrictions and perceived burdens related to the pandemic (e.g., “During the strictest pandemic measures, how restricted did you feel about social contacts?”). The perceived “pandemic burden” for parents and children was derived from the 5-point-answer (from 1 = *not at all stressful* to 5 = *very stressful*) to the global question: “Taken together, what do you think: How stressful is/was the COVID-19 pandemic for you (please think of measures like social restrictions but also your personal experiences, related worries,...)?” and “Taken together, what do you think: How stressful is/was the COVID-19 pandemic for your child?”, respectively. The study team developed the questions due to the lack of validated instruments at this point in the pandemic. Previous publications on the CoronabaBY study could show that these questions on pandemic burden represent the pandemic in a comprehensible way (perceived stress due to the pandemic follows the degree of restrictions) and correlate significantly with each other as well as with other psychosocial stress factors (e.g., Parenting Stress Index, PSI) (7, 8).



Parenting stress

To assess parenting stress, we applied the parent domain of the German Version of the “Parenting Stress Index (PSI)” [“*Eltern-Belastungs-Inventar*” EBI; (43)]. High scores indicated limited parental resources for upbringing and care for the child. The parent domain includes the following subscales: “health” (parental health impairment as a cause or a result of parenting stress), “isolation” (lacking integration in social networks), “role restriction” (perceived limitations as a result of being parent), “parental competence” (parental doubt about their abilities to manage upbringing and care for their child), “attachment” (emotional relation of parent on the child), “depression” (limited emotional availability within the parent-child-relationship) and “spouse related stress” (as a result of being a parent). Answers were given on a 5-point Likert scale ranging from 1 = *strongly agree* to 5 = *strongly disagree*, resulting in a possible score range of 28–140. The three cut-off categories for each subscale and the whole parent domain were “*not stressed*” (T-value < 60), “*stressed*” (T-value = 60–69), and “*strongly stressed*” (T-value ≥ 70) (43). Internal consistency of the parent domain has been proven to be good ($\alpha = .93$), and retest reliability after one year is $r = .87$. Correlations with stress indicators and related constructs have resulted in the assumption of test validity (43, 44).

Parental depression and anxiety symptoms

Current parental depression and anxiety symptoms were assessed with the State-Trait-Anxiety-Depression Inventory [STADI; (45)]. The questionnaire, including four subscales (“emotionality”, “worry”, “anhedonia”, and “dysthymia”), was answered on a 4-point scale ranging from 1 = *not at all* to 4 = *very much*, resulting in a possible score range of 20 to 80. Based on age- and sex-dependent standardized cut-off T-values, each domain (“depression”, “anxiety”, “total”) was defined by symptoms to be “*far below average*” (T-value < 30), “*below average*” (T-value = 30–39), “*average*” (T-value = 40–60), “*above average*” (T-value = 61–70), or “*far above average*” (T-value > 70). Internal consistency of the global State-Scales ($\alpha = .92$), the State-Depression-Scale ($\alpha = .87$), and the State-Anxiety-Scale ($\alpha = .90$) have been proven to be good. Validity can be assumed based on comparison with other test procedures (46).

Infants’ crying, sleeping and feeding problems and toddlers’ emotional and behavioral problems

For infants (until checkup U6, about one year), the two subscales “crying/whining/sleeping” and “feeding” of the Questionnaire for Crying, Feeding and Sleeping [CFS; (47)] were applied. Parents answered 38 questions on behaviors in their infants. Answers were given on 4-point scales, and mean values were calculated (ranging from 1 to 4). According to validated cut-off values, the dichotomous outcome *noticeable problems* and *no problems* were calculated for the domains “crying/whining/sleeping” (cut-off value: 1.84, sensitivity: 87%, specificity: 92%) and “feeding” (cut-off value: 1.27, sensitivity: 57%, specificity: 77%). The validity of the questionnaire has been secured by the proof of high internal consistencies of the scales and by correlations with behavior diaries and clinical diagnoses (47).

For toddlers (from checkup U7 on, about two years), the Strengths and Difficulties Questionnaire [SDQ, short form of the German Version; (48)] was used to examine emotional and behavioral problems. Parents were asked to classify the individual characteristics to be *not true*, *somewhat true*, or *certainly true* for their child in four domains (“emotional symptoms”, “conduct problems”, “hyperactivity/inattention”, and “peer relationship problems”), resulting in a score range of 0 to 40 points. Cut-off values indicated child behavior to be “*no problems*” (0–13 points), “*borderline*” (14–16 points), or “*noticeable problems*” (17–40 points). Internal consistency has been shown to range between $\alpha = .73$ and $\alpha = .86$. By comparison with other corresponding scales (e.g., Child Behavior Checklist), the instrument’s validity can be assumed (49, 50).

Statistical analyses

The present longitudinal study was based on data collected between February 2021 and November 2022. If the two measurement points were closer than 12 weeks ($n = 31$) the family was excluded from the analyses.

Statistical differences between the sociodemographic and psychosocial characteristics of the follow-up participants (= sample) vs. the dropouts were detected using the Chi-square test for categorical and T-test for continuous variables.

To answer the first research question, Chi-Square Tests and where appropriate T-Tests were calculated to detect potential differences in the proportions of the addressed psychosocial stress factors for baseline and follow-up. If appropriate, the outcome variables were dichotomized: Perceived pandemic burden was dichotomized into stressful/ very stressful (points 4 and 5 on a 5-point Likert-scale) compared to less stressful (points 1–3). Parenting stress (EBI) was classified into stressed/ strongly stressed vs. not stressed. Parental mental health problems (STADI) were dichotomized into above average/ far above average vs. average/ below average/ far below average, and toddler’s emotional and behavioral problems (SDQ) into borderline/ noticeable problems vs. no problems. A cut-off variable was available for the CFS subscore crying/whining/sleeping, dividing symptoms into noticeable problems vs. no problems. To find out to what extent a stress factor at baseline determines itself at follow-up, logistic regression models were conducted. The outcomes (EBI, STADI, CFS subscore crying/whining/sleeping, SDQ) were dichotomized as described above. We adjusted for those variables that had a significant effect in the multiple linear regression models (see Table 1). Conditions for calculating the logistic regression models (i.e., no multicollinearity between predictor variables) were checked.

Regarding the second research question, we addressed which factors might have contributed to the surveyed psychosocial stress factors at follow-up. To check the stability of psychosocial stress factors over time, we included the corresponding factors at baseline, as well as pandemic-related factors and sociodemographic factors as potential predictors. We explored if and to what extent these factors predicted parenting stress (EBI total score, T-value),

TABLE 1 Multiple linear regression models for follow-up EBI, STADI (mothers), crying/whining/sleeping (CWS) and SDQ score.

Outcomes	EBI total score T value (FU) ^a			STADI total score (mothers) (FU) ^b			CWS sub score (FU) ^c			SDQ total score (FU) ^d		
	B	SE B	β	R ²	B	SE B	β	R ²	B	SE B	β	R ²
				.600				.460				.439
Predictors												
EBI Total Score T value (baseline)	0.669	0.024	.675**						0.001	0.002	0.015	
STADI total score mothers (baseline)					0.475		.473**					
CWS sub score (baseline)								.530**	0.503	0.056		
SDQ total score (baseline)												
Interval (weeks) btw. baseline & FU	0.053	0.016	.084**		0.038	0.023	.051		0.002	0.003	.078	
Perceived pandemic burden parent FU	0.876	0.250	.091**		0.287	0.362	.025		−0.015	0.022	−.044	
Social contacts FU	0.372	0.257	.043		0.442	0.369	.043		0.000	0.021	−.001	
Family support services FU	−0.271	0.227	−.036		−0.100	0.327	−.011		−0.002	0.017	−.008	
Increased Family Conflicts FU	1.060	0.232	.121**		2.584	0.328	.250**		0.061	0.020	.200*	
Changes in child-care situation FU	0.173	0.207	.022		0.087	0.295	.009		−0.004	0.019	−.013	
Fear of COVID-infection FU	0.227	0.183	.031		0.803	0.262	.092*		0.013	0.015	.050	
Financ. burden due to pandemic FU ^e	−0.020	0.543	−.001		1.020	0.780	.038		−0.015	0.048	−.019	
Age child FU	−0.005	0.019	−.007		0.028	0.028	.031		−0.002	.014	−.016	
Age parent	−0.018	0.049	−.008		−0.010	0.079	−.003		0.005	0.005	.058	
Single parent	−0.302	0.897	−.008		0.732	1.259	.016		−0.062	0.082	−.041	
Chronic illness/disability child ^e	0.830	0.739	.025		0.584	1.041	.015		−0.021	0.078	−.014	
Parental education ^e	0.377	0.460	.019		−0.693	0.656	−.029		−0.040	0.039	−.057	
Financial situation ^e	0.453	0.471	.023		0.107	0.676	.005		0.018	0.039	.026	

^aN = 844.

^bN = 787.

^cN = 264.

^dN = 375.

^eDichotomized.

Significance indicated by **p* ≤ .05, ***p* ≤ .001. FU, follow-up.

maternal depression and anxiety symptoms (STADI total score, T-value), infants' crying/whining/sleeping problems (subscore of CFS crying/whining/sleeping scale), and toddlers' emotional and behavioral problems (SDQ total score) at follow up. Four multiple linear regression models were calculated. The individual predictors considered were chosen on the basis of previous evaluations of the CoronabaBY study and were in detail: the respective psychosocial stress factors at baseline (EBI total score, STADI total score, CFS crying/whining/sleeping subscore, SDQ total score), pandemic related variables (baseline-follow-up-interval in weeks, perceived pandemic burden at follow up, restricted parental social contacts at follow up, restricted family support services at follow up, increased family conflicts at follow up, changes in childcare due to pandemic at follow up, worries about infection at follow up, financial burden due to pandemic at follow up) and sociodemographic variables (child age at follow up, parents age, single parent status, chronic illness/disability of the child, parental education status, parental financial status before the pandemic). The formation of the models resulted in the calculation of beta weights and their *p*-values for corresponding predictor variables. Conditions for calculating the multiple linear regression models—including linear association between dependent and independent variables, homoscedasticity, normally and independently distributed residuals, no multicollinearity between predictor variables—were checked.

For the linear regression models, four independent variables had to be dichotomized since the scale level was not interval scaled. Consequently, education status was dichotomized into *high* (university degree and high school diploma) and *low* (secondary and lower secondary school diploma). Financial status was also dichotomized into *high* ("large expenses possible" and "bigger additional expenses possible") and *low* ("smaller additional expenses possible", "little scope for additional expenses", "additional expenses not possible"). Accordingly, the financial burden due to the pandemic was dichotomized (yes: small, medium, or substantial financial burden vs. no financial burden due to the pandemic). Chronic illness or disability of the child was defined as any chronic illness (also allergy, hyperactivity) and/or disability.

Since submission of questionnaires was only possible when all items were completed, there were only a few missing values because of obvious misreporting of parental age.

All described results were based on an alpha level of 5%. Analyses were performed in IBM SPSS Statistics Version 29.0.

Results

Sample characteristics

In total, we examined 932 parent-child dyads with full information at baseline and follow-up ("sample"). *N* = 2014 participants did not submit the follow-up questionnaire ("dropouts"). Of the surveyed parents, 94.7% (*n* = 883) were mothers with a mean age of 33.7 years (SD: 4.7), 4.6% were fathers (mean age: 34.9 years, SD: 5.5), and 0.6% were grandparents. Children were on average 14.7 months old at baseline (SD: 12,

range: 1–39 months). They were divided into "infants" (*n* = 518) with a mean age of 5.1 months (SD: 3.4) and "toddlers" (*n* = 414) with a mean age of 26.8 months (SD: 6.6). On average, participants completed the follow-up questionnaires around 40 weeks after baseline (*M* = 39.55, *SD* = 15.94).

Sample vs. Dropouts

Sample and Dropouts differed significantly concerning sociodemographic factors: in the sample there were significantly more often mothers, born in Germany, with German mother tongue and higher financial status, less often single parents and less often parents of children with chronic illness and/or disability (see Table 2).

At baseline, 48% of the dropouts experienced parenting stress which is significantly more often than in the sample (40.1% with parenting stress at baseline). Dropouts showed significantly more often symptoms of depression and anxiety (29.8%) compared to the sample (20.6%). At baseline, significantly more dropouts reported a high pandemic burden for their child (36.4%) than participants of the sample did (30.3%).

Perceived pandemic burden and pandemic-related restrictions

At baseline, 60% of the parents of the sample perceived the pandemic as stressful or very stressful. This proportion decreased

TABLE 2 Sample characteristics.

	Sample	Drop-outs	<i>p</i>
	% (<i>n</i>)		
Parents			
Mothers ^a	94.7 (883)	91.8 (1,848)	0.004
Born in Germany ^a	93.1 (868)	90.5 (1,822)	0.017
Mother tongue German ^a	94.4 (880)	91.3 (1,839)	0.003
Level of education			0.485
University degree	42.6 (397)	41.1 (827)	
High school diploma	18.7 (174)	17.7 (356)	
Secondary school diploma	28.4 (265)	29.5 (594)	
Lower sec. school diploma	8.3 (77)	8.8 (178)	
Other	1.9 (18)	2.8 (57)	
High financial status ^b	60.3 (528)	56.1 (1,041)	0.038
Single parent status ^a	6.2 (58)	8.4 (170)	0.038
Vaccinated, respondent at FU	92 (856)		
Vaccinated, partner at FU	92 (856)		
Children			
M _{age} infants	5.1 months, SD = 3.4 (518)	6.2 months, SD = 4.3 (865)	<0.001
M _{age} toddlers	26.8 months, SD = 6.6 (414)	27.0 months, SD = 7.2 (1,148)	0.479
Boys	51.1 (476)	53.0 (1,068)	0.341
Chronic illness and/or disability ^a	6.6 (61)	9.3 (185)	0.015

^aOutcomes dichotomized.

^bOutcome (scale) dichotomized into: high (very large/large additional purchases possible) vs. low (small/very small/no additional purchases possible). FU = follow-up.

significantly to 50% at follow-up. Almost one-third of the parents rated their children's pandemic burden as high or very high at baseline, which did not significantly decrease until follow-up. A significant reduction of individually perceived pandemic-related restrictions was detected (see Figure 2).

Parenting stress and parental mental health

High or very high parenting stress was present in 40.1% of the parents at baseline and increased significantly to 45.4% at follow-up (see Figure 3). This difference is also evident in the mean values: the comparison of the mean EBI total T-values yielded a mean value of 56.02 at baseline vs. 57.42 at follow-up, $t(931) = 6.18$, $p < .001$, $d = .20$. Of the strongly stressed parents at baseline, 61.4% were still strongly stressed at follow-up, and only 2.4% were not stressed. Over both measurement points, "depression" was the most pronounced parenting stress subscale, followed by "health" and "social isolation". The proportions were higher for follow-up (64.3% respectively 50.9%, and 48.2%) compared to baseline (61.5% respectively 41.7%, and 44.0%), with the increase only being significant for "health".

Proportions of maternal anxiety and depression symptoms differed slightly but not significantly between baseline (20.6%) and follow-up (23.7%). Among the parents with conspicuous values far above average (above average) at baseline, still 33.3% (47.2%) were far above average (above average) at follow-up.

Child mental health (crying, sleeping and feeding, emotional and behavioral problems)

On the CFS's crying/whining/sleeping subscale, there was no significant difference between baseline and follow-up (35.1% vs. 31.8%). The proportion of infants with a feeding problem was similar and did not change significantly between baseline and follow-up (see Figure 3). Of the infants who showed elevated values on the crying/whining/sleeping subscale at baseline, 58.1% were still conspicuous at follow-up. This was similar for those with feeding problems (52.8%).

At baseline, 18.1% of the toddlers showed at least borderline emotional and behavioral problems which remained constant until follow-up (17.2%). Among the toddlers with noticeable problems at baseline, 51.4% were still noticeable at follow-up.

Risk of perceiving follow-up parenting stress, maternal symptoms of depression and anxiety, infants' crying/sleeping problems, and toddlers' emotional and behavioral problems

The adjusted logistic regression models yielded significant Odds Ratios (OR) for all psychosocial outcomes at follow-up (EBI, STADI, CFS crying/whining/sleeping, SDQ) if

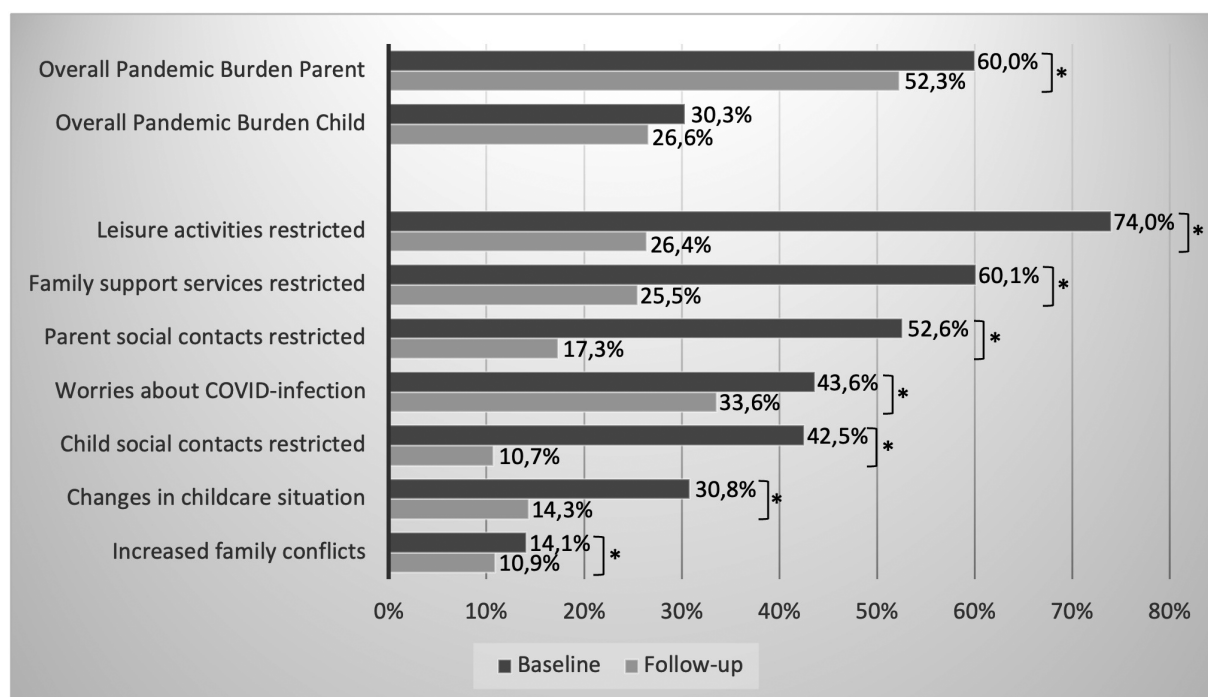


FIGURE 2

Percentage of parents/children with noticeable values in pandemic-related burdens at baseline and follow-up (*indicates a sign. difference with $p \leq .05$).

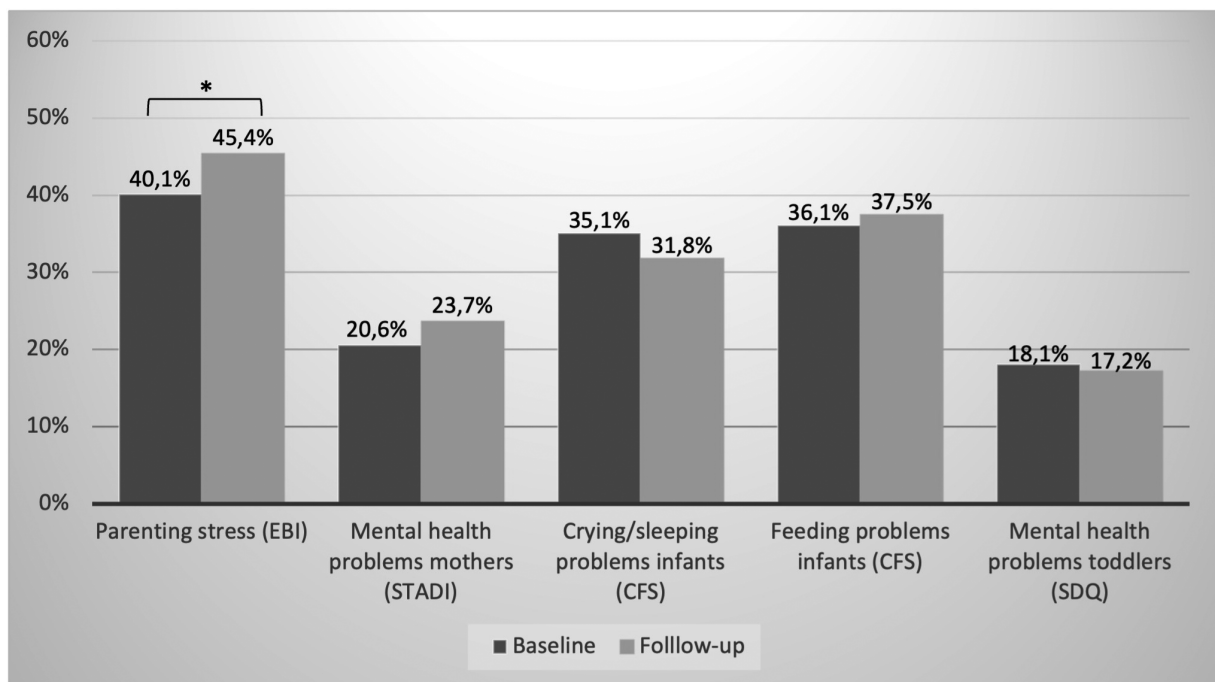


FIGURE 3

Percentage of parents/children with noticeable values in psychosocial stress factors at baseline and follow-up (*indicates a sign. difference with $p \leq .05$).

corresponding symptoms were already noticeable at baseline (ORs ranged from 5.7 to 9.6, Nagelkerkes R^2 from .214 to .421, see Table 3).

Influencing factors on follow-up parenting stress, maternal symptoms of depression and anxiety, infants' crying/sleeping problems, and toddlers' emotional and behavioral problems

The linear regression model [$R^2 = .600$, $F(15, 828) = 82.84$, $p < .001$] showed parenting stress at baseline (EBI total score

T-value baseline) to have the highest effect size ($\beta = .675$, $p < .001$) on the follow-up outcome parenting stress (EBI total score T-value follow up), followed by increased family conflicts at follow up ($\beta = .121$, $p < .001$), pandemic burden at follow up ($\beta = .091$, $p < .001$) and longer baseline-follow-up-interval ($\beta = .084$, $p < .001$) (see Table 1). For maternal symptoms of depression and anxiety at follow-up (STADI total score follow-up) [$R^2 = .460$, $F(15, 771) = 43.73$, $p < .001$], STADI total score at baseline had the highest effect ($\beta = .473$, $p < .001$), followed by increased family conflicts ($\beta = .250$, $p < .001$) and fear of COVID-infection ($\beta = .092$, $p < .05$). Sociodemographic factors did not significantly affect parenting stress and parental mental health symptoms during follow-up (see Table 1).

TABLE 3 Odds ratios for elevated values of EBI, STADI (mothers), crying/whining/sleeping (CWS) and SDQ-scores at follow-up.

Factor	Outcome	OR (95%CI)	Sig	Nagelkerke R^2
EBI baseline ^{a,b} "stressed/strongly stressed"	EBI follow-up ^a "stressed/strongly stressed"	9.623 (6.940–13.343)	***	.421
STADI baseline (mothers) ^{a,c} "above average/far above average"	STADI follow-up (mothers) ^a "above average/far above average"	5.676 (3.842–8.385)	***	.324
CWS baseline ^{a,d} "noticeable problems"	CWS follow-up ^a "noticeable problems"	6.105 (3.546–10.509)	***	.238
SDQ baseline ^{a,e} "borderline/noticeable problems"	SDQ follow-up ^a "borderline/noticeable problems"	7.439 (4.161–13.297)	***	.214

^aDichotomized.

^bAdjusted for: interval (weeks) between baseline and FU, perceived pandemic burden parent FU, increased family conflicts FU.

^cAdjusted for: increased family conflicts FU, fear of COVID infection FU.

^dAdjusted for: increased family conflicts FU.

^eAdjusted for: social contacts FU, age child FU.

*** $p < .001$. FU, follow-up.

Looking at infants' crying/sleeping problems at follow-up (CFS crying/whining/sleeping subscore follow-up), the model [$R^2 = .348$, $F(16, 247) = 8.24$, $p < .001$] showed crying/sleeping problems at baseline (CFS crying/whining/sleeping subscore baseline) to have a significant effect ($\beta = .530$, $p < .001$), as well as increased family conflicts at follow-up ($\beta = .200$, $p < .05$). Parenting stress at baseline, however, did not significantly affect crying/sleeping problems in infants at follow-up (see Table 1).

For toddlers' emotional and behavioral problems at follow-up (SDQ total score follow-up) both toddlers' emotional and behavioral problems at baseline (SDQ total score baseline) ($\beta = .536$, $p < .001$), the restriction of social contacts at follow up ($\beta = .151$, $p < .05$) and child's age at follow up ($\beta = .128$, $p < .05$) had a significant effect in the model [$R^2 = .439$, $F(16, 358) = 17.54$, $p < .001$]. Again, parenting stress at baseline did not significantly affect toddlers' mental health at follow-up.

Discussion

According to the present results of the German longitudinal CoronabaBY study, parents experienced a significant increase of parenting stress over the course of the pandemic, whereas parental and child affective symptoms remained constant. The percentage of overall perceived pandemic burden and perceived restrictions in parents decreased. Among the factors influencing psychosocial outcomes during follow-up, their counterparts at baseline proved to be most predictive ones. In addition, family conflicts were relevant for higher parenting stress, parental affective symptoms, and infants crying/whining/sleeping problems whereas a higher degree of social contact limitation and increased child age were predictors for toddlers' emotional and behavioral problems.

Looking at the findings in more detail, significantly less parents perceived the pandemic as highly stressful ("pandemic burden") at follow-up compared to baseline (52% vs. 60%). This might be due to the fact that most of the follow-up data was collected when restrictions were step by step withdrawn in Germany, and pandemic conditions slightly disappeared. The estimated pandemic burden for children ranged at a much lower level from the beginning and did not change significantly. Most likely, very young children, as considered in the present study, were less directly affected by the pandemic measures.

The proportion of parents who experienced parenting stress at baseline (40.1%) was already high compared to pre-pandemic data [see (7)]. However, although pandemic burden was slightly fading, significantly more parents perceived high parenting stress at follow-up (45.4%). This development was also evident in the comparison of the mean EBI T-values which increased significantly from baseline to follow-up (56.02 vs. 57.42). A previous repetitive cross-sectional analysis of the CoronabaBY study with a comparison of three subsamples also showed an increase in parenting stress over different waves in the 2nd year of the pandemic (8). High levels of parenting stress in the pandemic have already been proven by previous studies, but so far only for the initial phase of COVID-19 [e.g., (12–15)]. To our knowledge, there are no comparable studies yet available for the further course

or later periods of the pandemic. It is also alarming that two-thirds of the parents constantly showed conspicuously high values in the "depression" subscale of the EBI, i.e., limited emotional availability within the parent-child relationship was indicated. This, in turn, could negatively impact the young child's needs as they are still highly dependent on their caregivers' external regulation and support for their emotional regulation (41, 51). In addition, the proportion of parents with high values on the EBI-"health" subscale increased significantly. The growing parenting stress in the course of the pandemic, despite a reduced perceived pandemic-related stress, might reflect a stable state of the parental psychosocial symptoms rather than acute reactive stress experiences to relatively short-term changing pandemic restrictions (8, 52). Further, the duration of the pandemic, with no foreseeable end in the meantime, might have led to a perceived prolonged state of emergency and a so-called "pandemic fatigue" (2, 8, 53). Accordingly, already in early 2020, experts described a mental ill crisis that may follow the wave of infections (2, 11). In this study, most follow-up data was collected in 2022 (by 90%) when pandemic restrictions were reduced or removed altogether. This probably explains the lowered perceived pandemic burden, whereas the emergence of new crises (e.g., War in Ukraine, inflation) might have caused a complex stress situation keeping parenting stress on a high level. Proportions of parental depression and anxiety symptoms did not differ significantly between follow-up and baseline (23.7% vs. 20.6%) and still correspond to comparative values from a pre-pandemic German study, where 20.1% of the parents with children under three years of age perceived affective symptoms (54). This is somewhat surprising, since the State-subscale of the STADI was used, which rather depicts short-term affective states. Elevated scores in acute response to the pandemic (or new emerged crises) were expected since other studies have shown higher affective symptoms in parents during COVID-19 [e.g., (55)]. Nevertheless, more than half of the parents with depression and anxiety symptoms at baseline were still conspicuous at follow-up.

Looking at the infants and toddlers, there were no significant changes over time in all psychosocial outcomes measured. This is reassuring and confirms that children under three years of age were probably less directly affected by the pandemic restrictions. However, since infants and toddlers predominantly depend on their parents care and hence might be influenced by their stress (40, 41), a detrimental effect from parents on child symptoms over time, i.e., an increase of child's psychological problems, could be assumed (8). This assumption could not be confirmed in this longitudinal analysis as the noticeable parenting stress at baseline was not a significant predictor of the child's crying/sleeping or emotional and behavioral problems at follow-up. However, the proportion of infants with crying and sleeping or feeding problems remained high until follow-up. While the proportion of toddlers with emotional or behavioral problems is within the normal range (56), the proportion of infants who show problems in regulating themselves exceeds the findings of various studies before the pandemic (57–61), even if not wholly comparable pertaining study design and definition of regulation problems. Presumably, infants have an even more exclusive dependence on

the emotional attention of their parents (62). High parenting stress could therefore impact the children's ability to regulate themselves (63–65), although our data did not confirm this effect. With growing age, children have more social contacts outside and go more often to care facilities, which were increasingly facilitated and opened in 2022. This may have also affected the toddlers in our sample which is supported by the finding that the degree of social contact restrictions had an impact on the emotional and behavioral problems of the toddlers in the follow-up. A previous evaluation of the CoronabaBY study on different waves (repetitive cross-sectional comparison) (8) showed significant higher prevalences of problems in crying, whining, and sleeping later during the pandemic (10/21–03/22) compared to earlier (02–06/21), which was not observed in the present longitudinal evaluation. This might be explained by the naturally increased age in the intra-individual follow-up over 3–12 months: Evidence suggests that regulation problems decline with growing age (66), which aligns with the trend in the present findings. Nevertheless, around half of infants and toddlers with noticeable problems at baseline were still conspicuous at the follow-up. According to a German longitudinal study on mental health of children and adolescents (≥ 7 years) during the three years of the COVID-19 pandemic, affective symptoms (also measured by the SDQ questionnaire) improved in the third year. However, mental health was still lower compared to before the pandemic (23).

To better understand the underlying mechanisms in the longitudinal development of the psychosocial markers, we identified factors influencing them over the course of the pandemic. On both parental (EBI total score, STADI total score) and child outcomes (CFS crying/whining/sleeping subscore, SDQ total score) at follow-up, their respective counterparts at baseline had the most significant influence (small to medium effects), indicating a stable state of these psychosocial burdens over time. The logistic regression models confirmed that being affected at baseline increases the risk for being affected at follow-up by a multiple. Further influencing factors had weak effects. For parenting stress, these were increased family conflicts at follow-up, perceived pandemic burden at follow-up, and a longer time interval between baseline and follow-up. The latter indicates increasing psychosocial stress in parents with the duration of the pandemic and persistent perceptions of related restrictions and burdens. For parental depression and anxiety symptoms at follow-up, increased family conflicts (at follow-up) were also influential, as well as the fear of a COVID-infection (with a weak effect). This is where interventions could come in and show relieving ways of solving and coping with conflict situations. Toddlers' emotional and behavioral problems increased with a higher degree of social contact limitation and rising child age, which is in line with other studies (67–69). In infants, only increased family conflicts further influenced their symptomatology at follow-up. This is in line with a general population study in Denmark in which regulation problems in early infancy turned out to be the main predictor of late combined regulation problems, i.e., two or more simultaneous problems of feeding, sleeping, or excessive crying (70). Being significantly affected by conflicts in the family also indicates the

close sensitivity of the infants to their caregivers. Sociodemographic factors consistently showed no significant effects on the parental and child's psychosocial outcomes in our sample, except for child age among toddlers.

The study shows several strengths and limitations. To our knowledge, the CoronabaBY study is the first and only longitudinal study on psychosocial stress factors during the COVID-19 pandemic in families with children under three years. It covers an extensive period of the pandemic and considers a large sample in the follow-up evaluation despite the omission of dropouts. The questionnaires used are validated and established instruments for the assessment of parents' and child's psychosocial stress. The study team developed the questions on pandemic-related burdens since appropriate questionnaires were not available. However, according to previous publications on the CoronabaBY study, significant correlations of the pandemic-related questions among each other and with other validated stress instruments (e.g., EBI) were evident (7, 8). Since all questionnaires had to be filled out completely before submission, there are no missing values, except for only a few cases where incorrect entries were made (e.g., parental age). Looking at the limitations, it has to be mentioned that mainly well-off, higher educated German mothers participated in the study. This is not uncommon, as is often the case in scientific studies (71), but could limit generalizability. Likewise, only parents using the app could participate. As all eligible families were invited—providing a quick and low-threshold access to the study due to high pandemic loads—this is a convenient sample. Furthermore, it was recruited in Bavaria and might not completely represent the German population. A further limitation is the high dropout rate of about two thirds. The dropouts showed significantly higher psychosocial stress already at baseline (i.e., parenting stress and parental affective symptoms). In addition, they exhibited significant differences in sociodemographic factors compared to the participants of the later follow-up (sample), indicating greater loads (e.g., being a single parent or having a child with a chronic illness and/or disability). As for the longitudinal perspective we merely compared participants with data at baseline and follow-up, further statements about the dropouts cannot be made. However, it has to be assumed that the psychosocial stress scores would have developed even more if these parents had also participated in the second part of the survey and could have been included in the follow-up. Thus, our results may have been underestimated.

In summary, a long-term trend can be identified over the pandemic with a mean interval of almost 40 weeks between baseline and follow-up. Although the CoronabaBY study started at the beginning of the second pandemic year, assuming that the highest loads were in the first year of COVID-19, intra-individual psychosocial stress factors in young families partly remained constantly high (crying/feeding/sleeping problems) or even increased (parenting stress) from the second into the third pandemic year. Hence, longitudinal effects of the pandemic on psychosocial health in these families seem to be present, although the pandemic and related burdens were fading through 2022. Our results indicate a need for action and can serve as a basis for decision-makers to better understand young families'

needs in times of crises and adapt or develop appropriate low-threshold support services for this vulnerable target group. Accessible support for parents and their children is indispensable, ensuring a healthy development of children as this goes along with parental mental health and well-being (72–77). Guidance can relieve parents psychologically by showing them resolutions for solving conflict situations and improving the family climate. Furthermore, ways can be identified to reduce parenting stress and thus strengthen the important ability to be emotionally available to the child's needs and ensuring appropriate care for the youngest. According to the present longitudinal results, existing measures and services seem to be insufficient to adequately support parents. This is particularly relevant as young families are facing further crises (e.g., armed conflicts, inflation, societal disparities, and climate change). Given these challenges, psychosocial stress factors in this target group might more and more increase and should therefore be further monitored and evaluated. This is the aim of the continuing JuFaBY study, which follows the CoronabaBY study and started in February 2023.

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, Catherine Buechel, catherine.buechel@tum.de.

Ethics statement

The studies involving humans were approved by the Ethics Committee of the Technical University of Munich (vote no. 322/20 S) and pre-registered in OSF (<https://osf.io/search/?q=tksh5&page=1>). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their informed consent to participate in this study via app.

Author contributions

CB: Conceptualization, Formal Analysis, Methodology, Visualization, Writing – original draft. AF: Conceptualization,

Writing – review & editing. SE: Writing – review & editing. UB: Writing – review & editing. VM: Conceptualization, Writing – review & editing. IN: Conceptualization, Methodology, Supervision, Writing – original draft.

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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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The interrelationship between sleep disturbance symptoms and aggression before and after the campus closure of the COVID-19 pandemic: insight from a cross-lagged panel network model

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Background: The COVID-19 pandemic is detrimental to sleep quality and increases aggression among college students. Nevertheless, relevant studies were rare. Hence, we collected longitudinal data during and post-campus closure in the current study to investigate the relationship between sleep disturbance and aggression.

Methods: Data from 665 college students (59.2% females, $Mean_{age} = 19.01$, $SD_{age} = 1.25$) were collected before (wave 1) and after (wave 2) the campus closure of COVID-19. All participants were asked to fill out the Buss-Perry Aggression Questionnaire and the Youth Self-Rating Insomnia Scale. Two symptom networks and a cross-lagged panel network were formed and tested.

Results: Hostility has the highest centrality in the symptom network both in waves 1 and 2, and it bridges sleep disturbance and aggression. "Easily be woken" – "wake up too early" and "wake up with tired" – "function hindrance" are two important symptom associations in networks of waves 1 and 2. All symptoms except "difficulty in falling asleep" and "easily be woken" ameliorated after closure. Moreover, "physical aggression" and "hostility" can trigger other symptoms in wave 2.

Conclusion: As the first study about aggression and sleep disturbance in the background of COVID-19, we provide valuable information about the relationship between sleep disturbance and aggression on the symptom dimension.

KEYWORDS

sleep disturbance, symptoms, aggression, cross-lagged panel network, college students

1 Introduction

Due to the COVID-19 pandemic, college students have witnessed and experienced school closures or the transition to online teaching (1). While strict containment measures aim to prevent the spread of the virus, they also have wide-ranging effects on students' wellbeing (2). Deng et al. (3) found that 33% of college students suffer from sleep disturbances during COVID-19, particularly during online courses (4–7).

Poor sleep quality among college students is associated with an increased likelihood of aggression (8). This is because sleep deprivation affects prefrontal cortical functioning, leading to a loss of emotional control and ultimately triggering aggressive behavior (9). In the context of COVID-19, sleep disturbance is also closely linked to interpersonal violence (10) and aggression (11). However, the relationship between sleep disturbance and aggression during and after campus closure has been rarely studied. To address this gap, the current study collected longitudinal data and investigated the relationship between sleep disturbance and aggression in a sample of college students affected by the COVID-19 campus closures.

From a psychological perspective, aggression is a typical behavior characterized by purposeful attacks or hostility toward others (12). The general aggression model (GAM) (13) offers a comprehensive theoretical framework that integrates both personal factors (e.g., cognitions, feelings, and emotional arousal) and situational factors (such as COVID-19), which ultimately influence behaviors such as aggression. A meta-analysis revealed that lockdown characteristics, such as isolation, restricted social contact, quarantine duration, and limitations, significantly increase college students' negative emotional symptoms, including anxiety, depression, and stress (14). Moreover, longitudinal studies found that negative emotional arousal resulting from sudden public health events may trigger adolescent aggression (15, 16). Research on college students indicates a close association between sleep disturbance and anxiety and depression during COVID-19, which can serve as risk factors for aggressive decision-making (5, 17–20).

In the proximal path perspective of the GAM (13), contingent situations, such as campus closures, can significantly impact aggressive decision-making. Specifically, Mazza et al. (21) and Overall et al. (22) noted a significant increase in aggression during campus closures. Birmingham et al. (23) indicated that college students experienced restless sleep during the lockdown period, which could trigger aggression. Additionally, in a survey conducted by Kormukcu (24), college students exhibited more anger during university closures, although overall aggression did not increase significantly. Given the inconsistent results mentioned above, further study to explore the relationship between sleep disturbance and aggression during the lockdown period is of great necessity.

Nevertheless, solely considering the proximal path is insufficient to fully explain the mechanism linking sleep disturbance and aggression. The distal path perspective of the GAM should also be considered (13). In the distal path, long-lasting environmental modifiers or biological factors, such as peer relationships, family background, and testosterone levels, influence personal traits related to aggression arousal (25–27). For college students, COVID-19 has disrupted their educational routine by shifting from offline teaching to online teaching, with uncertainty regarding when life will return to pre-pandemic norms (28). According to the social displacement hypothesis (29), college students may spend more time engaging in online courses, using social media, or playing video games to cope with negative emotions, thereby increasing sleep disturbances and aggression (30, 31). Additionally, considering biological factors in the distal path, sleep disturbance can disrupt testosterone rhythms, which are closely linked to aggressive behavior (32, 33).

The COVID-19 pandemic has brought about sleep disturbances for college students who are already contending with significant

academic stress, changes in course delivery, and diminished motivation (34). College students often rely on media to maintain interpersonal relationships, but the side effect of problematic media use is poor sleep quality, which can contribute to aggressive behavior (35). Additionally, chronic exposure to social media and competitive video games has been associated with the provocation of aggressive behavior (36, 37). In such aggressive environments, college students' sleep is put at risk (38). Furthermore, individuals with severe aggressive tendencies show abnormal theta and delta power during the sleep stage (39). Considering the bidirectional relationship between sleep disturbance and aggression and recognizing the negative effects of both on mental and physical health, untangling their relationship in the context of COVID-19 is of significant importance.

However, in almost all previous studies, aggression or sleep disturbance has been considered a latent variable (34, 40, 41). Aggression and sleep disturbance encompass a dynamic cluster of dimensions and symptoms that interact dynamically to manifest the variable (42–44). For instance, as illustrated by Borsboom and Cramer (45), a college student who wakes up too early due to nightmares may exhibit hostility toward peers online. Consequently, feeling guilty, the college student may experience difficulties falling asleep in the evening. To uncover the bidirectional relationship between sleep disturbance and aggression on the symptom dimension, the network approach is optimal, as it renders symptoms (nodes) and associations between symptoms (edges) visible (46). Furthermore, through network analysis, key symptoms linking aggression and sleep disturbance can be readily identified (47). Additionally, by employing a cross-lagged panel network (CLPN), we can even identify symptoms during the COVID-19 campus closures that may trigger other symptoms after the closures.

In the existing research, Li et al. (48) and Hirota et al. (49) formed and analyzed the network structure of aggression in patients with schizophrenia and autism. However, to our knowledge, no study has been conducted with network analysis on the association between sleep disturbance and aggression among college students. As previously mentioned, since COVID-19 has introduced new norms to college life (50), in the current study, based on network analysis, we aimed to start from symptoms to depict a vivid map of college life from the perspective of aggression and sleep disturbance.

In summary, in the current study, we have five goals: (1) to find critical symptoms or behaviors in sleep disturbance and aggression; (2) to identify essential associations from the perspective of sleep disturbance and aggression; (3) to portray bridge symptoms that can connect sleep disturbance and aggression; (4) to identify how levels of symptoms will change with the lifting of closures through longitudinal data; and (5) to depict key symptoms before (wave 1) that can cause other symptoms after (wave 2) the campus closure due to COVID-19.

2 Method

2.1 Participants and procedure

The baseline data met the criterion that all participants had not experienced campus quarantine. Subsequently, all participants met

the criteria of residing on campus and experiencing at least 1 month of mandatory school lockdown, during which students were not allowed to leave the school premises and could only engage in activities and studies on campus. One month after the school lifted the lockdown, college students were allowed to freely enter and exit the campus, and the second round of data collection was conducted. Hence, the baseline datasets (October to November 2021) contained 1,302 participants ($Mean_{age} = 19.38$, $SD_{age} = 1.32$; $N_{female} = 847$), while the second wave of datasets (January 2022) included 1,359 participants ($Mean_{age} = 19.65$, $SD_{age} = 1.45$; $N_{female} = 815$), both from a university in China. When the datasets from both waves were combined according to the student's school numbers, 665 students ($Mean_{age} = 19$, $SD_{age} = 1.25$; $N_{female} = 394$) were included in the final analysis. All participants ultimately passed a validation question in the electronic questionnaire, which presented the prompt: "Among the four options, lion, dog, cat, and panda, please select the panda."

All datasets were collected via the online questionnaire platform "Wenjuanxing".¹ Students were asked to provide signed informed consent before participation. The research was examined and approved by the Ethics Committee of the First Author's Affiliated Institution.

2.2 Measures

2.2.1 Buss-Perry aggression questionnaire

The 29-item Buss-Perry Aggression Questionnaire (BPAQ) assesses the tendency toward aggression (42). Each item is rated from 1 (very unlikely) to 5 (very like). The BPAQ has four empirical subscales: physical aggression (nine items), verbal aggression (five items), anger (seven items), and hostility (eight items). Physical aggression and verbal aggression are both motor components of behavior, while anger is the emotional or affective component of aggressive behavior, and hostility is the cognitive component of behavior. The Chinese version was revised by Li et al. (51). In the present study, the Cronbach α values of four factors were 0.80, 0.65, 0.75, and 0.84, respectively.

2.2.2 Youth self-rating insomnia scale

The Youth Self-Rating Insomnia Scale (YSIS) is a 5-point Likert questionnaire assessing sleep disturbance in the past month (43). Participants answered two questions about overall sleep quality and six about the frequency of specific sleep disturbance symptoms. Total scores ranged from 8 to 40, and higher scores indicated poorer sleep quality. The Chinese version was revised by Liu et al. (52). In the current study, YSIS has a high internal consistency with the Cronbach α value of 0.91.

2.3 Network analysis

2.3.1 Item check

We used R version 4.2.1 (53) to perform all analyses. Means, standard deviation (SD), skewness, and kurtosis of all item scores were

calculated. We assessed item redundancy using the R package *networktools* 1.5.0 (54). For informativeness, items should be excluded if their scores were 1.5 SD below the mean item SD (i.e., poorly informative). For redundancy, if more than 75% of correlations between two variables and all other variables were not significantly different, these two variables were considered redundant.

2.3.2 Cross-sectional network estimation

An extended Bayesian information criterion (EBIC) graphical least absolute shrinkage and selection operator (LASSO) model (55) was used to estimate the network. Each node (i.e., item) in the network represents a symptom, and each edge represents the partial correlation between two symptoms. The correlation matrix was shrunk to obtain simpler and sparser networks. Blue and red edges denote positive and negative correlations, respectively. The R packages *bootnet* 1.4.3 and *qgraph* 1.6.9 were employed for network estimation and visualization (46, 56). The expected influence (EI) was used to assess the centrality of nodes in this study. Predictability (i.e., R^2) was estimated using the R package *mgm* 1.2–12 (57). Bridge symptoms serve as the channel connection between different disorders (47). Following previous research (58, 59), we screened bridge symptoms based on the criterion of standardized values of bridge strength ≥ 1 in the current study.

2.3.3 Cross-lagged network estimation

A CLPN was conducted to examine the connections between the first and second assessments over time by using the *glmnet* package (60). A CLPN illustrates how a single node (i.e., symptom) at the first time point predicts other nodes at the second time point after adjusting for all other variables at the first time point. The directed edges of each node pointing to itself represent the autoregressive coefficients, while the directed edges pointing to other nodes represent the cross-lagged coefficients. The color of the arrows indicates the directionality of the effect, with green arrows indicating positive effects and red arrows indicating negative effects. The line thickness indicates the strength of the association. To simplify the network, we employed the LASSO approach to shrink small regression coefficients to 0. For directed CLPNs, we calculated two centrality indices: cross-lagged "in expected influence" (IEI) and "out expected influence" (OEI). IEI signifies the degree to which one symptom is predicted by other symptoms (i.e., the sum of values of incoming edges associated with one symptom), while OEI signifies the degree to which one symptom can predict other symptoms (i.e., the sum of values of outgoing edges associated with one symptom).

2.3.4 Network comparison

The network comparison test (NCT) was employed to evaluate the difference between edge invariance (distributions of edge weights) and global strength (the sum of all edge weights) between the networks in waves 1 and 2 using the R package *NetworkComparisonTest* 2.2.1 (61).

2.3.5 Network stability and accuracy

The case-dropping bootstrap procedure was used to assess the stability of centrality indices (46), providing the correlation stability coefficient (CS-C). The CS-C represented the proportion of samples that could be removed, with a 95% probability that the correlation between the original centrality indices would be at least 0.70. Generally, the CS-C should be ≥ 0.25 , preferably ≥ 0.50 . Bootstrapped

¹ <https://www.wjx.cn>

confidence intervals (95% CIs) were computed to analyze the accuracy of edges. Narrower CIs indicated a more accurate network. Differences between edge weights and centrality strengths were also analyzed by bootstrap tests based on 0.95 CIs. If CIs did not include zero, there was a statistical difference between two edges or two nodes. All analyses were performed using the R package *bootnet* 1.4.3 (46).

3 Results

3.1 Descriptive statistics and item check

The item check results revealed that YSIS1-YSIS5 and YSIS1-YSIS2 are redundant. Specifically, only 20% of correlations were significantly different for YSIS1 and YSIS5, and only 16.7% of correlations were significantly different for YSIS1 and YSIS2. Considering that YSIS1 and YSIS2 pertain to overall sleep quality rather than specific symptoms, we excluded them from the subsequent analyses. No items were found to be poorly informative. The means, SDs, skewness, kurtosis, and *t*-test results of all symptoms are shown in Table 1. There were no significant differences in gender across all variables in both waves 1 and 2 ($p > 0.05$).

3.2 Cross-sectional symptom networks

The aggression-sleep disturbance networks at two time points are shown in Figure 1 and Supplementary Figure S1, and weighted adjacency matrices are shown in Supplementary Tables S1, S2.

For the first time point, 17 edges were not zero (38%) among 45 possible edges, and all edges were positive. The edge of “wake up with tired” – “function hindrance” (YSIS7 – YSIS8) showed the strongest association, followed by the edge of “easily be woken” – “wake up too early” (YSIS4 – YSIS5) and the edge of “sleep deprivation” – “wake up with tired” (YSIS6 – YSIS7), see Figure 1A. For the second time point, 19 edges were not zero (42%) among 45 possible edges, and all edges were positive. The edge of “easily be woken” – “wake up too early” (YSIS4 – YSIS5) showed the strongest association, followed by the edge of “wake up with tired” – “function hindrance” (YSIS7 – YSIS8)

and the edge of “verbal aggression” – “hostility” (BPAQ2-BPAQ4), see Figure 1B.

In Figure 1C, “hostility” (BPAQ4) had the highest node EI, followed by “function hindrance” (YSIS8) and “sleep deprivation” (YSIS6) at the first time point. Each node’s neighbors could potentially account for an average of 53% of the variance ($M_{\text{predictability}} = 0.53 \pm 0.07$). Similarly, in Figure 1C, “hostility” (BPAQ4) had the highest node EI, followed by “function hindrance” (YSIS8) and “sleep deprivation” (YSIS6) at the second time point. Each node’s neighbors could potentially account for an average of 60% of the variance ($M_{\text{predictability}} = 0.60 \pm 0.06$).

“Hostility” (BPAQ4) and “wake up with tired” (YSIS7) emerged as the bridge symptoms at the first time point (see Figure 1D). However, only “hostility” (BPAQ4) emerged as the bridge symptom at the second time point (see Figure 1D).

3.3 Cross-lagged panel network

The CLPN structure is shown in Figure 2A, and all edge weights are shown in LASSO cross-lagged regression matrices in Supplementary Table S3.

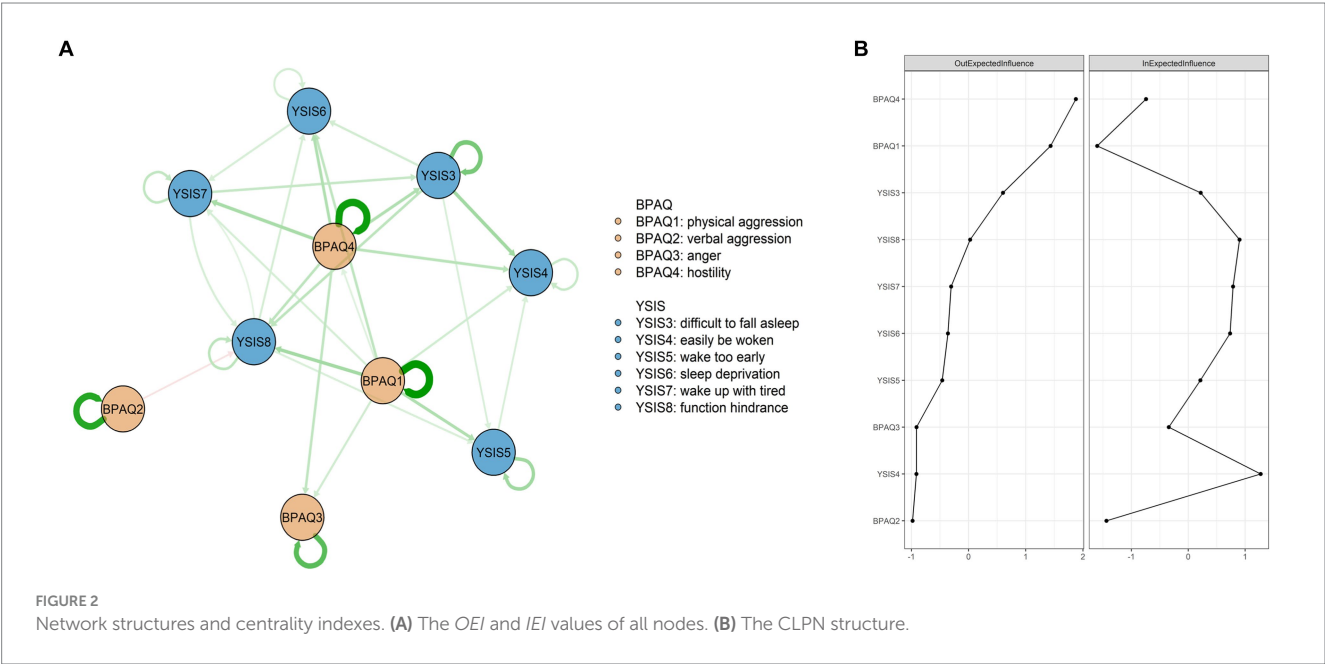
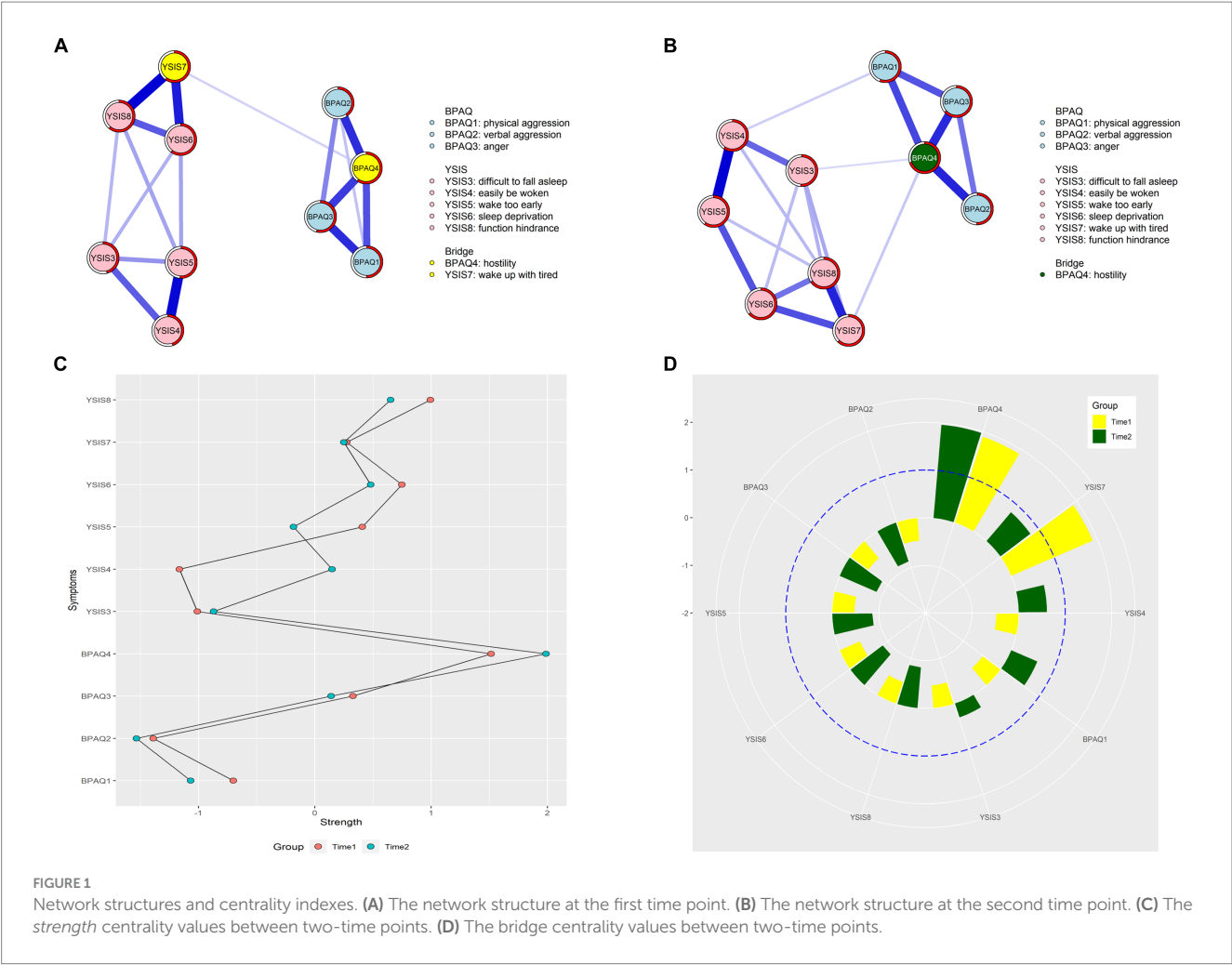
A total of 68 edges were not zero (68%) among 100 possible edges. Except for autoregression paths, the edge of “difficulty in falling asleep” – “easily be woken” (YSIS3 – YSIS4) showed the strongest cross-lagged association, followed by the edge of “physical aggression” – “function hindrance” (BPAQ1 – YSIS8) and the edge of “hostility” – “wake up with tired” (BPAQ4 – YSIS7). Figure 2B shows the OEI and IEI values. “Hostility” (BPAQ4) had the highest node OEI, followed by “physical aggression” (BPAQ1) and “difficulty in falling asleep” (YSIS3). “Easily be woken” (YSIS4) had the highest node IEI, followed by “function hindrance” (YSIS8) and “wake up with tired” (YSIS7). Autoregression paths are shown in Supplementary Figure S2.

3.4 Network accuracy and stability

In Figure 3, the case-dropping bootstrap procedure showed that CS-Cs of EI at the first and second time points were 0.44 and 0.59, respectively. The CS-Cs of OEI and IEI were 0.42 and 0.71, respectively.

TABLE 1 Descriptive information and *t*-test results of data from two-time points.

	First wave				Second wave				t-test	
	Mean	SD	Skew	Kurtosis	Mean	SD	Skew	Kurtosis	<i>p</i>	Cohen’s <i>d</i>
BPAQ1	1.99	0.69	0.57	0.17	1.9	0.64	0.47	−0.6	−0.09	−0.14
BPAQ2	2.64	0.67	−0.15	0.65	2.46	0.74	−0.32	0.01	−0.18	−0.24
BPAQ3	2.3	0.71	0.2	−0.33	2.19	0.67	0.29	−0.32	−0.10	−0.15
BPAQ4	2.38	0.75	0	−0.27	2.13	0.77	0.14	−0.69	−0.24	−0.33
YSIS3	1.94	1.07	0.9	0.04	1.96	1.07	0.86	−0.09	0.03	0.02
YSIS4	1.77	1.05	1.24	0.76	1.68	0.95	1.25	0.79	−0.09	−0.08
YSIS5	1.73	1.04	1.31	0.85	1.58	0.92	1.59	1.93	−0.15	−0.13
YSIS6	2.2	1.22	0.67	−0.61	1.72	1.01	1.31	0.9	−0.48	−0.36
YSIS7	2.36	1.27	0.58	−0.69	1.87	1.08	1.08	0.31	−0.49	−0.36
YSIS8	1.88	1.09	1.1	0.42	1.64	0.95	1.47	1.46	0.25	−0.21



Case-dropping test results indicated good stability for centrality indicators. 95% of bootstrapped CIs of edges were narrow (Supplementary Figure S3), suggesting that edges were trustworthy.

The results of the non-parametric bootstrap procedure revealed that most comparisons among edge weights and centrality indicators were statistically significant (Supplementary Figures S4–S6).

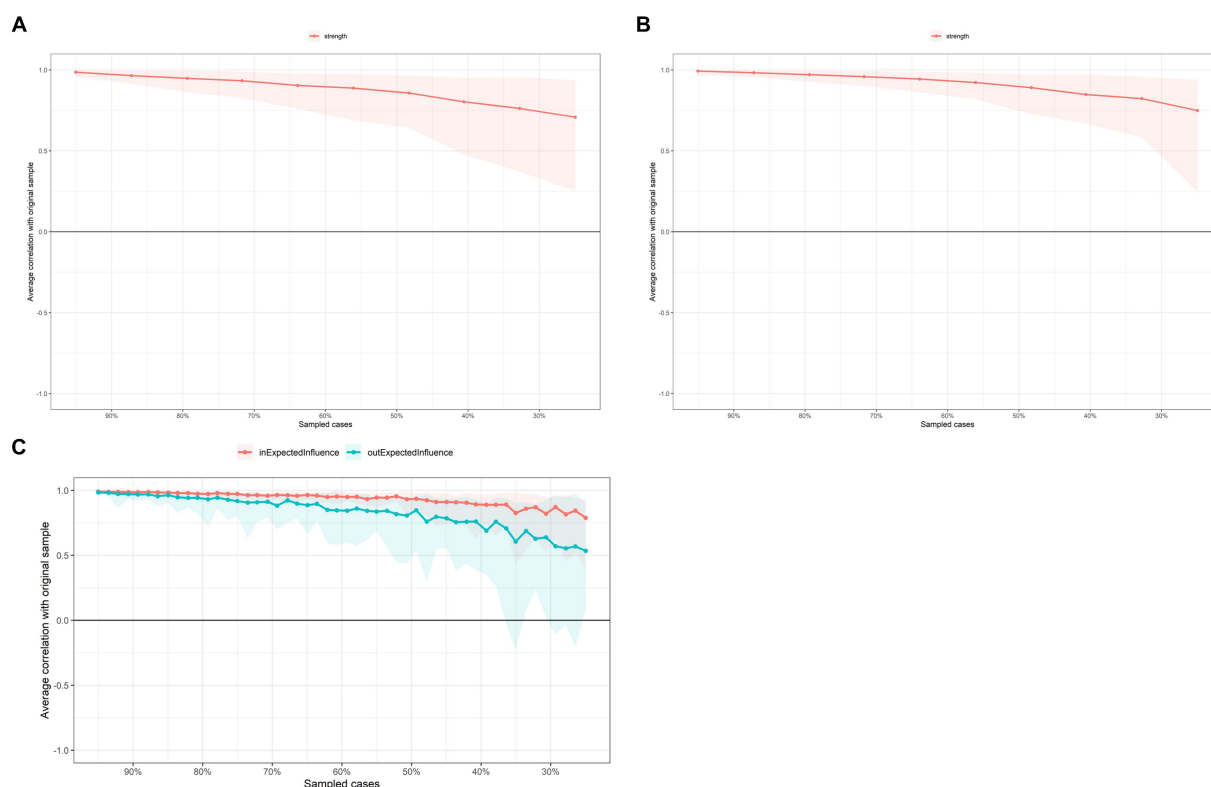


FIGURE 3

Case-dropping bootstrap test of centrality indices. The x-axis indicates the percentage of cases in the original sample included at each step. The y-axis indicates the correlations between the centrality indices from the original network and the indices from the networks re-estimated after excluding increasing percentages of cases. (A) First-time point. (B) Second time point. (C) CLPN.

3.5 Network comparison between the baseline and the second time point

The *t*-test result is shown in Figure 4A, except for “difficulty in falling asleep” and “easily be woken,” other symptoms decreased significantly. NCT results are shown in Figure 4. The value of the maximum difference in any edge weights (1,000 permutations) was not significant ($M=0.14$, $p=0.39$) (Figure 4B). The value of the difference in global network strength was also not significant (baseline = 4.31; second time = 4.60, $p=0.10$) (Figure 4C).

4 Discussion

To the best of our knowledge, this is the first study on sleep disturbance and aggression among college students during COVID-19. In the research, data were collected from 665 college students regarding their sleep quality and aggressive behaviors during the period of campus closure and post-closure. Two cross-sectional symptom networks and a CLPN were formed for further analysis. Several points in the study are worth discussing.

The most critical node in the networks of waves 1 and 2 was hostility, a psychological dimension of aggression known for its more detrimental impact on interpersonal relationships compared to physical aggression (62). Notably, hostility served as

the connecting link between aggression and sleep disturbance in both waves, consistent with the findings of Sun et al. (63). The pandemic has the potential to induce significant psychological distress (64), often manifesting as hostility (30). Furthermore, our results align with a key discovery regarding the long-term effects of COVID-19: even after the lifting of containment measures, college students may continue to experience affective and somatic symptoms such as anxiety, sleep disturbance, and hostility, albeit to a lesser extent (65). Considering another factor, sleep disturbance, our findings echo the research conducted by Granö et al. (66) on employees, indicating a correlation between sleep disturbance and hostility across different populations. Bringing together all the relevant factors discussed in our study, it becomes evident that during the COVID-19 pandemic, societal factors contributed to increased engagement in online courses, internet usage, and video games, all of which were directly linked to sleep disturbance and, consequently, heightened hostility (67, 68).

In the two networks of waves 1 and 2, symptoms underlying sleep disturbance were significantly associated, particularly “easily be woken” – “wake up too early” and “wake up with tired” – “function hindrance.” On the one hand, this association highlights a mutually reinforcing relationship. For instance, a college student who tends to wake up too early is also more likely to be easily awakened and vice versa. Similarly, the connection between “wake up with tired” and



In addition to examining symptom networks, we investigated changes in networks during the closure period and after the lifting of closures. With the exception of difficulty in falling asleep and

easily be woken, two symptoms of sleep disturbance did not show significant changes in statistics, all other symptoms decreased 1 month after the containment measures were lifted. Previous studies have yielded varied results, primarily due to differences in considering all dimensions of sleep disturbance. In our current study, we obtained similar results to those of Salfi et al. (41) in Italy, indicating that although most sleep disturbance symptoms diminish after home quarantine, COVID-19 still has a long-term effect on reducing the sleep quality of college students. Regarding aggression, our findings provide further insights from two perspectives. First, during the closure period, the uncertainties brought about by COVID-19 led to a greater increase in aggressive behavior than

usual (21, 22, 71). Additionally, our results strongly support the GAM, suggesting that closure can serve as a triggering situation for aggressive decision-making. Consequently, when such circumstances dissipate, the corresponding aggressive behavior also significantly decreases.

At the disease level, sleep disturbance, as a comprehensive issue, can potentially lead to aggressive behaviors (72). However, as indicated by Bubier and Drabick (73), conclusions drawn at the symptom level may even overturn results obtained at the disease level. In our current study, physical aggression and hostility emerge as two symptoms capable of inducing other symptoms. In essence, while sleep disturbance may seem to cause aggressive behaviors when viewed broadly, a closer examination of symptoms reveals that aggressive symptoms can trigger other symptoms within the network. Physical aggression entails intentional actions aimed at physically harming others (74). In college students, physical aggression can be predicted by personality traits such as low agreeableness, high extraversion, and high conscientiousness (75). Additionally, anger is identified as a critical risk factor for physical aggression among college students (76). Observations by Ostrov et al. (77) suggest that, typically, college students resort to physical aggression when they find themselves victimized in peer relations, which can exacerbate hostile attribution bias. Drawing from our results and previous observations, and considering the GAM, in the context of the COVID-19 pandemic, college students experiencing rejection or low-quality relationships with peers may resort to physical aggression as a coping mechanism, particularly when they exhibit impulsive traits or other personality characteristics such as low extraversion.

In terms of hostility, our results successfully replicate the findings of Shapiro et al. (78), indicating that negative mood and hostility can elevate blood pressure during sleep. Moreover, our results suggest that, on the one hand, the isolation resulting from COVID-19 is also a risk factor for hostility among college students (79). On the other hand, our findings provide somatic evidence of the chain effect of COVID-19 on college students. During the closure period, students tend to increase their internet usage for online courses, and this heightened social isolation may predispose them to internet addiction or substance abuse (80). In our current study, we take a step further by showing that during the closure, college students who exhibit problematic internet use are more likely to display hostility both online and offline (81).

An important factor worth noting is waking up too early. This finding aligns with previous studies on the impact of COVID-19 on the sleep quality of college students (18, 82, 83). During closures, negative news, academic stress, depression, and interpersonal relationships can act as early risk factors (65, 84). Our results reveal an additional pathway: aggressive behaviors such as “physical aggression” and “hostility” can trigger early awakening.

5 Limitations

In the current study, we disclose features of sleep disturbance and aggressive behaviors via longitudinal data. However, several

shortcomings should be mentioned for further research. First, in the current research, self-report scales are utilized as tools to measure the tendency toward aggression and sleep disturbance. In the future, researchers can incorporate additional methods to facilitate diagnosis. Second, the current generalizability of the results is somewhat limited due to the inadequate consideration of whether participants have been diagnosed with insomnia disorders in the past or present, as well as factors measuring participants' levels of academic stress during participant recruitment. Finally, since aggression and sleep disturbance are closely related to depression and anxiety, future studies could include more variables to enable more precise speculation (81).

6 Conclusion

In the current study, with longitudinal data, we disclose the bidirectional relationship between sleep disturbance and aggression. In the cross-sectional symptom network, hostility is the critical symptom both in waves 1 and 2. Furthermore, hostility can cause aggression and sleep disturbance in college students. In a time sequence, difficulty in falling asleep and easily be woken did not change after closure lifted significantly, whereas other symptoms declined. Two symptoms, physical aggression and hostility, can trigger other symptoms and easily be woken, which are induced by other symptoms.

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 humans were approved by the research was examined and approved by the Ethics Committee of the First Author's Affiliated Institution. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

JZ: Formal analysis, Methodology, Writing – original draft. BB: Investigation, Writing – review & editing. ML: Conceptualization, Supervision, Writing – review & editing. GL: Conceptualization, Funding acquisition, Supervision, Writing – review & editing.

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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/fpubh.2024.1357018/full#supplementary-material>

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Exploring adolescent mental health during the COVID-19 crisis – strengths and difficulties

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Introduction: The SARS-CoV-2 pandemic has significantly impacted children and adolescents, leading to mental health challenges. Knowledge on their resources and difficulties is crucial and there is a need for valid instruments to assess their psychosocial condition especially in this exceptional situation. We assessed psychopathological symptoms using the SDQ during the pandemic, comparing to pre-pandemic data. Our study aims to understand adolescents' strengths and difficulties amidst COVID-19, evaluating the SDQ's utility in crisis settings.

Methods: Within the German school-based surveillance study ("B-Fast"), we assessed behavioral strengths and difficulties in 664 adolescents aged 11–17 years during the peak of the German COVID-19 pandemic using the validated Strengths and Difficulties Questionnaire (SDQ) for both external and self-assessed data collection. Data were collected between November 2020 and April 2021. We compared self-assessed SDQ-scores to pre-pandemic data from a comparable sample and examined adolescent classification as "normal" or "borderline/abnormal" based on both external and self-assessed SDQ subscale scores using established cut-off values. Additionally, we conducted sex and rater-based score comparisons.

Results: In our study, we observed a significant worsening of "Emotional Symptoms" compared to pre-pandemic levels, while "Conduct Problems" and "Prosocial Behavior" showed improvement. Variations in classification to "normal" and "abnormal" emerged when applying German versus British cut-off values. Females scored higher on "Emotional Symptoms" while males scored higher on "Hyperactivity Symptoms." Correlations between external and self-assessed SDQ ratings ranged from 0.43 ($p < 0.001$) for "Prosocial Behavior" among girls to 0.62 ($p < 0.001$) for "Peer Problems" among boys, indicating moderate to high consistency.

Discussion/conclusion: Our study contributes to understanding the psychosocial impact of the COVID-19 pandemic on German adolescents. Compared to other symptoms, we observed a particular worsening in "Emotional Symptoms" based on our data. Despite the moderate correlation between parental and self-reported evaluations, there appears to be a certain discrepancy in the perception of adolescent quality of life. Therefore, it seems prudent to assess both the external and self-reported evaluations and amalgamate the results from both parties to obtain a comprehensive problem profile of the individual. These findings underscore the importance of using country-specific cutoff values and reaffirm the utility of the SDQ as a valuable assessment tool, even within the unique circumstances posed by a pandemic.

KEYWORDS

COVID-19 pandemic, adolescents, mental health, SDQ-questionnaire, crisis, mental health assessment

Introduction

Since its outbreak and global spread, the SARS-CoV-2-pandemic has been a major challenge to the world's population and a major burden to health, social and economic systems worldwide, especially threatening vulnerable groups, such as children and adolescents (1). While it is currently believed that COVID-19 infections among them mostly result in mild courses with few complications (which is not yet conclusively understood and currently still under investigation), numerous studies have demonstrated the devastating indirect effects of this pandemic on the well-being of children and adolescents (2–14). For example, In the nationwide representative COPS study, the mental health and quality of life of children and adolescents during the pandemic were examined and compared with pre-pandemic data. Results indicated a high level of distress, diminished quality of life, and a significant increase in mental health issues (11–13). These findings align with a systematic review conducted by Loades and colleagues (7), which explored the repercussions of social isolation on children's mental health during the COVID-19 pandemic in several countries. The review revealed elevated levels of depression and anxiety persisting even beyond the period of isolation. Similarly, Fong and Iarocci (5) emphasized the substantial negative impact of COVID-19 and related social isolation/quarantining practices on child anxiety, post-traumatic stress disorders and fear symptoms. Potential reasons for these severe impacts of the pandemic on children, adolescents and their families include the drastic mitigation measures that severely limit social and educational opportunities for personal development, constant fear for the own health and that of parents and loved ones, potentially threatening economic consequences and the loss of a predetermined daily structure (15–17).

A Lancet article by Jiao et al. (18) delved into the implications of extended home confinement and school closures during the COVID-19 pandemic on children's mental health. It highlights concerns about increased anxiety, depression, and psychological distress among children due to disrupted routines and limited social interactions. Drawing on evidence from previous outbreaks, the study emphasized the urgent need for targeted interventions to address mental health concerns during public health emergencies. Additionally, it underscored the critical role of parents, schools, and communities in supporting children's mental well-being during crises.

It has been shown that during COVID-19 pandemic a significant increase of psychological distress, Covid-19 anxiety syndrome, loneliness, fatigue, and worry has been observed across different populations (19–22). Overall however, several studies so far during the SARS-CoV-2-pandemic in children and adolescents focused on physical health or measures of quality of life (11) but still less on psychopathological symptoms. To fill this gap, we conducted a dimensional approach to assess the frequency and number of psychopathological symptoms with the SDQ-questionnaire, which

also delves into aspects of psychopathology and offers self-assessed as well as external ratings. This approach was deemed important, as the WHO reports increased rates of psychiatric disorders (23). Good agreement between an SDQ assessment and the respective clinical diagnoses has already been demonstrated, in principle making the SDQ a useful screening tool for emotional and behavioral strengths and difficulties in children and adolescents (24). We wanted to find out whether the SDQ, instead of the lengthy Child Behavior Checklist (CBCL) questionnaire, is also suitable for use during a pandemic, assessing to what extent it can effectively serve as a time-efficient and cost-effective tool to serve as a proxy for potential psychopathological symptoms. Furthermore, differentiated knowledge in terms of a profile of psychopathological aspects is needed. This allows an assessment of how various domains of psychopathology were affected by the pandemic stress. The COSMO study (12) has reported important data about increased emotional problems in children and adolescents during the SARS-Cov-2 pandemics using the SDQ, however, no data on other psychopathological dimensions or consequences for how many subjects are detected as “abnormal” were reported in this study.

More specifically, the study at hand aims to examine how suitable the SDQ is to measure psychopathological symptoms among children and adolescents aged 11–17 years during the SARS-CoV-2 pandemic. Further, with the data of a convenience sample, the study aims to convey an impression on children's and adolescents' strengths and difficulties during the pandemic. To do so we are (1) providing a description of their SDQ-scores, highlighting the strengths and difficulties faced by the adolescents in the cohort. In addition, we are (2) using the externally- and self-assessed ratings for comparative analyses. This includes the comparison of (a) these SDQ-scores with normative pre-pandemic data, (b) the application of different country-specific cut-off-values to the results for a classification to normal and borderline/abnormal, (c) outcomes of male and female participants across the different SDQ subscales of the Questionnaire separately for external and self-ratings and (d) results of the external and self-assessed SDQ ratings separately for males and females. All results are interpreted and contextualized against the backdrop of previous knowledge about the psychological situation of adolescents in order to assess the validity of the SDQ during global crises.

Methods

The National Research Network of the university hospitals in Germany initiated the B-Fast Project with the goal to collect and bundle pandemic information and knowledge to contribute to the management and control of the SARS-CoV-2 pandemic, especially in institutions of children's everyday life. The project received funding from the Federal Ministry of Education and Research. The study was approved by the ethics committee of the medical

faculty of the University of Cologne and the respective ethics committees of all participating study sites and is registered with the German Clinical Trials Register (<http://www.drks.de/DRKS00023911>).

The project was divided into several work packages and application areas. Participants and their parents were asked to fill in a questionnaire focusing on potential behavioral strengths and difficulties of the adolescents (SDQ).

In the school and day care-centers project, COVID-19-tests were carried out at five locations (Düsseldorf, Heidelberg, Homburg, Cologne, Munich) in a total of 14 institutions. The project was implemented in 2 phases of 3 weeks each in the period from September 2020 to March 2021.

At the beginning of test phase 1 (September–December) and test phase 2 (January–March) the SDQ-questionnaire was distributed. The SDQ was used to assess psychopathological symptoms. The questionnaires were answered by the parents of children and adolescents aged 2–17 (parent ratings) and to the adolescents aged 11–17 (self-ratings). The questionnaires could be filled in as online or paper-pencil versions.

Population

Study sample

The participating facilities were selected at the five participating locations. School selection aimed to cover a variety of population densities and social settings, not to be population-representative. Furthermore, the site selection was intended to reflect differences in the various German school types as well as German federal structural differences. Site recruitment required approval of communities, school boards and local health authorities.

Students needed written consent of the legal guardians. Participation was voluntary and consent could be withdrawn at any time. Adolescents aged 11–17 years who had a valid¹ self-assessed SDQ-score as well as a valid externally assessed SDQ-score by one respective parent were included in our study population. To be considered valid, at least 80% of the (externally or self-assessed) SDQ-questionnaire needed to be completed.

No incentives were offered for participation. While $n=4,866$ students were eligible for the B-FAST study, $n=1,536$ had no informed consent, resulting in $n=3,386$ students to be enrolled in the study. In total, there were $n=3,970$ participants from 14 primary and secondary schools enrolled in the main study, including students, parents and staff.

From the total study-population, $n=1,023$ students filled in the self-assessed SDQ-questionnaire and $n=1,605$ parents filled in the externally assessed SDQ-questionnaire. For our analyses, we only included adolescents between the age of 11 and 17 with a self-assessed SDQ-score as well as the corresponding externally assessed SDQ-score. After data cleaning, our final sample included $n=664$ children. From these, there were $n=385$ female, $n=278$ male and $n=1$ child with none specified gender. A flowchart to visualize this inclusion process can be found in [Figure 1](#).

Strengths and difficulties questionnaire

The main outcome of our analysis, the behavioral strengths and difficulties of adolescents in Germany, was assessed via the SDQ. It is

a validated and widely applied instrument to identify children and adolescents at risk for behavioral and mental health problems via a questionnaire that can be completed by either the child or adolescent themselves (self-assessed) or by a respective parent or teacher (externally assessed) (25). In the following, the term “externally assessed” is used in the sense of “parental assessed.”

The SDQ is composed of the following five subscales: Conduct Problems, Emotional Symptoms, Hyperactivity Symptoms, Peer Problems, and Prosocial Behavior. All subscales contain 5 questions each to be answered on a 3 step Likert scale (0 = not true; 1 = somewhat true; 2 = certainly true) (26, 27).

Statistical analyses

Preceding the main analyses, we provide descriptive statistics of relevant covariates, namely age, gender and type of school, socioeconomic status. The type of school refers to the school types of the German school system. School education at “Hauptschule” and “Mittelschule” lasts 9 years and qualifies students for vocational training afterwards. Schooling at “Realschule” lasts 10 years and is designed for slightly academically higher-achieving students. Students at “Gymnasium” attend school for 12–13 years and graduate with the university entrance qualification (“Abitur”), which enables them to pursue further studies at universities or colleges. Admission to “Realschule” and “Gymnasium” is restricted by academic performance during elementary school. “Gemeinschaftsschulen” are a hybrid model where all students, regardless of their academic performance, learn together in common class structures. The school level refers to the year in which the respective student is currently in his/her school. Lower level consists of the years 5–6, middle level of the years 7–9 and finally high level of the years 10–12.

In a first step, each subscale was analyzed individually, with the respective five items being added together, resulting in a value range of each subscale between 0 and 10, with higher values indicating more problems. The total score (“Total Problem Score”) is calculated by adding up the values of all subscales, except the Prosocial Behavior subscale. This scale ranges from 0 to 40 and can also be interpreted independently. These scores were used for the following analyses. We compared our data to normative data from the pre-pandemic situation. These German norm values stem from the KIGGS study (28). The German KIGGS study is a cohort-sequential study that gathered comprehensive data on the health status of children and adolescents in Germany. It was part of the German health-monitoring system established at the Robert Koch Institute, Berlin, on behalf of the German Federal Ministry of Health (29). The data used for establishing German norm values by Hölling et al. for the self-assessed SDQ and for our comparison is from KiGGS wave 1, which took place between 2003 and 2006 and involved a total of 17,641 adolescents and children and their parents. Here 6,726 participants aged 11–17 years were involved. As we did not have access to the full data set, the data was simulated based on Hölling et al. (30). This enabled a comparison of our data dimensionally to the German normative data. To do so, a descriptive analysis was conducted, presenting the arithmetic means, standard deviation (SD), and the 95% confidence interval (95%CI). This was solely performed for the self-assessed data as Hölling does not provide normative data for the externally assessed values. In addition, we classified resulting scores into the categories “normal”

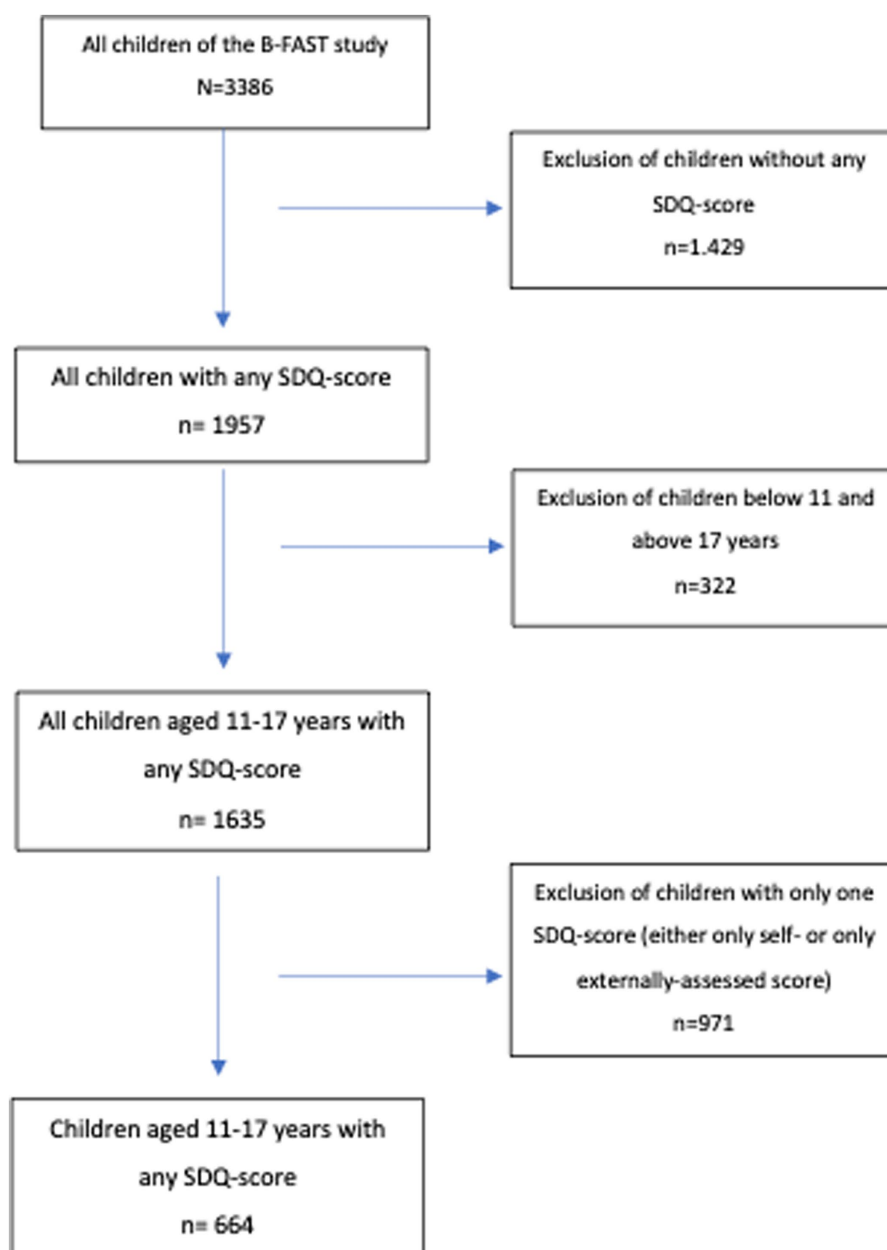


FIGURE 1
Flowchart inclusion process.

“borderline” and “abnormal” by applying the German bandings provided by Hölling (30) to the self-assessed data as well as for the externally assessed data provided by Woerner et al. (31) and compared the results to the classification based on the United Kingdom bandings provided by Goodman (25, 32). Comparisons between male and female participants’ values of the externally assessed SDQ-scores were conducted by using the Mann–Whitney *U*-test presenting the median, the interquartile range (IQR), arithmetic mean, confidence interval and the *p*-value. Similarly, we compared external and self-assessed ratings separately for male and female participants by calculating Spearman’s correlation. Finally, as a result of the previous steps, we present the arithmetic means and 95%CI of all (sub)scales

separately for participants attending Realschule or Gymnasium (school types), respectively.

The simulation of the data of the KiGGS study was performed with R, Version 4.1.2. All other analyses were performed using SPSS, Version 29.

Results

The adolescents were on average 13.44 years old and fairly evenly distributed in terms of age groups (11–13 years: 54.8%; 14–17 years: 45.2%). Slightly more girls than boys participated (58.0%). The

majority of our study participants attended “Gymnasium” (69.3%), i.e., had taken the highest possible educational path. In our sample, this was followed by “Realschule” (21.8%), which is the second highest educational path in this age group. “Hauptschule” and “Mittelschule” together accounted for only 4.4% of our cohort. “Gemeinschaftsschule” was even less represented at 0.6% (Tables 1, 2).

A visualization of the comparison between SDQ-values in children and adolescents before the pandemic vs. our population during the pandemic (self-report, 11–17 years) can be found in Figure 2.

Regarding self-assessed ratings on the subscale Emotional Symptoms the pandemic-cohort is worse off than the pre-pandemic study cohort (mean = 2.89 vs. mean = 2.43). However, on the subscales Conduct Problems, Hyperactivity and Prosocial Behavior (higher values on the subscale prosocial behavior indicate a higher social competence, i.e., resources not difficulties), the pre-pandemic population rated themselves more negative than our population.

Table 3 displays the differences in results using different cut-off-values for the self-report, using German norm values based on Hölling et al. (30) and British norm values based on Goodman (25).

We found the bandings to be the same on the subscales Conduct Problems and Hyperactivity as well as on the subscale Peer Problems.

On the subscales where the groupings differed, namely on the Total Problem Score, the subscale Emotional symptoms and the subscale Prosocial Behavior, we observed a larger proportion of cases labeled as “normal” when using the British bandings. Consequently, we saw a higher number of cases in the categories “borderline” and “abnormal,” when using the German bandings.

Table 4 displays the differences in results for the externally assessed report, using the German norm values based on Woerner et al. (31), and the British norm values based on Goodman (25).

We found the bandings to be the same on the subscales Emotional Symptoms, Hyperactivity and Prosocial Behavior. Due to different cut-offs on the Total Problem Score, we found more cases in the category “normal” and fewer cases in the categories “borderline” and “abnormal,” when using the British bandings. Also, the subscales Conduct Problems and Peer Problems use different cut-off values based on the branding, therefore we saw a larger proportion of cases in the category “normal” and a smaller proportion of cases in the category “borderline” and “abnormal” when using German bandings.

As shown in Table 5, when comparing scores between male ($n=278$) and female participants ($n=385$) separately for externally and self-assessed data, differences were statistically significant for the external ratings in three of the six (sub-)scales (Emotional Symptoms, Hyperactivity, Prosocial Behavior), while this was the case for four

TABLE 1 Sample characteristics: cross-sectional population of students with both self-assessed and externally assessed (via parent) SDQ-score from November 2020 to April 2021 ($n = 664$).

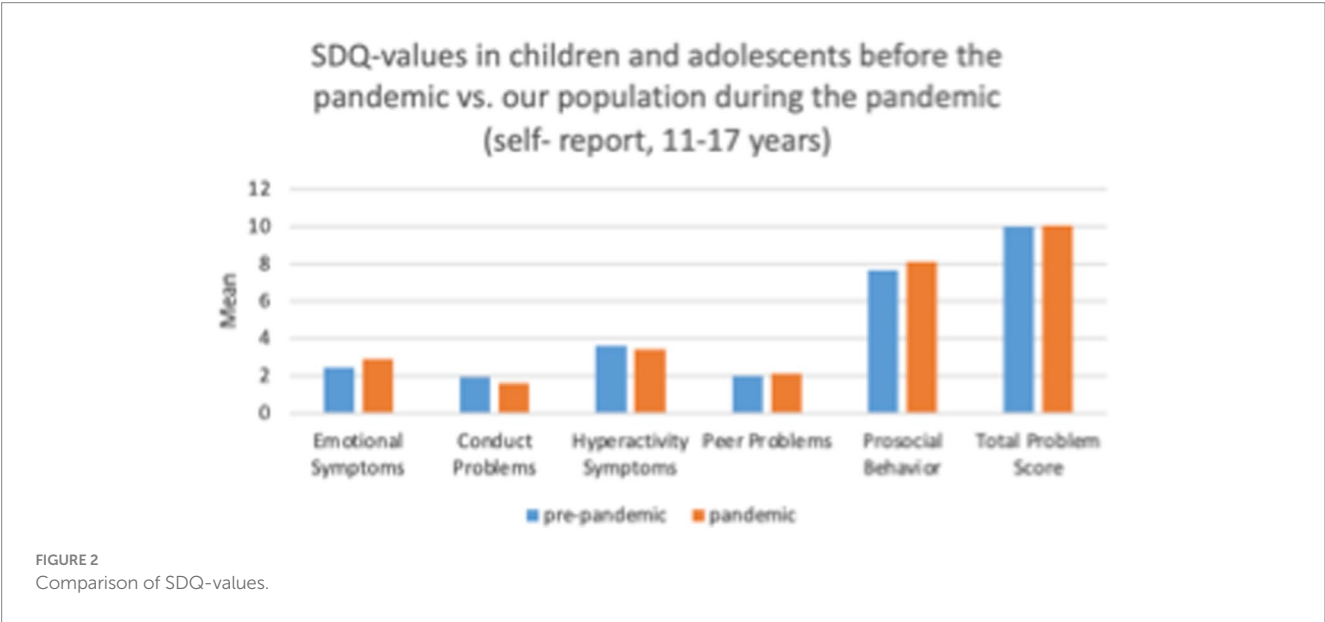
Variables	<i>n</i>	%/Mean \pm SD
Age in years (cont.)	664	13.44 \pm 1.905
Age in categories		
11–13 years	365	11.95 \pm 0.81
14–17 years	299	15.26 \pm 1.11
Gender		
Male	278	41.9%
Female	385	58.0%
Not specified	1	0.2%
Type of Secondary School Institution		
Hauptschule (secondary modern school, graduation after year 9)	5	0.8%
Realschule (secondary school, graduation after year 10)	145	21.8%
Gymnasium (grammar school, graduation after year 12/13)	460	69.3%
Mittelschule (middle school, graduation after year 10)	24	3.6%
Gemeinschaftsschule (mixed school type)	4	0.6%
Other	25	3.8%
School year		
Lower grade (school year 5–6)	184	27.71%
Middle grade (school year 7–9)	316	47.59%
Higher grade (school year 10–12)	164	24.70%
Location and social structure index*		
Heidelberg	11	1.7%
Homburg	3	0.5%
Cologne	464	69.9%
Munich	186	28.0%

n, absolute frequencies; %, percent frequencies; SD, standard deviation.

TABLE 2 SDQ-values in simulated pre-pandemic sample versus B-fast sample during the pandemic (self-report, 11–17 years).

SDQ (sub-)scales	Report	Mean	SD	95% Confidence interval	
Emotional symptoms	Pre-pandemic*	2.43	0.09	2.38	2.48
	Pandemic	2.89	0.02	2.71	3.07
Conduct problems	Pre-pandemic	1.95	0.02	1.91	1.98
	Pandemic	1.62	0.06	1.51	1.73
Hyperactivity symptoms	Pre-pandemic	3.62	0.02	3.57	3.67
	Pandemic	3.42	0.09	3.25	3.59
Peer problems	Pre-pandemic	2.00	0.02	1.97	2.04
	Pandemic	2.12	0.64	1.99	2.24
Prosocial behavior	Pre-pandemic	7.69	0.21	7.65	7.73
	Pandemic	8.10	0.70	7.97	8.23
Total problem score	Pre-pandemic	10.02	0.07	9.86	10.16
	Pandemic	10.06	0.21	9.65	10.47

*Using the simulated data of the KiGGS study of the SDQ self-report based on the results by Hölling et al. (2018) with $n=6,726$ participants, aged 11–17 years. SD, standard deviation.



(sub)scales in the self-assessed ratings (Emotional Symptoms, Peer Problems, Prosocial Behavior, Total Problem Score). For example, on the subscale Peer Problems, sex-specific differences were statistically significant in the self-assessed but not in the external ratings (p -value 0.02 vs. 0.94), whereas it was the other way around for Hyperactivity symptoms (p -value 0.838 vs. 0.001). On the latter scale, parents rated boys more negatively than they did for girls. On the subscale Prosocial Behavior both, the externally and self-assessed scores, showed more positive ratings for girls than for boys (p -value parental assessed: 0.006; self-assessed: 0.001).

The correlation coefficients between external and self-assessed ratings (Table 6) overall show a moderate to high correlation (between 0.43 for Prosocial Behavior among girls and 0.62 for peer problems among boys) with a higher consistency for boys (on average 0.55 vs. 0.49). The correlation was statistically significant in all cases.

The school-specific presentation of arithmetic means for all scales consistently show higher values on the problem scores (see Appendix).

This particularly becomes obvious in the total score 9.79 versus 6.95 (external report) and 11.67 versus 9.54 (self-report) for adolescents attending Realschule vs. Gymnasium, respectively.

Discussion

Our main findings were (1) that in our sample, the subscale affected the most during the pandemic was the Emotional Problems subscale. In contrast, an amelioration on the subscales Conduct Problems and Prosocial Behavior was observed. We furthermore found that (2) country-specific normative data seem to be important. Our data indicated that increased emotional problems would not be detected applying other European (British) norms. Thirdly, the detailed problem profile showed sex-specific differences and differences between adolescents attending different types of school. While we found a moderate to good correlation between self-ratings

TABLE 3 Bandings of raw scores of self-assessed SDQ-scores using normative German data (Hölling) (30) and normative British data (Goodman) (25).

	"Normal"				"Borderline"				"Abnormal"			
	Bandings		Proportion of cases		Bandings		Proportion of cases		Bandings		Proportion of cases	
	Hölling	Goodman	Hölling	Goodman	Hölling	Goodman	Hölling	Goodman	Hölling	Goodman	Hölling	Goodman
Total Problem Score	0–14	0–15	81.60%	85.20%	15–16	16–19	6.90%	9.30%	17–40	20–40	11.50%	5.50%
Emotional Symptoms	0–4	0–5	76.70%	84.30%	5	6	7.60%	6.00%	6–10	7–10	15.70%	9.70%
Conduct Problems	0–3	0–3	90.60%	90.60%	4	4	5.10%	5.10%	5–10	5–10	4.30%	4.30%
Hyperactivity	0–5	0–5	84.50%	84.50%	6	6	6.00%	6.00%	7–10	7–10	9.50%	9.50%
Peer Problems	0–3	0–3	81.40%	81.40%	4	4–5	9.40%	14.30%	5–10	6–10	9.20%	4.30%
Prosocial Behavior	7–10	6–10	84.40%	90.20%	6	5	5.70%	5.90%	0–5	0–4	9.90%	3.90%

TABLE 4 Bandings of raw scores of externally assessed SDQ-scores using normative German data (Woerner) (31) and normative British data (Goodman) (25).

	"Normal"				"Borderline"				"Abnormal"			
	Bandings		Proportion of cases		Bandings		Proportion of cases		Bandings		Proportion of cases	
	Woerner	Goodman	Woerner	Goodman	Woerner	Goodman	Woerner	Goodman	Woerner	Goodman	Woerner	Goodman
Total problem score	0–12	0–13	80.90%	84%	13–15	14–16	9.30%	7.20%	16–40	17–40	9.80%	8.80%
Emotional symptoms	0–3	0–3	76.20%	76.20%	4	4	10.10%	10.10%	5–10	5–10	13.70%	13.70%
Conduct problems	0–3	0–2	89.20%	77.50%	4	3	6.60%	11.60%	5–10	4–10	4.20%	10.90%
Hyperactivity	0–5	0–5	86.60%	86.60%	6	6	6.60%	6.60%	7–10	7–10	6.80%	6.80%
Peer problems	0–3	0–2	84.60%	73.30%	4	3	7.80%	11.30%	5–10	4–10	7.60%	15.40%
Prosocial behavior	6–10	6–10	89.20%	89.20%	5	5	5.40%	5.40%	0–4	0–4	5.40%	5.40%

TABLE 5 Comparison of males and females on the self- and externally-reported SDQ-scores via Mann–Whitney *U*-test.

SDQ (sub-) scales	Report	Sex	Median	IQR	<i>p</i> -value	Mean (SE)	CI
Emotional symptoms	Parent	Male	1	0–3	<0.001	1.78 (0.11)	(1.55; 2.00)
		Female	2	1–4		2.36 (0.11)	(2.14; 2.57)
	Self	Male	2	1–5	<0.001	1.99 (0.11)	(1.77; 2.21)
		Female	3	1–5		3.55 (0.13)	(3.30; 3.80)
Conduct problems	Parent	Male	1	0–2	<0.262	1.58 (0.09)	(1.40; 1.76)
		Female	1	0–2		1.50 (0.08)	(1.34; 1.67)
	Self	Male	1	1–2	<0.390	1.56 (0.08)	(1.40; 1.73)
		Female	1	1–2		1.67 (0.08)	(1.53; 1.82)
Hyperactivity symptoms	Parent	Male	3	1–5	<0.001	3.15 (0.15)	(2.85; 3.44)
		Female	2	0–4		2.35 (0.11)	(2.13; 2.56)
	Self	Male	3	2–5	<0.838	3.42 (0.13)	(3.16; 3.67)
		Female	3	1–5		3.44 (0.12)	(3.21; 3.67)
Peer problems	Parent	Male	1	0–3	<0.943	1.61 (0.10)	(1.41; 1.81)
		Female	1	0–3		1.62 (0.09)	(1.44; 1.80)
	Self	Male	2	1–3	<0.022	1.98 (0.10)	(1.78; 2.18)
		Female	2	1–3		2.22 (0.08)	(2.06; 2.38)
Prosocial	Parent	Male	8	7–9	<0.006	7.74 (0.12)	(7.51; 7.98)
		Female	9	7–10		8.15 (0.09)	(7.96; 8.33)
	Self	Male	8	7–9	<0.001	7.70 (0.12)	(7.47; 7.93)
		Female	9	8–10		8.40 (0.08)	(8.24; 8.56)
Total problem score	Parent	Male	7	4–12	<0.407	8.11 (0.33)	(7.47; 8.75)
		Female	7	4–11		7.83 (0.29)	(7.26; 8.40)
	Self	Male	9	5–12	<0.001	8.95 (0.29)	(8.38; 9.52)
		Female	10	7–14		10.88 (0.28)	(10.32; 11.43)

TABLE 6 Spearman's correlation between self- and externally assessed ratings by sex.

	Males		Females	
	Correlation coefficient	<i>p</i> -value	Correlation coefficient	<i>p</i> -value
Emotional problems	0.4386	<0.001	0.482	<0.001
Conduct problems	0.4946	<0.001	0.4628	<0.001
Hyperactivity	0.5757	<0.001	0.521	<0.001
Peer problems	0.6246	<0.001	0.5055	<0.001
Prosocial behavior	0.5815	<0.001	0.4318	<0.001
Total problem score	0.5637	<0.001	0.5414	<0.001

and external ratings in the SDQ, our data show that both ratings should be included to obtain reliable and valid results. The SDQ is sensitive to sex and rater effects.

The present study aimed to show a dimensional problem profile of adolescents during the COVID-19 pandemic and thereby provide information on how suitable the SDQ is to measure the emotional situation of an adolescent population during a global crisis. Therefore, we used the SDQ to investigate dimensional psychopathological symptoms instead of quality of life or frequencies of categorical psychiatric disorders in a subgroup of adolescents 1 year into the SARS-CoV-2-pandemic in Germany. Both the students and their

parents completed the questionnaire on psychosocial health. We observed a deterioration in our cohort on the self-assessed subscale Emotional Symptoms compared to the pre-pandemic population of the KiGGS study population (29). Similarly, comparing the classification of our sample to the classification of the pre-pandemic sample using the German cut-off-values provided by Hölling (30) for the subscale Emotional Symptoms we found a larger number of cases in the category “abnormal” (15.7% vs. 7.5%). These results are in line with a previous nationwide representative study performed during the SARS-CoV-2-pandemic showing that two thirds of the participating children and adolescents are highly

burdened by the pandemic. They experienced significantly lower health related quality of life, more mental health problems, and higher anxiety levels (33). Taking into consideration that hyperactivity is more genetically determined, it is not surprising that no statistically significant changes occur on this scale before and during the pandemic. On the subscale “Conduct Problems,” we observed an improvement that is not entirely explicable based on our dataset; however, it may be attributed to alterations in daily routines (such as school closures and increased time spent at home), which potentially resulted in stress reduction for certain adolescents.

In contrast, using the bandings provided by Goodman (25), the deterioration during the SARS-CoV-2-pandemic was less accurately captured for our sample: only 9.7% are classified as “abnormal.” As a methodological consideration, the results therefore also show how different cut-offs lead to different classifications and underline the need of using country specific cut-off values (30).

Importantly, as Robert Goodman stated: “The main implication is that users probably should not be too focused on whether the score is just this side or just the other side of an arbitrary boundary. We may need to use fairly arbitrary cutoffs in terms of rules such as that above a score of X we will carry out more detailed screening, but that sort of pragmatic rule should not blind us to the fact that one point above threshold and one point below threshold actually have almost identical implications.”

Several other authors (3–11, 33) have also shown the deterioration of the mental health situation of adolescents in Germany and elsewhere. Ravens Sieberer, for example, included internationally established and validated instruments for measuring the health-related quality of life (KIDSCREEN-10), mental health problems (SDQ), anxiety (SCARED), and depression (CES-DC) (33). The deterioration of the mental health situation is not only pictured by German authors but also internationally. For example, in two Chinese studies, one in which data of Chinese primary school students were collected on depressive and anxious symptoms, non-suicidal self-injury, suicide ideation, suicide plan, and suicide attempt (34). The other, using a questionnaire, which was completed by parents, incorporating the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) criteria commonly used for a cross-cultural assessment of anxiety disorders, including depression (18). Also, on a systematic review conducted by an international team from Canada, Pakistan and Australia who included 18 articles in their review with the overall finding that Children and adolescents are more likely to experience high rates of depression and anxiety during the pandemic (4).

However, on two subscales (Conduct Problems, Prosocial Behavior) our specific cohort appeared to be better off than the pre-pandemic population (30).

Bringing together our results with other studies conducted during the pandemic in Germany using the SDQ (9), our study offers further knowledge concerning mental health problems of adolescents. It does not only give insight into the externally assessed data but also self-assessed data of the adolescent. While the pre-pandemic Germany-wide BELLA study reported that 17.7% of all 7–17-year-olds are at risk for mental problems on the Total Problem Score of the SDQ (9), the COPSYP study showed that this proportion of 7–17-year-olds at risk increased drastically to 30.3% (11). However, the COPSYP study particularly focused on quality of life by using the KIDSCREEN and used the SDQ only to display the Total Problem Score, symptoms of

depression and anxiety were generated by using different screening methods (SCARED, CES-DC, PHQ-2) (11). Our specific findings not only add knowledge regarding dimensional aspects with the full profile of the SDQ of adolescents’ well-being and psychopathology. They also give information about the consistency of ratings by parents and by the adolescents themselves. On the subscale Emotional Symptoms, for example the externally and the self-assessed SDQ-scores did not greatly deviate from each other. This confirms the existing evidence according to which externally- assessed and self-assessed SDQ-scores usually agree better as the child gets older (35, 36). The fact that we solely included adolescents, but not younger children may have contributed to this finding.

Also, equally high results for German children and adolescents were reported by the Corona Snapshot Monitoring (COSMO) study, a serial cross-sectional study designed to assess the psychosocial condition of Germans during the SARS-CoV-2-pandemic (12). Here, also approximately one-third of all under-aged children was found to be at risk for Emotional Symptoms on the SDQ scale. Still, these results were also well above pre-pandemic levels.

In contrast, the overall SDQ-scores of our cohort were more consistent with the pre-pandemic scores. For example, in the externally assessed report, merely 19% (German banding) of our cohort were classified as “at risk” on the Total Problem Score, which is rather consistent with the pre-pandemic levels of the BELLA study (9). This is also true for most externally assessed SDQ-subscale scores in our study. Except for Emotional Symptoms, 80.9–89.1% (German bandings) of all adolescents were not at risk (category “normal”), reflecting the pre-pandemic SDQ levels.

Regarding sex differences on the self- and externally assessed perceptions of adolescent mental health during the pandemic, our results are mostly consistent with previous studies (37, 38). Concerning Emotional Symptoms, girls seem to be slightly worse off than boys. For internalizing symptoms, females compared to males have been found to be more likely to react with anxiety (37). It has also been observed in a previous study that females were more likely to show symptoms of depression and anxiety than males during the SARS-CoV-2-pandemic (38). Males in our cohort were rated worse than the females solely on the externally assessed scale Hyperactivity-Symptoms. This might be due to the fact that boys are more likely to stand out with symptoms of hyperactivity (39, 40) and that these symptoms are usually more obvious and conspicuous making them more consistently discernible by parents (41, 42). On the same subscale the self-assessed scores for boys and girls demonstrate greater comparability as girls showed higher values in the self-ratings compared to their parents’ ratings. There is a lot of evidence supporting higher hyperactivity among boys than among girls (39), leading to the conclusion that self-ratings for hyperactivity might not be reliable.

However, a similar picture with self-ratings resulting in higher values than external ratings particularly in females, could be observed for emotional symptoms (2.36 vs. 3.55) and peer problems (1.62 vs. 2.22). This pattern is in line with previous literature, which indicates that self-ratings tend to reflect more problematic perceptions compared to external ratings (25, 30, 43), highlighting the importance of surveying adolescents themselves, as parents may not be aware of everything. Consequently, this not only makes our data plausible and is a confirmation of previous findings from pre-pandemic times. Furthermore, according to our data, this pattern seems to have

persisted during the pandemic, even though adolescents spent significantly more time at home during this period.

In attempting to elucidate the observed sex differences, it is imperative to consider pre-pandemic research findings, emphasizing that these disparities are not solely pandemic-specific. These antecedent studies generally corroborate our observations regarding sex disparities amidst the pandemic. Numerous investigations support the differential manifestation of ADHD and anxiety disorders in boys and girls. Biologically, variations in neurobiological functioning and hormonal regulation are posited as potential contributing factors. Moreover, gender-specific social dynamics and patterns of upbringing are proposed to exert influence over the prevalence of these psychiatric conditions (44–47).

We found the SDQ to be a reliable tool to measure strengths and difficulties of adolescents during a crisis such as a global pandemic. From our data, it seems that adolescent-centered interventions should focus on emotional and psychosomatic but also externalizing difficulties and should consider that males and females might react differently to stressful situations and show different symptoms. In the light of the children and adolescents-focused mental health surveillance program planned by the central German public health institute, the Robert Koch Institute (RKI) (48), these findings could contribute to a potential starting-point to draw meaningful conclusions for a mental health monitoring strategy in future crisis situations. Also, we found no existing normative German data to sufficiently compare parents and their children using the SDQ. We merely found normative German data for the self-assessed SDQ and in another study conducted on another population normative German data for the externally assessed SDQ. Therefore, our findings help to show that there are corresponding normative German data on the self- and the externally assessed SDQ missing. We recommend conducting a representative study to generate normative data for both the externally and self-assessed SDQ-scores.

In addition, our study also provides insight into who can be reached with surveillance studies in schools during a time of crisis. Vulnerable groups seem to be insufficiently addressed by these participation offers and thus are hardly included, which leads to a major bias conflict of such study endeavors. In this respect, our experiences should provide an impulse to develop strategies for data collection at schools in order to prevent this problem in the future and to be able to represent the German general population more reliably.

Strengths and limitations

This study, despite its well-designed multicenter efforts of study facilities, universities and research institutes, has some limitations. Thus, it is likely that a selection bias of the participants led to a systematic bias of the study cohort, where the considered adolescents seem to be more educated, urban and financially better off than the German average. The SDQ-Questionnaire is available in over 80 languages; however, in this study it was solely administered in German. Consequently, the cohort is likely to have a lower proportion of participants with migration background compared to the general population. In addition, the uneven geographic distribution of study participants was influenced by the distribution of study centers. For example, no data collection took place at schools in northern or eastern Germany. Other potential homogeneities within our study sample, such as specific participation motivation or beliefs, could not be accounted for at all.

Therefore, the external validity of our results is restricted and can only be transferred to the general population in a limited way. Furthermore, as a cross-sectional approach, this study represents only a snapshot of the mental situation of adolescents during the SARS-CoV-2-pandemic. Furthermore, the cross-sectional design is a limitation of this study. It stems from the primary focus of the overarching B-Fast study, which was primarily concerned with testing strategies within schools. However, our paper effectively leveraged secondary outcomes from the main study to present a valuable snapshot of the mental well-being of adolescents during the SARS-CoV-2-pandemic.

In our sample social distancing seems to lead to reduced conduct problems or hyperactive behavior at school. This might be in part due to a selection bias in our cohort. The specific distribution of students across school institutions suggests that there is some middle-class bias in our study population. Good parental support and sufficiently large houses with gardens mitigate short-term negative effects of social distancing. In the 2018/2019 Germany-wide quota for the different school types, students of “Gymnasium” make up the largest share on average across Germany, but they only do so between 35% (49) and around 50% including “Fachhochschulreife” (=higher education entrance qualification for universities of applied sciences) (50), which is considerably less than in our study cohort. Certain social disparities are known to exist with regard to school transfer to a secondary school, so that children from financially stronger, more educationally advantaged families have a greater chance of attending “Gymnasium,” i.e., the highest possible educational path, than children from working-class families, even with the same aptitude (51). It can therefore be assumed that our cohort belongs to middle class at an above-average rate and is better off financially, socially and educationally than the average German population.

In terms of geographic distribution, it is striking that 69.9% of the participants were based in Cologne, 28.1% in Munich. Thus, our cohort is also more urban and metropolitan than the German average.

Evidence shows that socioeconomic factors such as lower income (52), migration status (9), or single parent status (53–56) are correlated with higher stressors and correspondingly poorer general mental health during the pandemic. These vulnerable groups were probably very underrepresented in our sample, which may have influenced our results. Therefore, our specific findings concerning Conduct Problems and Prosocial Behavior and those concerning scales with no changes might partly be related to the selection bias comprising the external validity of the study. More specifically, our cohort was less affected by the pandemic situation or it was better protected by resources and protective factors (e.g., financial stability and social support system). However, the deterioration on the subscale Emotional Symptoms is unlikely to be explained by the selection bias. It remains open whether in a representative sample, the deterioration on this subscale would be even stronger or whether this subscale mirrors in particular the problems of adolescents with a higher SES.

Conclusion

This study offers a noteworthy glimpse into the strengths and challenges experienced by adolescents in Germany during the first year of the SARS-CoV-2-pandemic. By delineating distinct problem profiles for boys and girls, we observed a remarkable impact on

emotional symptoms, while hyperactivity, largely determined by genetic factors, showed less susceptibility to the pandemic's effects. In addition, as methodological implications, the study underscores the importance of utilizing both self-reported and external assessments and emphasizes the necessity of employing country-specific cut-off values. Moreover and importantly, it reaffirms the utility of the SDQ as a valuable assessment tool, even within the unique circumstances posed by a pandemic.

Health and practical implications:

- The effort to collect both, external and self-assessed questionnaires, is worthwhile.
- The SDQ provides a comprehensive overview of psychiatric symptoms and effectively captures their changes within the context of the SARS-CoV2-pandemic. Therefore, the SDQ is a valid tool for assessing psychiatric symptoms during a pandemic.
- In our sample we saw a deterioration on the subscale emotional symptoms. The focus of a potential therapy could be directed towards addressing these symptoms. This might include approaches such as psychotherapy, cognitive-behavioral techniques and mindfulness-based interventions, emotion regulation training, and family therapy which have shown promise in targeting these needs. Further, using more specific questionnaires can enhance the assessment of symptoms, enabling clinicians to tailor interventions more effectively and to improve research. Gender specific differences should be considered in psychiatric treatment.

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: stephan.bender@uk-koeln.de.

Author contributions

JL: Writing – original draft, Writing – review & editing, Conceptualization, Formal analysis, Methodology, Supervision. JK: Writing – original draft, Writing – review & editing, Methodology. JD: Writing – review & editing. JF: Writing – review & editing, Data curation, Formal analysis, Methodology. SB: Writing – review & editing, Supervision, Conceptualization, Funding acquisition, Writing – original draft.

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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/fpubh.2024.1357766/full#supplementary-material>

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Determinants of default from completion of child immunization among children aged 15–23 months in Kacha Bira district, Kembata Tembaro zone, South Ethiopia: a case–control study

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Background: Child immunization is crucial to protect children from vaccine-preventable diseases. However, if a child defaults from completing immunization, they are at a greater risk of contracting such diseases. Previous studies have evaluated various factors that contribute to defaulting from immunization, but they did not consider the fear of COVID-19 as a variable. Additionally, there is inconsistency in the factors identified across different areas. This study aimed to examine the determinants of defaulting from child immunization among children aged 15–23 months in Kacha Bira district, Kembata Tembaro zone, South Ethiopia.

Methods: A study was conducted using a community-based unmatched case–control design to identify the determinants of child immunization completion. The study included 255 children aged 15–23 months in the Kacha Bira district from 3 May 2022 to 1 June 2022, using a multi-stage sampling technique. Face-to-face interviews of mothers or immediate caretakers of the child were conducted using a mobile device, and the questionnaire was developed using the Kobo Toolbox. The data collected were analyzed using SPSS version 25. Multivariable logistic regression was used to identify the determinants, and the adjusted odds ratio with 95% CI and a $p < 0.05$ were considered statistical significant.

Results: The multivariable logistic regression analysis identified four independent predictors of immunization defaulting. Antenatal care (ANC) follow-up [AOR = 5.40, 95% CI (2.24–13.52)], postponing vaccination schedule [AOR = 2.28, 95% CI: (1.05–4.93)], parity of the mother [AOR = 3.25, 95% CI: (1.45–7.27)], and knowledge of the mother about vaccination [AOR = 6.77, 95% CI: (2.33–19.64)] were determinants of immunization defaulting.

Conclusion: In this study, lack of ANC follow-up, postponement of the vaccination schedule, mothers with parity of greater than four, and poor knowledge of the mothers about immunization were identified as determinants of immunization defaulting.

KEYWORDS

immunization default, determinants, child immunization, children, South Ethiopia

Background

Immunization is considered one of the most effective and successful public health interventions globally, which helps in reducing childhood morbidity and mortality rates (1). Defaulting on immunization occurs when children miss at least one vaccine dose that is recommended by the National Expanded Immunization Program (EPI) (2). The diphtheria-tetanus-pertussis 3 (DPT3) vaccine is a crucial indicator of immunization completion since it is mainly distributed through horizontal health programs rather than vaccine campaigns (3).

In 2018, ~20 million children worldwide did not receive a complete set of basic vaccines, which include vaccines against tuberculosis (BCG), three doses of the DPT-HepB-Hib vaccine (pentavalent), vaccines against polio, and vaccines against measles (4). In Africa, nearly one in five children miss out on all necessary and basic vaccines (5). In Ethiopia, only 43% of children received all basic vaccinations, and in the Southern Ethiopia region, the percentage is even lower, with only 38% receiving them (6).

The COVID-19 pandemic has had a significant impact on the health system and immunization programs worldwide. As a result, the global coverage of DPT3 vaccines decreased from 86% in 2019 to 83% in 2020. This decrease has led to an increase of 3.4 million completely unvaccinated children, and ~23 million infants did not receive basic vaccines in 2020. This represents the highest number of unvaccinated infants since 2009 (7).

In 1974, the WHO launched the Expanded Program on Immunization (EPI) to ensure the coverage of immunization throughout the world (3). Over the last two decades, vaccine-preventable disease (VPD) surveillance has been conducted in Africa in an integrated manner. All African countries have committed to achieving universal immunization coverage and high-quality surveillance, although this is challenging (5).

In Ethiopia, the Ministry of Health adopted the Expanded Program on Immunization (EPI) in 1980 to reduce morbidity and mortality rates of children with VPDs. Two new approaches, Reaching Every District (RED) and sustainable outreach services (SOS), were introduced in 2003 to enhance immunization coverage and to show progress in the area (8).

Owing to its reliability, cost-effectiveness, and relatively easy administration, EPI is one of the most effective ways to improve health in developing countries. Although there are strategies to overcome the immunization defaulting, it is still a problem. Of the 23 million children who were unvaccinated or under vaccination in 2020, 5.6 million (24%) were defaulters globally. More than 60% of these unvaccinated children are in just 10 countries: India,

Nigeria, Congo (DRC), Pakistan, Indonesia, Ethiopia, Brazil, the Philippines, Angola, and Mexico (9).

According to the 2019 mini Ethiopian Demographic and Health Survey (EDHS) data, 76% of children received the first dose of diphtheria, tetanus, and pertussis (DPT) vaccine. However, only 61% of children received all three recommended doses of DPT. This indicates that the magnitude of the immunization default was 15%. Among children aged 12–23 months, the percentage of children who received the first dose of DPT was 72.7%, while only 50.8% received the third dose of DPT, which indicates that the prevalence of immunization defaulting was 21.9% (10).

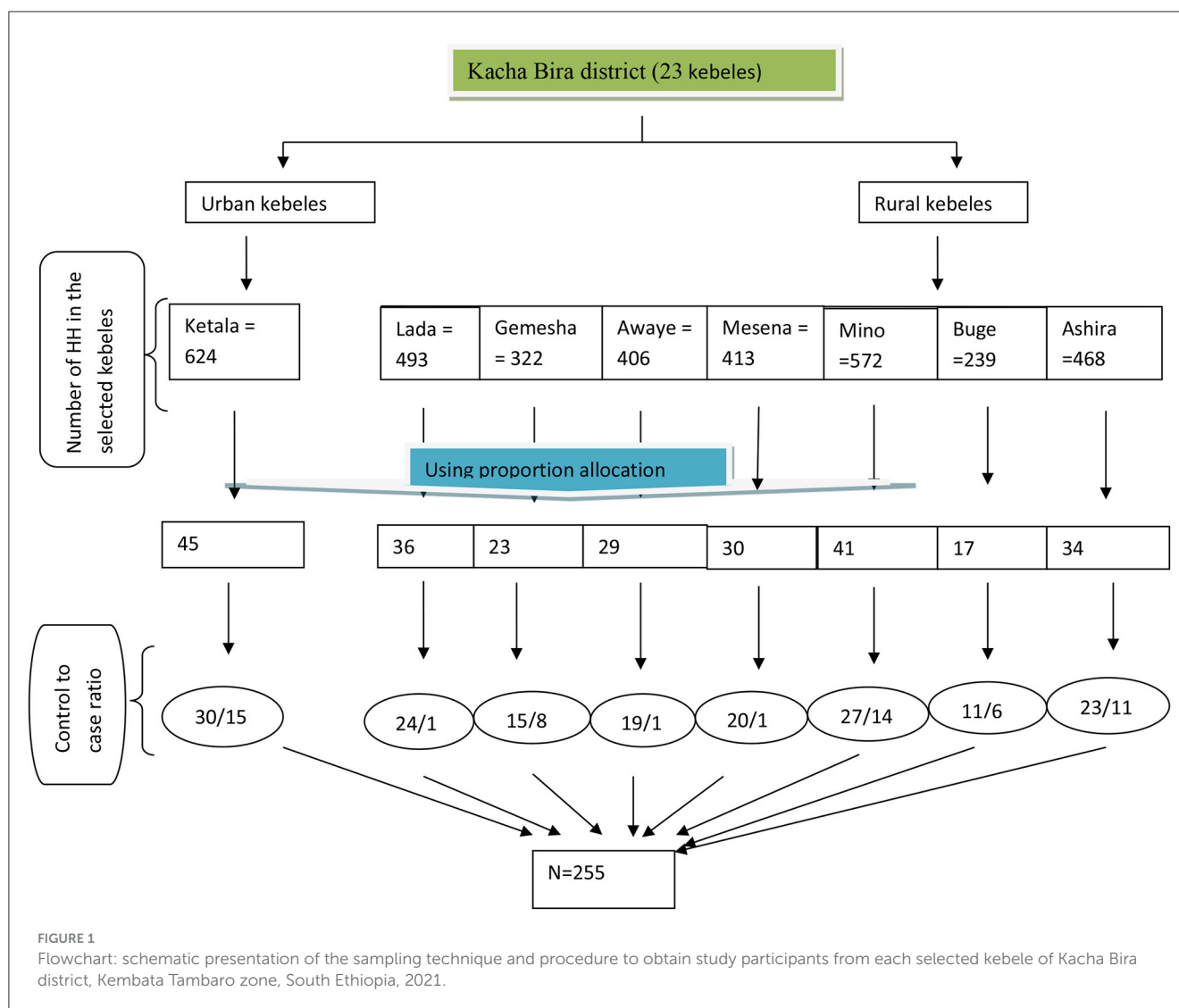
Defaulting from immunization puts a child at a greater risk of contracting vaccine-preventable diseases (11). Every year, an estimated 2.5 million children under the age of 5 years die due to VPDs worldwide (12). Globally, in 2015, more than 90 million children under the age of 5 years suffered from vaccine-preventable diseases (13). In 2017, more than 17 million cases and 83,439 deaths due to defaulting from immunization were reported worldwide (14). In Africa, over 30 million children under the age of 5 years suffer from VPDs every year because of immunization defaulting, accounting for 33% of the VPD incidence among under-fives worldwide. Recurrent outbreaks of VPD have persisted in many African countries. VPD-related outbreaks tend to occur in areas where low immunization coverage rates are low (5).

When the EPI program was introduced in Ethiopia in 1980, it aimed to fully vaccinate 100% of children less than the age of 2 years by 1990. The target coverage was reset to 75% and the target age group was changed to <12 months in 1986. However, the program was not successful according to the plan (15, 16).

Previous studies in Ethiopia have identified several factors related to immunization defaulting, including monthly income, number of under-five children, maternal age, parents' educational status, mothers'/caretakers' knowledge about vaccination, and maternal healthcare utilization (17–19).

Previous studies conducted in the Northern region of Ethiopia have shown that certain sociodemographic and economic characteristics, along with maternal knowledge on immunization, place of delivery, and ANC follow-up, can affect the completion of child immunization. However, these studies were carried out in areas where traditional birth attendants were not common, and they were conducted before the COVID-19 pandemic (20, 21).

In the Kacha Bira district, the coverage of the Expanded Program on Immunization (EPI) decreased by 20% in 2019 and 2020. Traditional birth attendants were prevalent in this area, and health facilities were situated at a distance from residential areas. Moreover, there had been no recently published independent



research on child immunization in the Southern Ethiopia region. Hence, this study aimed to identify the determinants of defaulting from completion of childhood immunization among children aged 15–23 months in the Kacha Bira district, Southern Ethiopia.

Materials and methods

Study design

We employed a community-based unmatched case–control study design.

Study setting

The study was carried out in the Kacha Bira district, which is situated in the Kembata Tembaro zone in Southern Ethiopia. The district is located 137 km west of Hawassa, the capital of the Southern Nations, Nationalities, and People's Region (SNNPR) and the Sidama Region, and 297 km south of Addis Ababa, the capital

of Ethiopia. The district comprises 23 kebeles, with 2 being urban and the remaining 21 rural. According to the Kacha Bira Woreda Health Bureau 2020/21 Report, the estimated total population of the district was 164,382, out of which 21,657 were children under the age of 5 years, and 4,128 were aged between 15 and 23 months. The district has 23 health posts, 6 health centers, and 1 primary hospital, all of which offer immunization services on a routine basis. The study was conducted between 3 May 2022 and 1 June 2022.

Participants

The source population of the study consisted of all children aged 15–23 months in households located in the Kacha Bira district of the Kembata Tembaro zone in South Ethiopia. The study population, on the other hand, consisted of selected children aged 15–23 months residing in in households located in the chosen kebeles of the Kacha Bira district in the Kembata Tembaro zone. For the purpose of this study, cases were defined as children who had missed at least one recommended immunization dose,

while controls were defined as children who had received all recommended immunization doses (20).

Eligibility criteria

Inclusion criteria

Case: All children aged 15–23 months who have received at least one vaccination are included.

Control: All children aged 15–23 months who have received all the recommended vaccinations are included.

Exclusion criteria

Children whose parents were too severely ill to respond or who had no full information on the vaccination status of their children were excluded from both cases and controls.

Sample size determination

We calculated the required sample size using Epi Info software version 7.2.4, with the following parameters: 95% significance, power of 80%, and adjusted odds ratio of 2.33. The case-to-control ratio was 1:2, and the proportion of controls exposed was 48.3%. The odds ratio was taken from a study conducted in the Sodo and Hawasa Zuria districts of Southern Ethiopia (38), taking the mother's educational status as a determinant of default from immunization, resulting in a maximum sample size of 255 (85 cases and 170 controls).

Sampling procedure and technique

A multi-stage and stratified sampling technique was used to select participants for the study. First, the participants were divided into urban and rural groups. Then, eight kebeles (one urban and seven rural) were chosen using a lottery method from a total of 23 kebeles in the district (two urban and 21 rural). In each selected kebele, a list of cases and controls, along with their complete addresses, were obtained from the health post-EPI registration book. A sampling frame was then prepared from this list. A total sample size of 255 participants (85 cases and 170 controls) was allocated proportionally to each selected kebele. Households with eligible children were chosen through simple random sampling. In households with twins, one child was randomly selected. Tracers were used to locate the selected households. Sampling procedures was shown on Figure 1.

Variables

Dependent variable

- Default from completion of immunization (yes/no).

Independent variables

- **Sociodemographic characteristics:** place of residence, family size, average family income, maternal employment, maternal age, mother's education, and father's education.
- **Maternal characteristics:** mother's knowledge, PNC follow-up, ANC follow-up, parity, and tetanus toxoid (TT) vaccination.
- **Child characteristics:** sex, birth order, place of birth, and age of the child.
- **Health facility-related characteristics:** distance from the health facility, postponing vaccination schedule, waiting time spent in the health facility, and fear of COVID-19 to attend health facilities.

Operational definitions (work definition)

Defaulting from completion of immunization: A child aged between 15 and 23 months who had missed at least one dose of the recommended routine vaccination schedule at the time of data collection (20).

Completion of immunization: A child between 15 and 23 months of age who had received all recommended routine vaccinations at the time of data collection (20).

Knowledge of mothers about immunization: Mothers' awareness of the schedule and importance of immunization. This was assessed using eight immunization-related yes/no knowledge questions. The mothers who answered four or more questions were considered to have good knowledge and those below were considered to have poor knowledge (22).

Immunization status: Being fully/partially vaccinated or unvaccinated (22).

Measurement

An electronic data collection system using Kobo Collect version 2021.2.4 software was utilized to collect data. The questionnaire was developed by reviewing relevant literature. To ensure the completeness of data, face-to-face interviews were conducted with the mother or the immediate caretaker of the child. Additionally, the immunization certificate was obtained, if available. The vaccination status was determined by obtaining vaccination cards, vaccination history, or both from the mother or the caretaker.

The study participants were assigned identification numbers, which were used to distinguish between cases and controls. The identification number of the supervisor was used to determine whether a participant was a case or a control before data collection. To ensure unbiased data collection, the data collectors were intentionally kept blind to the status of the respondents, preventing them from identifying the participants as cases or controls.

Data quality management

The survey was first prepared in English and later translated into Amharic. To ensure consistency, the Amharic version of the questionnaire was then translated back into English. The data were

collected by two nurses and one supervisor, all of whom received 2 days of training from the principal investigator. The data collectors were nurses with diplomas, while the supervisor held a BSc in Nursing. Before the actual data collection began, a pre-test was conducted on 5% of the sample, consisting of 13 participants (eight controls and five cases) outside the study area. Throughout the data collection process, the supervisor checked for completeness and consistency of the collected data.

Statistical method

The data were collected, entered into the electronic system, and then downloaded and exported to SPSS version 25 for statistical analysis. Before the analysis, the data were arranged, edited, and cleaned by running simple frequencies and cross-tabulations. Distributional plots, tests, and categorization of quantitative variables were performed. The distribution of the continuous variables was checked for normality. Means with standard deviations and medians with interquartile ranges were used to summarize the normally and non-normally distributed continuous variables, respectively. The bivariate logistic regression analysis was used to determine the association between the explanatory and outcome variables. This was followed by a multivariable logistic regression analysis using those variables with a *p*-value of 0.2 or less in the bivariable analysis. The goodness of fit of the statistical model was checked using the Hosmer–Lemeshow test. Multicollinearity was assessed using a tolerance test and a variance inflation factor. Odds ratios (ORs) with 95% confidence intervals were used to measure the strength between dependent and independent variables. Statistical significance was set at a level of 0.05.

Results

Sociodemographic characteristics of the respondents

Out of 255 children aged between 15 and 23 months, 249 caretakers, including 83 cases and 166 controls, were interviewed. The response rate for this study was 97.6%. Most primary caretakers for both cases (69, 83.1%) and controls (150, 90.4%) were mothers. The educational background of care givers evaluated. Then, 39 (47%) of mothers among and 65 (39.6%) among controls group attended primary school (grade 1 to 8) while 18 (21.7%) of mothers among cases and 39 (23.8%) among controls completed secondary education (grade 9 to 12). Sociodemographic characteristics are shown in [Table 1](#).

Maternal and child-related characteristics

The average age of the children was 19.1 months, with a standard deviation of 2.47. Most cases (85.5%) and controls (97.6%) were born in a health institution. During data collection, 64 (77.1%) cases and 148 (89.2%) controls had vaccination cards. Among respondents, 53 (63.9%) cases and 149 (89.8%) controls

TABLE 1 Socio demographic characteristics of the respondents at Kacha Birra district, kembata Tembaro zone, south Ethiopia, 2022.

Variables	Category	Immunization default	
		Cases [No. (%)]	Controls [No. (%)]
Primary care takers	Mother	69 (83.1)	150 (90.4)
	Father	9 (10.8)	10 (6.0)
	Others	5 (6.1)	6 (3.6)
Maternal age	≤24 years	15 (18.3)	27 (17.0)
	25–34 years	50 (61.0)	89 (56.0)
	≥35 years	17 (20.7)	43 (27.0)
Father's age	≤24 years	6 (7.9)	20 (12.6)
	25–34 years	19 (25.0)	46 (28.9)
	≥35 years	51 (67.1)	93 (58.5)
Marital status	Married	67 (80.7)	143 (86.1)
	Divorced	5 (6.1)	9 (5.4)
	Widowed	4 (4.8)	6 (3.6)
	Single	7 (8.4)	8 (4.9)
Religion	Orthodox	12 (14.7)	30 (18.1)
	Protestant	60 (72.3)	117 (70.5)
	Catholic	9 (10.8)	15 (9.0)
	Muslim	1 (1.2)	3 (1.8)
	Others	1 (1.2)	1 (0.6)
Family size	≤5	37 (44.6)	75 (45.2)
	>5	46 (55.4)	91 (54.8)
Monthly income	≤1,000 ETB	13 (15.7)	30 (18.1)
	1,001–3,000 ETB	42 (50.6)	78 (47.0)
	>3,000 ETB	28 (33.7)	58 (34.9)
Place of residence	Rural	69 (83.1)	137 (82.5)
	Urban	14 (16.9)	29 (17.5)
Mother's educational status	Illiterate	17 (20.5)	24 (14.6)
	Primary school (1–8)	39 (47.0)	65 (39.6)
	Secondary school (9–12)	18 (21.7)	39 (23.8)
	College and above	9 (10.8)	36 (22.0)
Mother's occupation	Housewife	54 (65.1)	95 (58.3)
	Government employee	8 (9.6)	29 (17.8)
	Merchant	17 (20.5)	28 (17.2)
	Other	4 (4.8)	11 (6.7)
Father's educational status	Illiterate	8 (9.6)	18 (10.8)
	Primary school	15 (18.1)	35 (21.1)
	Secondary school	31 (37.3)	64 (38.6)

(Continued)

TABLE 1 (Continued)

Variables	Category	Immunization default	
		Cases [No. (%)]	Controls [No. (%)]
	College and above	19 (22.9)	44 (26.5)
Father's occupational status	Government employee	17 (20.5)	38 (22.9)
	Merchant	18 (21.7)	58 (34.9)
	Farmer	35 (42.2)	60 (36.1)
	Other	2 (2.4)	2 (1.2)

reported having regular antenatal care (ANC) follow-ups and receiving tetanus toxoid (TT) vaccination during their follow-ups. Furthermore, 49 (66%) mothers categorized as cases and 126 (80.8%) categorized as controls reported having a parity of less than four. Maternal and child-related factors are listed in [Table 2](#).

Knowledge of mothers regarding immunization

Mothers' knowledge was assessed using eight immune-related questions. Accordingly, mothers who answered four or more questions were assigned as having good knowledge, while those who answered less than four questions were assigned as having poor knowledge about immunization. Accordingly, 53 (63.9%) respondents categorized as cases and 157 (94.6%) respondents categorized as controls had good knowledge about immunization.

Health facility and COVID-19-related characteristics

As reported by 64 (77.1%) cases and 151 (91%) controls, health facilities were found to be less than an hour's commute from their homes for vaccination services. The fear of COVID-19 to attend health facilities for vaccination was reported by most caretakers in 77(92.8%) cases and 153 (92.2%) controls, respectively. The health facility and COVID-19-related characteristics are shown in [Table 3](#).

Determinants of default from completion of child immunization

According to the results of the multivariable logistic regression analysis, several factors were found to be significantly associated with default from completion of child immunization. These factors include postponing the vaccine schedule, poor knowledge of mothers or caretakers about vaccination, parity greater than four, and no ANC follow-up. These findings were obtained after adjusting for all other variables.

The odds of immunization default were five times higher among children born to mothers who had no ANC follow-up compared to those born to mothers who had ANC follow-up

TABLE 2 Maternal and child related characteristics of the respondents at Kacha Birra district, kembata Tembaro zone, south Ethiopia, 2022.

Variables	Category	Immunization default	
		Cases [No. (%)]	Controls [No. (%)]
Sex of the child	Male	39 (47.0)	85 (51.2)
	Female	44 (53.0)	81 (48.8)
Place of birth	Home	12 (14.5)	4 (2.4)
	Health institution	71 (85.5)	162 (97.6)
Age of the child	15–17 months	27 (32.5)	47 (28.3)
	18–20 months	30 (36.1)	65 (39.2)
	21–23 months	26 (31.3)	54 (32.5)
Birth order of the child	1st–3rd	48 (57.8)	102 (61.4)
	4 th and above	35 (42.2)	64 (38.6)
Availability of vaccination card	Yes	64 (77.1)	148 (89.2)
	No	19 (22.9)	18 (10.8)
ANC follow up	Yes	53 (63.9)	149 (89.8)
	No	30 (36.1)	17 (10.2)
Number of ANC visits	≤2 visits	12 (22.6)	39 (26.2)
	>2 visits	41 (77.4)	110 (73.8)
TT immunization	Yes	50 (60.2)	132 (79.5)
	No	33 (39.8)	34 (20.5)
PNC follow up	Yes	33 (39.8)	118 (71.1)
	No	50 (60.2)	48 (28.9)
Parity	≤4	49 (66.2)	126 (80.8)
	>4	25 (33.8)	30 (19.2)

[AOR = 5.40, 95% CI (2.24–13.52)]. The odds of immunization default were twice as high among children born to mothers who postponed vaccination schedules as those born to mothers who non-postponed vaccination schedules [AOR = 2.28, 95% CI: (1.05–4.93)].

The odds of immunization default among children born to mothers with a parity greater than four were three times higher compared to those born to mothers with a parity less than or equal to four [AOR = 3.25, 95% CI: (1.45–7.27)].

The odds of immunization default were 6.7 times higher among children born to mothers with poor knowledge of immunization compared to those born to mothers with good knowledge about immunization [AOR = 6.77, 95% CI: (2.33–19.64)]. The results of the multivariate analysis are presented in [Table 4](#).

Discussion

This study assessed the determinants of defaulting from completion of immunization among children aged 15–23

TABLE 3 Health facility and COVID-19 related characteristics of the respondents at Kacha Birra district, kembata Tembaro zone, south Ethiopia, 2022.

Variables	Category	Immunization default	
		Cases [No. (%)]	Controls [No. (%)]
Presence of nearby health facility	Yes	64 (77.1)	151 (91.0)
	No	19 (22.9)	15 (9.0)
Type of nearby health facility	Hospital	13 (15.7)	28 (16.9)
	Health center	9 (10.8)	19 (11.4)
	Health post	42 (50.6)	104 (62.7)
Distance to health facility (in walk time)	≤15 min	14 (16.9)	59 (35.5)
	15–30 min	29 (34.9)	66 (39.8)
	30–60 min	19 (22.9)	28 (16.9)
	>60 min	21 (25.3)	13 (7.8)
Postponing vaccine schedule	Yes	37 (44.6)	29 (17.5)
	No	46 (55.4)	137 (82.5)
Waiting time spent in the health facility	≤1 h	28 (33.7)	95 (57.2)
	1–2 h	41 (49.4)	48 (28.9)
	2–3 h	11 (13.3)	17 (10.2)
	>3 h	3 (3.6)	6 (3.6)
Ever tested for COVID-19	Yes	16 (19.3)	32 (19.3)
	No	67 (80.7)	134 (80.7)
Result of COVID-19 test	Positive	2 (12.5)	6 (18.8)
	Negative	14 (87.5)	26 (81.3)
Fear of COVID-19 to attend health facility	Yes	6 (7.2)	13 (7.8)
	No	77 (92.8)	153 (92.2)

months living in the Kacha Bira district of South Ethiopia. The study found that the absence of antenatal care follow-up, postponement of the vaccination schedule, having more than four children, and poor knowledge of mothers about immunization were the main reasons for defaulting from completion of immunization among children aged 15–23 months.

Failure to receive ANC follow-up was a determinant of default from completion of child immunization. The odds of defaulting from completion of immunization among children born to mothers who had no ANC follow-up was five times higher compared to those born to mothers who had ANC follow-up. This is in line with the studies conducted in Ethiopia, Senegal, Nigeria, and the Wonago district of South Ethiopia (21, 23–25). This finding was not surprising, given that attending antenatal care

during pregnancy creates opportunities for pregnant mothers to obtain adequate information on immunization and vaccine-preventable diseases.

Our findings also showed that postponing the vaccination schedule was a factor that determined defaulting from immunization. This finding was similar to those studies conducted in Malaysia, Gambella district in Southwest Ethiopia, and Arbegona district in South Ethiopia (26–28). A possible reason could be related to the accessibility of health facilities, vaccine stock-outs in the facility, forgetting the schedule of immunization, and long waiting times in the facility. This is because, in developing countries such as Ethiopia, accessibility of health facilities and vaccines is very challenging, especially in rural areas. In addition, caretakers/mothers often forget their appointments for vaccination.

The findings of this study also revealed that the parity of the mother is a determinant of immunization defaulting. The odds of defaulting from immunization for mothers with parity greater than four were three times higher compared to others. This finding is supported by the studies conducted in Bangladesh, Kenya, and the Ginir district of southeastern Ethiopia (17, 29–31). This might be because having more children may lead to resource constraints, and as the number of children is higher, the cost and demand for resources become higher, which has a negative impact on healthcare utilization.

Maternal knowledge about immunization was another factor that determined defaulting from immunization. The odds of defaulting from completion of immunization were seven times higher for mothers (caretakers) who had poor knowledge of immunization compared to those with good knowledge about immunization. This finding can be explained by the fact that mothers who have good knowledge about immunization may have better attitudes about the benefit of child immunization than mothers who have poor knowledge. The finding was consistent with the study conducted here in Ethiopia (20), Nepal, Nigeria, and Southwest Ethiopia (19, 20, 32, 33). A possible explanation for this could be that mothers (caretakers) who had good knowledge of immunization were encouraged more to immunize their children regularly than mothers (caretakers) who had poor knowledge of immunization.

Limitation

Recall bias may occur if mothers forget details about their children's vaccinations, including the number of vaccine doses received and other related information.

Conclusion and recommendation

This study aimed at identifying the factors that contribute to the failure of completing immunization among children aged 15–23 months. The study found that a lack of antenatal care follow-up, postponing vaccination schedule, mothers with more than four children, and inadequate knowledge of

TABLE 4 Multivariable analysis of determinants of default from completion of childhood immunization among children 15–23 months old, Kacha Birra District, Kembata Tembaro zone, south Ethiopia, June 2022.

Variables	Category	Immunization default		COR, 95%CI	AOR, 95%CI	P-value
		Cases [No. (%)]	Controls [No. (%)]			
Place of birth	Health institution	71 (85.5)	162 (97.6)	1	1	
	Home	12 (14.5)	4 (2.4)	6.85 (2.13–21.9)	2.56 (0.48–14.0)	0.270
Availability of vaccination card	Yes	64 (77.1)	148 (89.2)	1	1	
	No	19 (22.9)	18 (10.8)	2.44 (1.20–4.96)	1.60 (0.63–4.10)	0.321
ANC follow up	Yes	53 (63.9)	149 (89.8)	1	1	
	No	30 (36.1)	17 (10.2)	4.96 (2.53–9.72)	5.40 (2.24–13.5)	<0.001
Received TT vaccine	Yes	50 (60.2)	132 (79.5)	1	1	
	No	33 (39.8)	34 (20.5)	2.56 (1.44–4.57)	1.19 (0.53–2.70)	0.673
PNC follow up	Yes	33 (39.8)	118 (71.1)	1	1	
	No	50 (60.2)	48 (28.9)	1.93 (1.13–3.29)	0.91 (0.43–1.94)	0.805
Presence of nearby health facility	Yes	64 (77.1)	151 (91.0)	1	1	
	No	19 (22.9)	15 (9.0)	2.99 (1.43–6.25)	0.63 (0.17–2.33)	0.482
Distance to health facility (in walk time)	≤15 min	14 (16.9)	59 (35.5)	1	1	
	15–30 min	29 (34.9)	66 (39.8)	1.85 (0.89–3.83)	1.5 (0.59–3.73)	0.393
	30–60 min	19 (22.9)	28 (16.9)	2.86 (1.25–6.50)	0.89 (0.28–2.79)	0.846
	>60 min	21 (25.3)	13 (7.8)	6.80 (2.76–16.8)	4.22 (0.96–18.5)	0.057
Postponing vaccine schedule	Yes	37 (44.6)	29 (17.5)	3.80 (2.11–6.85)	2.28 (1.05–4.93)	0.037
	No	46 (55.4)	137 (82.5)	1	1	
Waiting time spent in the health facility	≤1 h	28 (33.7)	95 (57.2)	1	1	
	1–2 h	41 (49.4)	48 (28.9)	2.89 (1.60–5.24)	1.75 (0.77–3.95)	0.178
	2–3 h	11 (13.3)	17 (10.2)	2.19 (0.92–5.23)	1.15 (0.37–3.59)	0.806
	>3 h	3 (3.6)	6 (3.6)	1.69 (0.39–7.22)	1.32 (0.19–9.06)	0.780
Parity	≤4	49 (66.2)	126 (80.8)	1	1	
	>4	25 (33.8)	30 (19.2)	2.14 (1.15–4.0)	3.25 (1.45–7.27)	0.004
Knowledge of mothers	Poor	30 (36.1)	9 (5.4)	9.87 (4.40–22.14)	6.77 (2.33–19.6)	<0.001
	Good	53 (63.9)	157 (94.6)	1	1	

The bold values shows significantly associated variables.

mothers about immunization were significant determinants of defaulting from completing immunization among children aged 15–23 months.

Based on the findings of this study, we offer the following recommendations:

- ✓ Health providers should motivate and counsel mothers to attend ANC at health facilities.
- ✓ Healthcare workers and health administering bodies should work together to avoid the problems that cause postponing vaccination schedules.

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 study was reviewed and approved by the Institutional Review Board of Wolaita Sodo University at the College of

Health Sciences and Medicine (CHSM/ERC/01/14). Besides, written informed consent for participation was obtained for all study participants.

Author contributions

SM: Conceptualization, Formal analysis, Project administration, Visualization, Writing—original draft. EW: Data curation, Methodology, Supervision, Validation, Visualization, Writing—review & editing. SK: Data curation, Methodology, Supervision, Validation, Visualization, Writing—review & editing. MU: Software, Writing—review & editing. SH: Software, Writing—review & editing. DL: Software, Writing—review & editing. EA: Writing—original draft, Writing—review & editing, Methodology, Validation, Software. EB: Formal analysis, Methodology, Software, Visualization, Writing—review & editing.

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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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Mental health symptoms and associated factors among primary healthcare workers in China during the post-pandemic era

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Background: The impact of the COVID-19 pandemic on mental health among healthcare workers has been widely reported during the initial and ongoing phases of the COVID-19 pandemic. Yet, little remains known about the mental health status of primary healthcare workers in China during the post-pandemic era.

Methods: A cross-sectional study was conducted between March 1, 2023, and May 31, 2023 in Anhui China. A total of 13,530 primary healthcare workers were recruited. Multiple logistic regression was used to identify potential factors associated with the incidence of depression and anxiety among primary healthcare workers.

Results: The prevalence of depression and anxiety among primary healthcare workers was 50.7 and 26.4%, respectively. Multiple logistic regression revealed that female gender (OR = 1.345, 95%CI = 1.222–1.479), being divorced or widowed (OR = 1.432, 95%CI = 1.128–1.817), being a nurse (OR = 1.250, 95%CI = 1.126–1.388), and working more than 8 h per day (OR = 1.710, 95%CI = 1.583–1.846) were significantly associated with depression. A higher risk of anxiety among primary healthcare workers was associated with female gender (OR = 1.338, 95%CI = 1.198–1.494), being divorced or widowed (OR = 1.373, 95%CI = 1.056–1.770), being a nurse (OR = 1.139, 95%CI = 1.013–1.282), and working more than 8 h per day (OR = 1.638, 95%CI = 1.497–1.794). Better monthly income, more than 21 years of working experience and without experience of workplace violence were protective factors against depression and anxiety during the post-pandemic era.

Conclusion: Depressive symptoms are more common among primary healthcare workers in China during the post-pandemic era. Female gender, being divorced or widowed, being a nurse, working years, working seniority, monthly income, and experience of workplace violence were identified as associated factors. Targeted intervention is needed when developing strategies to reduce depression and improve primary healthcare workers' wellness and mental health.

KEYWORDS

primary healthcare workers, mental health, associated factors, the post-pandemic era, China

Introduction

The COVID-19 pandemic has created a significant global challenge, and the impact of the pandemic on public health has been widely reported (1–6). Many individuals are experiencing increased levels of depression, anxiety, stress, insomnia, post-traumatic stress, fear, and burnout during the initial and ongoing phases of the COVID-19 pandemic (7–13). Previous studies on this topic focused on the acute effects of the COVID-19 pandemic on psychological symptoms among the general population (anxiety: 25.6%, depression: 23.1%) (14) and healthcare workers (anxiety: 36.2%, depression: 50.4%) (15) in different countries. A large-scale study revealed that during the first wave of the COVID-19 pandemic, 33.0 and 46.6% of the general public living in Wuhan China (the city experiencing the most severe COVID-19 outbreak), experienced anxiety and depressive symptoms (16). A systematic review and meta-analysis to estimate the prevalence of depression and anxiety related to COVID-19 among affected general populations were 15.97 and 15.15%, respectively (17), while a meta-analysis included 401 studies, representing 458,754 healthcare workers across 58 countries suggested that the prevalence of depression was 28.5%, anxiety was 28.7%, and insomnia was 24.4% (18). It can be seen that the epidemic has had a huge impact on the whole population, especially healthcare workers (13, 19).

Mental health symptoms of healthcare workers have become a significant public problem in the healthcare system during the COVID-19 pandemic (20–22). Healthcare workers have concerns about the risk of COVID-19, inadequate personal protective equipment, excessive workload, workplace violence, and many more easily experience mental health disturbances (23). Depression, particularly anxiety, increased in healthcare workers from the beginning to the COVID-19 pandemic peak (24). Martín-del-Campo F et al. found that the severity of anxiety increased immediately after the onset of the COVID-19 pandemic, and then decreased over time (25), while posttraumatic stress symptoms of healthcare workers increased over time during the COVID-19 pandemic (20). Depressive symptoms may persist well after the pandemic, and such problems are often precursors of psychiatric disorders. Healthcare workers who develop depressive disorder during COVID-19 may be at greater risk for long-term adverse outcomes. Therefore, it is important to investigate the impact of the long-term effects of the COVID-19 pandemic on the mental health status of healthcare workers.

In China, primary healthcare workers play a vital role as the “first line of defense” in protecting public life and health. They have to deal with pre-screening, referrals, public awareness of the epidemic, and also ensure that basic health services are available for other diseases. The physical and psychological burden on primary healthcare workers has significantly increased (26, 27). In addition to the unreasonable allocation of medical resources, primary healthcare workers have faced increased workplace violence during the COVID-19 pandemic (28, 29). To the best of our knowledge, most existing studies have focused on frontline healthcare workers in COVID-19 designated hospitals (30, 31), while overlooking primary health workers involved in epidemic prevention and control in primary hospitals. We have very limited information regarding the changes in the psychological well-being of these primary health workers after China lifted its social blockade and epidemic control measures on January 8, 2023. Moreover, psychiatric symptoms among healthcare workers can persist long after a pandemic, often serving as a precursor to mental

illness and potentially leading to long-term adverse outcomes. Paying attention to the mental health status of primary health workers in the post-pandemic era is important for implementing targeted intervention measures. Therefore, it is of great significance to investigate the mental health status in the post-pandemic era.

Methods

Study design, setting, and participants

To investigate depression and anxiety among primary healthcare workers and identify associated factors during the post-pandemic era, an online survey was conducted among primary healthcare workers working in Anhui China. This cross-sectional study utilized the random whole cluster sampling method and was active between March 1, 2023, and May 31, 2023. This timeframe coincided with the lifting of societal lockdown in China. There are 138 county hospitals in 59 counties of Anhui Province. Firstly, 25 counties were randomly selected from the 59 counties of Anhui Province, and then one county hospital was randomly selected from each of the 25 counties to participate in the survey. The study targeted the 25 county hospitals in Anhui Province, and primary healthcare workers from these hospitals were invited to participate in the survey. Finally, the study targeted the 25 county hospitals in Anhui Province, and primary healthcare workers from these hospitals were invited to participate in the survey. All participants read and agreed to the informed consent form before the survey, which stated the importance, objectives, voluntariness, and confidentiality principles of the survey. Before volunteers filled out the online questionnaires via mobile phone or computer, they were informed that they had the right to withdraw at any time. To achieve the most honest answers, three pairs of the same questions were set in the questionnaire. Questionnaires with inconsistent responses were excluded, as well as questionnaires with a response time of less than 45 s and questionnaires with missing questions. Finally, a total of 12,764 primary healthcare workers ($n = 13,530$) were included in the statistical analyses, and the valid response rate was 94.3%.

In this cross-sectional study, socio-demographic characteristics (gender, age, educational level, marital status), work-related variables (technical post title, profession, monthly income, work seniority, daily work hours, experience of workplace violence), and mental health variables (depression and anxiety) were collected using this online questionnaire. The Patient Health Questionnaire (PHQ-9) was used to investigate the depressive symptoms of primary healthcare workers, and the 7-item Generalized Anxiety Disorder Scale (GAD-7) was used to investigate their anxiety. The research protocol was approved by the Ethics Committee of Chaohu Hospital of Anhui Medical University.

Questionnaire

Anxiety symptoms were measured using clinically validated scales for GAD-7, which evaluate the frequency of anxiety symptoms over the past 2 weeks (32, 33). The total score ranges from 0 to 21, with a high score indicating a greater severity of anxiety. The presence of anxiety was defined as a GAD-7 score ≥ 5 , with scores of 5–9 indicating mild anxiety symptoms, scores of 10–14 indicating moderate anxiety symptoms, and scores of ≥ 15 indicating severe

anxiety symptoms. The Chinese GAD-7 scale has been widely used in previous studies. The Cronbach's α coefficient for this study was 0.942.

PHQ-9, which provides a reliable and valid measure for depressive symptoms over the past 2 weeks, has been used in different settings (27, 34, 35). It consists of 9 items, and each item is answered on a 4-point Likert-type scale, with scores ranging from 0 ("never") to 3 ("nearly every day"). The PHQ-9 total score ranges from 0 to 27, and a higher total score indicates greater severity of depression. A total score of ≥ 5 represents the presence of depressive symptoms, with scores of 5–9 indicating mild depression, scores of 10–14 indicating moderate depression, scores of 15–20 indicating moderate to severe depression, and scores of ≥ 20 indicating severe depression. The Cronbach's alpha of the PHQ-9 in our study was 0.909, which demonstrates good reliability.

Statistical analysis

Statistical analysis was performed with IBM SPSS Statistics version 25.0. The sample distribution was conducted using frequency for categorical variables and mean \pm standard deviation for continuous variables. For the statistical analysis, the Chi-square test was utilized to assess variables that were not in a normal distribution. The independent correlates of depression and anxiety were examined through multiple logistic regressions, with the symptoms of depression or anxiety as the dependent variables (yes, no). Gender (male and female), educational level (associate degree, bachelor degree, and master degree or more), marital status (single, married, and divorced/widowed), technical post title (junior title, intermediate grade, and senior title), profession (doctor, nurse, and medical technicians), income ($\leq 3,000$ RMB, 3001–8,000 RMB, $\geq 8,001$ RMB), work seniority (≤ 10 years, 11–20 years, ≥ 21 years), daily work hours (≤ 8 h, > 8 h), and experience of workplace violence (yes, no) were entered as the independent variables. The level of statistical significance was set at p -values of 0.05 (two-tailed).

Results

Socio-demographic characteristics of primary healthcare workers in China

The socio-demographic characteristics of Chinese primary healthcare workers were shown in Table 1. The mean age of participants was 37.2 years old. 8,829 participants (69.2%) were female, 6,029 (47.2%) were under the age of 34, and 10,217 (80.0%) were married. 7,530 (59.0%) participants had a bachelor degree or more, 6,952 (54.5%) had a junior title, 4,072 participants (31.9%) were doctors, 5,717 (44.8%) were nurses, and 2,975 (23.3%) were medical technicians. Additionally, 8,245 participants (64.6%) reported working more than 8 h per day. Of all the participants, 8,442 (66.1%) had no experience of workplace violence.

6,466 primary healthcare workers (50.7%) were classified as having depressive symptoms (a score of PHQ-9 ≥ 5), and 3,367 primary healthcare workers (26.4%) were classified as having anxiety symptoms (a score of GAD-7 ≥ 5). Significant differences were found between primary healthcare workers with and without depression and

anxiety symptoms in relation to the demographic variables as shown in Table 1.

Prevalence of depression and anxiety among primary healthcare workers

More than two-thirds (72.2%) of primary healthcare workers with depression were female, and 73.3% of primary healthcare workers with anxiety were female. The prevalence of depression in primary healthcare workers was 50.7%, and there was a significant gender difference (45.6% in males and 52.9% in females, $p < 0.001$). The prevalence of anxiety in primary healthcare workers was 26.4%, and there was a significant gender difference (22.8% in males and 28.0% in females, $p < 0.001$). Compared to those with bachelor degree or more (depression: bachelor degree 52.3%, master degree or more 51.4%; anxiety: bachelor degree 28.2%, master degree or more 28.2%), those with an associate degree (depression: 48.3%; anxiety: 23.7%) had significantly lower rates of depression and anxiety (both $p < 0.001$). The incidence of depression in primary healthcare workers who were divorced/widowed was higher than those who were married or single ($p < 0.01$). The incidence of anxiety in primary healthcare workers who were married was lower than those who were divorced/widowed or single (both $p < 0.05$). Compared to primary healthcare workers who were more than 45 years old (depression: 47.1%; anxiety: 21.7%), those who were less than 45 years old had a significantly higher incidence of depression and anxiety (both $p < 0.001$).

Compared to doctors and medical technicians (depression: doctor 48.1%, medical technicians 46.7%; anxiety: doctor 25.3%, medical technicians 22.7%), there was a significantly higher incidence of depression and anxiety in nurses (depression: 54.5%, anxiety: 29.1%, both $p < 0.001$). The prevalence of depression and anxiety in primary healthcare workers who work over 8 h per day was higher than those who work less than 8 h per day (depression: 55.5% vs. 41.9%; anxiety: 29.9% vs. 20.0%, all $p < 0.001$). The prevalence of depression among primary healthcare workers with low and medium ($\leq 8,000$ RMB) income was higher than those with high income ($\geq 8,001$ RMB), while there was no difference between low income and medium income. There was no significant difference in the prevalence of anxiety among different income groups. Compared to primary healthcare workers with no experience of workplace violence (depression: 46.1%, anxiety: 22.3%), those with experience of workplace violence (depression: 59.6%, anxiety: 34.4%) had a significantly higher prevalence of depression and anxiety (both $p < 0.001$) (Table 1).

Factors associated with depression and anxiety in multiple logistic regressions

We performed multiple logistic regression analyses to examine the associations between depression and other factors. The references of the categorical variables were defined as shown in Table 2. The results showed that female gender (OR = 1.345, 95%CI = 1.222–1.479), being divorced or widowed (OR = 1.432, 95%CI = 1.128–1.817), being a nurse (OR = 1.250, 95%CI = 1.126–1.388), and working more than 8 h per day (OR = 1.710, 95%CI = 1.583–1.846) were associated factors for depression among primary healthcare workers. Medium (OR = 0.860, 95%CI = 0.774–0.956) and high monthly income (OR = 0.672,

TABLE 1 Socio-demographic characteristics of primary healthcare workers (n = 12,764).

Variable	Participants	Depression		Anxiety		Depression	Anxiety
	n = 12,764	Yes (n = 6,466)	No (n = 6,298)	Yes (n = 3,367)	No (n = 9,397)	χ^2 (p-value)	χ^2 (p-value)
<i>Gender (N, %)</i>							
Male	3,935 (30.8)	1796 (27.8)	2,139 (34.0)	899 (26.7)	3,036 (32.3)		
Female	8,829 (69.2)	4,670 (72.2)	4,159 (66.0)	2,468 (73.3)	6,361 (67.7)	57.272 (<0.001)	36.556 (<0.001)
<i>Age (N, %)</i>							
≤34	6,029 (47.2)	3,122 (48.3)	2,907 (46.2)	1712 (50.8)	4,317 (45.9)		
35–44	3,750 (29.4)	1939 (30.0)	1811 (28.8)	1,007 (29.9)	2,743 (29.2)		
≥45	2,985 (23.4)	1,405 (21.7)	1,580 (25.1)	648 (19.2)	2,337 (24.9)	20.088 (<0.001)	46.593 (<0.001)
<i>Educational level (N, %)</i>							
Associate degree	5,234 (41.0)	2,528 (39.1)	2,706 (43.0)	1,242 (36.9)	3,992 (42.5)		
Bachelor degree	7,176 (56.2)	3,756 (58.1)	3,420 (54.3)	2025 (60.1)	5,151 (54.8)		
Master degree or more	354 (2.8)	182 (2.8)	172 (2.7)	100 (3.0)	254 (2.7)	19.861 (<0.001)	32.068 (<0.001)
<i>Marital status (N, %)</i>							
Married	10,217 (80.0)	5,157 (79.8)	5,060 (80.3)	2,638 (78.3)	7,579 (80.7)		
Single	2,246 (17.6)	1,132 (17.5)	1,114 (17.7)	635 (18.9)	1,611 (17.1)		
Divorced or widowed	301 (2.4)	177 (2.7)	124 (2.0)	94 (2.8)	207 (2.2)	8.188 (0.017)	9.438 (0.009)
<i>Technical post title (N, %)</i>							
Junior title	6,952 (54.5)	3,448 (53.3)	3,504 (55.6)	1792 (53.2)	5,160 (54.9)		
Intermediate grade	4,676 (36.6)	2,452 (37.9)	2,224 (35.3)	1,274 (37.8)	3,402 (36.2)		
Senior title	1,136 (8.9)	566 (8.8)	570 (9.1)	301 (8.9)	835 (8.9)	9.373 (0.009)	3.114 (0.077)
<i>Profession (N, %)</i>							
Doctor	4,072 (31.9)	1959 (30.3)	2,113 (33.6)	1,029 (30.6)	3,043 (32.4)		
Nurse	5,717 (44.8)	3,117 (48.2)	2,600 (41.3)	1,664 (49.4)	4,053 (43.1)		
Medical technicians	2,975 (23.3)	1,390 (21.5)	1,585 (25.2)	674 (20.0)	2,301 (24.5)	63.159 (<0.001)	45.712 (<0.001)
<i>Income (N, %)</i>							
≤3,000	1848 (14.5)	966 (14.9)	882 (14.0)	521 (15.5)	1,327 (14.1)		
3,001–8,000	10,265 (80.4)	5,203 (80.5)	5,062 (80.4)	2,683 (79.7)	7,582 (80.7)		
≥8,001	651 (5.1)	297 (4.6)	354 (5.6)	163 (4.8)	488 (5.2)	8.536 (0.014)	4.041 (0.133)
<i>Work seniority (N, %)</i>							
≤10	5,502 (43.1)	2,814 (43.5)	2,688 (42.7)	1,543 (45.8)	3,959 (42.1)		
11–20	4,239 (33.2)	2,250 (34.8)	1989 (31.6)	1,183 (35.1)	3,056 (32.5)		
≥21	3,023 (23.7)	1,402 (21.7)	1,621 (25.7)	641 (19.0)	2,382 (25.3)	32.615 (<0.001)	54.642 (<0.001)
<i>Work hours per day (N, %)</i>							
≤8	4,519 (35.4)	1893 (29.3)	2,626 (41.7)	903 (26.8)	3,616 (38.5)		
>8	8,245 (64.6)	4,573 (70.7)	3,672 (58.3)	2,464 (73.2)	5,781 (61.5)	251.181 (<0.001)	147.393 (<0.001)
<i>Experience of workplace violence (N, %)</i>							
No	8,442 (66.1)	3,888 (60.1)	4,554 (72.3)	1879 (55.8)	6,563 (69.8)		
Yes	4,322 (33.9)	2,578 (39.9)	1744 (27.7)	1,488 (44.2)	2,834 (30.2)	211.301 (<0.001)	218.031 (<0.001)

95%CI=0.549–0.823), and without experience of workplace violence (OR=0.558, 95%CI=0.515–0.604) were protective factors.

Table 3 displays the references of the categorical variables and the association between anxiety and other factors. Anxiety among primary healthcare workers was associated with female gender (OR=1.338, 95%CI=1.198–1.494), being divorced or widowed (OR=1.373, 95%CI=1.056–1.770), being a nurse (OR=1.139, 95%CI=1.013–1.282), and working more than 8 h per day (OR=1.638, 95%CI=1.497–1.794). More than 21 years of working experience (OR=0.721, 95%CI=0.6587–0.884) and without experience of workplace violence (OR=0.539, 95%CI=0.495–0.587) were protective factors.

TABLE 2 Multiple logistic regression examining individual characteristics associated with depression in primary healthcare workers.

Variables	B	p-value	OR	95% CI
Female (ref. Male)	0.296	<0.001	1.345	1.222–1.479
Age (ref. ≤34 years old)				
35–44	0.018	0.773	1.019	0.899–1.154
≥45	0.136	0.132	1.145	0.960–1.366
Educational level (ref. Associate degree)				
Bachelor degree	0.031	0.469	1.032	0.948–1.123
Master degree or more	0.041	0.733	1.042	0.822–1.322
Marital status (ref. Married)				
Single	−0.027	0.635	0.974	0.873–1.086
Divorced or widowed	0.359	0.003	1.432	1.128–1.817
Technical post title (ref. Junior title)				
Intermediate grade	0.060	0.203	1.062	0.968–1.166
Senior title	−0.015	0.857	0.985	0.838–1.159
Profession (ref. Doctor)				
Nurse	0.223	<0.001	1.250	1.126–1.388
Medical technicians	0.101	0.053	1.107	0.999–1.226
Income (ref. ≤3,000 RMB)				
3,001–8,000	−0.151	0.005	0.860	0.774–0.956
≥8,001	−0.397	<0.001	0.672	0.549–0.823
Work seniority (ref. ≤10 years)				
11–20	0.016	0.803	1.016	0.899–1.148
≥21	−0.202	0.025	0.817	0.685–0.974
Work hours per day (ref. ≤8 h)	0.536	<0.001	1.710	1.583–1.846
Experience of workplace violence (ref. Yes)	−0.584	<0.001	0.558	0.515–0.604

Discussion

Prevalence of depression and anxiety, and associated factors among primary healthcare workers

In this study, based on a large-scale, cross-sectional study, we primarily focused on depression and anxiety and their correlates. Our survey findings showed that 50.7% of primary healthcare workers scored above the PHQ-9 clinical cut-off score of 5, and 26.4% scored above the GAD-7 clinical cut-off score of 5. The prevalence of depression and anxiety in our study was higher than that among primary healthcare workers during the COVID-19 pandemic in Japan (depression: 15.0%; anxiety: 31.9%) (36), New York City (depression: 33.8%; anxiety: 48.2%) (22) and Colombia (depression: 26.85%; anxiety: 43.19%) (37). In the post-epidemic era, depression is more severe than anxiety among primary healthcare workers. A potential explanation is the selective dynamic temporal interplay between the COVID-19 pandemic and negative emotions. At the onset of the COVID-19 pandemic outbreak, the outbreak acted as a major stressor and significantly increased anxiety among primary healthcare workers, while the impact on depression among primary healthcare workers may take more time (9, 25).

More than two-thirds (72.2%) of primary healthcare workers with depression were female, and 73.3% of primary healthcare workers with anxiety were female. We found that the prevalence of depression and anxiety was both relatively high among some subgroups, such as female nurses (depression: 54.6%; anxiety: 29.2%), females who were divorced or widowed (depression: 60.3%; anxiety: 33.2%), and those with experience of workplace violence (depression: 64.0%; anxiety: 38.0%). Using a regression analysis, we also identified a few important work-related factors that were significantly associated with depression and anxiety in the whole sample. Among the risk factors that may increase the likelihood of developing depressive and anxiety symptoms among primary healthcare workers during the post COVID-19 pandemic, associated factors at the individual level have been highlighted such as female gender, being divorced or widowed, being a nurse, daily work hours, monthly income, working experience and experience of workplace violence.

Relationship between gender, profession, and depressive and anxiety symptoms

In correspondence, these study results reflect similarities with the already established gender and profession gap findings, suggesting that female healthcare workers were more vulnerable to

TABLE 3 Multiple logistic regression examining individual characteristics associated with anxiety in primary healthcare workers.

Variables	B	p-value	OR	95% CI
Female (ref. Male)	0.291	<0.001	1.338	1.198–1.494
Age (ref. ≤34)				
35–44	−0.031	0.663	0.970	0.844–1.114
≥45	0.027	0.795	1.027	0.839–1.258
Educational level (ref. Associate degree)				
Bachelor degree	0.049	0.316	1.050	0.954–1.156
Master degree or more	−0.002	0.989	0.998	0.766–1.301
Marital status (ref. Married)				
Single	0.044	0.475	1.045	0.926–1.180
Divorced or widowed	0.317	0.014	1.373	1.056–1.770
Technical post title (ref. Junior title)				
Intermediate grade	0.093	0.086	1.097	0.987–1.220
Senior title	0.085	0.370	1.088	0.905–1.309
Profession (ref. Doctor)				
Nurse	0.130	0.030	1.139	1.013–1.282
Medical technicians	0.010	0.865	1.010	0.896–1.139
Income (ref. ≤3,000 RMB)				
3,001–8,000	−0.174	0.004	0.840	0.747–0.945
≥8,001	−0.280	0.017	0.756	0.601–0.950
Work seniority (ref. ≤10 years)				
11–20	−0.036	0.609	0.965	0.842–1.106
≥21	−0.328	0.002	0.721	0.587–0.884
Work hours per day (ref. ≤8 h)	0.494	<0.001	1.638	1.497–1.794
Experience of workplace violence (ref. Yes)	−0.618	<0.001	0.539	0.495–0.587

mental and physical health problems during the pandemic than male healthcare workers (38–40). Our findings suggest that one of the main factors predisposing to depressive and anxiety symptoms could be female sex. This could be justified by the fact that female gender was easy to recognize depression and anxiety, as well as by demographic factors, social, and biological factors, as supported by previous studies (15, 41–43). Serious threats to the mental health of female healthcare workers had equally serious implications for the patients who relied on female healthcare workers in their personal roles as caregivers (38).

In addition, we performed multiple logistic regression analyses to examine the associations between depression/anxiety and other factors (Tables 2, 3), and our results showed that working as a nurse is one of the risk factors for an increase in the levels of depression and anxiety. Moreover, the unpredictable pressure exerted by the COVID-19 pandemic on healthcare systems brings big challenges to nurses, which may affect their mental health well-being (32, 44). Furthermore, several other studies conducted during the initial and ongoing phase of the COVID-19 pandemic also reported similar findings (23, 45). Nurses, as an eminently female profession, were also a higher risk group, and the results highlight the importance of addressing female nurses’ mental health (28, 43).

Relationship between monthly income, marital status, and depressive and anxiety symptoms

All of these depressive and anxiety symptoms were further exacerbated by variables other than the high workload generated by the COVID-19 pandemic, such as monthly income and marital status. Monthly income was also a documented factor in mental health (46). Primary healthcare workers with a monthly income above RMB 8000/– showed better mental health outcomes as they experienced less depression (297, 4.6%) and anxiety (163, 4.8%). A higher monthly income could bring a sense of security in life and work. This suggests an important role of income as a protective mechanism for mental health in primary healthcare workers, possibly reflecting the fact that individuals with lower income may experience higher financial stress as a consequence of the pandemic (47). Another study conducted in Pakistan by Ullah I et al. indicated that Pakistani healthcare workers having a monthly income of above PKR 100000/– showed worse mental health outcomes in all dimensions of interest, as they experienced more anxiety and stress during the COVID-19 pandemic (15). We hypothesized that higher incomes may be associated with a greater workload and other economic reasons, which may lead to negative emotions (48).

Indeed, a stable social support network had proven crucial for healthcare workers in coping under these strenuous circumstances (49), and a lower level of social support was associated with a greater risk of adverse psychological outcomes (28, 50). Our study suggested that being divorced or widowed by primary healthcare workers was correlated with a higher level of depression and anxiety. Compared with primary healthcare workers who were single and being married, being divorced or widowed by primary healthcare workers who could not get enough family support and share their mental burdens through communication and emotional support turned out to be a more important factor in differentiating depression and anxiety (36). Previous studies have indicated that family and social support, including support from friends and colleagues, may help alleviate feeling of insecurity and loneliness and reduce their depression and anxiety during the post-pandemic period (44, 51). Additionally, married individuals who have strong social support experience a buffering effect on the exacerbation of depression caused by disrupted biological rhythms. This effect is observed across different age groups (52). On the other hand, divorced and widowed individuals may struggle to effectively regulate negative emotions during the COVID-19 pandemic due to the emotional trauma they have experienced in their past marriages (50).

Relationship between working years, work hours, and depressive and anxiety symptoms

Previous studies have also shown a relationship between work experience and negative emotions, while the factor of working years has shown discrepancies among the different studies (15, 53). The findings suggest that fewer working years were significantly associated with the mental health status of healthcare workers, which was consistent with the findings of the study in Pakistan (15). That is, less work experience was found to be a risk factor for depressive and anxiety symptoms. According to Ullah I et al. (15), younger healthcare workers who had less working experience and were working as frontline forces had worse mental health outcomes. The participants aged between 20 and 24 years old experienced more depression and anxiety in contrast to healthcare workers aged >30 years old. Furthermore, several other studies conducted during the COVID-19 pandemic also represent similar findings that younger healthcare workers working as frontline force having less work experience had experienced more psychological distress (28, 53).

Another variable that generated a higher occurrence of work-related depressive and anxious symptoms in primary healthcare workers was daily work hours. The context of the pandemic had led to an excessive workload, resulting in an increase in depression and anxiety symptoms among healthcare workers (15, 43, 54). The data for this study was collected between 2023/03/01 and 2023/05/31, a timeframe during which our country lifted stringent measures and societal lockdown. As a result of the lifting of the societal lockdown, the number of patients infected with COVID-19 had increased dramatically, and the primary healthcare workers who are at the frontline of this crisis have been facing extreme psychological distress (55). Our findings showed that daily work hours >8 were positively correlated with depressive and anxiety symptoms and were significant predictors of such symptoms. These findings were similar to previous studies, which found that long working hours seemed to be more correlated with physical and psychological

problems (45, 56, 57). The irregular and unpredictable nature of working time may contribute to increased levels of psychological distress and challenges in maintaining work-life boundaries (58).

Relationship between workplace violence and depressive and anxiety symptoms

Furthermore, the findings in this study suggested that higher levels of depression and anxiety among healthcare workers during the post-COVID-19 pandemic era were associated with workplace violence. It was apparent that workplace violence in primary healthcare workers posed a significant risk to their mental health and an occupational health issue of growing concern (59–61). The implications of workplace violence harmed healthcare workers' psychological and physical well-being (62–64). Victims of workplace violence were more likely to experience depressive symptoms, fear of future workplace violence, poor sleep quality, as well as signs of post-traumatic stress symptoms like direct and vicarious trauma (65, 66). Furthermore, the negative effects of workplace violence on healthcare workers had a significant impact on the quality of care delivered and the turnover intention of healthcare workers (67). The findings of this study could inform the development of support systems to enhance the resilience of healthcare workers experiencing workplace violence by alerting governing institutions. This also leads us to think that the mental health problem of adolescents has become a prominent issue in China at present. School violence, similar to workplace violence, is considered one of the main causes of mental health problems faced by adolescents. Timely intervention on school violence may help solve the anxiety and depression problems of adolescents.

There were a few strengths about this study. First, it was among the first batch to investigate the long-term impact of COVID-19 on psychological symptoms among primary healthcare workers in China during the post-pandemic era. This study included >12,000 healthcare workers working in a primary hospital and having diverse specialties and job descriptions (including the three most important professionals: doctors, nurses, and medical technicians). Second, we used an internationally tested instrument (GAD-7 and PHQ-9) to collect data. This survey was conducted online anonymously, and to encourage honest reporting. Finally, thanks to the support and involvement of primary hospital administrators in Anhui China, the valid response rate was 94.3%, higher than most similar surveys in healthcare workers (23, 36, 68). There were also some limitations, which could be directions for future research. First, the findings of this study are based on self-reports of depressive and anxiety symptoms as opposed to diagnostic criteria or clinical measures. Second, as a cross-sectional survey, it prevents us from making causal claims between depression/anxiety and other factors. Future research using an instrumental variable approach or longitudinal data could better understand the dynamic role of associated factors in shaping depression and anxiety. Third, a limited number of questions included in the questionnaire prevents us from extracting other possible factors that affect the mental health of primary healthcare workers, such as exercise and other health-promoting behaviors. Fourth, due to selection bias caused by our samples, the conclusion could not be generalized to all healthcare workers, particularly those working in tertiary hospitals.

In addition to causing physical diseases, the COVID-19 pandemic has also placed a burden on the mental health of primary healthcare

workers that may persist after the pandemic. Health systems should prioritize enhancing the resilience of healthcare workers during the COVID-19 pandemic and recognize the importance of their mental well-being as a global public health priority. These approaches are crucial for effectively addressing the mental health challenges faced by healthcare workers (69, 70).

Conclusion

Depressive symptoms among primary healthcare workers were highly prevalent during the post-pandemic period. Female gender, being divorced or widowed, being a nurse, work experience, daily work hours, monthly income, and experience of workplace violence were identified as associated factors. Public health prevention programs are needed to prevent and reduce long-term adverse health outcomes and morbidity associated with depressive symptoms.

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 humans were approved by the Ethics Committee of Chaohu Hospital of Anhui Medical University (Approval number #202002-kyxm-02). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

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Anxiety among children a year after the onset of the COVID-19 pandemic: a Brazilian cross-sectional online survey

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Aim: This study seeks to build upon a prior investigation into the impact of the COVID-19 pandemic and to evaluate the prevalence of anxiety among Brazilian children, along with its associated factors, one year after the commencement of the pandemic.

Design: A cross-sectional study.

Methods: A survey was conducted from April–May 2021 in Brazil. Children aged 6–12 and their guardians from five Brazilian regions were included. The Children's Anxiety Questionnaire (CAQ; scores 4–12) and Numerical Rating Scale (NRS; scores 0–10) were used to measure anxiety.

Results: Of the 906 children, 53.3% were girls (average age = 8.79 ± 2.05 years). Mothers responded for 87.1% of the children, and 70.9% were from the Southeast region. Based on a CAQ score of ≥ 9 and an NRS score of ≥ 8 , the anxiety prevalence was 24.9 and 34.9%, respectively. Using logistic regression, a CAQ ≥ 9 score was associated with older children and children with chronic disease or disability. An NRS score of ≥ 8 was associated with reduced family income during the pandemic, the person caring for the children, and with children with chronic disease or disability.

Conclusion: These findings suggest the need to implement public health actions aimed at children with chronic diseases and disabilities and their parents to guide them regarding the warning signs and negative emotions. This study contributes to characterizing the evolution of the pandemic in Brazil and provides a basis for comparison with the literature from other countries.

KEYWORDS

anxiety, children, COVID-19, pandemics, pediatric nursing

Introduction

Owing to the COVID-19 pandemic, children and their guardians experienced extremely challenging and stressful situations such as a sudden change of routine, lack of in-person classes, reduced family budget, and social and familial distancing (1). The most prevalent measure to contain the contagion of the COVID-19 pandemic was social distancing. Hence, schools were closed during the first year of the pandemic in Brazil, which affected more than 35.2 million children and adolescents (approximately 17% of the nation's population)(2) compared with Sweden, where preschools and primary schools have remained open throughout the pandemic to prevent adverse effects such as loss of learning opportunities and a negative impact on children's mental and physical health (3).

Brazil has deep social inequalities. Children depend on public schooling, especially those living in highly vulnerable conditions, and the closure of on-site schools resulted in increased hunger and nutritional deficiencies in the absence of school meals, which increased violence. A narrative synthesis of reports from the first wave of the COVID-19 pandemic (February–July 2020) with 36 studies from 11 countries, which involved 79,781 children and adolescents and 18,028 parents, showed that short-term school closures, which were part of the social lockdown measures, resulted in adverse mental health symptoms and health behaviors among children and adolescents (4).

A global meta-analysis of 74 studies from 2023, which included 478,882 participants (mean age = 13.4 years, 52.3% female) shows the pooled rate of children and adolescents fulfilling diagnostic criteria for anxiety disorders was 13.0% (95% confidence intervals (CI) = 4.9–30.1); the pooled prevalence of anxiety symptoms was 26.5% (95%CI = 20.3–33.9). Anxiety symptoms were significantly more prevalent in females than males ($B = 0.103$, $p < 0.001$), significantly higher during the second wave of COVID-19, following July 2020, than during the first wave, prior to June 2020, ($Q = 8.136$, $p = 0.017$), and during school closure ($Q = 8.100$, $p = 0.014$) (5). Another meta-analysis of 191 studies, which included 1,389,447 children and adolescents, indicated that the pooled prevalence of depressive symptoms from 129 studies ($n = 524,417$) was 31% (95% CI 27–35%); and the prevalence of mild, moderate, and severe depressive symptoms was 19% (95% CI 15–24%), 13% (95% CI 10–16%), and 6% (95% CI 4–9%), respectively. The pooled prevalence of sleep disturbances from 50 studies ($n = 104,219$) was 42% (95% CI 33–52%) (6). Age, grade levels, education levels, gender, geographical regions, and electronics use were associated with an increased prevalence of mental health symptoms. The prevalence of mental health symptoms also increased as the pandemic progressed, although signs of recovery and stabilization were observed (6).

The present study, serving as a follow-up to the sole investigation conducted in Brazil, is not primarily aimed at statistical comparison between these time points. However, the antecedent study, included in a meta-analysis, revealed that the prevalence of anxiety among 289 Brazilian children aged 6–12 years at the onset of the pandemic was 19.4% ($n = 56$) based on the Children's Anxiety Questionnaire (CAQ) and 21.8% ($n = 63$) according to the Numerical Rating Scale (NRS). Higher levels of anxiety were associated with social distancing, identified primarily in people who lived together and had a lower level of education as reported by guardians, and children whose guardians were younger. Lower levels of anxiety were associated with social

distancing between children and their parents (7). Similar research with 774 Swedish children (6–14 years old) during the first wave of the COVID-19 pandemic showed that the prevalence of children with intense anxiety (CAQ score ≥ 9 or NRS score > 7) in the total study population was 2.5% (CAQ score), and 2.7% experienced high levels of anxiety, which is in contrast with many other studies. Maintaining a normal life could be critical in preventing higher anxiety and depression levels in children during a pandemic (3).

The COVID-19 pandemic has lasted longer than many of us expected. Researchers considered that more studies on the 2nd and 3rd waves of COVID-19 are needed to evaluate the long-term impact of COVID-19 on the mental health of young people (5).

This study seeks to build upon a prior investigation into the impact of the COVID-19 pandemic and to evaluate the prevalence of anxiety among Brazilian children, along with its associated factors, one year after the commencement of the pandemic.

Methods

Study design

A survey cross-sectional study was conducted between April 20 and May 31, 2021. Data communication follows the recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology STROBE statement (8) to ensure the study method quality [Supplementary file 1](#).

Sample and data collection

Residents (adults aged 18 years and older) across five regions in Brazil (North, Northeast, Midwest, Southeast, and South) were contacted to participate in this study. To reach all potential participants, we conducted an online survey using Google Forms during the period between April 20 and May 31, 2021. According to the Oxford Stringency Index for the survey period, in Brazil, the reported confirmed COVID-19-related deaths were 171.26 per 100,000 population on April 20, 2021, and 213.20 per 100,000 population on May 31, 2021. During the data collection period, school disclosure was categorized as level 3, meaning it was required at certain levels (9).

Brazil has around 27,424,401 children between 5 to 14 years old (10). Consequently, we employed a non-probability sampling method, specifically convenience sampling, to gather all the necessary information (11). The online survey was disseminated by four researchers and six collaborators (master's and doctoral student nurses) through social media platforms (Facebook and Instagram) as well as personal communication channels (WhatsApp and email). We provided guardians in these regions with a concise overview of the study's objectives and instructions on how to participate, complete the forms, and conduct interviews with their children.

The survey had 24 closed items. The variables measured for the children included gender (female, male, or non-binary), age, school status (vacation/not going to school, home school, online/home class, hybrid class, presential class), who took care of the children (father, mother, both, or other), if guardians were health professionals during COVID-19 (yes or no), if they had a chronic disease or disability (yes

or no), how many adults and children lived in the same house, whether there were suspected or confirmed diagnoses of COVID-19 among immediate family members (yes or no), how long the children had been social distancing, type of dwelling (house or apartment), region of residence (North, Northeast, Midwest, South, and Southeast), and individual response to the NRS and CAQ questionnaire. Owing to the high number of cases and deaths caused by the COVID-19 pandemic in Brazil, presential classes were not mandatory for children during the data collection period. The school status were: home school, hybrid classes, presential school, on vacation or missing school. The quantitative variables for the guardians included gender (female, male, or other), age, relationship with the child (mother/stepmother, father/stepfather, grandmother/grandfather, and others), schooling (elementary school, high school, college, or postgraduate degree), income reduced during the pandemic (yes or no), and their perceptions of their child's understanding of the pandemic (a lot, some, a little, or nothing). We followed the design used in a similar previous study, which assessed anxiety at the beginning of the pandemic between 25 April and 25 May, 2020 (7).

Participants

The inclusion criteria for enrolment included Brazilian school children aged 6–12 years and their guardians from all five regions in Brazil: North, Northeast, Midwest, Southeast, and South. The exclusion criteria encompassed guardians aged under 18 years and those lacking access to computers, telephones, and Wi-Fi and skills necessary to read and respond.

Assessments of anxiety

The CAQ and NRS were used to measure anxiety in the children. The CAQ, developed in Sweden is available in Arabic, English, Swedish, (12, 13), and Portuguese (14). The CAQ contains four items with four images of facial expressions and three response options; each represents different levels of emotional intensity (12, 13). Children responded based on the four facial expressions, one at a time, and choose between the three responses (i.e., a little = 1, some = 2, and a lot = 3). The faces of happy/content and calm/relaxed were measured as 3–2–1, and those of tense/nervous and worried/afraid were measured as 1–2–3. The minimum aggregate score was 4, representing the lowest anxiety level for all four items. The CAQ in Brazilian Portuguese was recently validated and demonstrated satisfactory results among professionals and children (14). The CAQ was based on the State-Trait Anxiety Inventory (15) and has previously shown construct validity in conjunction with outpatient surgery (16).

The NRS, an 11-point scale, is scored from 0–10. It has been validated for the evaluation of pain intensity in children (17) and unpleasantness. However, there is no consensus on the NRS anchors for measuring unpleasantness in children (18). In this study, anxiety was assessed using the NRS, where 0 was equivalent to “calm,” and 10 meant “very anxious.” The NRS was easy to administer and demonstrated good evidence for its construct validity (17, 18).

Following previous research, (7) the CAQ cut-off value was set at the level [low <9 or high ≥ 9]; scores of 9 and higher indicated intense

anxiety. For the NRS, the cut-off value was set at the level [low <8 or high ≥ 8]; thus, scores of 8 or higher indicated intense anxiety.

Statistical analysis

The Shapiro–Wilk test was used to evaluate the distribution of continuous data. Comparisons of continuous data between the groups were performed using the Mann–Whitney U-test for unpaired data that are not normally distributed. Kruskal–Wallis and Dunn's or ANOVA tests were performed for multiple-group comparisons. Spearman's rank (ρ) correlation coefficients were calculated between the CAQ and NRS scores. A chi-square test, as a two-tailed test ($n > 30$), and Fisher's exact test were used to compare the proportions in the different groups. Odds ratios (ORs) were calculated to evaluate the association between the outcome variables, such as the dependent variable (NRS or CAQ, as binary categories defined [$</>$]). For the CAQ, a score higher than or lower than the mean value, and a single standard deviation, resulted in the cut-off value as lower or higher than 9. In addition, scores of 9 and higher indicated intense anxiety. For the NRS, the cut-off value was set at the 8 and higher.

A logistic regression was performed to evaluate the associations between the dependent variable (i.e., high or low anxiety scores of the CAQ (≥ 9) and NRS (≥ 8), respectively) and the independent variables. The presence of anxiety was defined via the cut-off values of ≥ 9 and ≥ 8 for the CAQ and the NRS, respectively. For the analysis, we considered the children's anxiety as the dependent variable. Independent variables were age, gender, decreased income during the pandemic, presence of a chronic disease or disability, the region in Brazil, and who takes care of the child. The child's perceived comprehension of the situation was considered a potential confounder.

For all tests, the level of statistical significance was set at 5%. Statistical analyses were performed using IBM SPSS Statistics for MacBook, version 24 (IBM Corp., Armonk, NY, USA). Finally, the point prevalence of anxiety was compared with a previous survey via CI set at 95% and the respective ORs. For all tests, the level of statistical significance was set at 5%.

Ethical information

This study was approved by the Research Ethics Committee of Brazil (CAAE: 30547320.0.0000.0008 and Opinion n° 4.128.847) and a new application and approval were granted for data collection a year after the pandemic (Opinion n° 4.593.273). We obtained approval for data collection using the same design as that of the first study. The guardians and children agreed to participate in the study through an electronic register.

Results

A total of 920 respondents accessed the data collection instrument. Of these, ten refused to participate, and four were excluded as they did not meet the inclusion criteria (see above). Hence, 98.5% ($n = 906$) of children and their guardians participated in the study (Supplementary file 2).

Among 906 children, 53.3% were girls (average age = 8.79 ± 2.05 years), 70.9% were from the Southeast region, 67% ($n=607$) studied in private schools and 10.6% ($n=96$) had chronic diseases or disabilities. Based on a CAQ score of ≥ 9 and an NRS score of ≥ 8 , the anxiety prevalence was 24.9 and 34.9%, respectively. The most common chronic disease was asthma/bronchitis (48.0%, $n=46$) and the most common disability was attention deficit hyperactivity disorder (ADHD; 8.3%, $n=8$).

The guardians' mean age was 38.45 ± 8.07 years. Most guardians (87.1%; $n=789$) were mothers/stepmothers, approximately 49.6% ($n=449$) went to graduate school, and 70.9% ($n=642$) were from the Southeast region. Among the participants, 47.7% ($n=432$) had income reduction during the first year of the COVID-19 pandemic, 77.7% ($n=704$) lived in a house, 52.1% ($n=472$) suspected COVID-19 among family members, and 26.5% ($n=240$) received positive confirmation regarding the same. A total of 45.9% ($n=416$) of the guardians worked from home, and 22.5% ($n=204$) were healthcare and frontline professionals during the COVID-19 pandemic (Supplementary file 3).

Table 1 shows the significant difference in the prevalence of anxiety based on the CAQ ≥ 9 and NRS ≥ 8 scores at different ages. There were statistical differences between the prevalence of anxiety for CAQ ($p=0.028$), but not for NRS ($p=0.415$).

Table 2 shows the prevalence of anxiety according to both instruments and their associations with each variable. A chronic disease or disability influenced children's higher levels of anxiety, 40.6% ($n=39$) in the CAQ ≥ 9 ($p<0.001$) and 49% ($n=47$) in the NRS ≥ 8 ($p=0.002$).

Tables 3, 4 present the binary logistic regression results for the CAQ and NRS, with the independent variables included. Children with chronic illnesses or disabilities had higher CAQ ($p<0.001$) and NRS ($p=0.010$) scores and were likely to exhibit anxiety than those without them (CAQ: OR = 1.1 CI 1.067–1.24, Table 3; NRS: OR = 1.1 CI 1.067–1.24; Table 4).

Table 3 shows that the CAQ scores were also influenced by the child's age ($p<0.001$). The children's age was associated with the presence of anxiety. Older children were more likely to be anxious (OR = 1.1 CI 1.067–1.24).

Table 4 shows significant associations between anxiety and having a chronic illness or disability, decreased parental income during the pandemic, the children's caregiver, and the region where the child lives. The children whose parents reported decreased income during the

pandemic were more likely to exhibit anxiety than those whose parents did not (OR = 1.6 CI 1.5–1.2). In addition, compared with the children cared for by both mother and father, those cared for by a single parent, another relative, or a babysitter were more likely to exhibit anxiety.

Discussion

Different factors influenced the level of anxiety. According to the CAQ ≥ 9 ($p<0.001$) scores, children's age was associated with higher anxiety levels. The prevalence of anxiety was higher for 12-year-olds based on the CAQ ≥ 9 scores (39%, $n=113$) and for 6-year-olds based on the NRS ≥ 8 scores (63%, $n=31$). These differences may be due to the characteristics of the instruments. Conversely, the CAQ considers different feelings in measuring a child's anxiety than the NRS, which can be easier for young children.

The person who takes care of the children was another factor associated with a higher prevalence of anxiety. Children were less likely to experience anxiety when both parents cared for them, based on the NRS ≥ 8 scores. At the beginning of the COVID-19 pandemic, previous research showed that children who were keeping social distance together with their mothers and fathers had lower CAQ scores than those who were isolated with someone other than their parents (7). A systematic review highlighted the influence of the family relationships associated with mental health changes among children and adolescents during the pandemic. In several cases, parents and children reported that the pandemic had encouraged higher levels of family intimacy (19).

There was an association between the reduction in income among Brazilian families during the first year of the COVID-19 pandemic and the prevalence of related anxiety according to the NRS, which indicated the pandemic's adverse negative influence on families. Social distancing affected income from tourism and various services, such as clothing, toys, and home appliance stores, which affected daily consumption, purchase of medications, paying household bills, lower hiring by Brazilian commerce, and even the payment of health plans (20). Economic instability tended to increase anxiety levels among the population, as suggested by a study with 2,510 adults at the Brazilian borders, where the prevalence of anxiety was 63.5% during the pandemic. (21). We did not investigate whether an association exists between family income and children's anxiety, which prevents us from delving deeper into this critical aspect.

TABLE 1 Summary of the prevalence (%) and [95%CI] of anxiety (CAQ score ≥ 9 ; NRS score ≥ 8) for children by age, $n=906$, Botucatu, SP, Brazil, 2021.

Age (years)	Total (n)	CAQ score $\geq 9^1$	NRS score $\geq 8^2$
6	176	31 (17.6) [12.7–23.9]	63 (35.8) [29.1–43.1]
7	132	29 (22.0) [15.8–29.8]	50 (37.9) [30.1–46.4]
8	112	23 (20.5) [14.1–28.9]	34 (30.4) [22.6–39.4]
9	136	38 (27.9) [21.1–36.0]	56 (41.2) [33.3–49.6]
10	113	32 (28.3) [20.8–37.2]	37 (32.7) [24.8–41.8]
11	124	34 (27.4) [20.3–35.9]	36 (29.0) [21.8–37.6]
12	113	39 (34.5) [26.4–43.7]	40 (35.4) [27.2–44.6]
Total	906	226 (24.9) [22.2–27.9]	316 (34.9) [31.9–38.0]

CAQ, children's anxiety questionnaire; NRS, numerical rating scale.¹Chi-square test, $p=0.028$.

²Fisher's exact test, $p=0.415$.

TABLE 2 Comparison of the prevalence of anxiety among children (CAQ Score ≥ 9 ; NRS Score ≥ 8) based on the main characteristics of the population, $n = 906$, Botucatu, SP, Brazil, 2021.

	CAQ ≥ 9	%	p^1	NRS ≥ 8	%	p^2
<i>Gender</i>						
Girls ($n = 483$)	128	26.5	0.256	170	35.2	0.961
Boys ($n = 422$)	98	23.2		147	34.8	
<i>Decreased income during pandemic</i>						
Yes ($n = 432$)	119	27.5	0.084	176	40.7	<0.001
No ($n = 474$)	107	22.6		140	29.5	
<i>Chronic disease or disability*</i>						
Yes ($n = 96$)	39	40.6	<0.001	47	49.0	0.002
No ($n = 810$)	187	23.1		269	33.2	
<i>Region in Brazil</i>						
North ($n = 46$)	11	23.9	0.982	13	28.3	0.004
Northeast ($n = 92$)	24	26.1		21	22.8	
Midwest ($n = 46$)	11	23.9		13	28.3	
South ($n = 80$)	18	22.5		20	25.0	
Southeast ($n = 642$)	162	25.2		249	38.8	
<i>Take care of the children</i>						
Both parents ($n = 207$)	48	23.2	0.902	52	25.1	0.007
Mother ($n = 466$)	120	25.8		167	35.8	
Father ($n = 55$)	12	21.8		24	43.6	
Other relative ($n = 127$)	32	25.2		50	39.4	
Baby sister ($n = 47$)	13	27.7		21	44.7	
Alone ($n = 04$)	01	25.0		02	50.0	
<i>Child's perceived comprehension</i>						
None ($n = 10$)	3	30.0	0.594	4	40.0	0.001
A little ($n = 154$)	41	26.6		45	29.2	
Some ($n = 230$)	63	27.4		104	45.2	
A lot ($n = 512$)	119	23.2		163	31.8	

CAQ, children's anxiety questionnaire; NRS, numerical rating scale.¹Chi-square test.

²Fisher's exact test; significant at $p < 0.05$.

This study found a high prevalence of anxiety in Brazilian children compared to previous research (7). In the present study, the prevalence of anxiety among children, based on a CAQ score of ≥ 9 and an NRS score of ≥ 8 , was 24.9% ($n = 226$) and 34.9% ($n = 316$), respectively. These results endorse a systematic review and meta-analysis that shows that anxiety symptoms were more prevalent in the second wave of COVID-19 than in the first wave of COVID-19 (5). The results underscore the significance of consistently examining anxiety in children within the context of the COVID-19 pandemic. In this study, we replicated a prior investigation, a notable advantage. Furthermore, the data collection period might have coincided with the peak of the pandemic. Brazil is a continental country. At the same time, it has more developed cities and regions, such as the South and Southeast regions, and others with much lower development rates, such as the North and Northeast regions, which exacerbates social inequalities. Despite that, we did not find an association between children's anxiety and regions of Brazil.

According to the CAQ and NRS instruments, children's anxiety was significantly associated with chronic diseases or disabilities. A

systematic review, with a total of 116 articles representing more than 127,923 children and adolescents, shows that neurodiverse children and adolescents, and those with pre-existing mental illness have experienced higher levels of psychological distress, depression, anxiety, and behavior problems since the onset of the pandemic. Similarly, those with chronic physical health (including respiratory) conditions also experienced more severe mental health impacts than those without them (19). A cross-sectional study conducted in Brazil with 355 adolescents with different chronic conditions and 111 healthy adolescents, aged 10 to 18 years old, between July and October 2020, showed no statistical difference in the Strengths and Difficulties Questionnaire (SDQ) total score in patients with chronic disease and the control, 30% vs. 31%, $p = 0.775$, respectively. These findings differ from this study where chronic disease and disability increased anxiety one year after the onset of the pandemic (22).

Chronic diseases are health problems that persist over time, require continuous management in life, and could have periods of clinical instability, leading to hospitalizations and complex care. The most common chronic disease reported by parents was asthma/

TABLE 3 Logistic regression for the CAQ: anxiety (≥ 9) or Not (< 9), $n = 906$, Botucatu, SP, Brazil, 2021.

Variable	B	S.E.	Wald	df	Sig.	OR	95% CI for OR
Child's age	0.140	0.038	13.426	1	<0.001	1.1	1.0–1.2
Chronic disease or disability	0.874	0.227	14.816	1	<0.001	2.3	1.5–3.7

CAQ, children's anxiety questionnaire; CI, confidence interval; SE, standard error; OR, odds ratio.

TABLE 4 Logistic regression for the NRS ≥ 8 , $n = 906$, Botucatu, SP, Brazil, 2021.

Variable	B	S.E.	Wald	df	Sig.	OR	95% CI for OR
Chronic disease or disability	0.685	0.225	9.249	1	0.002	1.9	1.2–3.0
Decreased income during pandemic*	0.483	0.145	11.033	1	0.001	1.6	1.2–2.1
Region in Brazil**			11.786	4	0.019		
Northeast	−0.499	0.345	2.095	1	0.148	0.6	0.3–1.1
Midwest	−0.657	0.266	6.092	1	0.014	0.5	0.3–0.8
South	−0.301	0.346	0.755	1	0.385	0.7	0.3–1.4
Southeast	−0.623	0.275	5.130	1	0.024	0.5	0.3–0.9
Take care of the child†			11.494	4	0.022		
Only mother	0.436	0.193	5.123	1	0.024	1.5	1.0–2.2
Only father	0.840	0.324	6.723	1	0.010	2.3	1.2–4.3
Other relative	0.589	0.248	5.624	1	0.018	1.8	1.1–2.9
Baby-sitter	0.821	0.340	5.851	1	0.016	2.2	1.1–4.4
Child's perceived comprehension‡	0.292	0.192	2.309	1	0.129	1.3	0.9–1.9

CI, confidence interval; NRS, numerical rating scale; SE, standard error; OR, odds ratio.

*Reference category: no.

**Reference category: North.

†Reference category: both parents.

‡Reference category: No/some.

bronchitis, which could be a complication for a child with a COVID-19 diagnosis. Consequently, greater attention should be paid to these children and their families in the community, schools, primary care, and hospitals. During the COVID-19 pandemic, managing chronic diseases in childhood became more complicated for families and health professionals, as highlighted in different countries. A study in France revealed that 34.7% of children and adolescents with ADHD had or experienced marked deterioration in wellbeing, as shown by attitudes toward opposition or audacity, emotion, internal outbursts, sleep problems, and anxiety (23). A Dutch study of 75 children (median age = 10.5 years) with severe obesity showed that anxiety related to COVID-19 occurred in 32% (24). The possibility of health problems among children with chronic diseases justifies the higher anxiety levels among family members, which may, in turn, influence the child. This outcome was highlighted in an editorial about the challenges posed by COVID-19 to children with cancer at the beginning of the pandemic (25). In Germany, a survey of with 210 parents of children with rare congenital surgical diseases (anorectal malformations, biliary atresia, congenital diaphragmatic hernia, esophageal atresia, or Hirschsprung's disease) and 88 parents of children without rare diseases. Results of these studies showed that the former reported severe psychosocial impairment among themselves and their children during the COVID-19 pandemic (26).

Finally, the children school status was not associated with the CAQ or NRS. However, notably, 3.5% of the children attended presential class. Moreover, research shows an increase in mental health symptoms because of school closure (4, 5, 27). A systematic review and meta-analysis included 868,634 children and adolescents (≤ 19 years)

pre-pandemic and 807,480 during the COVID-19 pandemic in Europe. It compares the depression symptoms during the pre-pandemic vs. pandemic periods, showing that school closures during the pandemic resulted in a considerable increase in depression symptoms (27). Another systematic review and meta-analysis included 26 publications ($n = 15,038$ pre-pandemic, $n = 13,041$ during pandemic) in Europe, revealed during the pandemic a significant reduction in total physical activity and moderate-to-vigorous physical activity, corresponding to a decrease of 12 min per day. A decline in physical activity and a simultaneous increase in mental health disorders may have contributed to a general worsening of the health status of children and adolescents during the COVID-19 pandemic (28).

Hence, school staff and health professionals must increase awareness regarding feelings of anxiety in children for early prevention of mental illness, especially in children with chronic diseases or disabilities. To fully grasp how Brazilian children were affected by the pandemic, each federal state in Brazil should understand and fulfil the children's specific necessities required and conduct additional long-term studies. Moreover, new studies should evaluate anxiety among children in middle- and low-income countries such as Brazil and the return to school after absence due to school closures.

Limitations

Some limitations of this study should be noted. The main limitation is the sample and data collection. We employed a non-probability sampling method, and the data collection was affected

by participant selection bias. The data collection was conducted online, with participation restricted to those with access to resources (computers, telephones, and Wi-Fi) and those with the skills to read and respond. Then, more vulnerable adolescents without internet access were not represented in our study, which highlights the need for further studies that include this population.

Additionally, parents with more than one child in the house who answered multiple surveys were not excluded. We could not verify whether the research participation location was a quiet environment free from distractions. Furthermore, we did not investigate the guardians' income levels to associate with children's anxiety. Consequently, caution should be exercised when generalizing the data from the current study. Thus, future studies may adopt face-to-face interviews as a suitable data collection method, with face-to-face data collection.

Implications for nursing practice

Finally, we hope that our research contributes to knowledge that can guide public policies and contribute to the 17 sustainable goals aimed at ensuring that no child is left behind. Goal 3 describes good health and wellbeing, where fewer children are ill and all children have the right to feel physically and mentally healthy. This target, to be implemented by 2030, promotes preventive measures to prevent and improve children's mental health and wellbeing.

Conclusion

The prevalence of anxiety among children a year after the beginning of the COVID-19 pandemic was 24.9% ($n=226$) and 34.9% ($n=316$), according to the CAQ and NRS, respectively. Higher anxiety levels were found to be associated with chronic disease or disability in children.

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 humans were approved by the Research Ethics Committee of Brazil (CAAE: 30547320.0.0000.0008 and Opinion n° 4.128.847). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

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Author contributions

MA: Data curation, Funding acquisition, Investigation, Project administration, Writing – review & editing. TJ: Investigation, Writing – original draft. PF: Formal analysis, Methodology, Writing – review & editing. GA: Investigation, Writing – original draft. PO-C: Formal analysis, Methodology, Writing – review & editing. MB: Writing – review & editing. MJN: Writing – review & editing. SN: Conceptualization, Methodology, Writing – review & editing.

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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/fpubh.2024.1372853/full#supplementary-material>

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Influence parental- and child-related factors on the acceptance of SARS-CoV-2 test methods in schools and daycare facilities

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Introduction: Rapid testing for Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infections was an essential step in reducing the spread of the virus and monitoring pandemic development. Most mandatory standard pandemic testing in Germany has been performed in schools and daycare facilities. We investigated the influence of behavioral and attitudinal characteristics of children and caregivers on their acceptance of (i) antigen-based nasal swab rapid and (ii) oral saliva-based pooled Polymerase Chain Reaction (PCR) tests.

Methods: Conducted through a cross-sectional survey between November and December 2021, with 1962 caregivers and 581 children/adolescents participating, the study evaluated the acceptability of each testing method on a six-point scale. Participants scored one test method conducted on their child at one of six levels with 1 and 6 denoting “excellent” (1) and “inadequate” (6), respectively. We considered demographic variables, vaccination status, child mental health (measured by the SDQ-questionnaire), and facility type (kindergarten, primary school, secondary school) as covariates.

Results: Results reveal a preference for saliva-based PCR tests over nasal swabs by about one grade, particularly among parents of unvaccinated children, especially if their child expressed future vaccination reluctance. Testing acceptance was lower among children with mental health issues, primary school-aged, and those with less-educated parents. Perception of test accuracy and convenience influenced attitudes, favoring saliva-based PCR tests. Moreover, children with mental health issues felt less secure during testing.

Discussion: To our knowledge, this is the first study to investigate the influence of different testing methods on testing acceptance for SARS-CoV-2 in children and caregivers. Our study identifies predictors of lower acceptance of public health surveillance measures and enables the development of educational programs on testing and vaccination tailored to the needs of specific target groups. Moreover, we demonstrate that test acceptance in vulnerable groups can be enhanced by careful choice of an appropriate testing method.

KEYWORDS

COVID-19, SARS-CoV-2, surveillance, test method, school, acceptance

1 Introduction

The COVID-19 pandemic itself and its associated measures to protect the population have had far-reaching effects on the lives and well-being of children and adolescents worldwide (1, 2). Although children tend to have a milder clinical course of SARS-CoV-2 infections compared to adults, children can also become unwell either acutely or by developing Long Covid. Furthermore and in particular, the pandemic's indirect effects on children's socioeconomic, emotional, physical, and educational well-being and development have been immense (3). Children's and young people's daily lives have been affected by many pandemic-related public health measures – especially school and nursery closures.

1.1 COVID-19 transmission within educational institutions

The key argument for closing educational institutions was that transmission in such settings would play a significant role in driving up the incidence of SARS-CoV-2 infections (4). Closing these institutions was therefore a major public health strategy to reduce SARS-CoV-2 transmission and cut down its incidence. There were COVID-19-related school closures in 188 countries worldwide affecting over 1.5 billion students (5). For example, schools in Germany were closed for COVID-19-related reasons for a total of 38 weeks (as of June 2023) and approximately 55 million students in the USA could not physically attend classes for most of the 2020/2021 school year. However, according to current knowledge, the evidence supporting the effectiveness of school closures is mixed at best (6).

1.2 Consequences of closing educational institutions

Since educational institutions play a key role in ensuring children's psychological and physical health as well as their socioeconomic prospects, their closure has exerted widespread and deep effects on the wellbeing of children and families.

First, given the paramount importance of schools for children's educational development, a major potential long-term effect of the COVID-19 pandemic-caused school closures is the threat to their education (7). Compared to a typical school year, students have been returning to school with only 63–68% of the usual progress in reading and 37–50% in mathematics (8).

In addition, school closures have severe adverse effects on child health and well-being (9). These for example include malnutrition from having missed school meals, obesity due to lack of physical activity, and higher rates of mental health problems and intrafamilial abuse (10–14).

1.3 Targeted closures and avoiding school closures depend on regular testing

There is thus an inherent conflict of interest between limiting SARS-CoV-2 transmission on the one hand and the negative effects of school and daycare closures on the other. This is particularly true

in light of the mixed evidence regarding the actual effects of school closures (6). One strategy to mitigate this dilemma is to implement targeted closures instead of comprehensive closures. This means that specific schools, daycare centers, classes, or groups would only close if SARS-CoV-2 cases are present or above a particular threshold.

The success of such targeted closures depends on rapid and reliable case detection so that closures can be implemented before widespread transmission occurs (15–18). In turn, detecting such cases relies on extensive, regular screening for SARS-CoV-2 infections. Consequently, governments implemented various testing regimes. In Germany, routine COVID-19 tests in schools and daycare centers became a key pillar of the strategy to keep as many educational institutions open as possible. The most common test options were nasal antigen tests (at home or on site; 20) and saliva-based pooled PCR tests (“lollipop-method”) on site (19). Overall sensitivity of antigen tests was reported at 63.2% in RT-PCR positive cases. In asymptomatic patients, sensitivity was 57.6% (20). All options entailed multiple tests per week.

Human behavior is a key component in “flattening the curve” and minimizing virus transmission (3). Regular testing of children in schools and daycare centers depends on high acceptance and compliance of children and parents (21). The uptake of voluntary testing in pilot projects has varied widely, from 1 to 68% (22). Understanding people's attitudes toward testing may help to maximize the effectiveness of SARS-CoV-2 testing programs in educational settings and hence the success of the targeted-closures strategy. Moreover, understanding the emotional acceptance of routine screening in educational settings including that among different socioeconomic subgroups could yield insights into the acceptance of other public health interventions such as vaccine campaigns (23). Families with children in daycare and school settings represent an important group in the general population whose interests differ from those of adults without children or older adult people (24).

1.4 Factors influencing SARS-CoV-2 testing acceptance

Although weekly SARS-CoV-2 in-school testing was mandatory during the study period, questions remain regarding parents' and children's attitudes toward and their acceptance of such testing regimes. How well do people understand the importance of testing (25)? Do routine tests enable emotional acceptance by children and parents (26)? To what extent do socio-economic and demographic factors play a role in test acceptance (27–34)? Finally, is there a difference in the acceptance of different testing methods (antigen vs. PCR), maybe also due to their respective quality criteria (e.g., sensitivity)? COVID-19 incidence in the study period was high with 7-day incidences ranging between 91 per 100,000 in October to over 200 per 100,000 inhabitants in November and December 2021 (35). Regarding the perceived severity of the disease, it should be noted that until end of 2021 the Delta variant of COVID-19 was the most pervasive (36). Retrospective data indicate that the rate of hospitalizations with Delta was almost threefold higher compared to the Omicron variants. Therefore, the perceived severity of the disease might have been higher compared to subsequent periods of the pandemic.

Our sample was collected from November 11, 2021 to December 19, 2021. During the entire data collection, various vaccines were recommended and approved in Germany for children and adolescents aged 12 years and older. For children aged 5–12 years, the first vaccine was authorized during the period of data collection. According to data from the Robert-Koch Institute reported on December 20, 2021, 61.1% of children and adolescents aged 12 years and older had been vaccinated at least once; 50.6% were fully vaccinated. No specific data on the vaccination status of younger children were reported at this time nor were included in the above-mentioned percentages. First reported percentages from January 18, 2021 suggested a vaccination rate of 14.1% (vaccinated once) and 5.3% (fully vaccinated) for 5–11-year-old children (37).

Although there already is some evidence regarding the acceptability of SARS-CoV-2 testing in educational institutions, detailed studies including a broader set of further relevant aspects are scarce (38). To deepen this knowledge and to obtain a broader picture of associated factors, we examined the following:

1. What are different attitudes toward two SARS-CoV-2 testing methods [nasal antigen versus pooled PCR (19, 39)] in schools, and is there a relationship between different demographic factors (e.g., age, gender, parents' educational status) and testing appraisal by parents and children. These factors are known to exert effects on testing hesitancy (29–34).
2. Is there a difference in testing appraisal between different types of childcare institutions (daycare, primary and secondary schools)?
3. Whether and how does the acceptance or rejection of a COVID-19 vaccine influence the appraisal of SARS-CoV-2 surveillance measures in schools? With this approach, we plan to expand upon the existing literature examining attitudes toward COVID-19 vaccinations (40–44). For example, Ali and colleagues (45) reviewed the global landscape of COVID-19 vaccine hesitancy, identifying governmental, healthcare system, population, and vaccine-related causes. They highlighted factors such as knowledge/awareness and social media influence, and proposed strategies to mitigate hesitancy at multiple levels, including structural, extrinsic, intrinsic, and other factors, aiming to facilitate vaccination efforts and combat hesitancy. To this end, we examined if doubting the vaccine's benefit would be associated with a worse appraisal of testing as well.
4. How do mental health issues affect how surveillance is evaluated (46)? We examined this question due to the rise of mental health issues in children and adolescents during and after the pandemic (47, 48).

It should be noted that, as of December 2021, the German Standing Committee on Vaccination (STIKO) updated its COVID-19 vaccination recommendation, advising the vaccination of children aged 5–11 years with pre-existing conditions. In June 2021, the STIKO in Germany recommended COVID-19 vaccinations for adolescents aged 12–17, while in August 2021, they extended this recommendation to include COVID-19 vaccination for the general population within the same age group. As of now, there is no universal vaccination recommendation for individuals under 18 years of age in Germany.

2 Methods

2.1 Data

Data for this study refer to the COVID-19 pandemic situation in Germany and were collected between November 2021 and December 2021, a period where schools in Germany were operational, albeit with occasional adjustments such as the cancelation of mandatory attendance or the advancement of holiday breaks.

Study data were collected and managed using REDCap (electronic data capture tools), a web-based software platform (49, 50). Parents accordingly received links to online surveys for their participation. Links were distributed online and via schools, daycare facilities, clinics, and parent organizations. Children and adolescents aged 8 years and older were also provided with online links themselves.

Parents of children and adolescents aged 4–17 years in daycare facilities for children (pre-/playschools/kindergarten) as well as in primary and secondary schools in two German cities (Cologne and Freiburg) took part in this study. The sample is a convenience sample and therefore not representative of all of Germany. Recruitment was carried out by contacting school principals, parent organizations, and public city school councils who put up posters and involved their staff if they were willing to participate. Additionally, we put up study information in areas that are highly frequented by children and adolescents (e.g., pediatric emergency room). To minimize memory effects, the children's last COVID-19 test had to have occurred within 7 days prior to the participation. There were no other inclusion or exclusion criteria. The subgroups answered similar questions as the participants from the parent sample. The main focus in this study is on the parent sample, examining factors influencing their evaluation and the impact of SARS-CoV-2 testing on families, additional analyses examining the adolescent sample are included as well. Consent of all participating parents and children/adolescents was obtained online via REDCap. Ethical approval was sought from the ethics committee of the university hospital in Cologne and in Freiburg (21–1,617).

2.2 Measures

2.2.1 COVID-19 test methods

Subjects were asked to evaluate the last test for SARS-CoV-2 they had undergone within the previous 7 days, and whether they had experienced more than one test method ($n = 256$). As there were too few saliva antigen rapid tests, our analyses focused on comparing saliva-based PCR tests to nasal swab antigen rapid tests.

2.2.2 Child mental health status

The Strength and Difficulties Questionnaire (SDQ) was used to assess child mental health status (51). The SDQ is a brief behavioral screening questionnaire adapted for 2–17-year-olds. It consists of emotional and behavioral screening that can, depending on the version employed, capture the perspective of children and young people, their parents, and teachers. There are five subscales in the long version of the SDQ (25 items), comprising subscales on emotional symptoms, conduct problems, hyperactivity/inattention, peer relationships problems, and prosocial behavior. We calculated the total difficulties score.

2.2.3 Evaluation of COVID-19 tests

Subjects were asked to evaluate the COVID-19 tests according to the German school grading system ranging from 1 (best) to 6 (worst), with grades worse than 4 indicating failure in the class test in the school setting. This scaling was chosen because of its widespread use in various contexts in Germany and its suitability as a metric scale in statistical analyses. In emotional word lists according to the EWL-KJ (52), children reported their testing experience, and parents described how they thought their children experienced the test. Moreover, participants were asked about their attitudes toward SARS-CoV-2 testing via self-developed questionnaires on Likert scales ranging from 1 “false” and 2 “is probably not applicable” to 3 “is probably applicable” and 4 “true.”

We attached the respective questionnaires in the [Supplementary material](#) section.

2.3 Statistical analyses

First, we assessed potential differences in parent's appraisal of SARS-CoV-2 testing in schools and daycare facilities depending on the test method and children's age with a two-way ANOVA, with between-subjects factors being test method (swab antigen test/saliva-based PCR) and children's age (kindergarten, 4–6 years/primary school, 6–10 years/secondary school, 10–17 years). The latter age categorization was used given the distinct educational environments in the corresponding groups. Notably, kindergarten settings have higher staff-to-child ratios and lack compulsory learning objectives, allowing more time for testing without impacting learning outcomes. However, younger children in kindergarten required more assistance during tests, resulting in fewer nasal swab antigen tests conducted in this setting within our sample. Thus, the initial analysis included only kindergarten data without further adjustments for confounding variables. We chose ANOVA since the dependent variable (school marks) could be treated linearly, despite a slightly skewed distribution toward better marks, which did not significantly affect the ANOVA's robustness.

Second, we examined a general linear model to assess whether, how and which additional factors are associated with the appraisal of SARS-CoV-2 testing by parents. Due to the limited number of nasal swab tests in kindergartens, our analysis was confined to school-age children to ensure robust results. Linear predictors included age, gender, SDQ total score, attitude toward the COVID-19 vaccine and parents' educational level, with educational level being dummy coded, SARS-CoV-2 testing method (saliva-based PCR test, nasal swab antigen test), and the vaccination status of the child (vaccinated or willing to be, no vaccination and unwilling, or unclear vaccination status).

Cities (Freiburg/Cologne) were also included into the model.

We hypothesized that parents with higher educational levels would rate COVID-19 surveillance more positively due to their emphasis on their children's school education and better understanding of public health measures. Linear dummy coding was used to test this hypothesis, and additional regression models with different combinations of independent variables were calculated to examine the sensitivity of the model design.

Third, to examine how these factors are associated with the evaluation of SARS-CoV-2 testing, we applied an ordinal logit-model in a generalized linear model to establish how these factors covaried with specific aspects of SARS-CoV-2 testing as rated on the

above-mentioned self-developed questionnaires (4 steps-Likert scale). Similarly, we calculated additional ordinal models with the same items of specific aspects of SARS-CoV-2 testing using children's evaluation of SARS-CoV-2 testing, parents' SDQ total score, and children's vaccination status as dependent variables.

Despite the right-skewed distribution of the dependent variables (e.g., grade rated by parents: skewness = 1.43; kurtosis = 4.31), we opted to retain the original numerical values to preserve comprehensive data representation. Simplifying these ordinal variables might lead to significant information loss and reduced granularity, impacting the interpretation of our results and implications for policy decisions.

All analyses were performed with Statistica 13, TIBCO Software Inc.

3 Results

3.1 Participants

A sample of 1962 parents (371 male, 1,589 female, 2 diverse/non-binary; mean age 43.0; of 961 boys, 997 girls, and 4 diverse/non-binary children; mean age 8.6 years) participated in the study enabling complete data sets.

Additionally, we collected a sample of 581 children and adolescents (205 male, 372 female, 4 diverse/non-binary, mean age 13.1 years) which is part of further exploratory analysis.

Details on our sample's age distribution can be found in [Table 1](#). This includes a summary of the proportion of parents who (strongly) agreed with the corresponding statements to facilitate the assessment of the overall acceptance and the interpretation of the results.

Non-binary subjects were excluded from further statistical analyses because of their low number. Participating parents on average had a relatively high educational level (primary/middle school $n = 274$; “Fach-/Abitur”/high school $n = 533$; university $n = 1,149$). Two parents with no school qualification were excluded due to their low number ([Table 1](#)).

A total of $n = 440$ children of the participating parents were unvaccinated and did not want to be vaccinated in the future according to their parents. In sum, $n = 994$ children were either vaccinated, or their parents reported their intention to have their child vaccinated as soon as a recommended vaccination became available. $N = 524$ parents provided no information about their child's current vaccination status or their vaccination intention in the future. The children of $n = 1,863$ parents had never had a COVID-19 infection, $n = 81$ had, $n = 14$ did not give information about whether their child had had a COVID-19 infection. Children of 1,414 parents underwent saliva-based PCR tests, 503 antigen rapid tests via nasal swab (thereof 501 with ratings for the test method), and 43 antigen rapid tests based on saliva.

The proportion of (strong) agreement with the statements on average was 40%, it varied between 7% for “My child feels insecure when performing COVID-19 tests.” and 70% for “The COVID-19 test is usually over quickly for my child.”

3.2 COVID-19 test-method appraisal and influencing factors

First, the ANOVA revealed that saliva-based PCR testing was consistently and significantly rated better across all age groups [main

TABLE 1 Descriptive statistics on the age distribution of children of our parents and children/adolescents samples.

Parents sample			Children Sample		
Age of their children (years)	<i>n</i>	%	Age (years)	<i>n</i>	
4–5	520	26.50	8–9	66	
6–7	349	17.79	10–11	105	
8–9	310	15.80	12–13	122	
10–11	330	16.82	14–15	161	
12–13	230	11.72	16–17	127	
14–15	149	7.59			
16–17	74	3.77			

Sex of their children	<i>n</i>	%	Sex	<i>n</i>	%
Male	961	48.98	Male	205	35.28
Female	997	50.82	Female	372	64.03
Diverse	4	0.2	Diverse	4	0.69

Vaccination status	<i>n</i>	%	Vaccination status	<i>n</i>	%
Yes	350	17.84	Yes	205	35.28
No	1,590	81.04	No	372	64.03
No answer	22	1.12	No answer	4	0.69

Test method	<i>n</i>	%	Vaccination status	<i>n</i>	%
Lolli PCR	1,416	72.17	Lolli PCR	396	68.16
Nasal swab antigen	503	25.64	Nasal swab antigen	177	30.46
Saliva-antigen	43	2.19	Saliva-antigen	8	1.38

Location	<i>n</i>	%	Location	<i>n</i>	%
Cologne	904	46.08	Cologne	202	34.77
Freiburg	1,058	53.92	Freiburg	379	65.23
Total: 1962			Total: 581		

effect test method $F(1, 1,862) = 233.7$; $p < 0.0001$; $\eta_p^2 = 0.11$]. We also noted a statistically significant interaction between age and test-method [$F(2, 1,862) = 10.6$; $p < 0.0001$, $\eta_p^2 = 0.01$], indicating that only parents of primary school children rated antigen tests worse than did parents of adolescents in secondary school (Scheffe *post-hoc* test $p < 0.0001$). The parents of kindergarten children rated the tests better than those of children in primary school. That finding was significant for saliva-based PCR tests ($p = 0.004$), but not for the few antigen tests performed in kindergarten ($p = 0.35$) (Figure 1).

Due to the small number saliva antigen tests were omitted from these analyses as the added value of the additional information would be low. Allocation to one of the other two groups, i.e., testing salivary sampling versus swab sampling, could lead to a distortion of the results. Instead, Supplementary Table S1 provides a descriptive comparison of the parent ratings for the different test methods.

Second, our general linear model analyses showed that the categorical factors gender, SARS-CoV-2 testing method, vaccination status of the children and linear predictors age, mental health status and the parents' pseudo-coded educational level explained 34% of the variance (corrected R^2) in a highly significant model [$F(7, 1,307) = 97.1$; $p < 0.0001$]. All factors except for age and gender showed highly

significant influences on the parents' evaluation of SARS-CoV-2 testing by school grades (Figure 2). In contrast, the additional factor "region" (Cologne or Freiburg) did not enter the final model as it had no significant effect [$F(1, 1,306) = 0.55$; $p = 0.46$] and did not increase the explained variance. Mean values and standard errors are presented in Table 2, further details are provided in Table 3.

For the full model, R^2 was 0,342 and adjusted R^2 was 0,339. Results of the additional models with different combinations of independent variables confirmed the results. Corresponding results including R^2 and adjusted R^2 can be found in Supplementary Tables S2–S7.

We found a strong association between vaccination status and appraisal of SARS-CoV-2 testing [$F(2, 1,306) = 135.6$; $p < 0.001$], with parents with unvaccinated children and unwilling to be vaccinated rating COVID-19 tests about one and a half school grades lower than parents whose children were vaccinated or who reported that their child wanted to be vaccinated. Higher SDQ scores, i.e., more mental health issues, also predicted a worse COVID-19 test evaluation [$F(1, 1,306) = 38.8$; $p < 0.001$], with about 10 SDQ-total score points triggering an about half-grade worse evaluation (cf. Table 3). Finally, we observed a small effect of parent's educational level [$F(1,$

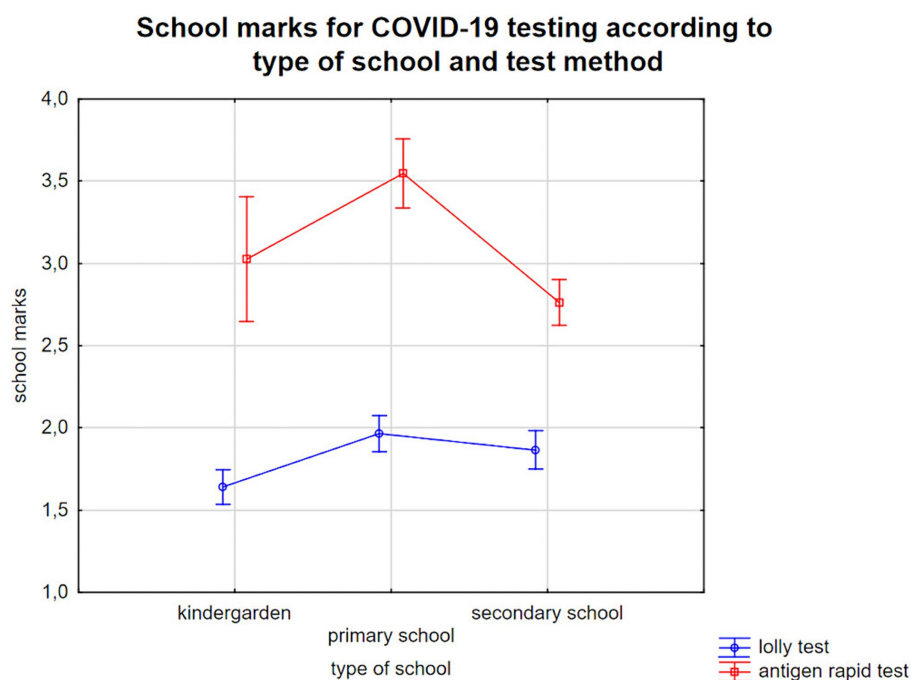


FIGURE 1

School grades (1—very good, 2—good, 3—satisfactory, 4—sufficient, 5—insufficient, 6—poor) for COVID-19 testing according to the child care setting and the children/adolescents' age (kindergarden: 4–6 years, primary school: 6–10 years, secondary school: 10–17 years).

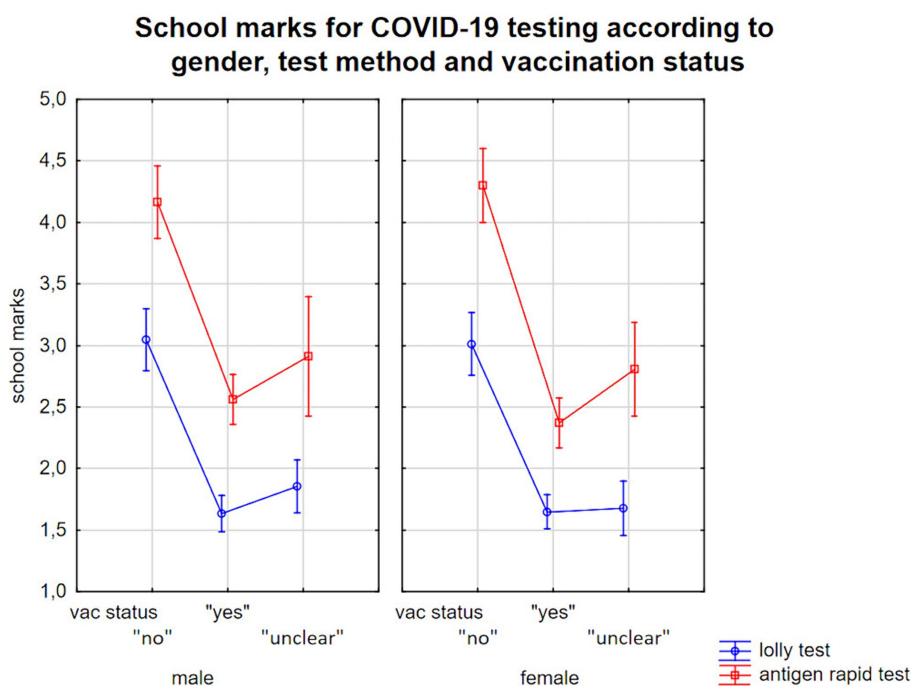


FIGURE 2

School grades for COVID-19 tests according to test method, children's gender and vaccination status/parents report on their children's' willingness to be vaccinated.

1,306)=6.0; $p=0.01$], with parents with no high-school degree evaluating SARS-CoV-2 testing about 0.2 evaluation scores lower than parents with a university degree (cf. Table 3).

Third, in an ordinal logit-model we showed that parents based their rating mainly on a correct test result (Wald statistic=142.5; $p<0.001$) and on whether the tests helped that their child could attend

TABLE 2 Mean values and standard errors (SE) assessing COVID-19 tests by parents (school grades ranging from 1 to 6).

	Vac status	Saliva-based PCR test			Nasal swab antigen test		
		N	Mean	SE	N	Mean	SE
Male	“No”	82	3.05	0.13	60	4.17	0.15
	“Yes”	242	1.63	0.07	123	2.56	0.10
	“Unclear”	110	1.85	0.11	22	2.91	0.25
Female	“No”	78	3.01	0.13	57	4.30	0.15
	“Yes”	275	1.65	0.07	127	2.38	0.10
	“Unclear”	105	1.68	0.11	36	2.81	0.20

Vac Status = vaccination status; no = unvaccinated/no vaccination information and unwilling to be vaccinated, yes = vaccinated or willing to be, unclear = no information provided about vaccination or vaccination intention.

TABLE 3 Effects of age, gender, SDQ total score, parents’ educational level, vaccination status/hesitancy and test method on COVID-19 test ratings—regression coefficients ($n = 1,315$).

Effect	Parameter	SE	p	95% CI	
				Lower bound	Higher bound
Age	−0.01	0.01	0.91	−0.02	0.02
Gender	0.01	0.03	0.85	−0.06	0.07
SDQ total	0.04	0.01	0.001*	0.05	0.05
Educational level	−0.11	0.04	0.001*	−0.20	−0.02
Vaccination status (unvaccinated vs. vaccinated)	0.87	0.05	0.001*	0.76	0.98
vaccination status unvaccinated vs. unclear status)	−0.52	0.05	0.001*	−0.61	−0.43
COVID-19 test method	−0.47	0.03	0.001*	−0.53	−0.40

* statistically significant, $p < 0.05$.

school safely (Wald statistic = 40.4; $p < 0.001$). They also worried about whether their child felt comfortable with the test but to a lesser extent.

We tested additional ordinal logit-models exploratorily. Contrary to their parents, children and adolescents placed stronger emphasis on the test’s convenience and painlessness (Wald statistic = 29.4; $p < 0.001$). Among them, this was the most important factor. Details are found in Table 4.

The SDQ total score was predicted by items referring to the children’s insecurity or irritability, how easy or difficult the test itself would be, as well as whether it was perceived as a burden by the child (Table 5). This score reflects the relationship between children’s testing experience, irritability, and an increased burden of mental health problems.

Finally, we found that the vaccination status was associated with the parent’s willingness to have their child undergo COVID-19 tests at school, and whether they believed such tests would help their child attend school safely (Table 6).

3.3 Child mental health status

The parent-rated SDQ revealed a mean total score of 8.9 ± 5.9 in this non-clinical sample. $N = 1,692$ parents rated their children in the 90% “normal” range according to German norms (53), while $n = 264$ parents (13.5%) rated their children as having more mental health problems (compared to 10% in the normative sample). The 8.9 mean value was significantly higher ($p < 0.001$) than the mean value in normative samples in Germany or in the USA before the pandemic

(53, 54), indicating a slight increase in overall mental health issues associated with the pandemic in the examined sample.

4 Discussion

Several studies have already investigated the acceptance of COVID-19 tests by using different samples (e.g., parents, students, school staff) and methodological approaches (online surveys, qualitative interviews, focus groups, experimental designs) (38, 55–60). Our study is primarily related to those studies that either included the perspective of parents or of parents/school staff and children (38, 57–60). In terms of the evaluation of saliva-based COVID-19 tests, other studies indicated a high level of acceptance and feasibility among parents and their children (59). Only one study specifically aimed to provide a comparison of different COVID-19 test methods (nasal swab testing vs. saliva-based testing) and included the perspective of children and adolescents (38). Within the group of children and adolescents, this study showed balanced evaluations between the two different test methods in terms of preference. Reasons for favoring the nasal swab included that it is quicker and easier. Reasons for favoring saliva-based tests included that it was more fun and easier. However, the study does have limitations in terms of generalizability due to its small sample size ($N = 135$ with $n = 67$ students) and the fact that no parent ratings were collected. In the adult population, there are already larger studies aimed at comparing acceptance ratings of different COVID-19 test methods (56). Our study provided substantive additional knowledge by analyzing the acceptance of two different

TABLE 4 Ordinal logit model—prediction of COVID-19 test evaluations (school grades) by parents/children's attitudes toward SARS-CoV-2 testing ($n = 1962/n = 581$).

		Coefficient	$P > z $	[95% CI]
Parents				
1	"The COVID-19 test is easy for my child."	0.159	0.123	−0.043; 0.361
2	"My child feels insecure when performing COVID-19 tests."	0.044	0.621	−0.130; 0.217
3	"The COVID-19 test is usually over quickly for my child."	0.091	0.288	−0.076; 0.258
4	"I think my child loses a lot of time performing COVID-19 tests"	0.164	0.006	0.048; 0.281
5	"I think it's a good idea, and consent to my child's being tested for COVID-19 at school/in kindergarten."	−0.427	<0.001	−0.589; −0.265
6	"I think my child likes the COVID-19 test."	0.314	<0.001	0.168; 0.459
7	"I have to wait too long for the test result."	0.105	0.048	0.001; 0.209
8	"I believe the COVID-19 test result is accurate."	−0.715	<0.001	−0.851; −0.580
9	"My child finds the COVID-19 test disgusting."	−0.159	0.051	−0.320; 0.001
10	"My child does not find the COVID-19 test unpleasant."	0.052	0.373	−0.063; 0.168
11	"My child dislikes the COVID-19 test (e.g., it hurts)."	0.090	0.226	−0.056; 0.235
12	"My child is embarrassed to do the COVID-19 test together with its class/group."	−0.066	0.388	−0.217; 0.084
13	"COVID-19 testing helps my child attend school safely."	−0.366	<0.001	−0.520; −0.211
14	"It helps my child that COVID-19 test result from school makes it easier to engage in leisure activities."	−0.017	0.727	−0.113; 0.079
15	"My child would feel embarrassed to get a positive test result in the classroom and have to be taken home by their parents."	0.040	0.409	−0.055; 0.134
16	"My child prefers/would like to get the result on the next day (and not in the classroom)."	−0.117	0.010	−0.206; −0.028
17	"Which grade would your child give the current test method in school or daycare?"	1.882	<0.001	1.725; 2.039
Children				
1	"The COVID-19 test is easy for me."	0.003	0.986	−0.323; 0.329
2	"I feel insecure when performing COVID-19 tests."	0.105	0.446	−0.165; 0.375
3	"The COVID-19 test is usually over quickly."	−0.122	0.372	−0.389; 0.145
4	"I think we lose a lot of time performing COVID-19 tests."	0.395	<0.001	0.203; 0.587
5	"I think it's a good idea and agree to perform this COVID-19 test at school."	−0.651	<0.001	−0.917; −0.385
6	"I have to wait too long for the test result."	0.069	0.437	−0.106; 0.244
7	"I believe the COVID-19 test result is accurate."	−0.568	<0.001	−0.815; −0.322
8	"I find the COVID-19 test disgusting."	0.146	0.239	−0.097; 0.390
9	"I do not find the COVID-19 test stressful."	0.052	0.539	−0.114; 0.218
10	"I find/found the COVID-19 test unpleasant."	0.630	<0.001	0.411; 0.850
11	"I'm embarrassed to do the COVID-19 test together with my class/group."	0.178	0.0186	−0.086; 0.441
12	"I think the COVID-19 tests help me attend school safely so that I do not have to do home-schooling."	−0.662	<0.001	−0.935; −0.388
13	"It helps that COVID-19 test result from school makes it easier for me to engage in leisure activities."	−0.136	0.083	−0.291; 0.018
14	"I would feel embarrassed to get a positive test result in the classroom and have to be taken home by my parents."	0.045	0.573	−0.111; 0.200
15	"I prefer/would like to get the result on the next day (and not in the classroom)."	−0.076	0.296	−0.219; 0.067

Bold text indicates statistically significant predictors, $p < 0.05$.

testing methods and potential risk factors in large samples, including the experiences of parents and their children.

Summarizing our main findings, we discovered:

1. overall better acceptance of saliva-based PCR tests rather than rapid nasal swab antigen tests
2. less acceptance of SARS-CoV-2 testing by parents of children in primary school compared to those with children in kindergarten and secondary school
3. an association between SARS-CoV-2 testing acceptance, test methods, and vaccination status: results reveal a preference for saliva-based PCR tests over nasal swabs by about one grade,

TABLE 5 Prediction of parents-rated SDQ total score by parental attitudes toward SARS-CoV-2 testing.

		Coefficient	$P > z $	[95% CI]
1	"The COVID-19 test is easy for my child."	−0.235	0.006	−0.402; −0.068
2	"My child feels insecure when performing COVID-19 tests."	0.25	<0.001	0.109; 0.390
3	"The COVID-19 test is usually over quickly for my child."	−0.101	0.153	−0.240; 0.038
4	"I think my child loses a lot of time performing COVID-19 tests"	−0.01	0.841	−0.109; 0.089
5	"I think it's a good idea, and consent to my child's being tested for COVID-19 at school/in kindergarten."	−0.032	0.644	−0.166; 0.103
6	"I think my child likes the COVID-19 test."	−0.029	0.631	−0.147; 0.089
7	"I have to wait too long for the test result."	0.058	0.185	−0.028; 0.144
8	"I believe the COVID-19 test result is accurate."	−0.07	0.213	−0.179; 0.040
9	"My child finds the COVID-19 test disgusting."	−0.064	0.363	−0.203; 0.074
10	"My child does not find the COVID-19 test unpleasant."	−0.138	0.005	−0.235; −0.041
11	"My child dislikes the COVID-19 test (e.g., it hurts)."	0.053	0.396	−0.070; 0.176
12	"My child is embarrassed to do the COVID-19 test together with its class/group."	0.17	0.010	0.041; 0.299
13	"COVID-19 testing helps my child attend school safely."	0.105	0.120	−0.027; 0.237
14	"It helps my child that COVID-19 test result from school makes it easier to engage in leisure activities."	−0.114	0.004	−0.193; −0.036
15	"My child would feel embarrassed to get a positive test result in the classroom and have to be taken home by their parents."	0.108	0.007	0.030; 0.187
16	"My child prefers/would like to get the result on the next day (and not in the classroom)."	0.03	0.408	−0.042; 0.103
17	"Which grade would your child give the current test method in school or daycare?"	0.021	0.700	−0.087; 0.129

particularly among parents of unvaccinated children and if their child expressed future vaccination reluctance

4. a negative association between mental health problems and SARS-CoV-2 testing acceptance.

4.1 Saliva-based PCR testing versus nasal swab antigen testing

Overall, our research suggests better acceptance of saliva-based PCR testing compared to nasal swab antigen testing among parents of children across all three age groups. This is in line with prior studies that also reported a high acceptance of PCR saliva-based testing in children (19, 39, 61, 62). Similarly, combined throat and nasal swabs have also been described as a feasible alternative down to 4 years of age in Western Australia (63).

The saliva-based method's test ratings were on average 1.5 evaluation scores higher than those of nasal swab antigen tests. Compared to antigen tests, parents valued the PCR tests' greater accuracy, while children found the test to be less uncomfortable. It is evident from our results that the comfort level of the test is highly relevant for children and adolescents, underlining the importance of individual testing experience in this population. Therefore, gaining insight into the children's experiences with the tests is vital and needs to be considered to develop a child-centered approach.

The delay in receiving the results on the next morning was rated less important. This finding is in line with studies reporting perceived test-correctness as an important factor (26, 64, 65).

Importantly, our results regarding the mandatory serial testing of asymptomatic children at school differ from how self-collected nasal

swab antigen tests collected by symptomatic children and adolescents actively cared for by the healthcare system were rated in France (66), with the latter rating nasal swabs more positively. The same seems to apply to adult subjects in Germany (67). Together, these findings suggest benefits of voluntary surveillance measures and imply that in case of mandatory testing the most reliable and convenient test method should be employed (saliva-based PCR tests). Other studies also showed that the highest long-term participation rates in school surveillance settings were obtained using saliva-based testing (68) and biweekly saliva testing of at least 50% of children and staff has been recommended to limit secondary infections (69). Such rates seem attainable through voluntary saliva-based PCR tests, also due to perceived high reliability of the results. Alternatives to saliva-based PCR tests have been proposed, such as gargling at home and pooling probes at school (70, 71).

4.2 Understanding the test-taking population and their motivation

4.2.1 The influence of age on test ratings

Age has been shown to be an important predictor for the attitude and acceptance of both COVID-19 vaccination and testing (30–32, 72). While this might reflect age-associated differences in attitude toward the pandemic situation in adults, it could indicate a shortage of resources to deal with test requirements relative to the available support by adult caregivers (teachers, educational staff) in children and adolescents. In contrast to schools and kindergartens, the acceptability of all test methods has been suggested to be high in university settings (55).

TABLE 6 Prediction of vaccination status by parents' attitudes toward SARS-CoV-2 testing.

		Coefficient	$P > z $	[95% CI]
1	"The COVID-19 test is easy for my child."	−0.327	0.038	−0.636; −0.018
2	"My child feels insecure when performing COVID-19 tests."	0.222	0.083	−0.029; 0.472
3	"The COVID-19 test is usually over quickly for my child."	−0.032	0.807	−0.286; 0.222
4	"I think my child loses a lot of time performing COVID-19 tests"	−0.076	0.428	−0.262; 0.111
5	"I think it's a good idea, and consent to my child's being tested for COVID-19 at school/ in kindergarten."	−0.745	<0.001	−0.970; −0.520
6	"I think my child likes the COVID-19 test."	−0.345	0.002	−0.560; −0.129
7	"I have to wait too long for the test result."	−0.126	0.154	−0.300; 0.047
8	"I believe the COVID-19 test result is accurate."	−0.163	0.111	−0.364; 0.038
9	"My child finds the COVID-19 test disgusting."	0.296	0.018	0.051; 0.541
10	"My child does not find the COVID-19 test unpleasant."	−0.081	0.397	−0.268; 0.106
11	"My child dislikes the COVID-19 test (e.g., it hurts)."	−0.153	0.217	−0.396; 0.090
12	"My child is embarrassed to do the COVID-19 test together with its class/group."	0.007	0.955	−0.234; 0.248
13	"COVID-19 testing helps my child attend school safely."	−0.417	<0.001	−0.642; −0.191
14	"It helps my child that COVID-19 test result from school makes it easier to engage in leisure activities."	0.308	<0.001	0.138; 0.479
15	"My child would feel embarrassed to get a positive test result in the classroom and have to be taken home by their parents."	0.008	0.915	−0.140; 0.156
16	"My child prefers/would like to get the result on the next day (and not in the classroom)."	0.12	0.096	−0.021; 0.262
17	"Which grade would your child give the current test method in school or daycare?"	−0.034	0.74	−0.233; 0.165

Consequently, primary school children might need more support while testing compared to older individuals, as they might be already burdened by the requirements of learning at school (higher demands but fewer adult caregivers available than in pre-school children's daycare facilities).

4.2.2 Vaccination willingness and association with test ratings (school grade)

Vaccination status and children's willingness to be vaccinated were important predictors of how surveillance was rated by the parents, with rejecting vaccination being associated with lower acceptance of COVID-19 surveillance. In general, we observed many more families who categorically either favored or rejected COVID-19 measures than families who harbored specific concerns about the vaccination and would readily agree to serial testing to protect their child. For future vaccination and surveillance strategies, information campaigns should consider specific concerns as well as a general mistrust toward public health measures. In the group of parents reporting that their children were unwilling to be vaccinated, the antigen test ratings dropped to a mean level of a grade 4 (on the scale from 1 to 6). Considering the variance in the other group's ratings, this can be deemed a considerable difference in test perception and suggests that antigen testing could be an insufficient surveillance strategy in this group. In comparison, screening via saliva-based PCR tests did not dissolve the effect of general attitudes toward COVID-19 public health measures, but appeared to mitigate this effect and elevate ratings to the "satisfactory" level (grade 3). Therefore, this test method might be an especially important factor in raising the acceptance of test

strategies in vulnerable groups and also emphasizes a potential benefit of adapting public health measures to specific target groups.

4.2.3 Testing acceptance and mental health problems

Our study found that children and adolescents with mental health issues were more likely to reject COVID-19 surveillance measures in public schools and daycare facilities compared to those without such issues. Their reluctance toward testing methods correlated with higher levels of anxiety or insecurity, underscoring the need for tailored support and reassurance during virologic tests. Screening these vulnerable groups for concerns about testing could prove beneficial in alleviating apprehensions.

The pandemic itself has exacerbated anxiety and mental health symptoms in children and adolescents (47, 48, 73), possibly due to reduced social contact and physical activity (74). Thus, specific assistance for vulnerable groups is crucial in shaping effective public health measures (47, 48, 73). While more anxious adults are generally more accepting of testing (75), parents of children with behavioral or mental health issues in our study reported more negative perceptions and greater difficulties with testing. Notably, we did not find an association between mental health issues and a negative attitude toward pandemic public health measures overall, unlike findings in samples of depressed individuals (76).

4.2.4 The influence of parental educational background

Consistent with previous research (26, 32), our study revealed a modest impact of parental educational background on perceptions of

COVID-19 tests. Parents with higher educational attainment may have better access to information and tend to weigh the benefits and costs of SARS-CoV-2 testing differently. Conversely, individuals with lower educational backgrounds may rely more on information from family and friends rather than scientific sources (77). However, corresponding findings have been inconsistent (78–80). Thus, each country's specific conditions have to be considered and examined separately.

4.3 Limitations

When interpreting the results, some limitations need to be considered. Convenience sampling was used, which is known to be limited by potential selection bias and external validity of findings. This may hinder the ability to make causal inferences. Although we were unable to collect data from a representative sample for German society, our large cohorts and the absence of effects of the place of residence suggest that valid conclusions can be drawn and somewhat generalized. We still need to confirm our results with independent samples, as we cannot exclude the possibility that certain parent groups were more likely to respond to our survey than others (81). There is evidence of local differences among adult subjects in different regions (UK, China) (82). Though public health measures differ somewhat among the German states of North Rhine-Westphalia (Cologne) and Baden-Württemberg (Freiburg), the environmental variables between Cologne and Freiburg seem to have been quite homogeneous.

As only a tiny subgroup of children had experienced both sampling methods and were asked to evaluate the last sampling method employed, we were unable to conduct within-subject comparisons of the two methods. However, our results converge with findings of within-subject comparisons in smaller samples, showing a preference for saliva sampling over nasopharyngeal swabs (83).

In addition to distributing the online survey to parents and children via teachers and educators, we advertised our study via notice boards in schools and daycare centers. It is therefore possible that people may have participated who do not belong to the intended sample group, which could have compromised the validity of our results. However, any biases, if evident, should not be significant thanks to our large sample.

An additional limitation is that we did not incorporate the latest epidemiologic data in our analyses. The number of infection rates and the current pandemic situation might have a biasing effect on how people rate COVID-19 tests. Any proposals we have for future testing should be derived after considering the most recent epidemiologic data.

5 Conclusion

In this study, we observed wide variability in testing acceptance across different demographic groups and factors. We identified parental educational level, children's age, mental health status, and vaccination willingness as significant factors influencing acceptance of COVID-19 surveillance measures. Saliva-based PCR testing emerged as a preferred method, particularly for serial testing in schools and daycare facilities, potentially enhancing acceptance among vulnerable groups. These findings provide valuable insights for

policy makers when formulating future testing strategies. While our results need replication due to our non-representative sample, the implications from this large cohort study should be carefully considered in shaping future public health policies.

6 Propositions for public health testing strategies

Our study aims to provide precise and actionable recommendations for future pandemic testing strategies, applicable to COVID-19 or other infectious diseases irrespective of specific virus variants. Building on the WHO framework for vaccination behavioral and social drivers (69), alongside our comprehensive analysis and existing literature, we propose the following recommendations:

1. Choosing the right test method

Voluntary testing: Whenever feasible, offering voluntary testing options enhances individual autonomy and ownership, potentially improving test acceptance rates.

Saliva-based pooled PCR tests: Recommending the use of saliva-based PCR tests, particularly for their acceptability in school and kindergarten settings, should be considered. This method has shown promise in our study for increasing testing compliance, especially among vulnerable groups. However, decision-making on whether tests should be mandatory must be context-specific, considering pandemic dynamics.

Other considerations: Besides acceptance, sensitivity/specificity, testing time, invasiveness, and cost-effectiveness are crucial factors that should guide the selection of the appropriate test method.

2. Specific assistance for vulnerable groups

Age-specific support: For younger children, such as those in primary school, integrating external educational professionals to assist school staff can alleviate their workload. These professionals can explain tests in child-friendly terms and administer them efficiently to minimize discomfort.

Support for children with mental health issues: Tailored preparation and support are essential for children with mental health challenges, ensuring they feel comfortable and reassured during testing procedures.

3. Additional education and motivation

Targeted educational campaigns: Regions with higher proportions of parents with lower educational levels would benefit from enhanced educational campaigns about testing benefits and procedures.

Testing ambassadors: Introducing "testing ambassadors" within communities could effectively raise awareness and promote testing. These ambassadors, trained individuals from local communities, can advocate for testing benefits and provide guidance tailored to community needs (84).

These propositions aim to leverage our study findings to optimize testing strategies, fostering broader acceptance and effectiveness of public health measures by providing a clear path forward based on empirical findings, ensuring relevance and applicability in real-world public health settings. Implementing these recommendations could contribute to mitigating the impact of infectious diseases and enhancing overall community health resilience.

Data availability statement

The datasets presented in this article are not readily available because the ethics committee did not grant permission to share study data with third parties or to upload data in an anonymized form. Requests to access the datasets should be directed to stephan.bender@uk-koeln.de.

Ethics statement

The studies involving humans were approved by Ethik-Kommission der Albert-Ludwigs-Universität Freiburg; Ethikkommission der Medizinischen Fakultät der Universität zu Köln. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

JL: Methodology, Formal analysis, Writing – review & editing. CK: Writing – review & editing, Writing – original draft. SK: Writing – review & editing, Validation, Data curation. HW: Writing – review & editing. TL: Writing – review & editing, Supervision. EB: Writing – original draft, Writing – review & editing. SB: Writing – review & editing, Writing – original draft, Supervision, Resources, Methodology, Formal analysis, Data curation, Conceptualization.

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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.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2024.1264019/full#supplementary-material>

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