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REVIEW

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Prevalence of mental health symptoms in children and adolescents during the COVID-19 pandemic: A meta-analysis

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Abstract

The COVID-19 pandemic and its accompanying infection control measures introduced sudden and significant disruptions to the lives of children and adolescents around the world. Given the potential for negative impacts on the mental health of youths as a result of these changes, we conducted a systematic review and meta-analysis to examine the prevalence of depressive symptoms, anxiety symptoms, and sleep disturbances in children and adolescents during the pandemic. We searched major literature databases for relevant cross-sectional or longitudinal studies that included primary and secondary school students or children and adolescents ≤18 years of age. Prevalence values were extracted, logit-transformed, and pooled. Based on 191 included studies with 1,389,447 children and adolescents, we found the pooled prevalence of depressive symptoms, anxiety symptoms, and sleep disturbances to be 31%, 31%, and 42%, respectively. Age, grade levels, education levels, gender, geographical regions, and electronics use were correlated with the prevalence of mental health symptoms. The prevalence of mental health symptoms also increased with time, although signs of recovery and stabilization were also observed. Overall, the results from this

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review demonstrate the need for increased mental health research, monitoring, and intervention for children and adolescents during the current and future pandemics.

KEYWORDS
adolescent, anxiety, children, COVID-19, depression, sleep disturbances

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic has greatly impacted the lives of people around the world, both physically and mentally. As countries and governments strived to mitigate the impact of the virus on vulnerable populations and overstretched healthcare systems using limited resources, the psychological wellbeing of their populations was often overlooked.[1] Before comprehensive vaccination programs were introduced, measures, such as widespread lockdowns, closure of businesses and public institutions, and the termination of social gatherings, were used as primary infection control strategies.[2] These restrictions caused significant psychological aggravations as they led to familial separation, reduced personal freedoms and socialization, and increased risks of financial instability due to unemployment and disruptions to global supply chains.[3] The continuously evolving nature of the pandemic also serves as a constant stressor, as previous studies have shown that large-scale, unpredictable, traumatic events can intrinsically leave affected individuals in a state of shock and insecurity.[4] These aforementioned factors, compounded by alarmist reporting from influential news sources and social media,[5,6] have shaped the pandemic into an unprecedented threat to the global mental health landscape.

Indeed, systematic reviews conducted during the early periods of the COVID-19 pandemic have shown worrying mental health trends involving multiple populations. Among the general global population, the estimated prevalence of major depressive disorders and anxiety disorders increased by over 20% during 2020.[7] Additionally, elevated levels of mental health disorders were commonly reported by studies conducted among vulnerable populations, such as COVID-19 patients,[8] college students,[9] and healthcare workers.[10] Despite the implementation of COVID-19 vaccines and new antiviral therapies, resistant viral variants, such as Omicron and Omicron sublineages,[11] continue to affect the daily lives of individuals, especially those residing in low- and middle-income countries (LMICs) that have limited access to vaccines.[12] Recent COVID-19 resurgences in densely populated countries, such as China, have also led to renewed lockdown measures in an attempt to curb viral transmission.[13,14] It is evident that the psychological impact of the virus will persist as the world enters the third year of the pandemic; thus, continued mental health research and monitoring are warranted to evaluate the need for implementing mental health services and preventive strategies for pandemic-related psychological disorders.

Children and adolescents, who often benefit from routine and structured activities,[15] have been particularly vulnerable to the psychological effects of the pandemic and its associated infection control measures.[16] In the fall semester of 2020, numerous countries, including Canada, the United States, Australia, and China, elected to only partially reopen schools in select low-risk regions or through the implementation of virtual learning technologies. According to worldwide data from the United Nations Educational, Scientific and Cultural Organization (UNESCO), over 600 million children and adolescents have been impacted by these schooling changes.[17] Previous investigations have shown that youths who are out-of-school or engaging in virtual learning are less physically active, have increased screen time, and have irregular sleeping patterns.[18–20] These factors have been shown in prepandemic studies to be major drivers of mental health disorders in children and adolescents,[21–23] and these problems were expected to worsen due to forced home confinement and decreased interaction with other youths during the pandemic.[24,25] Barring impacts from school closures, children and adolescents are also directly affected by the pandemic in ways similar to their adult counterparts.[26,27] For example, fear concerning the wellbeing of friends and family or externalization of finance-related problems from parents and guardians[28] can take a persistent toll on youths' mental health status.[25] Children who have parents or relatives infected with SARS-CoV-2 or working as frontline healthcare workers may also be particularly susceptible to mental health problems due to constant grief and worry.[25,29]

Without early detection and timely intervention, pandemic-related mental health issues can substantially disrupt children and adolescents' performance in school, as well as their behaviors and self-discipline at home and within their communities.[30,31] Undetected and untreated disorders may also lead to self-harm via increased risks of suicidal ideation, which became the second leading cause of mortality among adolescents aged 10–19 in the United States based on prepandemic data from 2019.[32] Additionally, youths struggling with emotional problems may adopt unhealthy coping strategies, such as substance abuse.[33,34] In the long-term, adults who have experienced mental health problems during childhood or adolescence may be at risk of developing substance dependence, having reduced earning potentials, or having difficulty forming long-lasting social relationships.[35]

Although there has been substantial research interest in the physical manifestations of COVID-19 in children and adolescents, more extensive research on the psychological impact of the pandemic in this population is required. A previous review published in August 2021 suggested that the prevalence of depressive and anxiety symptoms in children and adolescents was 25% and 21%, respectively.[36] However, its findings were limited by low sample sizes, significant publication bias, and a lack of in-depth analysis of effects from covariates, such as grade levels, electronics use, or physical activity. Additionally, while the study found significant positive temporal trends with mental

health symptoms, the majority of included studies were conducted in the early stages of the pandemic. Therefore, we conducted this systematic review and meta-analysis to provide an updated and more comprehensive assessment of the prevalence of depressive symptoms, anxiety symptoms, and sleep disturbances in children and adolescents. Additionally, we assessed the impact of different covariates and moderators on the mental health status of this population.

METHODS

We conducted this systematic review and meta-analysis in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines[37] (see Table S1 for the PRISMA checklist) and followed recommendations from the Cochrane Handbook for Systematic Reviews of Interventions.[38] This systematic review was prospectively registered on PROSPERO[39] (CRD42020195965).

Literature search

We systematically searched the following databases from January 1st, 2020 to October 10th, 2022 for relevant publications: (1) EBSCOhost CINAHL; (2) Ovid EMBASE; (3) Ovid MEDLINE; (4) Ovid PsycINFO; (5) PubMed Clinical Queries (with COVID-19 General Filter); (6) Web of Science Core Collection; and (7) China National Knowledge Infrastructure (CNKI). The search strategies used are appended in Tables S2–S8. Additionally, we hand-searched the reference sections of reviews identified during the database search for relevant publications.

Eligibility criteria

Publications were included in the meta-analysis if they met the following criteria: (1) primary cross-sectional or longitudinal studies conducted after January 2020 (or reported data from time points after January 2020); (2) included children and adolescents ≤18 years of age or students enrolled in primary or secondary educational institutions; and (3) reported the prevalence of depressive symptoms, anxiety symptoms, and/or sleep disturbances, as assessed using self-reported instruments or clinical interviews. Studies specifically targeting children with special needs or pre-existing mental health disorders were excluded. No limitations on the publication's language or country of origin were placed.

Study selection

Following deduplication using Endnote 20, we screened titles and abstracts retrieved from the database searches independently and in-duplicate using Rayyan[40] against the aforementioned eligibility criteria. Study entries deemed relevant by two reviewers were subsequently entered into an in-duplicate full-text screening process. Disagreements during both stages were resolved via arbitration with a senior author.

Data extraction

Data extraction was completed independently and in-duplicate using a standardized data extraction form designed *a priori*. The following data items were included in the data extraction form: (1) study methods and metadata (i.e., author's last name, year of publication, country of study origin, cross-sectional/longitudinal study design, duration of data collection, and response rate); (2) participant characteristics (i.e., sample size, gender distributions, mean/median age with variance, and inclusion criteria, such as grade level or education level); and (3) outcome-related data (i.e., assessment scales and thresholds for depressive symptoms, anxiety symptoms, and sleep disturbances, in addition to overall prevalence values, and prevalence values stratified by prespecified subgroups). Disagreements were resolved via arbitration with a senior author. When we encountered longitudinal studies that reported outcome values at multiple time points, we included only the prevalence at the earliest time point after January 2020 in the meta-analyses. Data from the remaining time points were included for completing the meta-regression analyses by the date of data collection.

For studies with missing information, we made attempts to contact the principal investigators to obtain relevant unpublished data.

Risk of bias assessment

We assessed the risk of bias for each included study using a validated tool developed by Hoy et al.[41] The tool assesses methodological quality across 10 items addressing a prevalence study's external and internal validity. Each criterion was given a score of 0 if it was unaddressed/unclear or a score of 1 if it was met. The overall risk of bias was rated as either low (score >8), moderate (score 6—8), or high (score ≤5) based on threshold values established in previous systematic reviews.[42,43]

Statistical analysis

We performed random-effects prevalence meta-analysis using the *meta 5.2-0* library in R.[44] Prevalence values were logit-transformed and pooled using a generalized linear mixed-effects model[45] with Hartung–Knapp adjustment.[46,47] In addition to synthesizing the total prevalence values, we also pooled the prevalence of the assessed mental health conditions by different severities (mild, moderate, or severe as defined by individual study criteria).

The presence of heterogeneity was assessed using Cochran's Q test with a significance level of $p_Q < 0.10$ following recommendations from the Cochrane Handbook.[38] We further quantified heterogeneity using I^2 statistics. An I^2 value ≥75% was considered to be indicative of

serious heterogeneity as recommended by the Cochrane Handbook.[38] Lastly, we assessed the presence of small study effects as an indication of publication bias using funnel plots and Egger's regression tests.[48]

Meta-regressions and subgroup analyses

To assess the impact of covariates and moderators on the pooled prevalences and heterogeneity, we conducted subgroup analyses based on the following prespecified subgroups: (1) gender; (2) education level (elementary/primary school vs. junior secondary/middle school vs. senior secondary/high school); (3) geographical region as defined by the World Health Organization regional classification; and (4) screening tools and threshold values used for assessment of mental health symptoms. Additionally, we performed subgroup analyses based on potential risk factors for mental health issues in youths identified in previous studies: (1) levels of physical activity (defined as per individual study criteria);[49] (2) level of electronics/Internet use (defined as per individual study criteria);[50,51] (3) infection in relatives;[25,29,52] (4) parents/guardians as healthcare workers;[25,29,52] and (5) financial difficulties.[53]

In addition to the subgroup analyses, we performed meta-regressions to assess correlations between the pooled prevalence and individual study-level covariates. We prospectively chose mean age, grade level, and date of data collection (expressed as the number of months since January 1st, 2020 to the last day of the study duration) as our covariates of interest. Only one covariate was fit into each meta-regression model.

Based on reviewer feedback, a *post hoc* nonlinear regression was completed for the date of data collection with a restricted cubic spline (RCS) model using the *metafor 3.8-1* and *rms 6.3-0* libraries in R.[54] The model consists of multiple connected, continuous cubic polynomials separated by knots. Five knots were used for nonlinear regressions in this review following recommendations from previous studies,[55] positioned at the 5th, 25th, 50th, 75th, and 95th percentiles of date distribution. The Akaike Information Criterion (AIC) was used to compare the model fit between the nonlinear and linear meta-regression models for the date of data collection. A lower AIC indicates a better relative model fit.

Sensitivity analyses

To assess the impact of study biases on the pooled prevalences, we conducted the following *post hoc* sensitivity analyses: (1) including only studies using validated screening tools; (2) including only studies using self-rated screening tools; and (3) excluding studies with a high risk of bias.

RESULTS

After deduplication, we assessed 24,926 abstracts for eligibility (see Figure 1). After the screening process, 191 studies were included in the systematic review[50,51,56–244] with a total of 1,389,447 children and adolescents. The mean age of the included participants ranged from 4.1 to 18.9 years old. Additional information regarding the included studies and participants is tabulated in Table S9.

A majority of the included studies used cross-sectional survey designs with convenience snowball sampling conducted online or in local schools. Overall, 135 studies (70.7%) were conducted in 2020, 26 studies (13.6%) were conducted in 2021, and one study (0.5%) was conducted in 2022. Four studies (2.1%) were conducted using longitudinal designs over multiple years. The remaining 25 studies (13.1%) did not explicitly report the duration of data collection.

Thirty-one studies (16.2%) assessed youths from Region of the Americas, nine studies (4.7%) assessed youths from the Eastern Mediterranean Region, 44 studies (23.0%) assessed youths from the European Region, 10 studies (5.2%) assessed youths from the South-East Asia Region, and 95 studies (49.7%) assessed youths from the Western Pacific Region. Two studies (1.0%) included participants from multiple geographical regions. No studies reported data originating from the African Region.

Risk of bias

Using the risk of bias tool developed by Hoy et al.,[41] 35 studies (18.3%) were rated as having a low risk of bias, 138 studies (72.3%) were rated as having a moderate risk of bias, and 18 studies (9.4%) were rated as having a high risk of bias. A majority of included studies were rated as having a moderate or high risk of bias due to deficiencies in items relating to external validity, such as the use of snowball/convenience sampling, the inclusion of mainly local youths (who may not be an accurate representation of the national or regional youth population), and low or unreported response rates. The risk of bias ratings are summarized in Figure 2 and tabulated in Table S10.

Prevalence of depressive symptoms

The pooled prevalence of depressive symptoms from 129 studies (n = 524,417) was 31% (95% CI 27–35%; see Figure 3 and Figure S1) with serious and significant heterogeneity (I^2 = 100%, $p_Q < 0.01$). 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.

There were significant subgroup differences by screening tools and threshold values ($p < 0.01$; see Figure S2). The most commonly reported screening tool was Patient Health Questionnaire-9 with a positive screening threshold of ≥5 (used by 22 studies with n = 155,587), which yielded a prevalence of 44% (95% CI 36–52%). This value is substantially greater than the overall prevalence estimate.

None of the sensitivity analyses led to any notable changes to the pooled prevalence (see Figure 3), and there were no significant small study effects as an indication of publication bias (p = 0.95; see Figure S3).

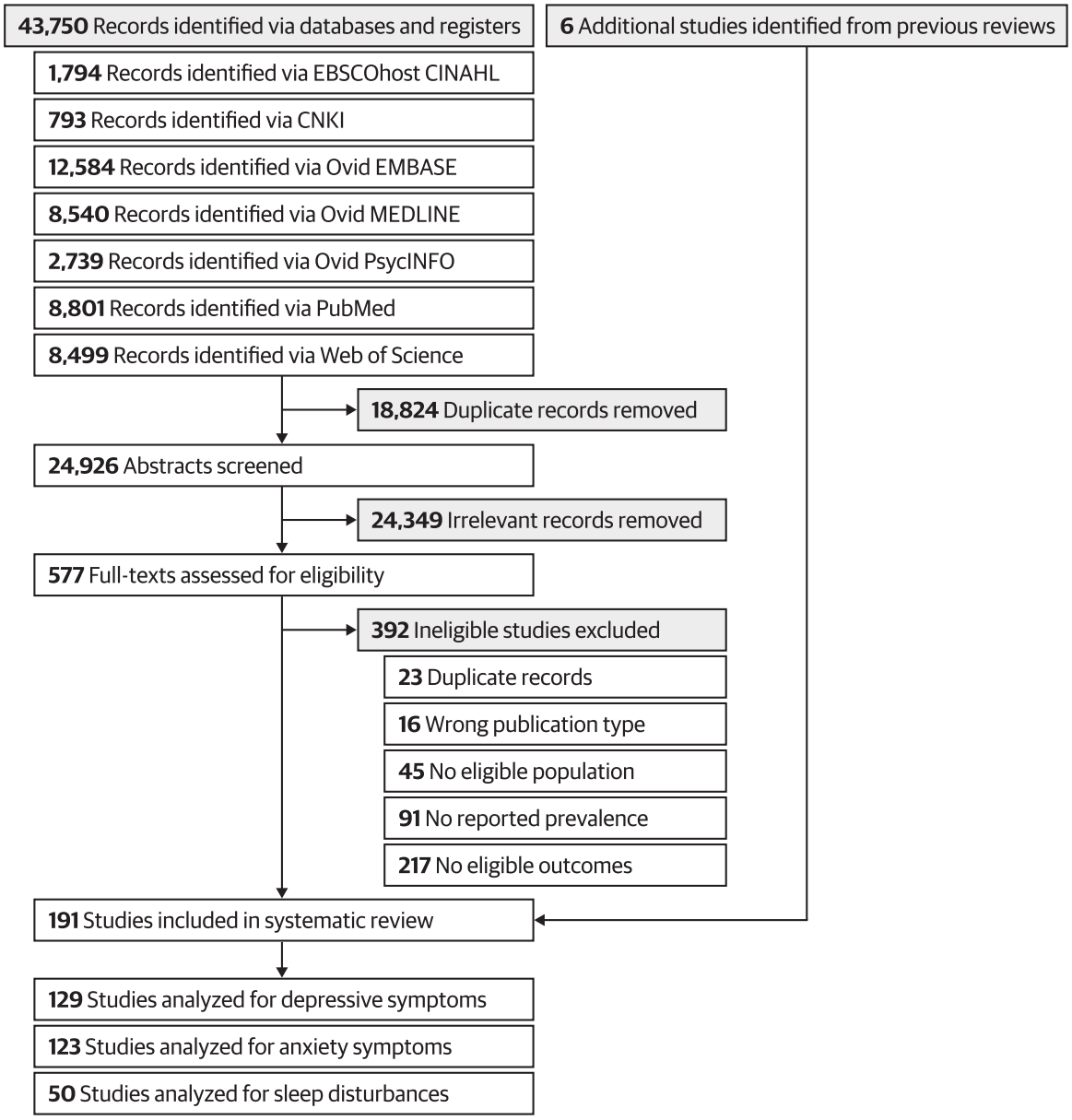

FIGURE 1 PRISMA flowchart for the identification and selection of relevant studies.

Prevalence of anxiety symptoms

The pooled prevalence of anxiety symptoms from 123 studies (n = 1,241,604) was 31% (95% CI 27–35%; see Figure 4 and Figure S4) with serious and significant heterogeneity (I^2 = 100%, $p_Q < 0.01$). The prevalence of mild, moderate, and severe anxiety symptoms was 19% (95% CI 15–24%), 12% (95% CI 8–17%), and 5% (95% CI 3–7%), respectively.

There were significant subgroup differences by screening tools and threshold values ($p < 0.01$; see Figure S5). The most commonly reported screening tool was Generalized Anxiety Disorder-7 with a positive screening threshold of ≥5 (used by 27 studies with n = 604,491), yielding a prevalence of 35% (95% CI 29–41%) which is 4% greater compared to the overall prevalence estimate.

Sensitivity analysis yielded minor changes in the prevalence estimates. Excluding studies using nonvalidated tools reduced the prevalence by 3%, while excluding parental-rated scales and studies with high risks of bias reduced the prevalence by 2% (see Figure 4). There were no significant indications of publication bias (p = 0.95; see Figure S6).

Prevalence of sleep disturbances

The pooled prevalence of sleep disturbances from 50 studies (n = 104,219) was 42% (95% CI 33–52%; see Figure 5 and Figure S7) with serious and significant heterogeneity (I^2 = 100%, $p_Q < 0.01$). We did not conduct analyses stratified by symptom severity due to a paucity of data. Excluding studies using nonvalidated tools and studies with a high

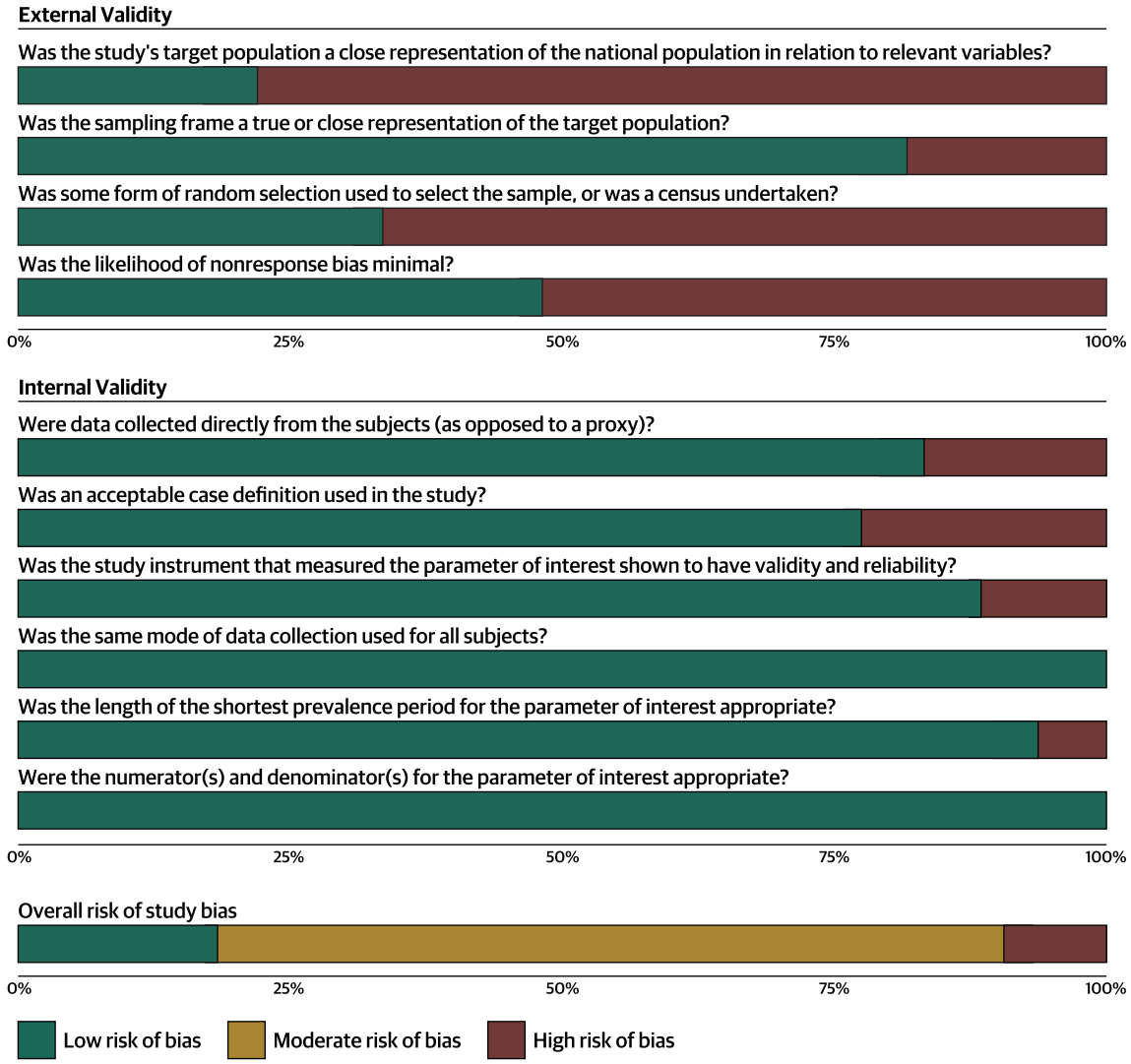

FIGURE 2 Summary diagram showing an overview of the risk of bias ratings of the included studies.

risk of bias increased the prevalence by 4% and 3%, respectively, while excluding studies using parental-rated tools reduced the prevalence by 5% (see Figure 5). There were no significant indications of publication bias ($p = 0.83$; see Figure S8).

There were significant subgroup differences by screening tools and threshold values ($p < 0.01$; see Figure S9). The most commonly reported screening tool was the Pittsburgh Sleep Quality Index (PSQI) with a positive screening threshold of >5, which was used by 13 studies with a collective sample size of 28,483 youths. The pooled prevalence based on assessments using the criteria of PSQI > 5 was 48% (95% CI 30–66%), which is 6% greater compared to the overall pooled estimate.

Subgroup analyses by geographical region

There were significant subgroup interactions by geographical regions for all assessed outcomes. Specifically, the prevalence of depressive and anxiety symptoms was substantially higher for youths from the Eastern Mediterranean and European Regions compared to other regions. Additionally, the prevalence of sleep disturbances was also higher for youths from the Eastern Mediterranean Region compared to other regions. In contrast, youths from the Western Pacific Region reported a substantially lower prevalence of sleep disturbances and anxiety symptoms compared to other regions (see Figures 3–5 and Figures S10–S12).

Subgroup analyses by education level

We found significant subgroup interactions by education level for the prevalence of depressive (see Figure S13) and anxiety (see Figure S14) symptoms but not for the prevalence of sleep disturbances. Students in high school reported a higher prevalence of depressive and anxiety symptoms compared to middle and elementary school students. Additionally, students in middle school also reported higher prevalences of depressive symptoms compared to elementary school students (see Figures 3–5).

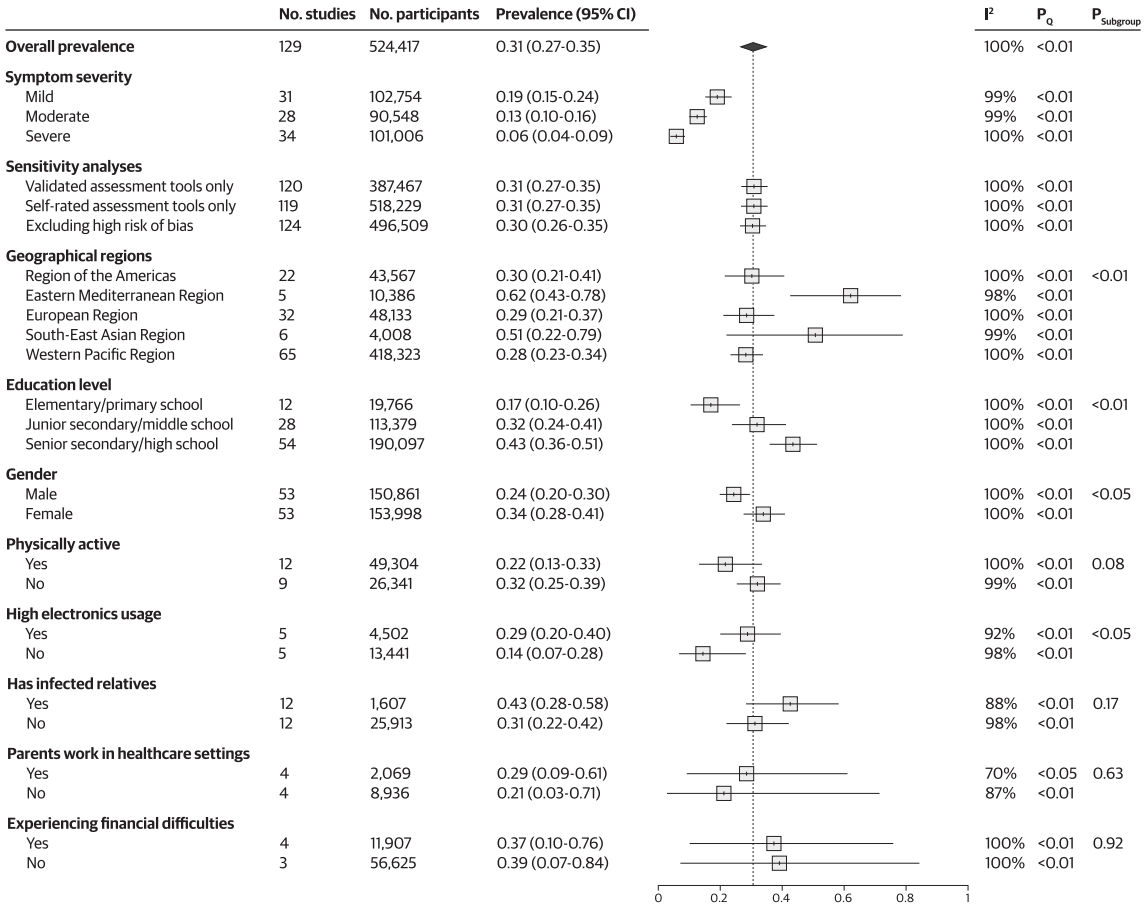

FIGURE 3 Forest plot showing the pooled prevalence of depressive symptoms and results of sensitivity analyses and subgroup analyses. $P_{subgroup}$ indicates the result of the test for subgroup differences. Abbreviation: CI, confidence interval.

Subgroup analyses by gender

There were significant subgroup interactions by gender for the prevalence of depressive (see Figure S15) and anxiety (see Figure S16) symptoms but not for the prevalence of sleep disturbances. While we planned to include other genders apart from male and female in this subgroup analysis, no studies reported relevant subgroup outcomes for noncisgender subgroups. Female youths reported higher prevalences of depressive and anxiety symptoms compared to male youths (see Figures 3–5).

Subgroup analyses by electronics usage

There were significant subgroup interactions by electronics usage for the prevalence of depressive (see Figure S17) and anxiety (see Figure S18) symptoms but not for the prevalence of sleep disturbances. The definitions used by each study to define high electronics usage are tabulated in Table S11. Youths with high electronics usage reported a higher prevalence of depressive and anxiety symptoms compared to youths with low electronics usage (see Figures 3–5).

Other subgroup analyses

None of the subgroup analyses yielded significant interactions apart from the aforementioned subgroups. Subgroup analyses by physical activity levels and parental healthcare occupations were not conducted for the prevalence of sleep disturbances due to a lack of data. The results of these subgroups are listed in Figures 3–5.

Meta-regression analyses

Based on the meta-regression analyses, there were significant positive correlations between the prevalence of depressive symptoms and age ($p < 0.01$; see Figure 6A) and grade levels ($p < 0.01$; see Figure 6B). The prevalence of anxiety was positively correlated with grade levels ($p < 0.01$; see Figure 6C) but not age ($p = 0.07$). The prevalence of sleep disturbances was not correlated with age ($p = 0.16$) or grade levels ($p = 0.65$).

All three outcomes were positively correlated with the date of data collection in the linear meta-regression ($p < 0.05$ for depressive symptoms and $p < 0.01$ for both anxiety symptoms and sleep disturbances; see Figure 6D–F). However, only the prevalence of anxiety

	No. studies	No. participants	Prevalence (95% CI)	I^2	P_Q	$P_{subgroup}$
Overall prevalence	123	1,241,604	0.31 (0.27-0.35)	100%	<0.01	
Symptom severity						
Mild	34	501,614	0.19 (0.15-0.24)	100%	<0.01	
Moderate	35	501,211	0.12 (0.08-0.17)	100%	<0.01	
Severe	40	508,785	0.05 (0.03-0.07)	100%	<0.01	
Sensitivity analyses						
Validated assessment tools only	109	1,202,837	0.28 (0.25-0.32)	100%	<0.01	
Self-rated assessment tools only	108	1,225,925	0.29 (0.25-0.34)	100%	<0.01	
Excluding high risk of bias	110	1,207,624	0.29 (0.25-0.33)	100%	<0.01	
Geographical regions						
Region of the Americas	16	36,321	0.32 (0.20-0.48)	100%	<0.01	<0.01
Eastern Mediterranean Region	8	11,758	0.62 (0.45-0.77)	98%	<0.01	
European Region	29	43,312	0.36 (0.29-0.44)	99%	<0.01	
South-East Asian Region	7	3,261	0.72 (0.22-0.96)	98%	<0.01	
Western Pacific Region	64	1,146,952	0.22 (0.19-0.25)	100%	<0.01	
Education level						
Elementary/primary school	14	27,915	0.20 (0.11-0.35)	100%	<0.01	<0.05
Junior secondary/middle school	31	358,441	0.24 (0.17-0.32)	100%	<0.01	
Senior secondary/high school	50	720,081	0.35 (0.27-0.44)	100%	<0.01	
Gender						
Male	55	552,512	0.20 (0.16-0.24)	100%	<0.01	<0.01
Female	55	531,432	0.29 (0.24-0.34)	100%	<0.01	
Physically active						
Yes	13	91,272	0.27 (0.17-0.39)	100%	<0.01	0.46
No	11	34,515	0.32 (0.23-0.42)	100%	<0.01	
High electronics usage						
Yes	8	18,905	0.37 (0.25-0.51)	99%	<0.01	<0.05
No	8	54,912	0.20 (0.10-0.34)	100%	<0.01	
Has infected relatives						
Yes	12	1,514	0.40 (0.26-0.55)	93%	<0.01	0.26
No	12	37,812	0.30 (0.22-0.41)	99%	<0.01	
Parents work in healthcare settings						
Yes	5	1,398	0.20 (0.13-0.29)	70%	<0.01	0.87
No	5	1,469	0.19 (0.11-0.31)	77%	<0.01	
Experiencing financial difficulties						
Yes	5	11,702	0.51 (0.27-0.75)	99%	<0.01	0.42
No	5	56,956	0.40 (0.18-0.67)	100%	<0.01	

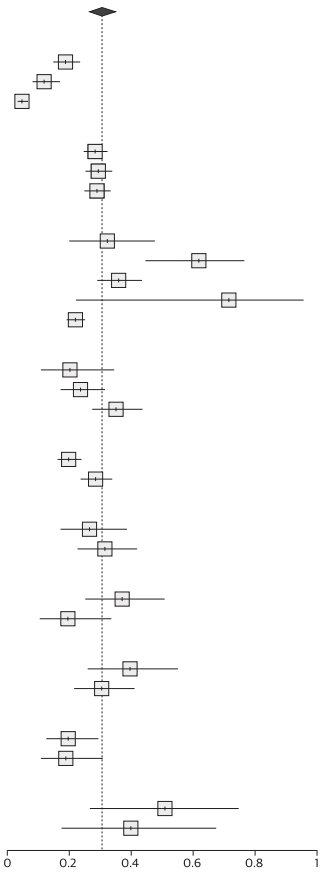

FIGURE 4 Forest plot showing the pooled prevalence of anxiety symptoms and results of sensitivity analyses and subgroup analyses. $P_{subgroup}$ indicates the result of the test for subgroup differences. Abbreviation: CI, confidence interval.

	No. studies	No. participants	Prevalence (95% CI)	I^2	P_Q	$P_{subgroup}$
Overall prevalence	50	104,219	0.42 (0.33-0.52)	100%	<0.01	
Sensitivity analyses						
Validated assessment tools only	41	69,979	0.46 (0.36-0.57)	100%	<0.01	
Self-rated assessment tools only	34	76,340	0.37 (0.26-0.48)	100%	<0.01	
Excluding high risk of bias	40	74,581	0.45 (0.33-0.57)	100%	<0.01	
Geographical regions						
Region of the Americas	7	2,300	0.45 (0.25-0.67)	98%	<0.01	<0.01
Eastern Mediterranean Region	2	2,485	0.70 (0.27-0.94)	95%	<0.01	
European Region	16	17,189	0.50 (0.28-0.72)	99%	<0.01	
South-East Asian Region	5	2,029	0.47 (0.13-0.84)	99%	<0.01	
Western Pacific Region	19	79,963	0.32 (0.21-0.45)	100%	<0.01	
Education level						
Elementary/primary school	4	9,346	0.39 (0.11-0.75)	99%	<0.01	0.48
Junior secondary/middle school	8	19,536	0.32 (0.19-0.49)	100%	<0.01	
Senior secondary/high school	17	25,897	0.44 (0.29-0.60)	99%	<0.01	
Gender						
Male	13	22,749	0.30 (0.16-0.51)	100%	<0.01	0.40
Female	13	25,386	0.41 (0.22-0.64)	100%	<0.01	
High electronics usage						
Yes	6	17,561	0.61 (0.32-0.84)	100%	<0.01	0.44
No	6	10,931	0.47 (0.17-0.80)	100%	<0.01	
Has infected relatives						
Yes	2	2,006	0.44 (0.00-1.00)	99%	<0.01	0.57
No	2	9,603	0.33 (0.00-1.00)	100%	<0.01	
Experiencing financial difficulties						
Yes	3	6,320	0.76 (0.73-0.78)	0%	0.76	0.07
No	3	7,151	0.66 (0.38-0.86)	99%	<0.01	

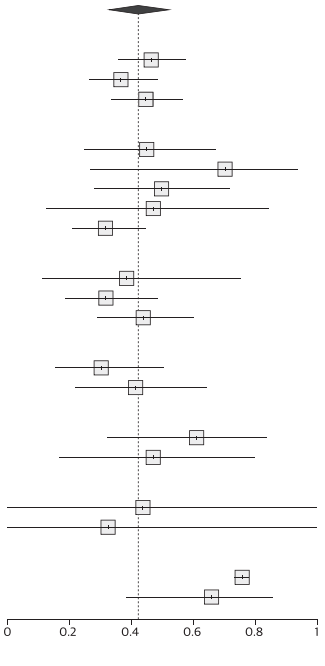

FIGURE 5 Forest plot showing the pooled prevalence of sleep disturbances and results of sensitivity analyses and subgroup analyses. $P_{subgroup}$ indicates the result of the test for subgroup differences. Abbreviation: CI, confidence interval.

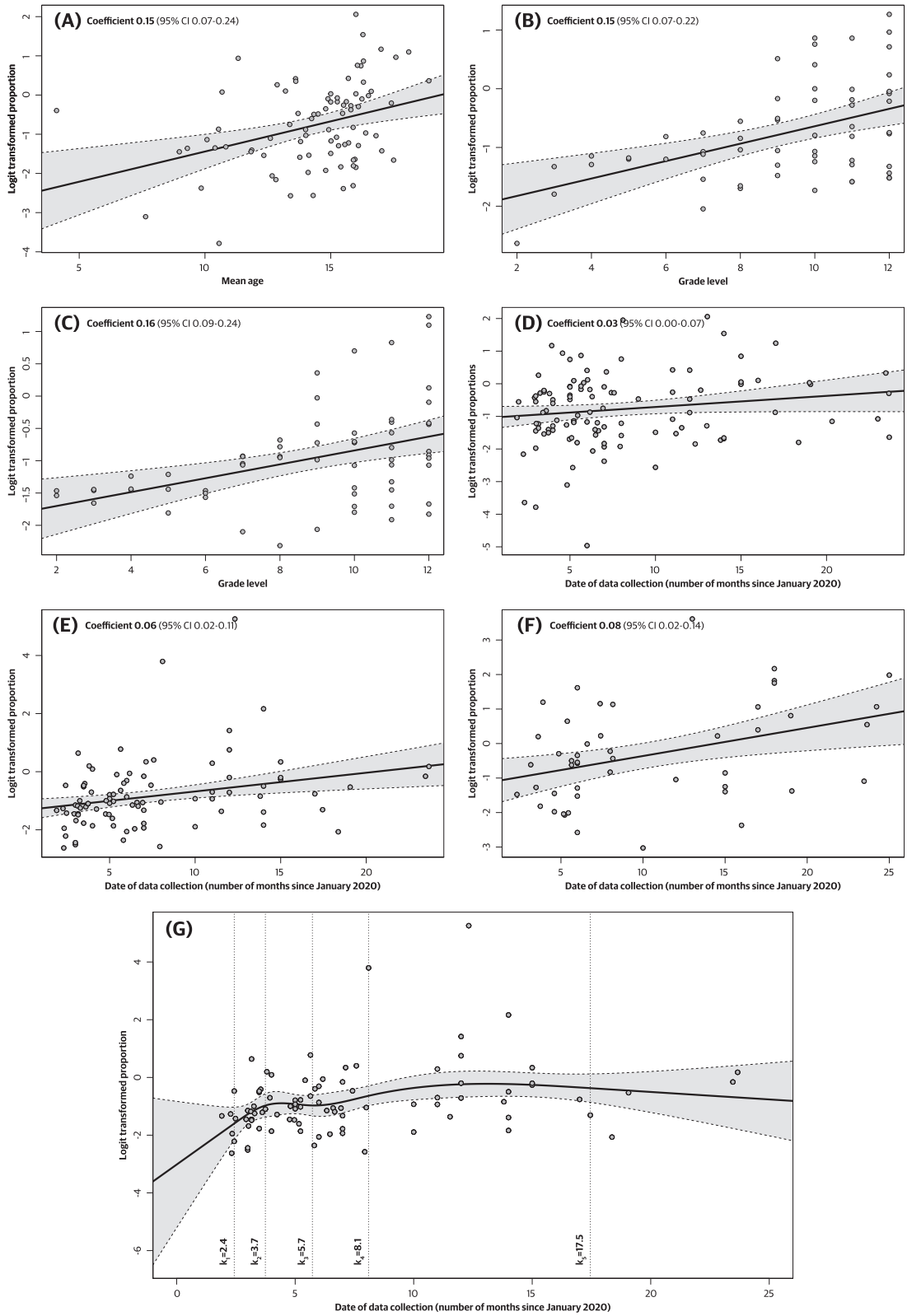

FIGURE 6 Bubble plots showing results of the meta-regression analysis between the prevalence of depressive symptoms, anxiety symptoms, sleep disturbances, and moderator variables. The solid line represents the regression line, while the dotted lines show the 95% confidence interval around the regression line. (A) Meta-regression between the prevalence of depressive symptoms and mean age. (B) Meta-regression between the prevalence of depressive symptoms and grade level. (C) Meta-regression between the prevalence of anxiety symptoms and grade level. (D) Meta-regression between the prevalence of depressive symptoms and date of data collection. (E) Meta-regression between the prevalence of anxiety symptoms and date of data collection. (F) Meta-regression between the prevalence of sleep disturbances and date of data collection. (G) Nonlinear meta-regression using a restricted cubic spline model between the prevalence of anxiety symptoms and date of data collection. Locations of the five knots are shown in the plot.

was correlated with date of data collection in the nonlinear RCS model meta-regression ($p < 0.01$, with $p = 0.13$ for depressive symptoms and $p = 0.10$ for sleep disturbances). As shown in Figure 6G, the prevalence of anxiety symptoms rapidly increased during the first 5 months of the pandemic, before transitioning to a more gradual rate of increase during the summer and the following fall school semester. Although study data became more scarce after 2020, a slight downward trend in the prevalence of anxiety symptoms can be identified starting in the winter semester of 2021. The nonlinear RCS model showed a slightly better model fit (AIC = 264.6) compared to the linear model (AIC = 269.5) for the prevalence of anxiety symptoms based on AIC.

DISCUSSION

The current systematic review and meta-analysis provides a comprehensive global estimate of the prevalence of depressive symptoms, anxiety symptoms, and sleep disturbances among youths during the COVID-19 pandemic. The pooled prevalence of depressive symptoms was 31% based on data from 129 studies, including 524,417 youths, the prevalence of anxiety symptoms was 31% based on 123 studies, including 1,241,604 youths, and the prevalence of sleep disturbances was 42% based on 50 studies, including 104,219 youths. These findings are higher compared to the previous review on this topic, which found a pooled prevalence of depressive and anxiety symptoms of 25% and 21%, respectively, based on early pandemic data from 80,879 youths.[36]

Differences in prevalence estimates by geographical regions

The results of our subgroup analyses and meta-regressions identified several significant associations. First, the prevalence estimates differed significantly based on geographical regions for all assessed outcomes. While the prevalence estimates for the Region of the Americas and the European Region were similar to the overall pooled prevalence, prevalence estimates from the South-East Asian Region and the Eastern Mediterranean Region were substantially elevated compared with other regions studied. A possible explanation for this observation is the more limited mental health coverage in these areas. For example, recent studies found that India (which constituted a majority of the sample size from the South-East Asian Region) has a treatment gap of approximately 95% in all age groups for common mental health disorders.[245] The national and state-level policies regarding mental health coverage in India also do not have a specific emphasis on children and adolescent mental health, with most initiatives in the country being led by nonprofit organizations.[245] Additionally, the disparities in prevalence estimates could be attributable to the higher rates of poverty in these regions. Notably, while the Eastern Mediterranean Region consists of a mix of high-income and LMIC countries, the participants included in this study mainly originated from LMIC countries in the region, such as Jordan and Iran. The impact of socioeconomic indicators on youth wellness and mental health has been well-established in previous studies.[246–248] Lastly, geopolitical instability and tension in the Eastern Mediterranean Region may also contribute to the high prevalence estimates in the region.[249]

Meanwhile, studies from the Western Pacific Region yielded a substantially lower prevalence of anxiety symptoms and sleep disturbances compared to other regions. This observation (which included mainly Chinese youths) is not unique to this review as similar trends have been observed in meta-analyses involving other populations in this region during the pandemic.[7,8] Previous reviews mainly attributed this observation to the stigma associated with the disclosure of mental health conditions in Asian countries, where mental illness and psychological disorders are commonly associated with a distorted personality or moral defects.[250–255] It has also been shown in prepandemic studies that most Chinese individuals with mental health issues do not exhibit help-seeking behaviors,[256] and the general Chinese population is not familiar with the causes and prevention methods of mental health illnesses.[257]

Differences in prevalence estimates by gender

Apart from geographical factors, we identified significant subgroup differences between girls and boys for the prevalence of depressive and anxiety symptoms, where girls exhibited higher prevalence estimates compared to boys. These observations are consistent with findings from prepandemic mental health studies.[258,259] The exact cause of this difference is multifactorial and not well understood.[260] However, previous research has shown that boys may have more difficulties acknowledging their mental health problems. Thus, they are more prone to masking these issues by displaying externalizing disorders, such as substance abuse or antisocial behaviors.[261] In contrast, girls are more likely to display internalizing disorders, such as depression and anxiety—both of which were assessed in this review.[261] Societal roles and cultural norms may also contribute to this difference, since girls are more commonly stereotyped as emotionally sensitive and are expected to have greater reactions to stressors and traumatic events (such as the pandemic or the death of family members from viral infection) than boys.[260,262]

Differences in prevalence estimates by age, education levels, and grade levels

In this review, we assessed the mental health symptoms of different age groups of youths using meta-regressions by mean age and grade levels as well as a subgroup analysis by education levels. We found that the prevalence of depressive symptoms was positively correlated with all three moderators, while the prevalence of anxiety symptoms was positively correlated with education levels and grade levels only. Similarly, the previous review by Racine et al. also failed to detect age as a significant moderator for the prevalence of anxiety symptoms. Specifically, they attributed this finding to increased anxiety from disruptions in the daily routines of young children.[36] This explanation may

be applicable to our current observations as the meta-regression by age included preschool and early primary school children who may be at-risk for developing anxiety symptoms due to routine disruptions. Additionally, these younger participants may not be accounted for in the meta-regression and subgroup analyses by education and grade levels, which consists largely of older children and adolescents.

For school-aged children, the positive correlation between symptoms of anxiety and depressive with grade and education levels may be attributable to increased academic demands in high school compared to middle and elementary school.[263] These pressures could have been exacerbated by the sudden transition to distance education during lockdowns.[264] Older adolescents may also be more aware of the implications of the pandemic due to greater exposure to news sources and social media,[265] which have been identified as key drivers of mental health issues during the pandemic.[4,266]

Temporal trends in prevalence estimates

The previous systematic review by Racine et al. identified a positive correlation between the date of data collection and the prevalence of depressive and anxiety symptoms; however, since a majority of the included studies were conducted during the early stages of the pandemic, it was unclear whether this trend would continue.[36] The current review identified a similar correlation after incorporating more studies from later stages of the pandemic (i.e., in late 2020 and 2021). It is likely that prolonged disruptions to youths' daily routines, academic milestones, and social interactions resulted in a compounding of mental health issues as the pandemic progressed.[36] Interestingly, nonlinear meta-regression using an RCS model showed that the rate of increase in the prevalence of anxiety symptoms may have slowed after the first 5 months of the pandemic, and a slight downward trend can be observed starting from the winter semester of 2021. This pattern could indicate the recovery or stabilization of mental health in children and adolescents as lockdown efforts eased and distance learning became better established. Further investigations are needed to assess whether this downward trend persists.

Impact of electronics use and screen time on prevalence estimates

Lastly, we identified significant subgroup differences in the prevalence of depressive and anxiety symptoms based on the level of electronics usage. The prevalence of depressive and anxiety symptoms was over 15% lower in children and adolescents with low electronics usage compared to those with high electronics usage. While the impact of screen time on children and adolescent mental health during the pandemic has been widely debated—with proponents demonstrating that one-on-one communication with electronic devices can greatly alleviate feelings of isolation and loneliness in this population[267,268]—the majority of current evidence suggests that the use of electronics and digital media is more likely to result in worsened mental wellbeing.[267] As previously discussed, exposure to excessive amounts of alarmist or deceptive pandemic-related information online can instill a constant feeling of worry and fear in youths, which can be detrimental to their mental health.[269] Social media use has also been associated with increased feelings of depression, anxiety, and low self-esteem due to social comparisons and appearance-related concerns in youths.[270,271] Finally, addiction to or over-reliance on electronic devices can discourage children and adolescents from engaging in healthy behaviors, such as physical exercise and maintaining regular sleep schedules.[267,268,272]

Implications of findings

The findings from our review show that the pandemic led to a high prevalence of mental health symptoms in children and adolescents, and these effects were exacerbated over time during the early stages of the pandemic. Among the youth population, girls and older adolescents were more prone to developing symptoms of depression and anxiety. Thus, the unique biological and social contexts surrounding these vulnerable populations demand mental health programs that are specifically tailored to their needs. Examples of possible adaptations include providing remote counseling services[273] and resilience-focused interventions[274] for high school students, working with family members to offer social support during stressful periods, such as university entrance exams, or introducing cognitive-based gender equality curriculums.[275] Educational antistigma interventions should also be incorporated into academic curriculums to help youths self-identify signs of mental health issues and encourage help-seeking behaviors. These measures may be especially important for children and adolescents in the Western Pacific Region.

In addition, we found that high electronics usage may be associated with an increased prevalence of depression or anxiety. It is notable that this finding is limited by small sample sizes and highly heterogeneous definition of electronics usage between studies, thus it should be viewed as hypothesis-generating and serve as the basis for future large-scale studies to further assess this association.

Apart from depression and anxiety, over a third of children and adolescents displayed symptoms of sleep disturbances in this review. Sleep disturbances may be a cause, symptom, or comorbidity associated with mental health disorders and substance abuse.[276,277] While we did not examine correlations between sleep disturbances and mental health impacts, previous studies have shown that having a regular sleep schedule can greatly improve the physiology and cognition of children and adolescents.[278] Thus, regulating sleep may be a viable way to introduce a routine schedule and reduce mental health disturbances during lockdowns and quarantine measures. Parents may also use the presence of sleep disturbances as an early indicator of mental health issues, thereby facilitating the ability to provide timely preventive measures and psychiatric assessments before the onset of mental health disorders.[279]

Overall, there is a great need for further research into children and adolescent mental health during the pandemic, as well as significant resources and investments into evidence-based and scalable mental

health programs for children and adolescents. During future public health emergencies, it is critical to minimize the impact and disruption to youths by leaving school closures as a last resort option.[280]

Study limitations

This systematic review has several limitations. First, we observed very high heterogeneity across our analyses. However, this observation is common among many prevalence studies—especially in studies concerning mental health—due to the wide variety of demographic, geographical, and methodological moderators that can lead to between-study variations in the reported prevalence.[36] In this review, we explored potential sources of heterogeneity using a series of subgroup and meta-regression analyses and identified several significant factors (such as age, gender, geographical regions, etc.) that may have contributed to the high heterogeneity.

Second, many of our subgroups were limited by low and/or imbalanced sample sizes and inconsistent definitions. As a result, we did not identify subgroup differences by financial difficulties, physical activity, parents who worked in healthcare settings, or children who had infected relatives. Nevertheless, these findings do not necessarily indicate that the aforementioned variables have no significant impact on the mental health of children and adolescents. Subgroup and meta-regression analyses are exploratory in nature,[281] so further research is needed to fully elucidate the protective and harmful factors involved in children and adolescent mental health during the pandemic.

Additionally, our included studies were mostly rated as having moderate or high risks of bias. The inclusion of studies that lacked random sampling or those that did not include a representative population may limit the external validity of our findings. Notably, because most of our included studies were designed and administered in short timespans, they relied on nonprobabilistic (i.e., convenience) sampling methods, which may lead to a systematic overestimation of prevalence values compared to studies using probabilistic sampling methods.[6,282] Thus, caution should be exercised when comparing findings from the current review with prevalence estimates from prepandemic studies.

It is also possible for the design of the included studies to change over time, such as shifting from using convenience sampling methods to probability-based methods as more time and resources become available. This shift may result in the appearance of a reduction in prevalence values. Thus, the temporal trends observed in this review, especially indications of decreased anxiety symptoms identified on the nonlinear RCS meta-regression, should be reassessed and confirmed in future longitudinal studies.

Lastly, there was a highly heterogeneous set of screening tools and threshold values used to define clinically relevant symptoms of mental health disorders. While we detected significant differences between the prevalence measures assessed by different screening tools and thresholds, we cannot determine if these differences are due to the construct of the tools themselves or due to other factors (such as gender distribution or differences in geographical regions).

CONCLUSION

The pooled prevalence of depressive symptoms, anxiety symptoms, and sleep disturbances among children and adolescents during the COVID-19 pandemic was 31%, 31%, and 42%, respectively. 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. Overall, our findings demonstrate the need for increased mental health research as well as monitoring and intervention for children and adolescents during the current and future pandemics.

AUTHOR CONTRIBUTIONS

J.D. conceptualized and designed the methodology of the study, performed database searches, supervised and performed article screening and data extraction, performed all statistical analyses, drafted the manuscript, and critically reviewed and revised the manuscript. F.Z. helped design the methodology of the study, performed article screening and data extraction, drafted the manuscript, and critically reviewed and revised the manuscript. W.H., K.H., S.L., U.A., Z.S., C.Y.W., O.C., E.H., Q.K.Z., M.M., H.B.R, and S.H. performed article screening and data extraction, as well as critically reviewed the manuscript. All authors have read and approved the final version of the manuscript to be submitted and published, and all authors accept responsibility for the integrity of the data analyzed.

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COMPETING INTERESTS

The authors declare no competing interests.

DATA AVAILABILITY STATEMENT

Data involved in statistical analyses are disclosed in the manuscript, figures, tables, and supplementary materials. Please contact the corresponding author for additional inquiries.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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