The Prevalence of Sleep Disorders Among Children in Mainland China: A Meta-analysis and Systemic-analysis

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Research article

Keywords: sleep disorders, Prevalence, Meta-analysis, China

Posted Date: December 8th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-122081/v1

Abstract

Background: We conducted a meta-analysis and systematic review to identify a reliable estimate of sleep disorders prevalence among children in mainland China and to describe its epidemiological characteristics.

Methods: Relevant studies were searched thoroughly via electronic databases included China National Knowledge Infrastructure, Wanfang,Weipu,PubMed,Web of Science and Medline databases from inception until December 2020.Prevalence estimates were calculated by random-effects models. The sources of heterogeneity were explored using subgroup analyses and Meta-regression analysis, and publication bias was estimated by funnel plots and Egger's Test.

Results: Overall, 66 studies were included in this meta-analysis, which revealed that the pooled prevalence of sleep disorders was 37.6% (95%CI: 34.3-40.9%)with high heterogeneity (I^2=99.6%,P=0.000).The prevalence rate of sleep disorders among males was higher than females (OR:1.01,95%CI:1.05-1.13).In all age groups, the prevalence rates of sleep disorders increased with age, including infancy or early childhood group(33.3%),pre-school group(38.9%), school-age group(43.7%). The prevalence rate in South China (30.4%, 95%CI: 23.9–36.8%) was the lowest, and the highest prevalence rate was in West China (47.4 %,95%CI:35.9–58.9%), which than any other region in China. The point estimate for sleep disorders prevalence obtained using the CSHQ criterion was higher than other criteria.Meta-regression indicated that age group could influence prevalence estimation (P = 0.011).

Conclusions: Over the past two decades, the prevalence rate of sleep disorders among children in mainland China has increased, significantly affecting two-fifth of the school-age children. The prevalence rate of sleep disorders in west China was significantly higher than in any other area. There is still a lack of guidelines on children's sleep disorders in mainland China, so future research should pay special attention to the sleep disorders of school-age children and children in economically backward areas.

Background

Sleep disorders among children have been identified as a global public health issue and continues to increase worldwide[1]. Pediatric sleep problems have been linked to a variety of consequences, including emotional or behavioral problems, fatigue, neurodevelopmental problems and accidental injury[2–5]. Currently, the published studies by Chinese scholars have shown that children and adolescents generally have varying degrees of sleep problems and become more and more serious, but the prevalence rate or research methods reported in relevant studies are mixed and uneven.

In 2001, Jiang Fan et al[6]. randomly selected 1,812 children aged 1 ~ 6 years from 5 administrative regions of Shanghai, and the incidence of sleep disorders was 46.97%, which was significantly higher than the data reported abroad(0.2%~10%).The prevalence of sleepwalking was 1.93%, sleep talking 24.83%, teeth grinding 19.00%, snoring 16.84%, urination in children older than 5 years was 4.29%, and dream demons and night terrors were 12.14%.In 2005, according to a survey conducted by Li Shenghui et

al.[7],the incidence of sleep deprivation among 19,299 school-age children in nine cities in mainland China was 71.4% on weekdays and 41.8% on weekends, with the incidence of various types of sleep problems ranging from 14.5% (sleep apnea) to 75.3% (daytime sleepiness).In the same year, Huang Xiaona et al. investigated sleep disorders in 14,883 children aged 0 to 5 years in 12 provinces and cities in China, with a prevalence rate of 20. 87%[8].In recent 15 years, there has been no multicenter study or large-sample epidemiological survey on sleep problems in children in mainland China.

Over the past two decades, a sleep disorders series study was designed and conducted to obtain insight into sleep health among Chinese children by examining sleep patterns and the longitudinal associations of sleep duration[9]. Although there are many studies on the prevalence of sleep disorders among children, the reported prevalence varies greatly depending on the study design, population, area, and sample size. From May to June 2018 in Shanghai, 22 kindergartens participated in the questionnaire survey,8,624 questionnaires were sent to parents and 8,586 valid questionnaires. The incidence of fear of going to bed was 72.4%, snoring was 62.5%, excessive daytime sleepiness was 51.2%, molars was 50.4%, night terrors was 49.2%, nightmare was 41.2%, difficulty falling asleep was 33.4%,and sleepwalking was 4.4%[10]. To date, no systematic review and meta-analysis of sleep disorders among children in mainland China has been reported. Based upon the above, the incidence of sleep problems are significantly higher than in previous studies,which should be paid attention to by the society and pediatrician. Therefore, this systematic review and meta-analysis aimed to estimate the pooled prevalence and associated effects of sleep disorders in mainland China.

Methods

Study design

We conducted this systematic review and meta-analysis in conformity to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2009) guidelines [11], which are shown in Additional file 1. Our meta-analysis was based on published studies,so this study does not require an ethical statement.

Search strategy

Published studies conducted were searched thoroughly using electronic databases included China National Knowledge Infrastructure(CNKI), Wanfang, Weipu databases, PubMed, Medline and Embase from inception date until December 2020.Besides, the available references of included studies articles and relevant reviews were also reviewed to identify gray literature. The literature searches were performed using Medical Subject Headings (MeSH terms) and free-text word: “ prevalence ”, “sleep”, “sleep disorders”, “sleep problems”, “sleep disturbances”, “sleep characteristics”, “children”, “child”, “chinese” and “china”.We used the search terms separately and Boolean operators like “OR” or “AND” in combination. Language of publication was restricted to Chinese and English.

Inclusion criteria

Study population: Children were aged ≤ 14 years and included a representative sample of Chinese

Mainland population.

Study period: The year of data collection of the study was limited by the period from January 1999 to November 2020.

Study type: Data from all study designs (i.e., cross-sectional, prospective, and cohort) with defined sleep disorders diagnostic criteria were included. Both published and unpublished articles reported in the Chinese and English languages were also included.

Study outcome indicators: Researches including directly and/or indirectly providing prevalence of sleep disorders and metrics for sample size were included.

Exclusion criteria

Studies were excluded, which were conducted in a population combined with other diseases: developmentally behavioral disorders (such as attention deficit/hyperactivity disorder, learning difficulties) and or psychotropic, anticonvulsant, antihistamine, etc. Reviews, graduation thesis, case reports, letters, and commentaries were also excluded. Duplicate literature or data were excluded, and only the most complete data of the same study or population are retained.

Data extraction and Quality assessment

Reference management software (NoteExpress V3.0 and endnote version X7.0) were used to remove duplicate articles. Two authors (XR C and ZL K) used a standardized data extraction format on WPS excel spreadsheet to extract the data. The data extraction checklist included the first outcome (prevalence or number of cases and sample size), author name, publication year, Screening Year,study design, Sample selection method(Methods of epidemiological investigation),region (the area where studies were conducted), Questionnaire reference criteria, age, and other necessary information.

The adopted Agency of Healthcare Research and Quality(AHRQ) assessment tool was used to assess each included original study by two authors (XR C and ZL K) independently.11 assessment criteria were included with three potential responses: Yes, No, or Unclear. Moreover, studies scored a scale of ≤ 5 points out of 11 were considered as having low quality[12]. During the time of data extraction and Quality assessment, discrepancies between two independent authors were resolved through a third author (XX L) after discussion and consensus.

Statistical analysis

Pooled prevalence and 95% confidence intervals (CIs) were adopted to estimate the prevalence rates of sleep disorders. Trough the point prevalence rates firstly transformed into arcsine square root and transformed proportions, DerSimonian-Laird weights was used for the transformed data with a fixed-effects model or a random effects model. Besides,studies with 0 cases were still included in the overall analysis [13]. The Cochran chi-square-based Q test and the I^2 Test were used to examine the

heterogeneity of the studies;<25%, 25–50%, and > 50% indicated a low, moderate, and a high level of heterogeneity, respectively[14]. A random effects model was performed to evaluate the prevalence of sleep disorders, and subgroup analyses by Screening Year (before 2006, and 2006–2020), region (urban, rural and mixed), area (North, South, East, West and Middle China), AgeGroup(0–3, 3–6, 6–14, and 0–14 years), gender (female and male), Questionnaire reference criteria (Australia version, ICSD, CSHQ, China version and unavailable) and Sample selection method(Stratified cluster sampling, Random cluster sampling, Random sampling, and Random stratified sampling)was required to address heterogeneity. In addition, we conducted meta-regression analysis in order to explore the sources of heterogeneity and the main factors influencing prevalence estimation. Publication bias was evaluated by a funnel plot of asymmetry with log prevalences and standard errors. Egger's Test was used to check the qualitative judgements of oublication bias. *P*-value less than 0.05 was considered statistically significant.STATA version 12 statistical software was used to analyze all the data.

Results

Study selection and characteristics of included studies

Our searches initially identified 2878 records from different databases. Through literature management software,520 duplicates were removed. 2241 records were excluded for different reasons after title and abstract screening.117 articles were assessed using the eligibility criteria compliance with the inclusion criteria. Finally, 66 studies (Additional file 2) were included in quantitative synthesis(Fig. 1).

A detailed description of the 69 included studies is shown in Additional file 3. The studies were published between 2001 and 2019. The sample size of each study ranged from 386 to 28,424, and the total population of 188,809 participants including 97,321 males and 91,488 females was included. The point prevalence of sleep disorders varied from 15.3–76.3%. All studies had a cross-sectional design. The survey response rates varied from 68.1–100%, with a mean of 88.9%. The quality scores of six studies were less than five points due to the insufficient sample sizes and no mention of inclusion or exclusion criteria, the excluded patients in detail, describing follow-up, patient response rates, the estimated percentage of incomplete data, and completeness of data collection, etc. Included in the study of the overall quality is acceptable.

Pooled prevalence of sleep disorders

Overall

The sixty-six included studies revealed that the pooled prevalence of sleep disorders was 37.6% (95%CI: 34.3–40.9%, Fig. 2)with high heterogeneity (I^2 = 99.6%, P = 0.000).

Subgroup analysis(Table 1)

Sex and Age groups

The prevalence rate of sleep disorders among males was higher than females (OR:1.01,95%CI:1.05–1.13).In all age groups, the prevalence rates of sleep disorders increased with age, including the infancy or early childhood group(33.3%), pre-school group(38.9%), school-age group(43.7%), and Mixed-age group(37.6%). Specifically, the prevalence rate was the lowest (15.3%) in the infancy or early childhood group and the highest (76.3%) in the school-age group.

Area and Region

The prevalence rate of sleep disorders in urban was slightly lower than in combined urban and rural areas (36.8% vs. 38.6%). The prevalence rate in South China (30.4%, 95%CI: 23.9–36.8%) was the lowest, and the highest prevalence rate was in West China (47.4%,95%CI:35.9–58.9%). But in East, North, and Middle China, the prevalence rates of sleep disorders were similar.

Screening Year

The meta-analysis results indicated that sleep disorders prevalence slightly increased with year. The prevalence rate with screening year after 2006(39.2%,95%CI: 34.9–43.5%) was slightly higher than before 2006 (37.6%,95%CI: 34.3–40.9%).

Questionnaire reference criteria and Sample selection method

The meta-analysis results showed that the point estimate for sleep disorders prevalence obtained using the CSHQ criterion was the highest(47.4%,95%CI:35.2–59.6%), which also higher than the prevalence using other criteria. The prevalence among studies with the Australia criterion(33.5%,95%CI:27.8–39.2%) was the lowest. There were some differences in sleep disorders prevalence among studies using the different sample selection methods. The prevalence(40.0%,95%CI:34.3–45.7%) observed from studies with stratified cluster sampling was the highest. However, the prevalence(28.3%,95%CI:21.1–35.6%) observed from studies with random stratified sampling was significantly lower than that observed from studies using all the other sample selection methods.

Table 1
Prevalence of sleep disorders according to different items

Category	Subgroup	NO.of Studies	Prevalence (95% *CI*)	N	I^2 (%)	*P*	Publication bias *P*(Egger)
Sex	Boy	44	0.36[0.32—0.41]	97321	99.40%	0.02	0.379
	Girl	44	0.33[0.29—0.38]	91488	99.30%	0.02	0.278
Age groups	infancy or early childhood	2	0.33[0.26—0.41]	3636	95.80%	0.00	/
	preschool	27	0.39[0.33—0.45]	46704	99.40%	0.02	0.115
	school-age	16	0.44[0.36—0.51]	66015	99.70%	0.02	0.92
	Mixed-age	21	0.32[0.28—0.36]	72454	99.20%	0.01	0.093
Area	E	23	0.37[0.32—0.42]	54162	99.40%	0.02	0.996
	W	6	0.47[0.36—0.59]	9735	99.30%	0.02	0.432
	S	4	0.3[0.24—0.37]	5064	95.80%	0.00	0.831
	N	20	0.37[0.31—0.42]	43567	99.40%	0.01	0.004
	M	10	0.38[0.3—0.47]	21276	99.50%	0.02	0.354
	T	3	0.34[0.14—0.54]	55005	100.00%	0.03	0.949
Region	Mixed	37	0.37[0.32—0.41]	140141	99.70%	0.02	0.283
	Urban	29	0.39[0.34—0.43]	48668	99.20%	0.02	0.673
Screening Year	Before 2006	34	0.36[0.31—0.41]	113836	99.70%	0.02	0.462
	2006-	32	0.39[0.35—0.44]	74973	99.40%	0.02	0.054

Category	Subgroup	NO.of Studies	Prevalence (95% *CI*)	N	I^2 (%)	*P*	Publication bias *P*(Egger)
Sample selection method	SCS	30	0.4[0.34—0.46]	81235	99.70%	0.03	0.898
	RCS	29	0.37[0.33—0.41]	94897	99.40%	0.01	0.038
	RS	3	0.37[0.34—0.39]	2610	23.20%	0.00	0.429
	RSS	4	0.28[0.21—0.36]	10067	98.10%	0.01	0.242
Questionnaire reference criteria	Australia	15	0.34[0.29—0.39]	57195	99.50%	0.01	0.193
	ICSD	15	0.36[0.31—0.41]	31727	99.10%	0.01	0.972
	CSHQ	9	0.47[0.35—0.60]	36934	99.80%	0.03	0.903
	China	13	0.38[0.30—0.46]	35794	99.60%	0.02	0.36
	N/A	14	0.37[0.30—0.44]	27159	99.40%	0.02	0.327

Meta-sensitivity and Meta-regression analysis

The heterogeneity of all studies evaluated overall was observed particularly high. In the meta-sensitivity analysis across all studies,no significant effect was observed. A meta-regression was performed by Publication Year, Area, ScreeningYear, AgeGroup, Sample selection method, Questionnaire reference criteria, Region, Samplesize, Sex, AHRQ Quality score, and Response rate to explain heterogeneity source.The results indicated that AgeGroup impacted the estimation of point prevalence ($P = 0.011$). However, this result doesn't fully clarify the high level of heterogeneity. (Table 3)

Table 3
Results of Meta-regression analysis for prevalence of sleep disorders

Covariate	Meta-regression coefficient	*95% CI*	*P* value
Publication Year	0.015	-0.009 to 0.039	0.208
Area	-0.014	-0.068 to 0.040	0.608
ScreeningYear	0.082	-0.099 to 0.263	0.369
AgeGroup	0.097	0.023 to 0.171	0.011
Sample selection method	-0.086	-0.196 to 0.024	0.124
Questionnaire reference criteria			
Region	-0.065	-0.247 to 0.118	0.483
Samplesize	0.000	0.000 to 0.000	0.633
Sex	-0.133	-0.709 to 0.444	0.647
AHRQ Quality score	0.022	-0.055 to 0.099	0.573
Response rate	-0.001	-0.007 to 0.004	0.586

Publication bias

A funnel plot including all studies did show evidence of symmetry (Fig. 5). The analysis results of Egger's tests were also consistent ($P = 0.099$). However, we still identified publication bias in some subgroups (Fig. 3).

Discussion

This meta-analysis and systematic review was conducted to evaluate the prevalence rates of sleep disorders among children in Mainland China and characterize the epidemiology of sleep disorders. Through analysis, we identified several characteristics of sleep disorders in Mainland China. Firstly, the point estimate for sleep disorders prevalence obtained in males was higher than in females. Secondly, the prevalence of sleep disorders among the Chinese school-age population observed in this study was observably high. Furthermore, various age groups could impact the prevalence estimation. Thirdly, the prevalence was obviously higher in West China than in South China(47.4% vs. 30.4%). Fourthly, the prevalence of sleep disorders slightly increased over the past two decades (from the point prevalence of 37.6% before 2006 to 39.2% after 2006). Fifthly, the pooled prevalence of sleep disorders among children could be impacted by the application of different questionnaire reference criteria.

Our study showed that the prevalence rates of sleep disorders among children in mainland China ranges from 15.3–76.3%, which was higher than in Europe and the United States(25%)[15]. It may be related to the existence of differences in the subjects' own sleep disorders, as well as to the evaluation tools used in

the study to assess children's sleep disorders, the screening year of the study, the economic and cultural differences in the study area, feeding practices, and various all kinds of questionnaire reference criteria or diagnostic criteria.In addition, sleep disorders among children may also be closely related with China's traditional culture which places greater emphasis on the cultivation of children's sense of family closeness (e.g., children sleeping in the same bed with parents), indulgently parenting style (e.g., children having a TV or computer in the bedroom), relatively overcrowded housing (e.g., small per capita housing area), and the lack of parental attention to children's sleep hygiene[7].The present study identified a higher prevalence of sleep disorders in boys than in girls, which may correlated with sex differences in the anatomy and physiology of the upper airway between males and females[16]. What's more, most boys are overly excited during the day,and the cerebral cortex is still in an excited state after sleep, prone to teeth grinding, night terrors, nightmares, sleepwalking or other sleep problems. However, studies have also shown that estrogen, as a protective hormone, can stabilize the respiratory control system and reduce the occurrence of apnea during sleep[7]. The prevalence of sleep problems in children increase with age, which may be related to a variety of reasons, including a higher burden of coursework and academic stress in older children[17]. Moreover, preschoolers and school-age children may be under the academic pressure to the process of children's transition including from kindergarten to primary school or elementary-school to junior high-school,combined with excessive daytime excitement and reduced sleep intake, which may lead to an increased incidence of teeth grinding.

There may be several reasons why the prevalence rates of sleep disorders among children in the western China was significantly higher than in the coastal areas of southern China.First, poor sleep habits are associated with backward regional cultural attitudes, such as having dinner just before bedtime, habit of the midnight snack, difficulty falling asleep alone, and needing assistance to fall asleep, etc., which result in inadequate sleep duration. Second, parental work schedules and sleep habits may have a direct impact on children's late sleep, insufficient sleep duration and poor sleep quality.The prevalence of sleep disorders has increased compared to previous studies. The development of the society and the increasing competitive pressures in the different years investigated may directly or indirectly affect sleep deprivation, poor sleep quality and irregular sleep patterns. In addition, the rapid economic development in mainland China has made electronic products (such as smartphones, tablet computers, laptops, etc.) widely popularized and applied[18], which may inhibit the brain's secretion of melatonin, leading to hyper-excitement and light sleep in children[19].

At present, the epidemiological investigation of sleep disorders among children mainly adopts a questionnaire survey to carry out a wide range of screening. In mainland China, the Chinese version of an epidemiologic survey questionnaire from the Sleep Center of the Sydney Children’s Hospital and Sydney University and Children's Sleep Habits Questionnaire (CSHQ), the Sleep Status of Self-rating Scale, and the Pittsburgh Sleep Quality Index (PSQI) are widely used to screen for sleep problems. Generally, parents completed the questionnaire, including information on child feeding at birth, children's sleep, parents' sleeping conditions, the incidence of respiratory illnesses, children's or parents' personal conditions, family environment, etc.[20]. Various reference standards or questionnaires have also contributed to the

wide variation in the results of the incidence of sleep problems, and continued research and improvement in future clinical work is needed.

This meta-analysis has its own limitations. Firstly, males included were more than females, which may have lead to an overestimation of the prevalence rate of sleep disorders. Secondly, the prevalence of sleep disorders in all included studies increased with increased age, especially among school-age children. In addition, the age-group categorized differently was associated with the high heterogeneity in all or subgroups analyses. Although we also identified different age groups as possible influencers of these results, the extent of this explanation was very limited. Thirdly, most of the included studies were conducted in the developed regions in mainland China. And some included studies conducted at the relatively backward western regions have an observably high prevalence of sleep disorders, which could lead to widely varying and poorly representative results. Nevertheless, our study had a large sample size and was in line with the PRISMA statement. The sample in the included studies was drawn from a sample survey, and the included cases were screened and clearly diagnosed, so the results have some confidence.

Conclusions

Over the past two decades, the prevalence rate of sleep disorders among children in mainland China has increased, significantly affecting two-fifth of the school-age children.The prevalence of sleep disorders in males was higher than in females. In the west of China, the prevalence rate of sleep disorders was much higher than in South China or other areas, it may be associated with economic differences. However, there is still a lack of guidelines on children's sleep disorders in mainland China, and future researches should pay special attention to the sleep disorders of school-age children and children in economically backward areas.

Abbreviations

E Eastern China,W Western China,S Southern China,N Northern China,M Middlel China,T nationwide,Mixed Urban and Rural,SCS Stratified cluster sampling, RCS Random cluster sampling , RS Random sampling, RSS Random stratified sampling,CSHQ Children's Sleep Habits Questionnaire,ICSD International Classification of Sleep Disorders,N/A unavailable

Declarations

Acknowledgements
We thank all our colleagues working in the Department of Epidemiology and Health Statistics, School of public health of Central South University.
Funding
No funding was obtained for this study.
Availability of data and material

All data generated or analyzed during this study are included in this published article.

Authors' contributions

XRC,ZL K and XXLparticipated in the design of the study and data collection.

XRC,ZL K and XXL performed the statistical analysis. XRC,YH C and XXL conceived of the study and participated in its design as well as coordination and helped to write and revise the manuscript. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable.

Ethics approval and consent to participate

The ethical approval is not necessary for the meta-analysis of the published studies.

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Figures

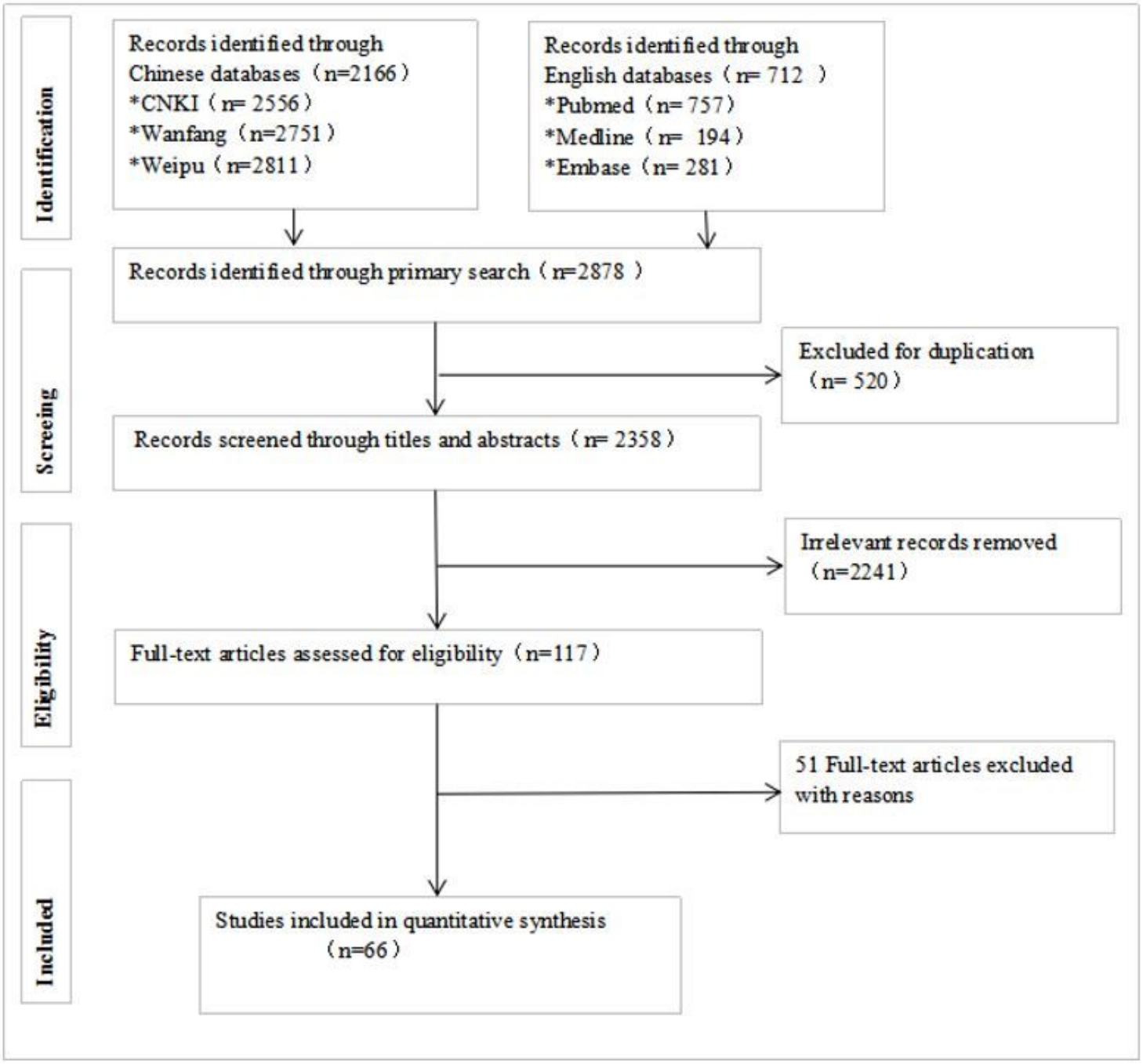
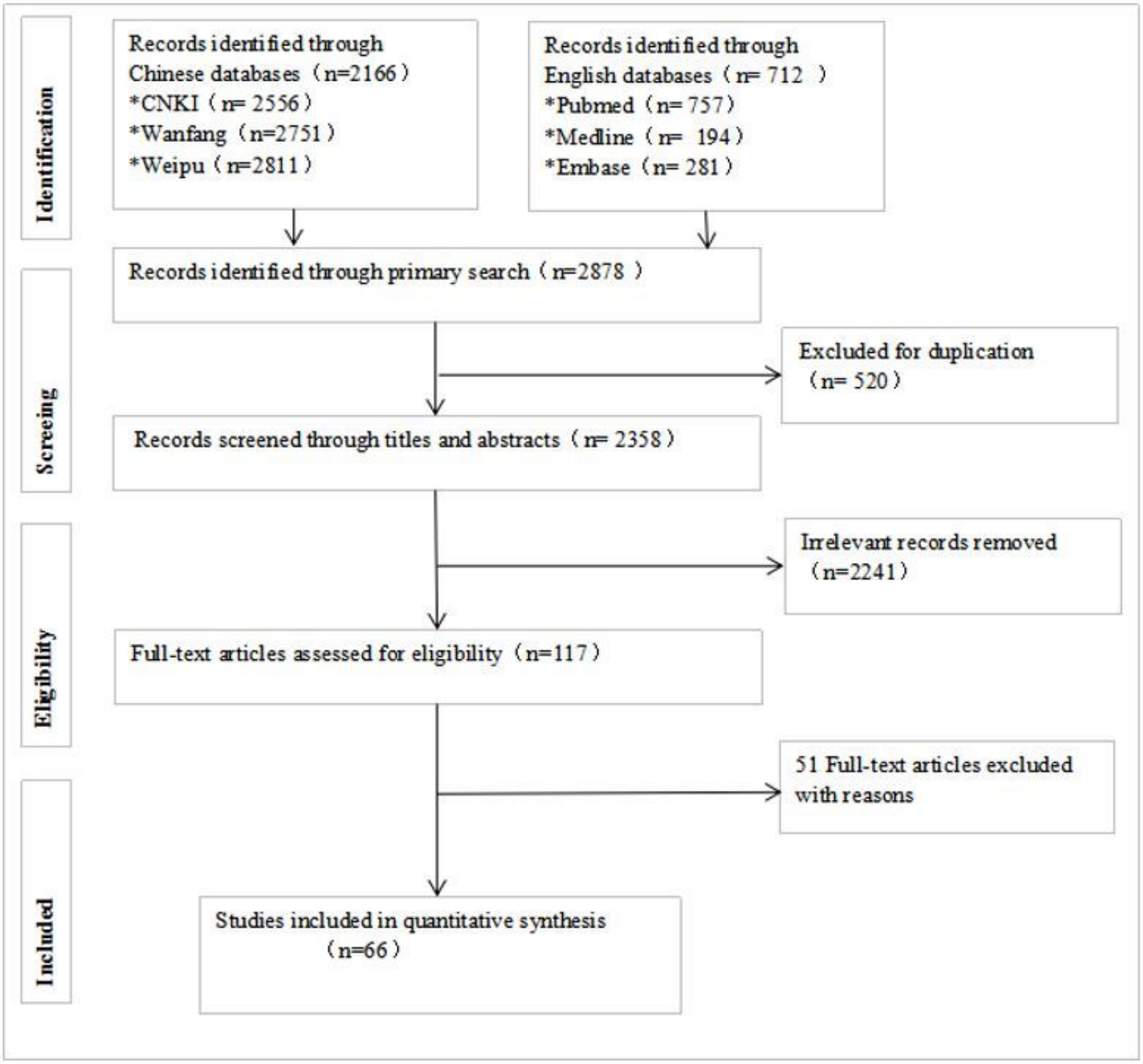


Figure 1

Flow chart of study selection for systematic review and meta-analysis



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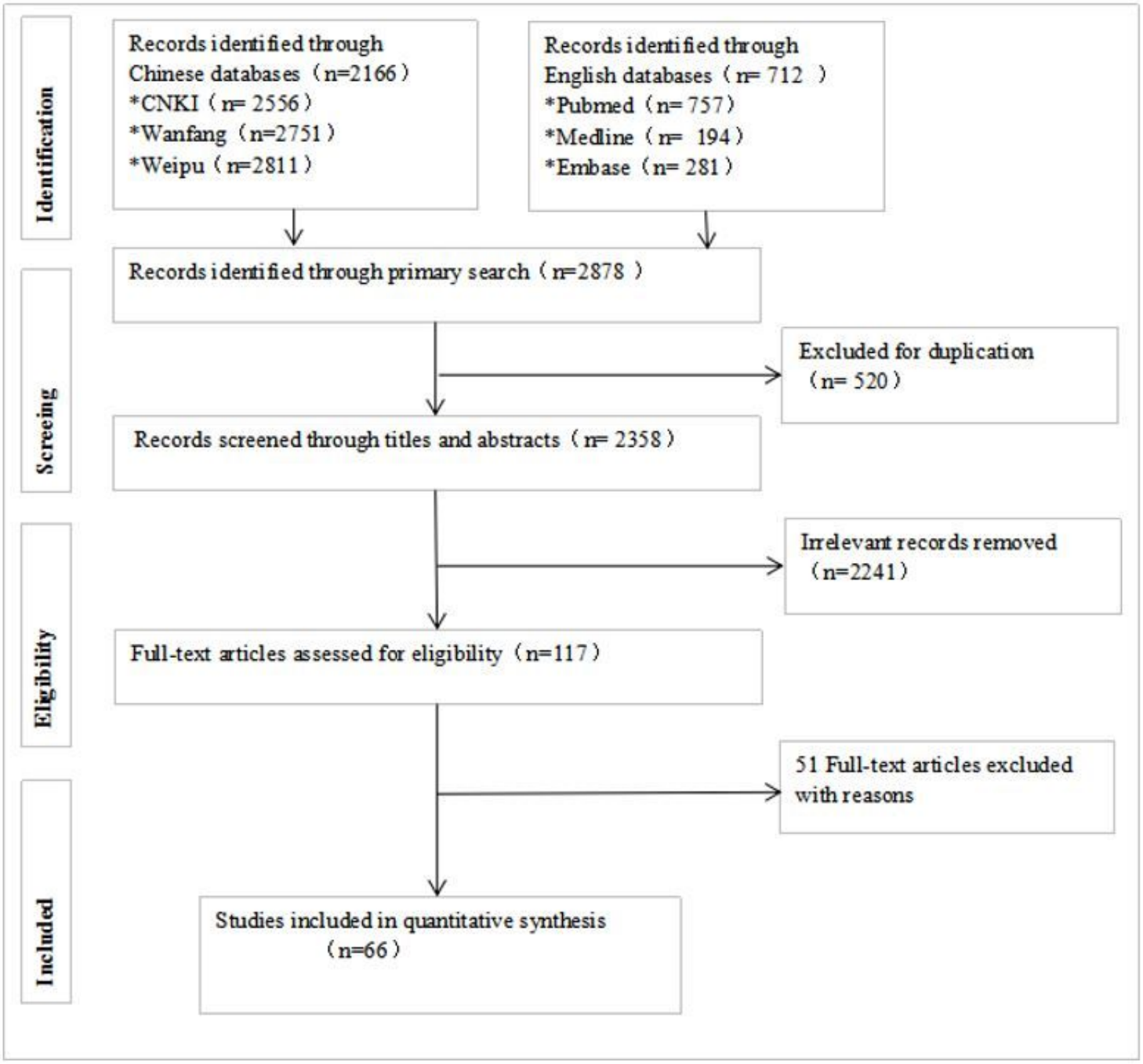


Figure 1

Flow chart of study selection for systematic review and meta-analysis

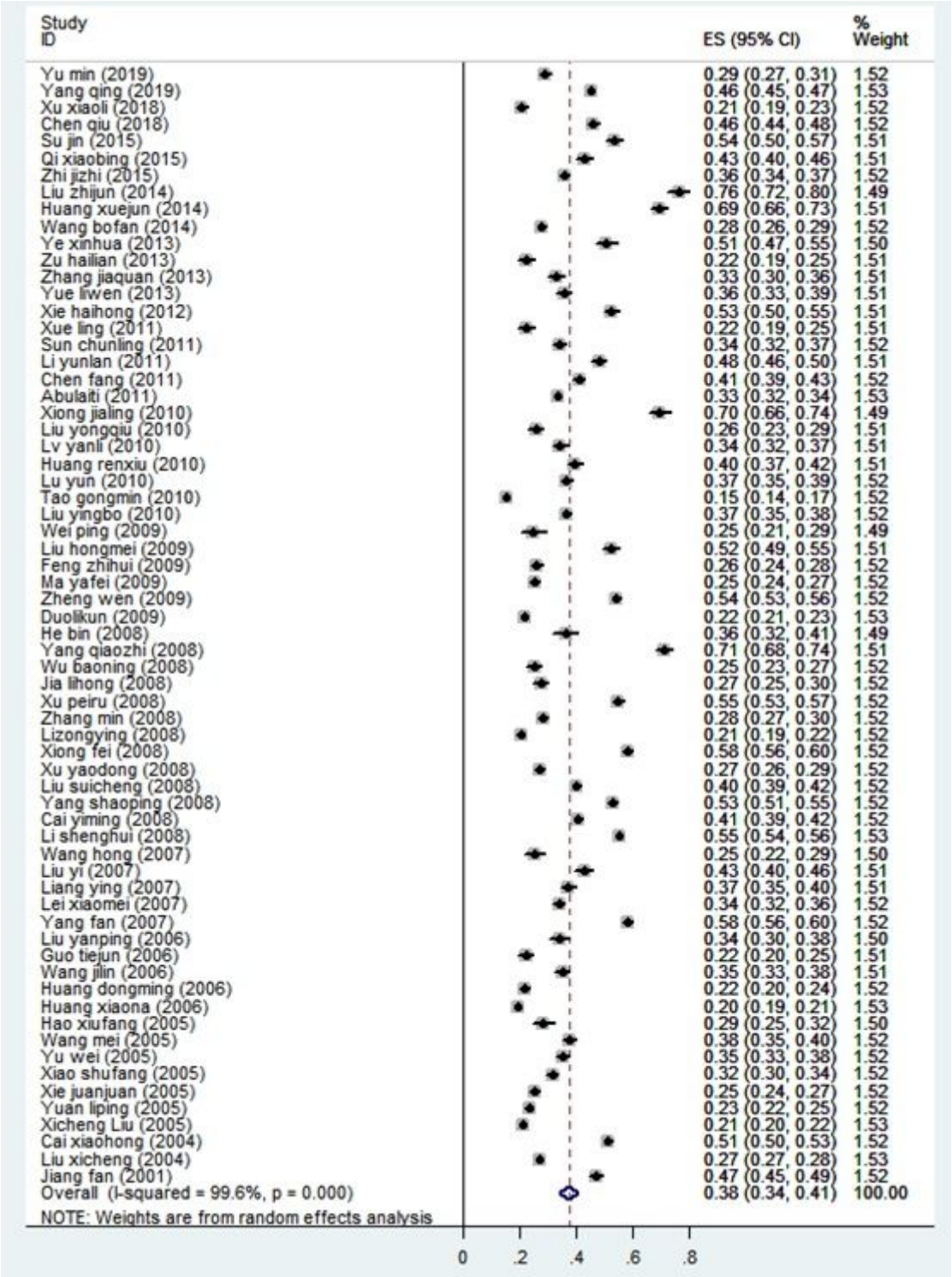
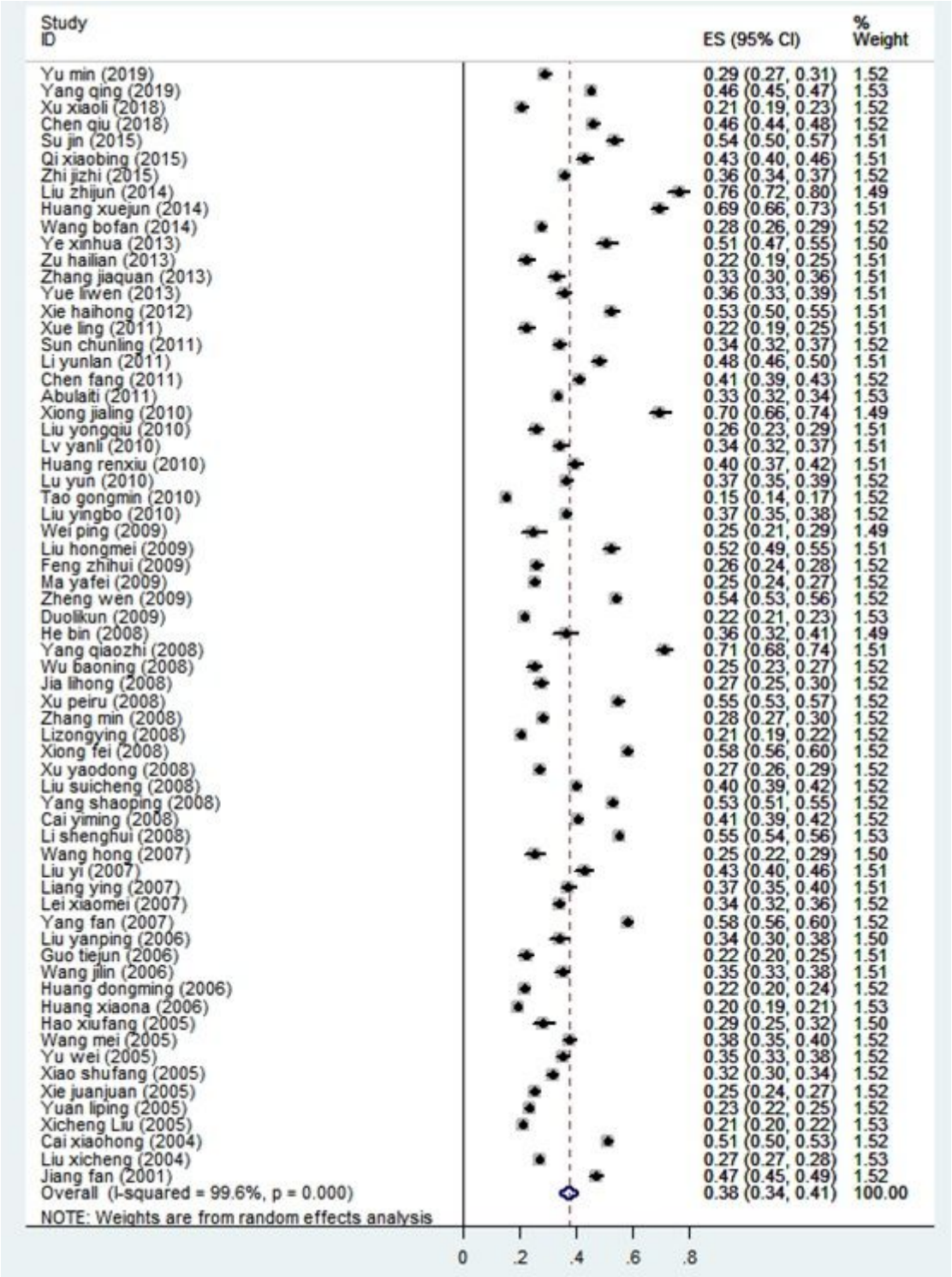


Figure 2

Forest plot of prevalence of sleep disorders for total children



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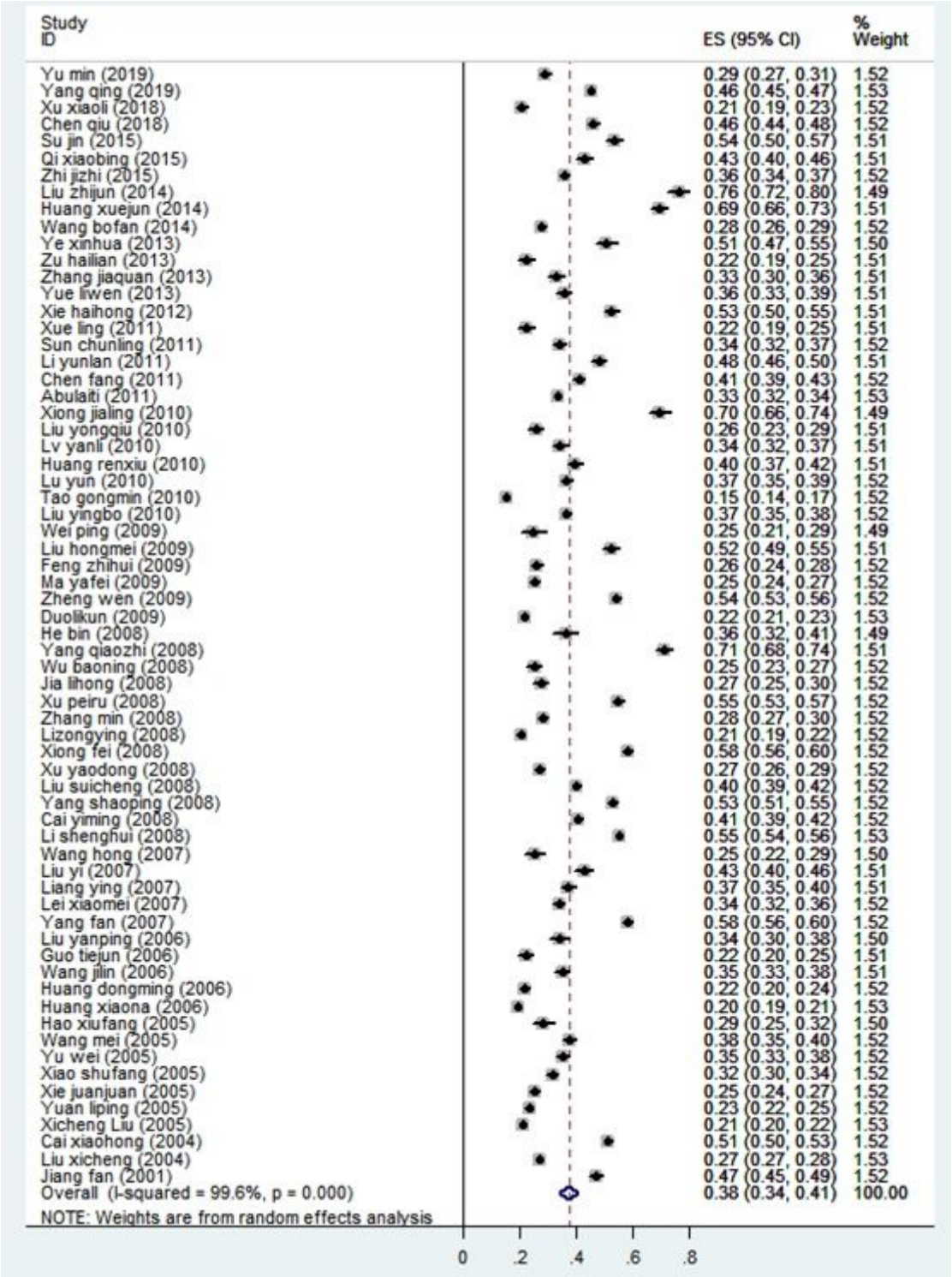

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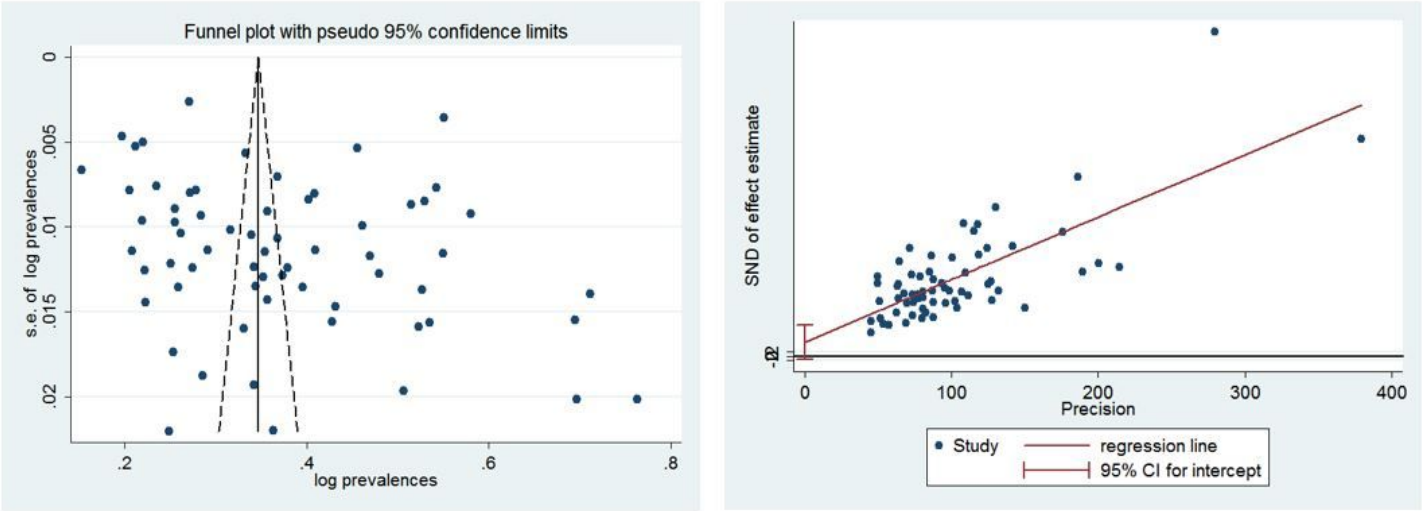

Figure 3

Funnel plot(Left) and Egger's tests for publication bias(Right)

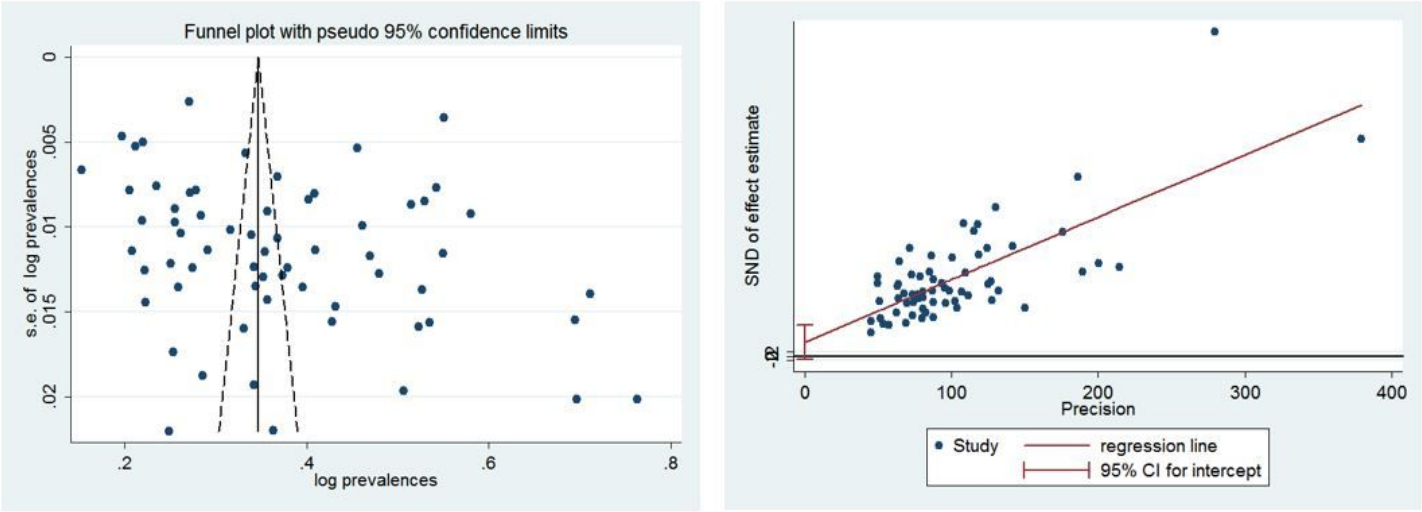

Figure 3

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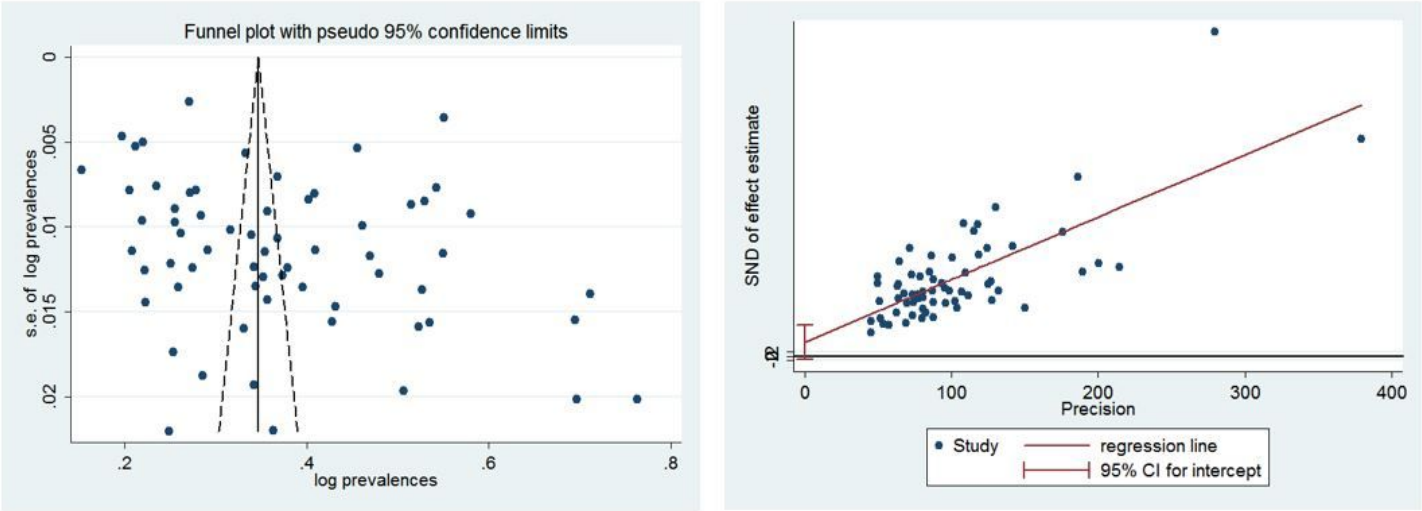

Figure 3

Funnel plot(Left) and Egger's tests for publication bias(Right)

Supplementary Files

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