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 Prevalence of mental health problems among children and adolescents during the COVID-19 pandemic: A systematic review and meta-analysis

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Article

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Highlights

- Twenty-three studies with 57,927 children and adolescents were included in the review.

- Prevalence of depression and anxiety were 29% and 26%, respectively.

- Prevalence of sleep disorders and posttraumatic stress symptoms were 44% and 48%.

- Adolescents exhibited higher prevalence of depression and anxiety than children.

- Females reported higher prevalence of depression and anxiety than males.

Abstract:

Background: This systematic review and meta-analysis examined the prevalence of depression, anxiety, sleep disorders, and posttraumatic stress symptoms among children and adolescents during global COVID-19 pandemic in 2019 to 2020, and the potential modifying effects of age and gender.

Methods: A literature search was conducted in PubMed, Web of Science, PsycINFO, and two Chinese academic databases (China National Knowledge Infrastructure and Wanfang) for studies published from December 2019 to September 2020 that reported the prevalence of above mental health problems among children and adolescents. Random-effects meta-analyses were used to estimate the pooled prevalence.

Results: Twenty-three studies (21 cross-sectional studies and 2 longitudinal studies) from two countries (i.e., China and Turkey) with 57,927 children and adolescents were identified. Depression, anxiety, sleep disorders, and posttraumatic stress symptoms were assessed in 12, 13, 2, and 2 studies, respectively. Meta-analysis of results from these studies showed that the pooled prevalence of depression, anxiety, sleep disorders, and posttraumatic stress symptoms were 29% (95%CI: 17%, 40%), 26% (95%CI: 16%, 35%), 44% (95%CI: 21%, 68%), and 48% (95%CI: -0.25, 1.21), respectively. The subgroup meta-analysis revealed that adolescents and females exhibited higher prevalence of depression and anxiety compared to children and males, respectively.

Limitations: All studies in meta-analysis were from China limited the generalizability of our findings.

Conclusions: Early evidence highlights the high prevalence of mental health

problems among children and adolescents during the COVID-19 pandemic, especially

among female and adolescents. Studies investigating the mental health of children and

adolescents from countries other than China are urgently needed.

Prevalence of mental health problems among children and adolescents during the COVID-19 pandemic: A systematic review and meta-analysis

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Introduction

The COVID-19 (Coronavirus Disease 2019) pandemic has affected the mental health
(e.g., depression, anxiety, sleep disorders, and posttraumatic stress symptoms) of children and
adolescents (Golberstein E, et al., 2020). As of April 8, 2020, schools have been suspended
nationwide in 188 countries (Lee J, 2020). Prolonged school closures, strict social isolation
from peers, teachers, extended family, and community networks, economic shutdown, and
the pandemic itself have contributed to the mental health problems of children and
adolescents (Holmes EA, et al., 2020; Tan W, et al., 2020). While some children may benefit
from increased interaction with parents and siblings, many have experienced elevated levels
of emotional distress (Sprang G and Silman M, 2013; Xie X, et al., 2020). Being confined to
home leads to disturbances in sleep/wake cycles and physical exercise routines, and promotes
excessive use of technology (Xie X, et al., 2020). The pandemic may increase family
financial stressors and parental unemployment, which were associated with short- and long-
term consequences on child mental health (Costello EJ, et al., 2003). There is also an
increased risk of seeing or experiencing domestic violence and emotional, physical and/or
sexual abuse (Costello EJ, et al., 2003). It is assumed that relaxing lockdown restrictions and
returning to school might improve the mental health status of children as the economy and
social practices begin to normalize globally (Tan W, et al., 2020). Understanding the
psychological impact of the COVID-19 pandemic on children and adolescents would provide
a theoretical basis for designing interventions, planning resources, and promulgating policies
necessary to protect young people from such occurrences in future (Pappa S, et al., 2020).

Several original studies have found high levels of mental health problems among

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children and adolescents during the COVID-19 pandemic (Duan L, et al., 2020; Pınar Senkalfa B, et al., 2020; Türkoğlu S, et al., 2020). However, to the best of our knowledge to date, no systematic review to synthesize the impact of the pandemic on their mental health has been performed. While there are some systematic reviews on the psychological impacts of COVID-19 on patients and healthcare workers (Pappa S, et al., 2020; Luo M, et al., 2020; Rogers JP, et al., 2020), evidence in children and adolescents is lacking.

The aim of this systematic review and meta-analysis was to examine the emerging evidence of the effects of the COVID-19 outbreak on the mental health of children and adolescents aged 18 years and under. In particular, we aimed to examine the prevalence of depression, anxiety, sleep disorders, and posttraumatic stress symptoms among uninfected/not known to be infected children and adolescents during the active phase of the pandemic during 2019 to 2020. The potential modifying effects of age and gender on the prevalence were also examined.

Methods and Materials

This study was developed and reported according to the Preferred Reporting Items for Systematic Reviews and Meta- Analyses (PRISMA) (Moher D, et al., 2009) and other standards (Johnson BT and Hennessy EA, 2019). The study protocol was registered with the International Prospective Register of Systematic Reviews, PROSPERO (registration no: CRD42020205166).

Literature search and study selection

A systematic search was performed in three English electronic bibliographic databases: PubMed, PsycINFO, and Web of Science, and two Chinese academic databases: China National Knowledge Infrastructure (CNKI) and Wanfang. The following search terms were

used: ("Novel coronavirus" OR "SARS-COV-2" OR "COVID-19" OR "2019-nCov") AND ("depression" OR "anxiety" OR "sleep*" OR "posttraumatic stress symptoms", "mental health*" OR "psychological*" OR "psychiatry" OR "insomnia"). The specific search algorithm is provided in **Supplemental Table 1**. Studies reported the prevalence of self-reported mental health problems and symptoms were included. Two authors independently searched the same database with these search terms to ensure that none of the relevant studies was missed.

Titles and abstracts of the articles identified were screened against the study selection criteria by two independent reviewers. Potentially relevant articles were retrieved for an evaluation of the full text. Inter-rater agreement was assessed using the Cohen's kappa (k=0.64). Disagreements were reviewed and resolved through discussion with third author to resolve persistent inconsistencies.

This search strategy was further supplemented with hand searching of reference lists of included articles and through tracking the citations of eligible references in Google Scholar. Articles identified from the reference lists were further screened and evaluated by using the same criteria. Reference searches were repeated on all newly identified articles until no additional relevant articles were found.

Study selection criteria

Studies were included if they: (a) evaluated the prevalence of depression, anxiety, sleep disorders, and posttraumatic stress symptoms using validated assessment method among children and adolescents aged 18 years and under; (b) were written in English or Chinese; (c) were carried out between December 2019 to September 2020; and (d) were cross-sectional or longitudinal studies. When there were studies involving the same participants, only the most comprehensive or recent publication was included.

Studies were excluded if they: (a) were qualitative studies, case reports, editorials, protocols, meta-analysis, or reviews, (b) computer-based simulation studies with no human participants, c) included participants with COVID-19 infected, d) studies that did not provide data on the levels of the outcomes of interest, or e) studies focused on the prevalence of suicidal behaviours, suidal ideations and attempts among children and adolescents during COVID-19 pandemic.

Data extraction and preparation

A standardized data extraction form was developed to extract the following data from each article: author, study design, country, survey years, average age of participants, sample size (percentage of male participants), sampling strategy, mental health problems, diagnostic or screening instrument used, specific diagnostic criteria or screening instrument cutoff, and reported prevalence estimates of mental health problems. The data were extracted independently by two independent reviewers, and disagreements were reviewed and resolved through discussion with third reviewer to resolve persistent inconsistencies.

Study quality assessment

Two authors independently assessed the quality of the articles using the U.S. National Heart, Lung, and Blood Institute's Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.[16] The assessment tool rates each study based on 14 criteria. For each criterion, a score of one was assigned if "yes" was the response, whereas a score of zero was assigned otherwise (i.e., an answer of "no," "not applicable," "not reported," or "cannot determine"). Overall quality was rated based on the total score of the scale: "$7 \leq$ total score" = good, "$4 <$ total score ≤ 6" = fair, "total score < 4" = poor. The risk of bias of each study decreased with the increase in the total score.

Statistical analysis

Prevalence estimates of mental health problems were calculated by pooling the study-

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specific estimates using random-effects (using the DerSimonian- Laird method) meta-analyses that accounted for between-study heterogeneity (Borenstein M, et al., 2010). When studies reported point prevalence estimates made at different periods within the year, the overall period prevalence was used.

Study heterogeneity was assessed using the I^2 index and Tau-squared (T^2). The level of heterogeneity represented by I^2 was interpreted as modest ($I^2 \leq 25\%$), moderate ($25\% < I^2 \leq 50\%$), substantial ($50\% < I^2 \leq 75\%$), or considerable ($I^2 > 75\%$). Sensitivity analyses was performed by serially excluding each study to determine the influence of individual studies on the overall prevalence estimates.

Results from studies grouped according to prespecified study-level characteristics were compared using stratified meta-analysis (gender, diagnostic criteria or screening instrument, region, and country).

Publication bias was assessed by a visual inspection of contour-enhanced funnel plots and Egger's regression tests. All statistical analyses were conducted in STATA with specific commands (e.g., Metan and Metareg) (Version 14.0; Stata Corp., College Station, Texas, U.S.). All analyses used two-sided tests, and *p-value* < 0.05 was considered statistically significant.

Results

1. Characteristics of included studies

A total of 23 studies were included in the systematic review, the characteristics of which are summarized in Table 1. These studies were published predominantly from February to May 2020 with one longitudinal study including data from October 2019. The vast majority of studies were from China (21 studies), with the remaining studies from Turkey (2 studies). The sample size of these studies varied greatly, ranging from 46 to 9,554 participants.

Two of the studies used teleconference survey, the others used online survey. Two of the

studies used random cluster sampling, the others used purposive sampling, snowball sampling, and convenient sampling (**Table 2**).

The study design and populations were diverse. There were 21 cross-sectional studies and 2 longitudinal studies. The majority of studies were carried out in healthy populations (21 studies), in a population with cystic fibrosis (1 study) and autism spectrum disorder (1 study). Some studies included adult participants in which case only data from child/adolescent participants was used in these analyses and participants' ages ranged from 0 to 18 years.

Of particular note is the diversity of mental health-related scales used among these studies which included. A brief description of each mental health scale follows (in order of descending frequency):

- 7-item Generalized Anxiety Disorder Scale (GAD-7) (6 studies): a self-report screening tool for generalized anxiety symptoms in the primary care setting consisting of 7 questions and validated in adolescents (Mossman SA, et al., 2017);

- Screen for Child Anxiety Related Emotional Disorders (SCARED) (5 studies): a self-report instrument for children and their parents that screens for several types of anxiety disorders including generalized anxiety disorder, separation anxiety disorder, panic disorder, and social anxiety disorder (Monga S, et al., 2000);

- 9-item Patient Health Questionnaire (PHQ-9) (4 studies): a self-questionnaire consisting of nine items that assess the presence and severity of depressive symptoms based on the DSM-IV criteria for major depressive disorder (MDD) (Richardson LP, et al., 2010);

- Depression Self-Rating Scale for Children (DSRS-C) (4 studies) is widely used to measure children's depressive symptoms and consists of 18 items (Ivarsson T, et al., 1994);

- Children's Depression Inventory (including short form) (CDI-S) (3 studies): a self-report scale consisting of 27-items which evaluates the severity of depression in children and

adolescents (Allgaier AK, et al., 2012).

- State and Trait Anxiety Inventory (STAI) (2 studies): assesses state and trait anxiety in children for the determination of anxiety disorder and contains two scales of 20 items each (Nunn GD, 1988);

- Self-rating Depression Scale (SDS) (2 studies): is used to assess depressive syndrome and is validated in Chinese urban children (Su LY, et al., 2003);

- Children's Sleep Habit Questionnaire (CSHQ) (2 studies): a parent administered survey to assess children's sleep problems and consists of as 48 items divided into 5 scales focusing on different aspects of sleep behaviour (Tan TX, et al., 2018);

- Autism, Behavior Checklist (AuBC) (1 study): designed for the identification of children suspected of having autism and consisting of a list of atypical behaviors characteristic of the pathology (Sevin JA, et al., 1991);

- Center for Epidemiologic Studies Depression Scale (CES-D) (1 study):screens for depressive disorders in population- based samples and is based on a multidimensional approach to measuring depression in children and adolescents aged 6 and 17 years (Li HC, et al., 2010);

- Self-Rating Anxiety Scale (SAS) (1 study): a norm-referenced screener that, in conjunction with the Self-rating Depression Scale has been shown to discriminate anxiety from mood disorders (Dunstan DA and Scott N, 2020);

- Impact of Events Scale-Revised (IES-R) (1 study):a widely used, 22 item questionnaire used to determine the degree of distress a patient feels in response to trauma and for identifying traumatic stress (Creamer M, et al., 2003);

- Spence Child Anxiety Scale (SCAS) (1 study): a 38-item parents-report measure of anxiety symptoms for children and adolescents developed using community samples (Wang M, et al., 2016);

- Insomnia Severity Index (ISI) (1 study): a brief self-report instrument measuring the patient's perception of both nocturnal and diurnal symptoms of insomnia and comprising seven items (Gagnon C, et al., 2013);

- Depression, Anxiety, Stress Scale 21 (DASS-21) (1 study): a set of three self-report scales designed to measure the emotional states of depression, anxiety and stress with each scale containing 7 items (Wang K, et al., 2016);

- The PTSD Checklist-Civilian Version (PCL-C) (1 study): a standardized self-report rating scale comprising 17 items that correspond to the key symptoms of PTSD (Blanchard EB, et al., 1996);

- Mental Health Inventory of Middle-school students (MMHI-60) (1 study): a total of 60 items in the scale are used to measure the level of mental health of middle school students (Wang JS, et al., 1997);

- Psychological Questionnaire for Sudden Public Health Events (PQSPHE) (1 study): a total of 25 items to measure depression, neurosism, fear, obsessive anxiety, and hypochondria among adolescents (Zhang ZJ, 2005).

2. Prevalence of mental health problems among children and adolescents

2.1 Depression

12 studies provided data on the prevalence of depression among children and adolescents during the COVID-19 pandemic. Meta-analysis of the results from these studies showed that the pooled prevalence of depression among children was 29% (95%CI: 17%, 40%) with a pooled heterogeneity of 99.9% ($p < 0.001$). The prevalence of depression reported in individual study ranges from 10% to 71% (**Figure 2**).

Sub-group analysis by age indicated that the prevalence of depression in adolescents age 13-18 years (34.4%, 95%CI: 18.2%, 50.7%; $p<0.001$) was higher than that of children age ≤ 12 years (11.8%, 95%CI: 1.3%, 22.3%, $p=0.028$). Sub-group analysis by gender showed that

the prevalence of depression in females (33.9%, 95%CI: 24.6%, 43.1%, p<0.001) was higher than that in males (28.9%, 95%CI: 14.1%, 43.7%, p<0.001) (**Table 3**).

2.2 Anxiety

A total of 13 studies provided data on the prevalence of anxiety among children and adolescents during the pandemic. Meta-analysis of the results from these studies showed that the pooled prevalence of anxiety among children and adolescents was 26% (95%CI: 16%, 35%) with a pooled heterogeneity of 99.9% (p< 0.001). The prevalence of anxiety reported in individual study ranges from 7% to 55% (**Figure 3**).

Sub-group analysis by age indicated that prevalence of anxiety in adolescents age 13-18 years (29.1%, 95%CI: 17.1%, 41.1%, p<0.001) was higher than that in children age ≤ 12 years (15.7%, 95%CI: 9.0%, 22.3%, p<0.001). Sub-group analysis by gender showed that the prevalence of anxiety of females (27.4%, 95%CI: 20.3%, 34.6%, p<0.001) was higher than that of males (22.3%, 95%CI: 14.2%, 30.4%, p<0.001) (**Table 3**).

2.3 Sleep disorders

Only 2 studies provided data on the prevalence of sleep disorders among children and adolescents. Meta-analysis of the results of the two studies showed that the pooled prevalence of sleep disorders was 44% (95%CI: 21%, 68%) with a pooled heterogeneity of 94.8% (p<0.001). The prevalence of sleep disorders of the two studies were 32% to 56%, respectively (**Figure 4**). Sub-group analyses by age and gender were not performed due to lack of data.

2.4 Posttraumatic stress symptoms

Only 2 studies provided data on the prevalence of post-traumatic stress symptoms among children and adolescents. In the pooled analysis, the prevalence of post-traumatic stress symptoms were not be statistically significant in children and adolescents (pooled prevalence 48% (95%CI: -0.25, 1.21, p=0.200) with a pooled heterogeneity of 100%

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($p<0.001$) (**Figure 5**). Sub-group analyses by age and gender were not performed due to lack of data.

3. Results of sensitivity analysis and meta-regression analysis

Sensitivity analysis consistently showed that removing individual studies from the meta-analysis did not lead to any change in the prevalence of depression or anxiety. Because only two studies were included in meta-analyses of sleep disorders and posttraumatic stress symptoms, sensitivity analysis was not conducted (**Supplemental Table 3**).

Meta-regression analysis was performed on the prevalence of depression (12 studies) and anxiety (13 studies). Results indicated that neither age nor sample size were significant factors contributing to the heterogeneity of studies (Depression: β=-0.02, 95%: -0.07 to 0.03, p=0.378; Anxiety: β=-0.01, 95%: -0.01, 0.01, p=0.285). However, the questionnaire used for assessment of anxiety or depression did significantly contribute to heterogeneity of studies. In the analysis of depression prevalence, PHQ-9 and CES-D, and in the analysis of anxiety prevalence, SCARED, SAS and PQSPHE contributed to heterogeneity **(Table 4)**.

4. Assessment of publication bias

The funnel plot and assessment of Egger's and Begg's tests did not reveal any significant publication bias in the prevalence of depression, anxiety, sleep disorders or post-traumatic stress symptoms (**Supplemental Table 2, Supplemental Figure 1**).

Discussion

A recent position paper in The Lancet Psychiatry identified the long-term consequences of COVID-19 for the younger generations are unknown and must be a priority (Holmes EA, et al., 2020). This systematic review and meta-analyses of 23 studies and a total of 57,927 participants provides evidence that 28.6%, 25.5%, 44.2%, and 48.0% of children and adolescents experienced depression, anxiety, sleep disorders, and posttraumatic stress symptoms, respectively, during the COVID-19 pandemic. All the studies included in meta-

analysis were from China and conducted among general children and adolescents. The prevalence of depression and anxiety was higher among adolescents and females compared with children and males, respectively.

The prevalence of depression and sleep disorders in children and adolescents during the COVID-19 were higher than the respective rates (19.9% for depression (Rao WW, et al., 2019) and 21.6% for sleep disorders (Xiao D, et al., 2019)), reported for the children and adolescents prior to the pandemic in China. However, no data on the prevalence of anxiety and posttraumatic stress symptoms were found among children and adolescents prior to the pandemic in China, thus, no comparisons could be made. Social isolation, school closures, and socioeconomic effects of the policies (increasing unemployment, financial insecurity, and poverty) during the COVID-19 pandemic have been reported to contribute to the mental health problems among children and adolescents (Holmes EA, et al., 2020; Lee J, 2020). While there was some research on the psychological impact of severe acute respiratory syndrome (SARS) and middle east respiratory syndrome coronavirus (MERS) on patients and health-care workers, such evidence in children and adolescents is scarce (Lee J, 2020). Therefore, no direct comparison of the prevalence of mental health problems with previous pandemics could be made. However, COVID-19 is much more widespread than SARS, MERS, and other previous epidemics. As the pandemic continues, monitoring young people's mental health status over the long term and implementation of interventions and policies to support them are urgent and important.

Our study revealed that sleep disorders and posttraumatic stress symptoms were the most severe mental health problems among children and adolescents, and about half of them experienced these disorders during the COVID-19 pandemic. These findings indicate that the COVID-19 pandemic has a substantial impact on young people's sleep. Many children and adolescents may be exposed to unconstrained sleep schedules, prolonged screen exposure,

and limited access to outdoor activities and peer interactions and these could have contributed to reported sleep disorders (Liu Z, et al., 2020). Sleep disturbances are often a precursor to other more severe mental problems and it is necessary and urgent to disseminate sleep health education and sleep hygiene behavior interventions to children and adolescents (Lin LY, et al., 2020). The COVID-19 pandemic is a traumatic event, and it is well known that surviving critical illness can induce posttraumatic stress symptoms (Vindegaard N and Benros ME, 2020). The COVID-19 pandemic may be an independent factor that cause posttraumatic stress symptoms in children and adolescents. Children might also be exposed to greater interpersonal violence and abuse, and this too might contribute to the high prevalence. However, the evidence is limited as only two studies reported on posttraumatic stress symptoms in this age group.

The subgroup meta-analysis revealed that the prevalence of depression and anxiety may be higher among adolescents and females. The higher prevalence among female reflects the already established gender gap for anxiety and depressive symptoms (Pappa S, et al., 2020). Again, adolescents exhibited much higher prevalence estimates both for depression and anxiety compared to younger children in our study. This may attribute to education is highly valued and regarded as the main path to success in traditional Chinese culture (Hou TY, et al., 2020). As adolescents face the most important tests of their lives (e.g., the college or high school entrance examination), the uncertainty and potential negative effects on academic development of prolonged school closure had more adverse effects on adolescents than children (Zhou SJ, et al., 2020), thus, adolescents had more depressive and anxiety symptoms. However, no subgroup meta-analysis based on age and gender could be conducted for sleep disorders and posttraumatic stress symptoms, because there is no data available. Future such studies should take the potential modifying effects of age and gender into consideration.

No subgroup meta-analysis based on preexisting conditions and country could be conducted in this study. Only two studies included were conducted among children and adolescents with preexisting conditions (i.e., Autism Spectrum Disorder and Cystic Fibrosis). However, the two studies were not used for meta-analysis because they did not report the prevalence of mental health problems. All the studies included in our meta-analysis were from China. In our review, only two studies included were conducted in other countries (i.e., Turkey). However, the two studies from Turkey did not report the prevalence of mental health problems, thus they were not included in the meta-analysis. Though the fact that China was severely affected, our findings may provide a reliable indication of the effects of COVID-19 pandemic on the mental health of children and adolescents globally. However, considering the severity of COVID-19, economic status, and healthcare systems vary greatly between countries, more such studies from other countries are warranted.

We found that the most frequently used scale to measure depression and anxiety were PHQ-9 (3 of 13) and GAD-7 (5 of 12), respectively. However, each of the two studies used a different scale to measure sleep disorders and posttraumatic stress symptoms. The PHQ-9 is a simple, widely used, and highly effective self-assessment tool for depressive symptoms during the last 2 weeks (Kroenke K, et al., 2001). GAD-7 measured seven anxiety symptoms that bothered participants during the last 2 weeks (Zhou SJ, et al., 2020). Both PHQ-9 and GAD-7 are widely used among children and adolescents. Using the same scale and cutoff point for specific mental health problems could be better for comparison across studies.

This study has several limitations. First, all the studies included in meta-analysis were conducted in China, thus, the generalizability of findings to other countries is limited. Moreover, most of the studies used online survey method and nonprobability sampling, which further limit its generalizability. Second, a variety of assessment scales were utilized to measure mental health problems and different cut-offs were used even though several studies

used the same tests. Third, due to the limited number of studies, we could not explore the potential modifying effects of preexisting conditions and country on the prevalence of mental health problems. Fourth, only two studies focused on children age <6 years were included; thus, the mental health status of these children warrants further research.

To advance research in this area, future studies target children and adolescents are warranted to improve the following aspects. First, longitudinal studies to examine the long-term implications of COVID-19 pandemic on mental health are needed. Second, further studies to examine the prevalence of sleep disorders and posttraumatic stress symptoms are needed. Third, besides the general children and adolescents, more studies are needed to focus on children and adolescents with preexisting conditions, such as chronic diseases and psychiatric conditions. Fourth, studies from countries other than China are needed to provide insight on the global impacts of COVID-19 pandemic on mental health.

Despite its limitations, this study is the first to examine the pooled prevalence of depression, anxiety, sleep disorders, and posttraumatic stress symptoms among children and adolescents during the COVID-19 pandemic. We conducted comprehensive literature search based on both English and Chinese databases, the findings have important clinical and public health implications. Furthermore, our subgroup analysis of depression and anxiety based on age and gender provided additional valuable insights of potential particular vulnerabilities.

In conclusion, our study highlighted the high prevalence of depression, anxiety, sleep disorders, and posttraumatic stress symptoms among children and adolescents during the COVID-19 pandemic, in particular, among the females and adolescents. Further research is needed to identify strategies for preventing and treating these disorders in this population.

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Author contributions

The authors's responsibilities were as follows: YFW and WDW designed the research; LM and MM wrote the protocol; KL, SQC and HXZ managed the literature searches and selection; RK and KL performed data extraction; NY performed verification of data extraction, YXL performed meta-analysis; SQC assessed the quality of the included articles; LM wrote the first draft of the manuscript; ML, AR, and MM revised the manuscript; and all authors read and approved the final manuscript.

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Table 1. Characteristics of the 23 studies included in the review

Author/Survey time (Year, month)	Study design	Country	Age, years (mean±SD or range)	Sample size (Boys, %)	Participant type [a]	Assessment method & cutoff score	Mental health problems (n, %/M±SD)		Sleep disorders	Posttraumatic stress symptoms
							Depression	**Anxiety**		
1.Türkoğlu S/ 2020, May[10]	Cross-sectional	Turkey	Mean:7.89/4—17	46(82.6%)	Autism Spectrum Disorder	AuBC, CSHQ (>41); Diagnosed by health providers	NR	NR	Total CSHQ scores increased from 47.82 ± 7.13 to 50.80 ± 8.15	NR
2.Senkalfa BP/2020, April[11]	Cross-sectional	Turkey	Cystic Fibrosis group 0-18 Control group 0-18	Cystic Fibrosis group 45 (51.1%) Control group 90(51.1%)	Cystic Fibrosis	STAI; Diagnosed by health providers	NR	Children aged 13–18 years in the control group：29.0 (27.8-32.3); Age-matched children with Cystic Fibrosis 41.5 (35.5-46.3)	NR	NR
3.Chen F/2020, April[45]	Cross-Sectional	China	6-15 Children:6-12 Adolescents:13-15	1036(51.0%)	General	DSRS-C (≥15), SCARED (≥25); Self-reported by participants	122(11.8%)	196(18.9%)	NR	NR

4.Chen IH/2019, October-2020, March[46]	Longitudinal	China	10.88±0.72	543(49.0%)	General	DASS-21; Self-reported by participants	Mean:1.22 95%CI: (1.19,1.25)	NR	NR	NR
5. Qi M/2020, March[47]	Cross-sectional	China	Adolescents:14-18	7202(46.4%)	General	PHQ-9 (≥5), GAD-7 (≥5); Self-reported by participants	3207(44.5%)	2736(38.0%)	NR	NR
6.Zhou SJ/2020, March[43]	Cross-sectional	China	Adolescents:12-18	8079(46.5%)	General	PHQ-9 (≥5), GAD-7 (≥5); Self-reported by participants	3533(43.7%)	3020(37.4%)	NR	NR
7.Xie X/ 2020, February-2020, March[5]	Cross-sectional	China	NR	1784(56.7%)	General	CDI-S (≥7), SCARED (≥23); Self-reported by participants	403(22.6%)	337(18.9%)	NR	NR
8.Zhu KH/2020, February-2020, March[48]	Cross-sectional	China	NR	1264(55.9 %)	General	SCARED (≥23); Self-reported by participants	NR	234(18.5 %)	NR	NR
9.Lin L/2020, February[40]	Cross-sectional	China	NR	76(NR)	General	ISI(≥10), PHQ-9 (≥10), GAD-7 (≥10), ASDS (≥28); Self-reported by participants	NR	NR	24(31.6%)	NR
10.Liu Z/2020, February[41]	Longitudinal	China	Children: 4-6	1619(48.9%)	General	CSHQ (≥41); Reported by	NR	NR	900(55.6%)	NR

						caregivers of participants				
11.Qi H/2020, February[49]	Cross-sectional	China	Adolescents:11-20	9554(NR)	General	GAD-7 (≥5); Self-reported by participants	NR	1814(19.0%)	NR	NR
12.Zhou J/2020, February[50]	Cross-sectional	China	Adolescents:11-18	4805(0.0%)	General	CES-D (≥16); Self-reported by participants	1899(39.5%)	NR	NR	NR
13.Li SW/2020, February[51]	Cross-sectional	China	12.82±2.61/8-18	396(50.3%)	General	SCARED(≥25); Self-reported by participants	NR	87(22.0%)	NR	NR
14.Mo DM/2020, February[52]	Cross-sectional	China	7-16 Children:7-12 Adolescents:13-16	5392(54.5%)	General	SCARED(≥23); Self-reported by participants	NR	1045(19.4%)	NR	NR
15.Tang S/2020, February[53]	Cross-sectional	China	640 primary school students and 233 junior high school students: NR	873(52.3%)	General	SAS(standard score ≥50) CDI(>19); Self-reported by participants	Children: 41(6.4%); Adolescents: 61(26.2%)	Children: 19(3.0%); Adolescents:46(19.7%)	NR	NR
16.Wang Y/2020, February[54]	Cross-sectional	China	12.82±2.61/8-18	396(50.3%)	General	DSRS(≥15); Self-reported by participants	41(10.4%)	NR	NR	NR
17.Yu QX/2020, February[55]	Cross-sectional	China	NR	2074(52.4%)	General	Psychological Questionnaire for Sudden Public Health Events (each factor	53(2.6%)	13(0.6%)	NR	NR

Study	Design	Country	Age	Sample (Female%)	Population	Measurement tool				
						score≥2); Self-reported by participants				
18.Zhang Y/2020, February[56]	Cross-sectional	China	NR	4225(47.4%)	General	PCL-C(≥39); Self-reported by participants	NR	NR	NR	448(10.6%)
19.Liu X/ 2020, January-2020, February[57]	Cross-sectional	China	NR	34(NR)	General	STAI, SDS (≥50); Self-reported by participants	13(38.2%)	NR	NR	NR
20.Hou TY/2020, NR[42]	Cross-sectional	China	NR	859(61.4%)	General	PHQ-9 (≥10), GAD-7 (≥8), IES-R(≥26); Self-reported by participants	614(71.5%)	468(54.5%)	NR	735(85.5%)
21.Li D/ 2020, NR[9]	Cross-sectional	China	7-18 Children:7-12 Adolescents:13-18	3613(50.2%)	General	SCAS, CDI(≥19); Self-reported by participants	805(22.3%)	Children: 23.87 ± 15.79 Adolescents:29.27 ± 19.79	NR	NR
22.Tang L/2020, NR[58]	Cross-sectional	China	14.01±1.56	3512(49.1%)	General	MMHI-60(each factor score ≥2); Self-reported by participants	924(26.3%)	1047(29.8%)	NR	NR
23.Wang NX/2020, NR[59]	Cross-sectional	China	NR	410(31.5%)	General	GAD-7(≥5); Self-reported by participants	NR	197(48.0%)	NR	NR

NR: Not reported.

DSRS-C: Depression Self-Rating Scale for Children; SCARED: Screen for Child Anxiety Related Emotional Disorders ; DASS-21: Depression, Anxiety, Stress Scale 21; PHQ-9: 9-

item Patient Health Questionnaire; GAD-7: 7-item Generalized Anxiety Disorder Scale; IES-R: Impact of Events Scale - Revised; SCAS: Spence Child Anxiety Scale; STAI: State and Trait Anxiety Inventory; SDS: Self-rating Depression Scale; CSHQ: Children's Sleep Habit Questionnaire; SCL-90: Symptom Checklist-90; AuBC: Autism, Behavior Checklist; CDI-S: Children's Depression Inventory–Short Form; ISI: Insomnia Severity Index; CES-D: Center for Epidemiologic Studies Depression Scale; SAS: Self-Rating Anxiety Scale; DSRS: Depression Self-rating Scale for Children; PCL-C: The PTSD Cheeklist-CivilianVersion; MMHI-60: Mental Health Inventory of Middle-school students.

Table 2. Survey and sampling method of the 23 studies included in the review

Author/Survey time (Year, month)	Survey method	Sampling method	
		Probability sampling	**Nonprobability sampling**
1.Türkoğlu S/ 2020, May	Teleconference survey		Purposive sampling
2.Senkalfa BP/2020, April	Teleconference survey		Control group: Purposive sampling
			Age-matched children with Cystic Fibrosis: Snowball sampling
3.Chen F/2020, April	Online survey		Purposive sampling
4.Chen I/2019, October-2020, March	Online survey		Purposive sampling
5. Qi M/2020, March	Online survey		Purposive sampling
6.Zhou S/2020, March	Online survey		Purposive sampling
7.Xie X/ 2020, February-2020, March	Online survey		Purposive sampling
8.Zhu KH/2020, February-2020, March	Online survey	Random cluster sampling	
9.Lin L/2020, February	Online survey		Snowball sampling
10.Liu Z/2020, February	Online survey		Convenient sampling
11.Qi H/2020, February	Online survey		Snowball sampling
12.Zhou J/2020, February	Online survey		Snowball sampling
13.Li SW/2020, February	Online survey		Snowball sampling
14.Mo DM/2020, February	Online survey		Purposive sampling
15.Tang S/2020, February	Online survey		Purposive sampling
16.Wang Y/2020, February	Online survey		Snowball sampling

17.Yu QX/2020, February	Online survey	Purposive sampling
18.Zhang Y/2020, February	Online survey	Purposive sampling
19.Liu X/ 2020, January-2020, February	Online survey	Snowball sampling
20.Hou T/2020, NR	NR	Random cluster sampling
21.Li D/ 2020, NR	Online survey	Convenient sampling
22.Tang L/2020, NR	Online survey	Purposive sampling
23.Wang NX/2020, NR	Online survey	Purposive sampling

NR: Nor reported.

Table 3. Total and subgroup meta-analysis of pooled prevalence [d] (%, 95%CI) of depression, anxiety, sleep disorders, and posttraumatic stress symptoms among children during the COVID-19 pandemic based on the included studies [a]

Type of analysis	Groups	N of studies	Prevalence (%, 95% CI)	P value	I^2 (%)	χ^2	P	Tau-squared
Depression	Total	12	28.6 (17.2, 40.1)	<0.001	99.9	8025.91	<0.001	0.0405
Anxiety	Total	13	25.5 (16.0, 35.1)	<0.001	99.9	10690.46	<0.001	0.0307
Sleep disorders [b]	Total	2	44.2 (20.7, 67.7)	<0.001	94.8	19.22	<0.001	0.0273
Posttraumatic stress symptoms [c]	Total	2	48.0 (-25.4, 121.4)	0.200	100	3364.24	<0.001	0.2804
Depression	Children (≤12 years)	3	11.8 (1.3, 22.3)	0.028	98.9	183.35	<0.001	0.0085
	Adolescents (13-18 years)	8	34.4 (18.2, 50.7)	<0.001	99.9	7695.86	<0.001	0.0548
Anxiety	Children	6	15.7 (9.0, 22.3)	<0.001	98.7	389.71	<0.001	0.0066
	Adolescents	11	29.1 (17.1, 41.1)	<0.001	99.9	10269.07	<0.001	0.0407
Depression	Male	4	28.9 (14.1, 43.7)	<0.001	99.6	670.02	<0.001	0.0228
	Female	5	33.9 (24.6, 43.1)	<0.001	99.2	506.21	<0.001	0.0110
Anxiety	Male	7	22.3 (14.2, 30.4)	<0.001	99.1	650.31	<0.001	0.0118

Female	7	27.4 (20.3, 34.6)	<0.001	98.6	431.08	<0.001	0.0091

a: All the studies included in meta-analysis were from China and among general children and adolescents, so no subgroup meta-analysis was

conducted based on country and pre-existing conditions of children and adolescents.

b: Only two articles were found on sleep disorders, one was conducted among children and both boys and girls, the age and gender of

participants in the other study were not reported, so no subgroup analysis was conducted based on age and gender.

c: Only two articles were found on posttraumatic stress symptoms, both studies did not report the age of participants and the gender-stratified

prevalence, so no subgroup meta-analysis was conducted based on age and gender.

d: Prevalence was calculated based on the random-effect models.

Table 4. Results of meta-regression analyses on the prevalence of depression and anxiety based on 12 studies on depression and 13 studies on anxiety [a,b]

Type of analysis		β	95% CI	P
Depression (n=12)	Age	-0.02	-0.07, 0,03	0.378
	Sample size	0.01	-0.01, 0.01	0.285
	Assessment			
	(~~r~~Reference: CDI (≥19))			
	DSRS-C (≥15)	-0.06	-0.20, 0.08	0.270
	PHQ-9 (≥5)	0.27	0.13, 0.41	**0.008**
	PHQ-9 (≥10)	0.54	0.37, 0.72	**0.002**
	CDI-S (≥7)	0.06	-0.12, 0.23	0.382
	CES-D (≥16)	0.22	0.05, 0.39	**0.025**
	PQSPHE (each factor score≥2)	-0.14	-0.31, 0.02	0.072
	SDS (≥50)	0.21	-0.10, 0.52	0.122
	MMHI-60 (each factor score≥2)	0.09	-0.08, 0.26	0.184
Anxiety (n=13)	Age	-0.01	-0.05, 0.03	0.722
	Sample size	0.01	-0.01, 0.01	0.813
	Assessment			
	(~~r~~Reference: GAD-7 (≥5))			
	SCARED (≥25)	-0.15	-0.33, 0.03	0.092
	SCARED (≥23)	-0.16	-0.32, -0.01	**0.045**
	SAS (standard score≥50)	-0.28	-0.51, -0.05	**0.026**
	PQSPHE (each factor score≥2)	-0.35	-0.58, -0.12	**0.011**
	GAD-7 (≥8)	0.19	-0.04, 0.43	0.094
	MMHI-60 (each factor	-0.06	-0.29, 0.18	0.581

	score≥2)

DSRS-C: Depression Self-Rating Scale for Children; SCARED: Screen for Child Anxiety Related Emotional Disorders ; PHQ-9: 9-item Patient Health Questionnaire; GAD-7: 7-item Generalized Anxiety Disorder Scale; SDS: Self-rating Depression Scale; CDI-S: Children's Depression Inventory–Short Form; CES-D: Center for Epidemiologic Studies Depression Scale; SAS: Self-Rating Anxiety Scale; MMHI-60: Mental Health Inventory of Middle-school students; PQSPHE: Psychological Questionnaire for Sudden Public Health Events.

a: Because only two articles were included for sleep disorders and posttraumatic stress symptoms, so no meta-regression analyses were conducted.

b: Meta-regression analysis was used to evaluate the heterogeneity of different studies, adjusting age, gender, and measurement scale of depression and anxiety.

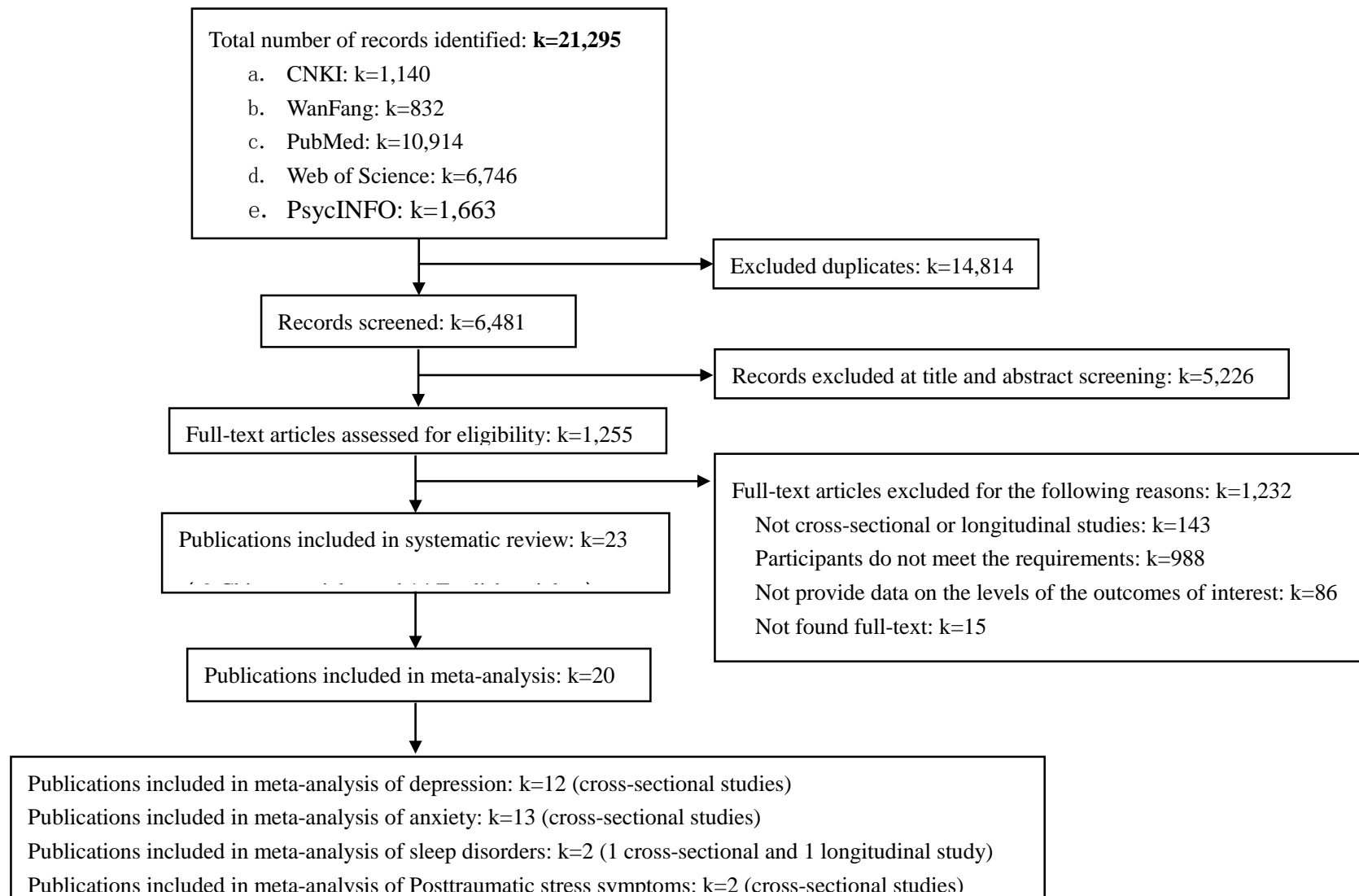Numbers in bold indicate significance.

Total number of records identified: k=21,295
- a. CNKI: k=1,140
- b. WanFang: k=832
- c. PubMed: k=10,914
- d. Web of Science: k=6,746
- e. PsycINFO: k=1,663

Excluded duplicates: k=14,814

Records screened: k=6,481

Records excluded at title and abstract screening: k=5,226

Full-text articles assessed for eligibility: k=1,255

Full-text articles excluded for the following reasons: k=1,232
- Not cross-sectional or longitudinal studies: k=143
- Participants do not meet the requirements: k=988
- Not provide data on the levels of the outcomes of interest: k=86
- Not found full-text: k=15

Publications included in systematic review: k=23

Publications included in meta-analysis: k=20

Publications included in meta-analysis of depression: k=12 (cross-sectional studies)
Publications included in meta-analysis of anxiety: k=13 (cross-sectional studies)
Publications included in meta-analysis of sleep disorders: k=2 (1 cross-sectional and 1 longitudinal study)
Publications included in meta-analysis of Posttraumatic stress symptoms: k=2 (cross-sectional studies)

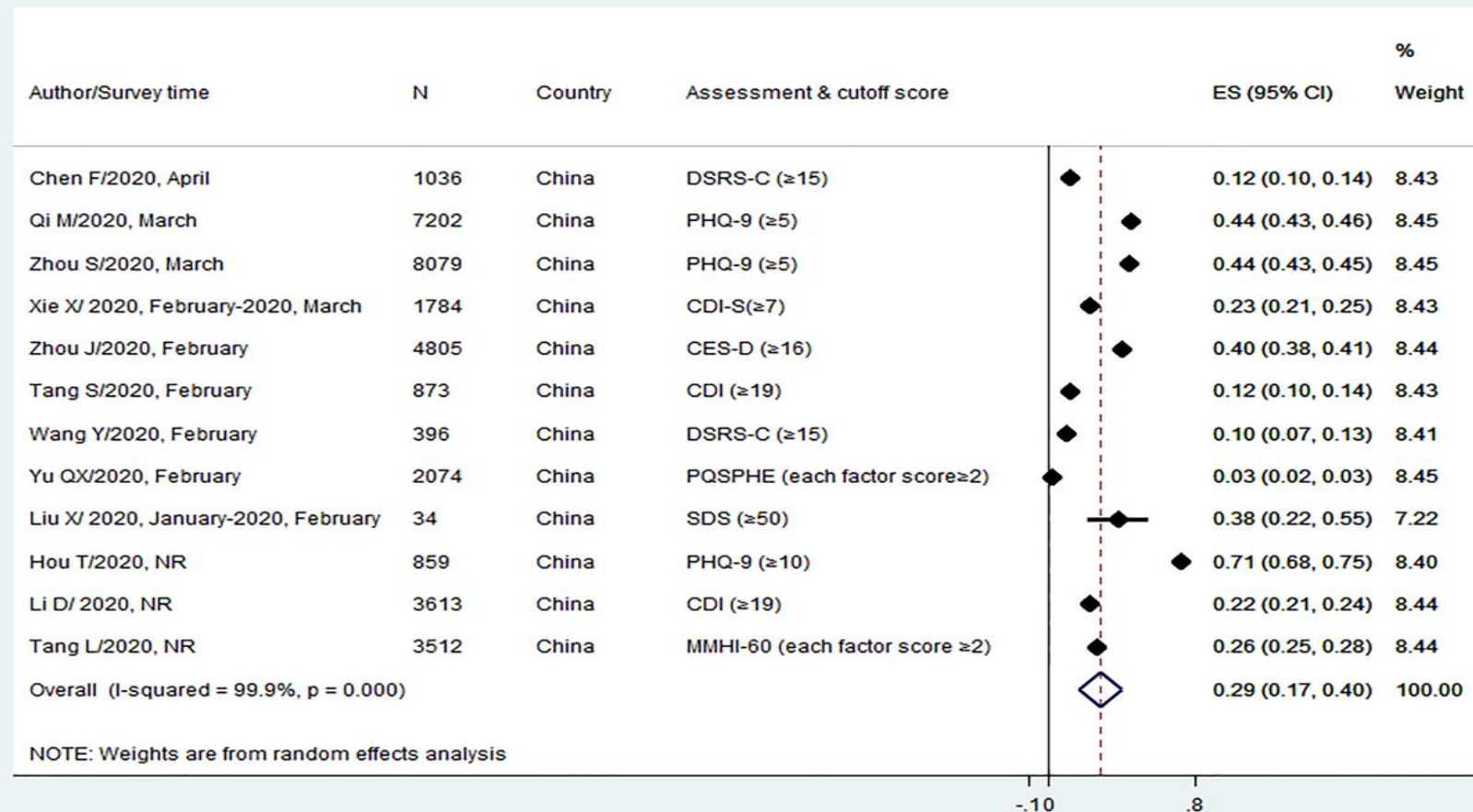**Figure 1. Flowchart of the literature search and study selection according to the PRISMA standard**

Figure 2. Meta-analysis of the pooled prevalence of depression among children and adolescents (n=13)

Abbreviations: DSRS-C: Depression Self-Rating Scale for Children; PHQ-9: 9-item Patient Health Questionnaire; CDI-S: Children's Depression Inventory–Short Form; CES-D: Center for Epidemiologic Studies Depression Scale; CDI: Children's Depression Inventory; DSRS-C: Depression Self-Rating Scale for Children; PQSPHE: Psychological Questionnaire for Sudden Public Health Events; SDS: Self-rating Depression Scale; MMHI-60: Mental Health Inventory of Middle-school students. Prevalence was calculated based on the random-effect models.
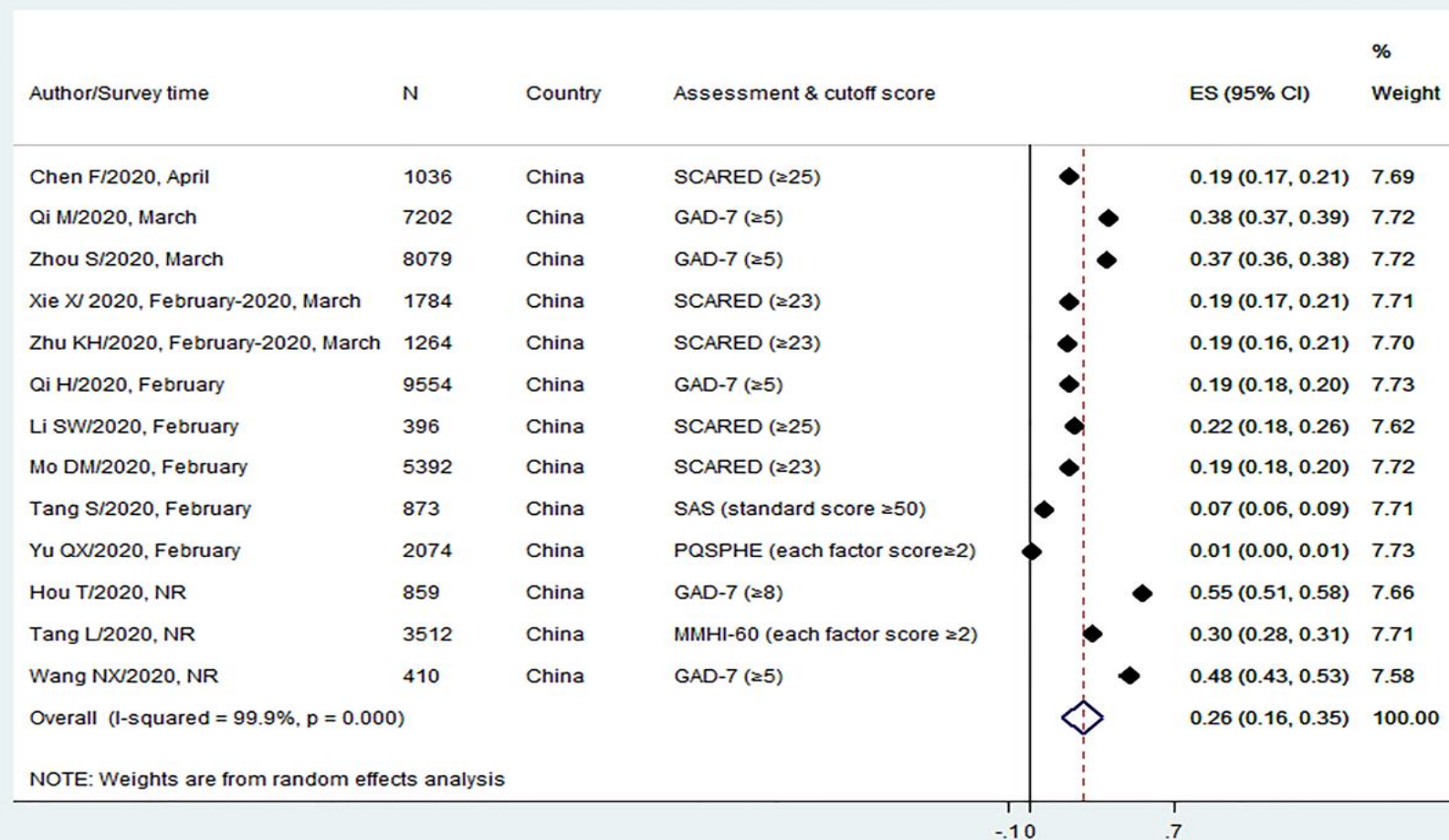
Author/Survey time	N	Country	Assessment & cutoff score	ES (95% CI)	% Weight
Chen F/2020, April	1036	China	SCARED (≥25)	0.19 (0.17, 0.21)	7.69
Qi M/2020, March	7202	China	GAD-7 (≥5)	0.38 (0.37, 0.39)	7.72
Zhou S/2020, March	8079	China	GAD-7 (≥5)	0.37 (0.36, 0.38)	7.72
Xie X/ 2020, February-2020, March	1784	China	SCARED (≥23)	0.19 (0.17, 0.21)	7.71
Zhu KH/2020, February-2020, March	1264	China	SCARED (≥23)	0.19 (0.16, 0.21)	7.70
Qi H/2020, February	9554	China	GAD-7 (≥5)	0.19 (0.18, 0.20)	7.73
Li SW/2020, February	396	China	SCARED (≥25)	0.22 (0.18, 0.26)	7.62
Mo DM/2020, February	5392	China	SCARED (≥23)	0.19 (0.18, 0.20)	7.72
Tang S/2020, February	873	China	SAS (standard score ≥50)	0.07 (0.06, 0.09)	7.71
Yu QX/2020, February	2074	China	PQSPHE (each factor score≥2)	0.01 (0.00, 0.01)	7.73
Hou T/2020, NR	859	China	GAD-7 (≥8)	0.55 (0.51, 0.58)	7.66
Tang L/2020, NR	3512	China	MMHI-60 (each factor score ≥2)	0.30 (0.28, 0.31)	7.71
Wang NX/2020, NR	410	China	GAD-7 (≥5)	0.48 (0.43, 0.53)	7.58
Overall (I-squared = 99.9%, p = 0.000)				0.26 (0.16, 0.35)	100.00

NOTE: Weights are from random effects analysis

Figure 3. Meta-analysis of the pooled prevalence of anxiety among all children and adolescents (n=12)

Abbreviations: SCARED: Screen for Child Anxiety Related Emotional Disorders; GAD-7: 7-item Generalized Anxiety Disorder Scale; SAS:

Self-Rating Anxiety Scale; PQSPHE: Psychological Questionnaire for Sudden Public Health Events; MMHI-60: Mental Health Inventory of

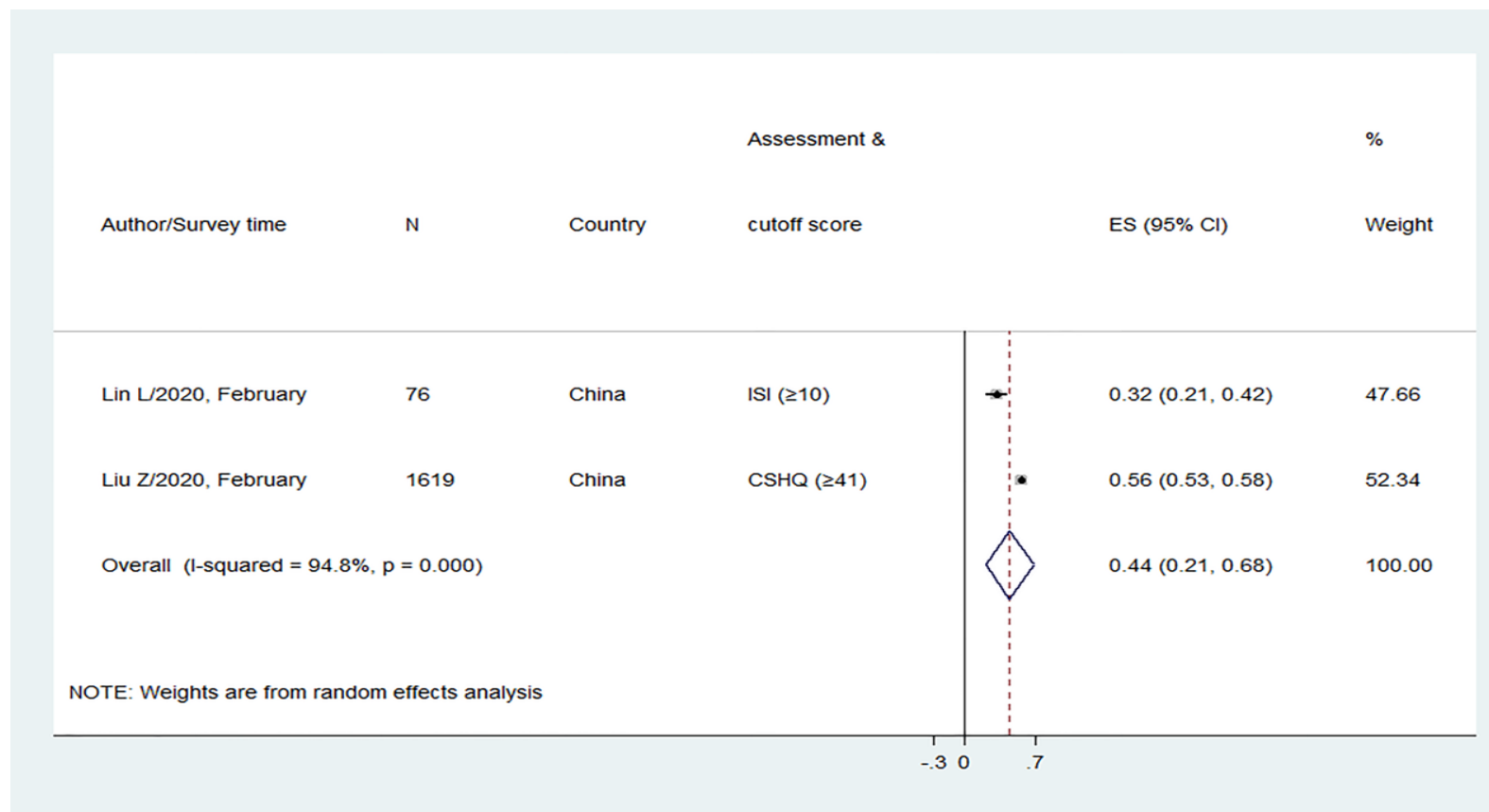Middle-school students. Prevalence was calculated based on the random-effect models.

Figure 4. Meta-analysis of the pooled prevalence of sleep disorders among all children and adolescents (n=2)

Abbreviations: ISI: Insomnia Severity Index; CSHQ: Children's Sleep Habit Questionnaire. Prevalence was calculated based on the random-effect models.
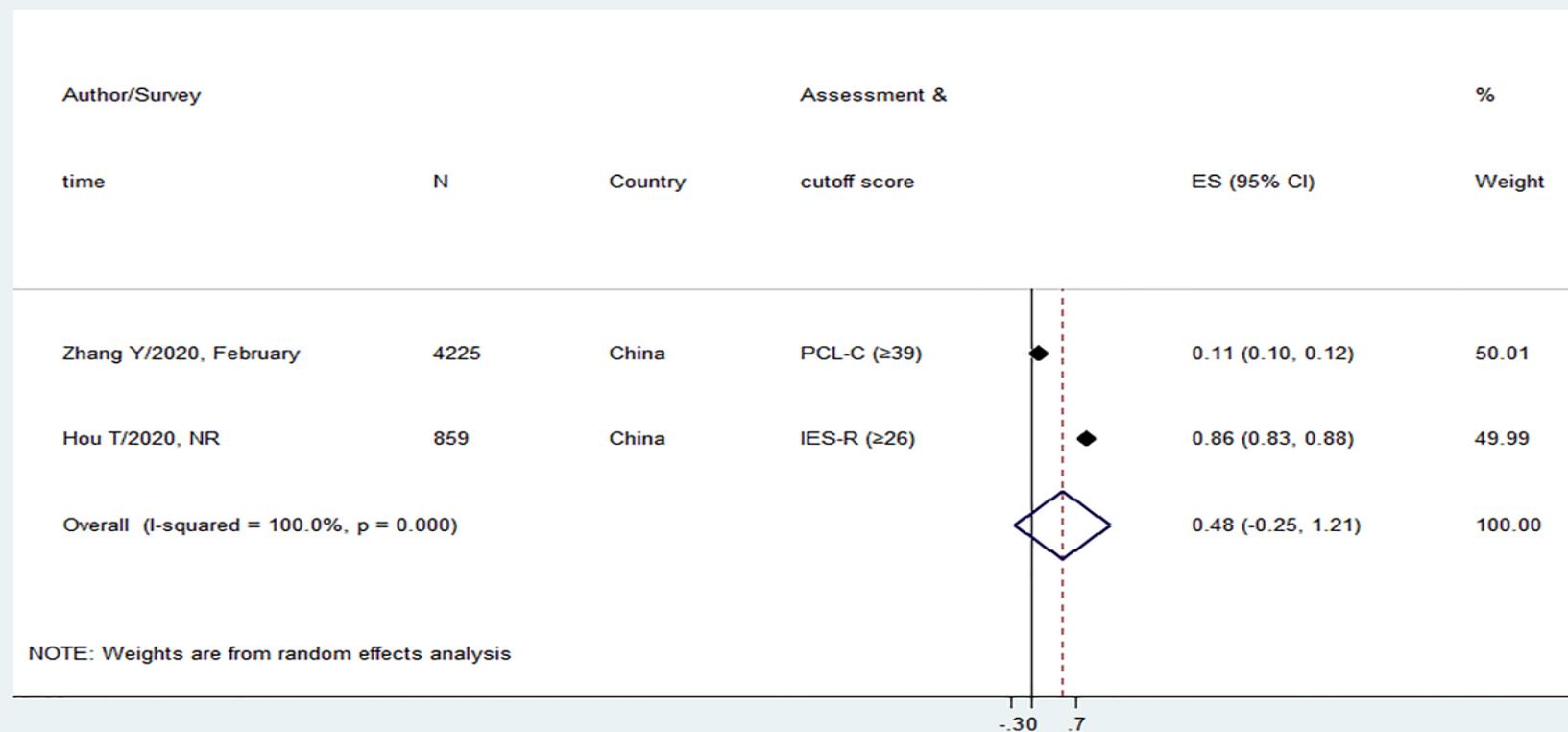
Figure 5. Meta-analysis of the pooled prevalence of posttraumatic stress symptoms among all children and adolescents (n=2)

Abbreviations: PCL-C: The PTSD Cheeklist-CivilianVersion; IES-R: Impact of Events Scale-Revised. Prevalence was calculated based on the

random-effect models.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Author contributions

The authors's responsibilities were as follows: YFW and WDW designed the research; LM and MM wrote the protocol; KL, SQC and HXZ managed the literature searches and selection; RK and KL performed data extraction; NY performed verification of data extraction, YXL performed meta-analysis; SQC assessed the quality of the included articles; LM wrote the first draft of the manuscript; ML, AR, and MM revised the manuscript; and all authors read and approved the final manuscript.