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REVIEW

Spatiotemporal Trends in the Prevalence of Obstructive Sleep Apnoea Across China: A Multilevel Meta-Analysis Incorporating Geographic and Demographic Stratification (2000-2024)

Yuqi Niu, Shanwen Sun, Yali Wang, Linlin Chen, Yefan Shao, Xiaochun Zhang

Department of Respiratory and Critical Care Medicine, First Affiliated Hospital of China Medical University, Shenyang, Liaoning, People's Republic of China

Correspondence: Xiaochun Zhang, The First Affiliated Hospital of China Medical University, 155 North Nanjing Street, Heping District, Shenyang, Liaoning, People's Republic of China, Tel +86 13898824248, Email xczhang73@cmu.edu.cn

Purpose: China bears the highest global burden of obstructive sleep apnea (OSA), yet its spatiotemporal and occupational patterns remain unclear. We quantified OSA prevalence across Chinese subpopulations, focusing on geographic disparities, temporal trends, and occupational risks.

Methods: Following PRISMA guidelines, we systematically searched six databases (2000–2024) for population-based OSA studies using polysomnography or validated portable monitoring. Two researchers independently screened studies with third-party adjudication of discrepancies. Risk of bias was assessed using Joanna Briggs Institute criteria. Random-effects models pooled prevalence estimates; meta-regression identified heterogeneity contributors. OSA diagnosis followed 2012 AASM criteria (AHI ≥5; pediatric studies: OAHI ≥1.5).

Results: From 62 studies (N=178,049), pooled OSA prevalence was 11.8% (95% CI:10.1–13.4%), rising from 8.1% (2000–2005) to 26.9% (2021–2024). Prevalence was higher in males vs females (11.1% vs 6.0%, P<0.001), with marked geographic disparities: Northwest China had the highest prevalence (17.8%, 16.3–19.3%) versus Southwest (6.9%, 3.7–10.9%). Drivers exhibited the highest occupational risk (15.3%). Low-quality studies overestimated prevalence (15.0% vs 7.6–10.2% in higher-quality studies), and two-step sampling yielded higher estimates than single-risk-group designs (13.6% vs 7.4%, P<0.001). Meta-regression identified survey period (β=0.036, P=0.025), male sex (β=−0.062, P=0.047), geographic area (β=0.268, P=0.035), occupation (β=0.254, P=0.047), and sampling strategy (β=−0.029, P=0.012) as key predictors of heterogeneity.

Conclusion: OSA prevalence in China has accelerated significantly. Standardized screening is urgently needed for aging populations, high-risk occupations (particularly drivers), and underserved regions. Policy priorities should address rural diagnostic inequities and integrate OSA surveillance into public health programs. Methodological harmonization is critical for tracking OSA's evolving burden.

Keywords: obstructive sleep apnoea, OSA, prevalence, China, subgroup analysis, meta-analysis

Introduction

Obstructive sleep apnoea (OSA) is a significant chronic disorder characterized by upper airway obstruction during sleep. It presents as nocturnal apnoea and recurrent hypoventilation events. The disorder has a markedly detrimental impact on the quality of sleep and daytime functionality of patients, and is Lregarded as aL significant risk factor for cardiovascular disease, metabolic syndrome, and other health complications.[1,2] Furthermore, it is a principal contributory factor in road traffic accidents and workplace accidents, resulting in a substantial economic burden on society.[3] In recent years, there has been a notable increase in the incidence of OSA globally, with an increasing number of adults and children affected, often without timely diagnosis and treatment.[4]

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A global epidemiological study on the prevalence of obstructive sleep apnoea (OSA) conducted in 16 countries revealed that 936 million adults aged 30–69 years had OSA, with 425 million exhibiting moderate-to-severe OSA.[4] The highest prevalence was observed in China, followed by the United States, Brazil, and India. A review of the Asian literature in 2019 by Mirrakhimov et al identified a range of adult OSA prevalence estimates, from 3% to 97%. A subsequent review of the European literature demonstrated that the prevalence of OSA in the general adult population ranged from 9% to 38%.[5] The Asian study reported an 11% prevalence of obstructive sleep apnoea in India.[6] The considerable disparity in these findings is attributable to a number of factors, including the diverse geographic regions under consideration, the varying study designs and methodologies employed, and the differing characteristics of the populations under investigation. It is also noteworthy that studies on OSA in the pediatric population are becoming increasingly prevalent. A number of studies have demonstrated a significant association between the prevalence of OSA in children and a range of factors, including age, sex, and obesity.[7] A systematic evaluation of the literature revealed that the prevalence of OSA was significantly higher in obese children, reaching 22%.[8] The available evidence from studies conducted in both developed and developing countries indicates that there are significant differences in the observed trends. In developed countries, there is a tendency for higher rates of identification and diagnosis, whereas in developing countries, the lack of relevant medical resources and awareness often results in a failure to complete a comprehensive assessment.[4]

As China transitions into the role of the world's largest developing country, the concomitant rapid economic growth and lifestyle changes are contributing to an increase in the prevalence of obstructive sleep apnea (OSA).[9] The rapid pace of urbanization, coupled with shifts in dietary habits and evolving lifestyles, has further compounded the complexity of this health issue. Furthermore, in conjunction with the aging of the population, the prevalence of OSA is gradually increasing across different age groups. However, due to the vast geographic area, large population, and dispersed, heterogeneous nature of research data in China, there is a dearth of comprehensive and accurate integrated assessments of the prevalence of OSA in the country. It is therefore clinically and epidemiologically important to conduct a meta-analysis, integrating data from existing studies, in order to systematically assess and estimate the prevalence of OSA in China.

The objective of this study was to conduct a systematic meta-analysis of the prevalence of obstructive sleep apnoea (OSA) in Chinese patients. A comprehensive search of the relevant literature and the application of statistical methods enabled us to derive an overall prevalence estimate and identify associated risk factors by summarising the data from several studies. To gain a deeper understanding of the prevalence of OSA in different subgroups of the Chinese population, this study conducted a meta-analysis of the prevalence of OSA in China by subgroup analysis methods based on age, gender, geographic region, year, urban/rural, and occupation.

Material and Methods

Study Design

The implementation of this systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 (PRISMA) statement.[10] As the meta-analysis was based on previously published studies, no ethical statement was required for this study.

Search Strategy

A comprehensive search was conducted for relevant studies published in Chinese and English bibliographic databases, including China Knowledge Network (CNKI), Wanfang, Weipu, PubMed, Web of Science, and Embase, between 1 January 2000 and 1 October 2024. The literature search was conducted using medical subject headings (MeSH terms) and free-text terms, with keywords including "prevalence", "OSA", "obstructive sleep apnea" and "China". A combination of Boolean logic operators (eg "OR" and "AND") was employed in the search strategy. Only studies published in Chinese or English were included in the review. To ensure comprehensive coverage, we conducted a manual search for references to include reviews and relevant studies. Please refer to the supplementary tables (Supplementary Table S1-S7) for a detailed account of the search terms and strategies employed.

Inclusion and Exclusion Criteria

The following criteria were used to determine inclusion: (a) the prevalence of OSA was either reported or calculable; (b) the participants were of Chinese nationality; (c) the presence of OSA symptoms was evaluated using a standardized instrument; (d) studies that directly and/or indirectly provided the prevalence of OSA and sample sizes; and (e) published or unpublished articles were reported in either Chinese or English. The following studies were excluded from the review: (a) reviews, case reports, commentaries, letters, and editorials; (b) studies involving different diseases or disease comorbidities; (c) studies that did not provide prevalence data; (d) studies for which the full text was not available through online databases, library requests, or e-mail correspondence with the authors; and (e) studies assessed to be of moderate or low quality based on the risk of bias tool for prevalence studies.

Data Extraction

Duplicate articles were removed using reference management software (NoteExpress V4.0 and EndNote version X9.0). Two authors (YQ N and SW S) undertook an independent screening of the titles and abstracts of the collected studies, followed by the retrieval and assessment of the full-text versions of the studies in accordance with the pre-established inclusion and exclusion criteria. In the event of multiple studies utilizing the same dataset, only the study comprising the largest sample size was included to ensure the accuracy of the assessment. In the event of any disagreement, a third investigator (YL W) was consulted to facilitate a negotiated resolution or, if necessary, to make a final adjudication. The data were extracted in Microsoft Excel using a standardized format. The extracted information included the name of the first author, key outcomes (prevalence or number of cases and sample size), year of data collection, region (where the study was conducted), study site (urban versus rural), age and sex of the participants, method of sample selection (epidemiological survey methodology), and other necessary information. Furthermore, the sampling strategy was documented, including the sampling frame, randomization techniques, and the use of screening questionnaires to identify subjects at risk. The type of sleep study conducted in each study was clearly documented, as well as the definition of OSA that was applied (eg, apnoea–hypoventilation index (AHI) or respiratory disturbance index (RDI) thresholds). The prevalence of reported OSA (AHI or RDI ≥5 events per hour) was recorded. In studies employing two-step sampling (ie, screening questionnaires followed by a sleep study), we documented whether only high-risk subjects or both high- and low-risk subjects underwent a sleep study. This was done in order to validate the weighted prevalence based on the proportion of subjects tested and found to have OSA in each risk category. Following the removal of duplicates from the initial search results, all data extraction was conducted by one evaluator (YQ N), while another evaluator (SW S) undertook a detailed examination of the extracted data and addressed any inconsistencies. Any discrepancies were resolved through discussion with the involvement of both evaluators. The data were primarily sourced from the primary literature, with supplementary information obtained through direct communication with the authors when necessary. In the event that no response was received within one month, the requested data were considered to be missing.

Quality Assessment

In order to assess the quality of the included studies, the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Studies Reporting Prevalence Data (hereafter referred to as the "JBI Checklist") was employed.[11] This consists of nine items, namely sample frame, sample size, and description of the sample. The following criteria were considered: sample size, subject characteristics, and environmental description, sample coverage for data analysis, the validity of the assessment method, standardization and reliability of the method of assessing the results, the accuracy of the statistical analysis, and response rate. A score of 1 was assigned for each criterion, and the evaluator determined the risk of bias by responding with one of four options: "yes", "no", "not sure", or "not applicable". This procedure allows for the identification of the cause of bias. The total RoB assessment score ranges from 0 to 9, with a higher score indicating a lower risk of bias. In this study, the results of the risk of bias assessment were categorized into three levels: low (RoB score of 8–9), medium (RoB score of 6–7) and high (RoB score of 3–5). A score of less than six out of a possible nine was deemed to indicate a low quality of study.[12] The quality assessment process was conducted by two independent evaluators (YQ N and SW S), with a third researcher (YL W) consulted in the event of any discrepancy.

Statistical Analysis

The pooled estimates of OSA prevalence for the included studies were tabulated, and the precision of the pooled results was assessed using 95% confidence intervals (CIs). The standard errors of prevalence were calculated on the basis of the prevalence of each included study in relation to the sample size. A meta-analysis was employed to derive pooled estimates of the prevalence of OSA and their 95% confidence intervals (95% CIs) for the overall sample and for each sub-cohort. The prevalence and combined estimates were displayed in forest plots. The Cochran-based chi-square Q-tests and I^2 tests were employed for the assessment of study heterogeneity. In instances where there was minimal evidence of heterogeneity (ie, $I^2 \leqslant 50\%$, heterogeneity $P>0.10$), a fixed-effects model was employed to generate the combined estimates. Conversely, in situations where heterogeneity was more pronounced, a random-effects model was utilized. Z-tests were employed to ascertain whether the combined rates differed significantly between cohorts. The sources of heterogeneity in prevalence estimates were explored through the use of subgroup analyses, which classified the cohorts based on a number of factors, including survey year (classified into five-year periods), sex (female and male), region (urban, rural, and mixed), geographic area (North China, Northeast China, East China, Central China, South China, Southwest China, and Northwest China), age, occupation, method of sample selection, method of sleep monitoring, and results of quality assessment. To evaluate the impact of study quality on prevalence estimates, we conducted sensitivity analyses excluding studies with Joanna Briggs Institute (JBI) scores ≤5 (low quality). A secondary analysis restricted inclusion to studies with JBI ≥8 (high quality). We assessed potential publication bias through visual inspection of funnel plot symmetry, Egger's test ($P<0.05$). Furthermore, meta-regression analyses were conducted to investigate the sources of heterogeneity and the primary factors influencing prevalence estimates. A two-sided p-value of less than 0.05 was considered statistically significant. All data analyses were conducted using STATA version 16.0 (StataCorp LP, College Station, Texas, USA).

Results

Study Selection and Characteristics of Included Studies

A total of 2,548 relevant studies were identified through the application of search techniques across six electronic databases and grey literature. Following the removal of 390 duplicates using literature management software, 2033 records were excluded for various reasons after title and abstract screening. An assessment method that met the inclusion criteria was employed, and 125 articles were ultimately selected for further review. Following a comprehensive assessment, 62 studies were ultimately deemed eligible for inclusion (see List of Studies). The inclusion process is outlined in Figure 1. All included studies employed a cross-sectional design, with sample sizes ranging from 144 to 13,625 and a total population of 178,049 participants. The prevalence of OSA ranged from 1.2% to 88.2%. All of the included studies employed polysomnography (PSG) techniques for the identification of OSA. For further details regarding the characteristics of the included studies, please refer to Table 1.

The studies included in the review were published between 2001 and 2024 and involved a total of 178,049 subjects. Of the studies included, 14 were focused on North China, 2 on Northeast China, 22 on East China, 4 on Central China, 6 on Southwest China, 2 on Northwest China, and 12 on South China. In addition, 37 studies were conducted in urban settings, with two studies conducted in rural settings. Furthermore, 23 studies employed a balanced recruitment strategy, ensuring an equal representation of urban and rural subjects. The age range of subjects used in the studies differed. All of the included studies employed a two-step sampling process. In the initial stage of the process, individuals deemed to be at risk of developing obstructive sleep apnoea (OSA) were identified through the utilization of vernacular versions of various questionnaires. The questionnaires employed included the Snoring Symptom Screen, the Epworth Sleepiness Scale, the Berlin Questionnaire, the STOP-Bang Questionnaire, the Paediatric Sleep Questionnaire (PSQ), and a self-designed questionnaire by the investigators. In the second step, subjects were invited to participate in a sleep study based on a risk assessment, with sample sizes of either a high- versus low-risk group (n = 25) or a high-risk group only (n = 37). The final prevalence was calculated by weighted averaging the proportions of individuals tested and diagnosed with OSA in the high- and low-risk groups. In some studies, the weighted prevalence rates were not reported directly; rather,

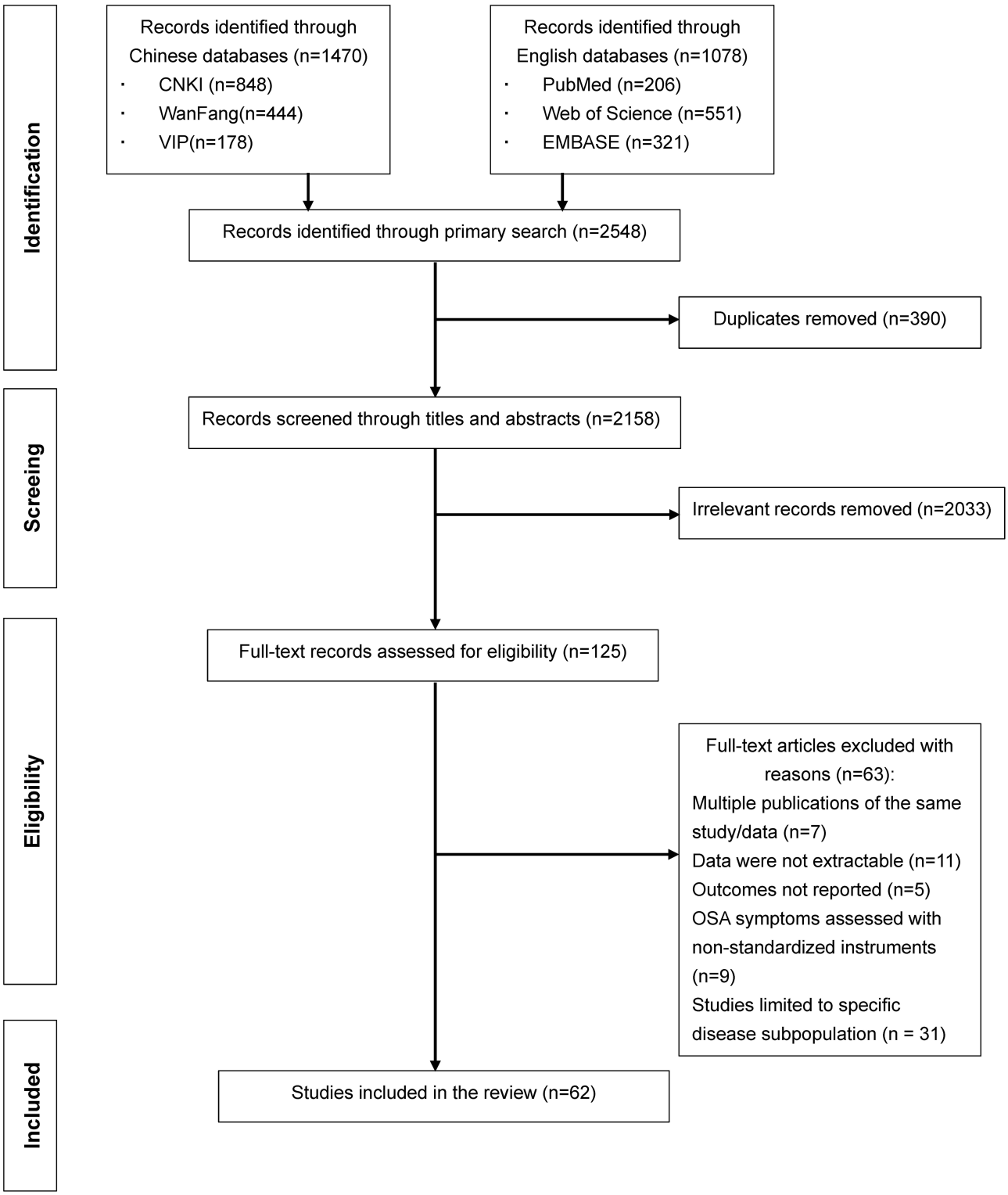

Figure 1 Flow chart of study selection for systematic review and meta-analysis.

they were extrapolated based on the number of sleep tests performed and the number of positive results in each risk group.

Of the studies included in the review, 43 employed all-night laboratory polysomnography (PSG), while the remaining 19 utilized portable sleep monitoring. With regard to the definition of apnoea, there was considerable consistency across

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Table 1 Characteristic of Studies on the Prevalence of Obstructive Sleep Apnoea

Author	Screening Year	Province or Municipality	Geographic Area	Region of Study	Age Range	Mean Age (SD)	Sex (M/F)	N with OSA	Total Sample Size	Prevalence Rate (%)	Sampling Method	Sampling Strategy	Diagnostic Method	OSA Diagnostic Criteria
Ip et al, 2001[13]	1997.07–1999.04	Xianggang	SC	Urban	30–60	41.2±6.4	784/-	32	784	4.08%	RCS	Both high- and low-risk	3	AHI≥5 (sleep lab PSG)
Lin et al,2002[14]	2000.06–2001.12	Weifang	EC	Mixed	1.2–87	N/R	2026/1874	47	3900	1.21%	*RS*	Only high-risk	1, 2, 3	AHI ≥5 (sleep lab PSG)
SRDSG.,2003[15]	N/R	Shanghai	EC	Urban	30–99	54.8±13.5	3378/3448	247	6826	3.62%	RCS	Only high-risk	2, 3	AHI ≥5 (sleep lab PSG)
Zhang et al,2003[16]	N/R	Chengde	NC	Urban	30–86	48.4 ±13.17	582/586	54	1168	4.62%	RCS	Only high-risk	1, 2, 3	AHI ≥5 (portable monitor)
Ip et al,2004[17]	1998.01–2000.12	Xianggang	SC	Urban	30–60	41.6 ±7.4	-/678	15	678	2.21%	RCS	Both high- and low-risk	3	AHI≥5 (sleep lab PSG)
Wang et al,2004[18]	1998.01–2001.12	Taiyuan	NC	Urban	0–100	N/R	2901/2227	179	5128	3.49%	RCS	Only high-risk	1, 2, 3	AHI ≥5 (sleep lab PSG)
Ye et al,2005[19]	N/R	Beijing	NC	Urban	40–101	N/R	-/1220	136	1220	11.15%	SCS	Both high- and low-risk	1, 2, 3	AHI≥5 (sleep lab PSG)
Li et al,2005[20]	2004.03–2004.06	Changchun	NEC	Urban	20–88	43±13	1842/1806	2262	3648	62.10%	RCS	Both high- and low-risk	1, 2, 3	AHI≥5, LSaO2<90%(sleep lab PSG)
Liang et al,2006[21]	2002.12–2004.06	Nanjing	EC	Urban	21–54	31.9±16.7	1063/2	20	1065	1.88%	RCS	Both high- and low-risk	1, 2, 3	AHI≥5 (sleep lab PSG)
Hou et al,2006[22]	2003.02–2005.05	Zhuzhou	CC	Urban	6–92	N/R	2025/1591	146	3616	4.04%	RCS	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Li et al,2006[23]	2005.08–2005.12	Guangzhou	SC	Urban	70–91	N/R	146/7	57	153	37.25%	RCS	Both high- and low-risk	3	AHI ≥5(sleep lab PSG)
Hu et al,2007[24]	2004.01–2005.01	Changchun	NEC	Mixed	15–70	N/R	4589/1715	131	6304	2.08%	RCS	Both high- and low-risk	1, 2, 3	AHI ≥5 (portable monitor)
Liu et al,2007[25]	2003.01–2005.03	Guangxi	SC	Mixed	14–99	39.60±17.46	5451/5080	448	10 531	4.25%	RCS	Both high- and low-risk	1, 2, 3	AHI ≥5(sleep lab PSG)

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Gong et al,2007[26]	N/R	Shanghai	EC	Urban	30–100	63.58±15.55	867/1133	73	2000	3.65%	RCS	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Zou et al,2007[27]	N/R	Shaoyang	CC	Urban	≥20	N/R	2071/1949	126	4020	3.13%	RCS	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Jing et al,2008[28]	2003.07–2003.08	Chengde	NC	Mixed	N/R	N/R	646/72	30	718	4.18%	RCS	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Zhang et al,2008[29]	2007.02–2007.07	Jinan	EC	Urban	3–6	4.1±1.7	395/372	17	767	2.22%	RCS	Both high- and low-risk	3, 7	AHI ≥3(sleep lab PSG)
Huang et al,2009[30]	2005.01–2005.06	Wenzhou	EC	Mixed	18–72	N/R	7102/6523	446	13 625	3.27%	RCS	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Lin et al,2009[31]	2005.05–2008.02	Fuzhou	EC	Urban	20–95	45±16	2168/2118	205	4286	4.78%	RCS	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Ge et al,2009[32]	2005.06–2006.12	Qindao	EC	Urban	≥20	N/R	3436/3594	237	7030	3.37%	RCS	Only high-risk	1, 3	AHI ≥5 (portable monitor)
Gao et al,2009[33]	N/R	Wenzhou	EC	Urban	20–69	N/R	1416/584	90	2000	4.50%	*RS*	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Ma et al,2010[34]	2006.06–2006.09	Xilinguole	NC	Rural	20–81	N/R	776/1242	325	2018	16.11%	RCS	Only high-risk	1, 2, 3	AHI ≥5 (portable monitor)
Zhang et al,2010[35]	2009.03–2009.06	Huhehaote	NC	Mixed	20–63	N/R	931/84	149	1015	14.68%	*RS*	Both high- and low-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Lin et al,2010[36]	2005.05–2008.02	Fuzhou	EC	Urban	60–95	69.0±7.6	481/423	93	904	10.29%	RCS	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Li et al,2010[37]	N/R	Xianggang	SC	Urban	5~13	N/R	3260/3187	310	6447	4.81%	RCS	Both high- and low-risk	3, 7	OAHI≥1(sleep lab PSG)
Wei et al,2010[38]	N/R	Beijing	NC	Urban	3~14	N/R	N/R	543	9198	5.90%	SCS	Only high-risk	3, 6	AHI ≥5 (portable monitor)
Ma et al,2011[39]	2000.01–2010.12	Taiyuan	NC	Mixed	0–70	N/R	N/R	428	1004	42.63%	RCS	Both high- and low-risk	1, 3	AHI ≥5 (portable monitor)
Che et al,2011[40]	2010.05–2010.12	Jinan	EC	Urban	30–97	55.1±12.5	3437/3387	272	6824	3.99%	RCS	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Jin et al,2012[41]	N/R	Guangzhou	SC	Urban	≥30	N/R	-/865	94	865	10.87%	SCS	Both high- and low-risk	3, 7	AHI ≥5(sleep lab PSG)
Xie et al,2012[42]	2010.08–2011.12	Quanzhou	EC	Mixed	16–47	34.46±8.12	N/R	92	3812	2.41%	RCS	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)

(*Continued*)

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Table 1 (Continued).

Author	Screening Year	Province or Municipality	Geographic Area	Region of Study	Age Range	Mean Age (SD)	Sex (M/F)	N with OSA	Total Sample Size	Prevalence Rate (%)	Sampling Method	Sampling Strategy	Diagnostic Method	OSA Diagnostic Criteria
Hu et al,2013[43]	2009.08–2010.08	Shanghai	EC	Urban	4~7	5.73 ± 1.17	2266/1779	158	4045	3.91%	RCS	Both high- and low-risk	2, 3, 4	AHI ≥5, LSaO2≤94% (sleep lab PSG)
Wang et al,2013[44]	2011.09–2012.10	Chengde	NC	Urban	19–60	36.05±9.17	455/-	55	455	12.09%	RCS	Only high-risk	2, 3	AHI ≥5 (portable monitor)
Zhao et al,2013[45]	2010.11–2011.10	Beijing	NC	Urban	14–78	31.3±12.4	2401/2587	481	4988	9.64%	RCS	Both high- and low-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Zheng et al,2013[46]	N/R	Guangzhou	SC	Mixed	19–53	N/R	323/12	42	335	12.54%	RCS	Both high- and low-risk	2, 3	AHI ≥5 (portable monitor)
Sun et al,2014[47]	2010.09–2012.09	Kunming	SW	Urban	20–60	N/R	1605/1480	121	3085	3.92%	*RS*	Both high- and low-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Hu et al,2014[48]	2012.04–2013.12	Shanghai	EC	Urban	20–95	48.3 ± 14.0	3552/3290	349	6842	5.10%	RCS	Both high- and low-risk	1, 2, 3, 4	AHI ≥5, LSaO2<90% (sleep lab PSG)
Peng et al,2014[49]	2012.12	Guangzhou	SC	Urban	3~6	N/R	724/602	96	1326	7.24%	RCS	Only high-risk	3, 7	AHI ≥5, LSaO2<92% (sleep lab PSG)
Chen et al,2014[50]	2011.06–2012.05	Chengdu	SW	Urban	23–88	40.92±15.54	968/721	94	1689	5.57%	RCS	Only high-risk	1, 2, 3	AHI ≥5 (portable monitor)
Liu et al,2014[51]	N/R	Guangxi	SC	Mixed	14–99	N/R	5594/5225	444	10 819	4.10%	RCS	Both high- and low-risk	1, 2, 3	AHI ≥5 (portable monitor)
Wu et al,2014[52]	2011.11–2013.10	Honghe	SW	Mixed	≥20	N/R	N/R	62	1566	3.96%	RCS	Only high-risk	3, 7	AHI ≥5(sleep lab PSG)
Ng et al,2015[53]	2007.9–2010.8	Xianggang	SC	Urban	≥60	73.9±7.5	207/612	33	819	4.03%	RSS	Both high- and low-risk	2, 3	AHI ≥5 (portable monitor)
Wu et al,2016[54]	2007.03–2014.10	Guiyang	SW	Mixed	19–60	36.02±9.09	510/57	155	567	27.34%	*RS*	Both high- and low-risk	2, 3	AHI ≥5(sleep lab PSG)

Jin et al,2016[55]	2013.06–2014.12	Beijing	NC	Urban	30–60	N/R	619/507	82	1126	7.28%	RCS	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Wang et al,2016[56]	2014.03–2014.09	Wuhan	CC	Mixed	24–58	36.0±5.6	389/-	46	389	11.83%	RCS	Only high-risk	1, 2, 3	AHI ≥5 (portable monitor)
Liu et al,2016[57]	2014.10–2015.09	Shanghai	EC	Mixed	25–53	40.4±6.0	823/-	111	823	13.49%	RCS	Only high-risk	1, 2, 3	AHI ≥5 (portable monitor)
Su et al,2016[58]	N/R	Dongying	EC	Urban	60–89	69±5.4	534/400	304	934	32.55%	RCS	Only high-risk	3, 4	AHI ≥5(sleep lab PSG)
Ma et al,2017[59]	2016.09–2016.12	Penglai	EC	Mixed	30–59	N/R	1398/1110	68	2508	2.71%	*RS*	Only high-risk	3, 7	AHI ≥5(sleep lab PSG)
Zhang et al,2017[60]	N/R	Nantong	EC	Mixed	≥30	N/R	N/R	118	3780	3.12%	RCS	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Hu et al,2017[61]	N/R	Ningxia	NW	Mixed	≥20	N/R	971/789	174	1760	9.89%	SCS	Only high-risk	1, 2, 3	AHI ≥5, LSaO2≤90% (portable monitor)
Deng et al,2018[62]	2016.07–2017.10	Jingmen	CC	Urban	18–78	31.3±12.4	-/1961	518	1961	26.42%	RCS	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Cao et al,2018[63]	2016.03–2016.04	Huhehaote	NC	Rural	17–29	N/R	200/-	32	200	16.00%	RCS	Both high- and low-risk	1, 3	AHI ≥5(sleep lab PSG)
Zhang et al,2018[64]	2015.07–2017.12	Taiyuan	SW	Urban	≥18	N/R	815/911	286	1726	16.57%	RCS	Both high- and low-risk	1, 2, 3	AHI ≥5 (portable monitor)
Zhang et al,2019[65]	2018.01–2018.06	Yibin	NC	Urban	6~12	9.6±1.2	1101/892	78	1903	4.10%	SCS	Only high-risk	3, 4	AHI ≥5, LSaO2<92% (sleep lab PSG)
Xie et al,2020[66]	2016.08–2018.12	Nanjing	EC	Mixed	20–49	33.19±8.27	3634/-	146	3643	4.01%	RCS	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Hong et al,2020[67]	2017.07–2017.09	Guangzhou	SC	Urban	22–63	41±9	799/237	103	1036	9.94%	*RS*	Only high-risk	2, 3, 4	AHI ≥5 (portable monitor)
Yang et al,2021[68]	2017.10–2019.05	Qinhuangdao	NC	Mixed	19–85	N/R	114/30	25	144	17.36%	RCS	Only high-risk	1, 2, 3	AHI ≥5(sleep lab PSG)
Ma et al,2022[69]	2020.01–2020.12	Xining	NW	Mixed	42–76	N/R	486/172	302	658	45.90%	RCS	Only high-risk	3, 5	AHI ≥5 (portable monitor)
Liu et al,2022[70]	2020.09–2020.12	Jinan	EC	Mixed	23–52	32.18±7.93	302/45	47	347	13.54%	RCS	Only high-risk	2, 3	AHI ≥5 (portable monitor)
Sun et al,2023[71]	2017.09–2017.11	Wuhu	EC	Mixed	≥20	N/R	N/R	46	808	5.69%	SCS	Only high-risk	3	AHI ≥5(sleep lab PSG)

(*Continued*)

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Table 1 (Continued).

Author	Screening Year	Province or Municipality	Geographic Area	Region of Study	Age Range	Mean Age (SD)	Sex (M/F)	N with OSA	Total Sample Size	Prevalence Rate (%)	Sampling Method	Sampling Strategy	Diagnostic Method	OSA Diagnostic Criteria
Guo et al,2023[72]	2021.04–2021.05	Guangzhou	SC	Urban	41–67	53.81±12.71	1098/2552	1119	3650	30.66%	SCS	Both high- and low-risk	2, 3, 5	ODI ≥7, AHI ≥5 (portable monitor)
Liu et al,2024[73]	2023.03–2023.06	Deyang	SW	Urban	3~6	4.8±0.9	801/607	64	1408	4.55%	RCS	Only high-risk	3, 6	OAHI>1(sleep lab PSG)
Zheng et al,2024[74]	2012.01–2021.10	Shanghai	EC	Mixed	≥18	N/R	879/276	1019	1155	88.23%	RCS	Both high- and low-risk	1, 3	AHI ≥5(sleep lab PSG)

Notes: Diagnostic Method: 1, Symptom Screen for Snoring; 2, Epworth Sleepiness Scale; 3, Polysomnography; 4, Berlin Questionnaire; 5, STOP-Bang Questionnaire; 6, Pediatric Sleep Questionnaire (PSQ); 7, Questions Designed by the Investigator.

Abbreviations: Geographic Area: NC, North China; NEC, Northeast China; EC, East China; CC, Central China; SW, Southwest China; NW, Northwest China; SC, South China;
Sampling Method: RCS, Random Cluster Sampling; SCS, Stratified Cluster Sampling; RS, Random Sampling; RSS, Random Stratified Sampling; OSA Diagnostic Criteria: AHI, Apnea-Hypopnea Index, events/h; LSaO2, Lowest Oxygen Saturation; OAHI, Obstructive Apnea-Hypopnea Index, events/h; ODI, Oxygen Desaturation Index, events/h; N/R, not reported.

studies, with the condition being defined as a reduction in airflow of either 100% or 90%, lasting for a minimum of 10 seconds. In contrast, the definition of hypoventilation employed the apnoea-hypoventilation index (AHI), which is the sum of apnoea and hypoventilation events per hour of sleep, with a threshold of ≥5 events/h.

Quality Assessment

The quality of the included prevalence studies was evaluated in accordance with the JBI checklist, with scores ranging from 3 to 9 out of 9 (see Table 2 for details). Of the studies included, 20 were deemed to be of high quality, as indicated by a score of 8 or 9 on the JBI checklist. Thirty studies were classified as moderate quality, with a score of 6 or 7, while

Table 2 Quality Assessments Using Joanna Briggs Institute Prevalence Critical Appraisal Tool (JBIPCAT)

Author, Year of Publication	1	2	3	4	5	6	7	8	9
Ip et al, 2001[13]	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No
Lin et al,2002[14]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No
SRDSG.,2003[15]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Zhang et al,2003[16]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Ip et al,2004[17]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No
Wang et al,2004[18]	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes
Ye et al,2005[19]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Li et al,2005[20]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Liang et al,2006[21]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hou et al,2006[22]	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes
Li et al,2006[23]	No	Yes	Yes	No	Yes	Yes	Yes	No	No
Hu et al,2007[24]	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes
Liu et al,2007[25]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gong et al,2007[26]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Zou et al,2007[27]	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Jing et al,2008[28]	No	No	Yes	Yes	No	Yes	Yes	Yes	No
Zhang et al,2008[29]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Huang et al,2009[30]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Lin et al,2009[31]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Ge et al,2009[32]	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Gao et al,2009[33]	Yes	No	Yes	Yes	No	Yes	Yes	No	No
Ma et al,2010[34]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Zhang et al,2010[35]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lin et al,2010[36]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	No
Li et al,2010[37]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wei et al,2010[38]	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Ma et al,2011[39]	No	Yes	Yes	No	No	Yes	Yes	No	No
Che et al,2011[40]	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes
Jin et al,2012[41]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Xie et al,2012[42]	No	No	Yes	Yes	No	Yes	Yes	No	Yes
Hu et al,2013[43]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Wang et al,2013[44]	No	No	Yes	Yes	No	Yes	Yes	Yes	No
Zhao et al,2013[45]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Zheng et al,2013[46]	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Sun et al,2014[47]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hu et al,2014[48]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Peng et al,2014[49]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Chen et al,2014[50]	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

(*Continued*)

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Table 2 (Continued).

Author, Year of Publication	1	2	3	4	5	6	7	8	9
Liu et al,2014[51]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wu et al,2014[52]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Ng et al,2015[53]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wu et al,2016[54]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jin et al,2016[55]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Wang et al,2016[56]	No	No	Yes	Yes	No	Yes	Yes	Yes	No
Liu et al,2016[57]	No	No	Yes	Yes	No	Yes	Yes	Yes	No
Su et al,2016[58]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Ma et al,2017[59]	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Zhang et al,2017[60]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Hu et al,2017[61]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Deng et al,2018[62]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Cao et al,2018[63]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Zhang et al,2018[64]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Zhang et al,2019[65]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Xie et al,2020[66]	No	No	Yes	Yes	No	Yes	Yes	Yes	No
Hong et al,2020[67]	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yang et al,2021[68]	No	No	Yes	Yes	No	Yes	Yes	No	No
Ma et al,2022[69]	No	No	Yes	Yes	No	Yes	Yes	No	No
Liu et al,2022[70]	No	No	Yes	Yes	No	Yes	Yes	No	Yes
Sun et al,2023[71]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Guo et al,2023[72]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Liu et al,2024[73]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Zheng et al,2024[74]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No

Notes: **Q1**: Was the sample frame appropriate to address the target population?**Q2**: Were study participants recruited in an appropriate way? **Q3**: Was the sample size adequate?**Q4**: Were the study subjects and setting described in detail? **Q5**: Was data analysis conducted with sufficient coverage of the identified sample?. **Q6**: Were valid methods used for the identification of the condition? **Q7**: Was the condition measured in a standard, reliable way for all participants? **Q8**: Was there appropriate statistical analysis? **Q9**: Was the response rate adequate, and if not, was the low response rate managed appropriately?
These questions can be answered either with a **yes, no, unclear, or not applicable**.

12 studies were rated as low quality, with a score of 3 or 5. All studies had an appropriate sample size and employed validated methods to reliably diagnose obstructive sleep apnoea (OSA) in all subjects.

The two most prevalent issues encountered during the assessment were the inappropriate sampling process (n=37) and low sample coverage (n=38). Twelve of the studies had quality scores below 5. The primary reasons for this included inadequate sample size, sampling bias, low sample coverage for data analysis, and poor standardization and reliability of methods for assessing outcomes. Furthermore, the studies lacked sufficient data on the percentage of incomplete data and the completeness of data collection. The overall quality of the included studies was deemed acceptable, although there are still some areas that require improvement.

Pooled Prevalence of Obstructive Sleep Apnoea

Overall

The 62 included studies demonstrated an overall prevalence of obstructive sleep apnoea (OSA) that ranged from 1.2% to 88.2%. The random-effects pooled estimate of the prevalence of OSA in China was 11.8% (95% CI: 10.1–13.4%) (Figure 2), with high heterogeneity (I^2= 99.7%, P<0.001). No apparent publication bias was observed via funnel plot (Supplementary Figure S10) and Egger's test (P=0.065).

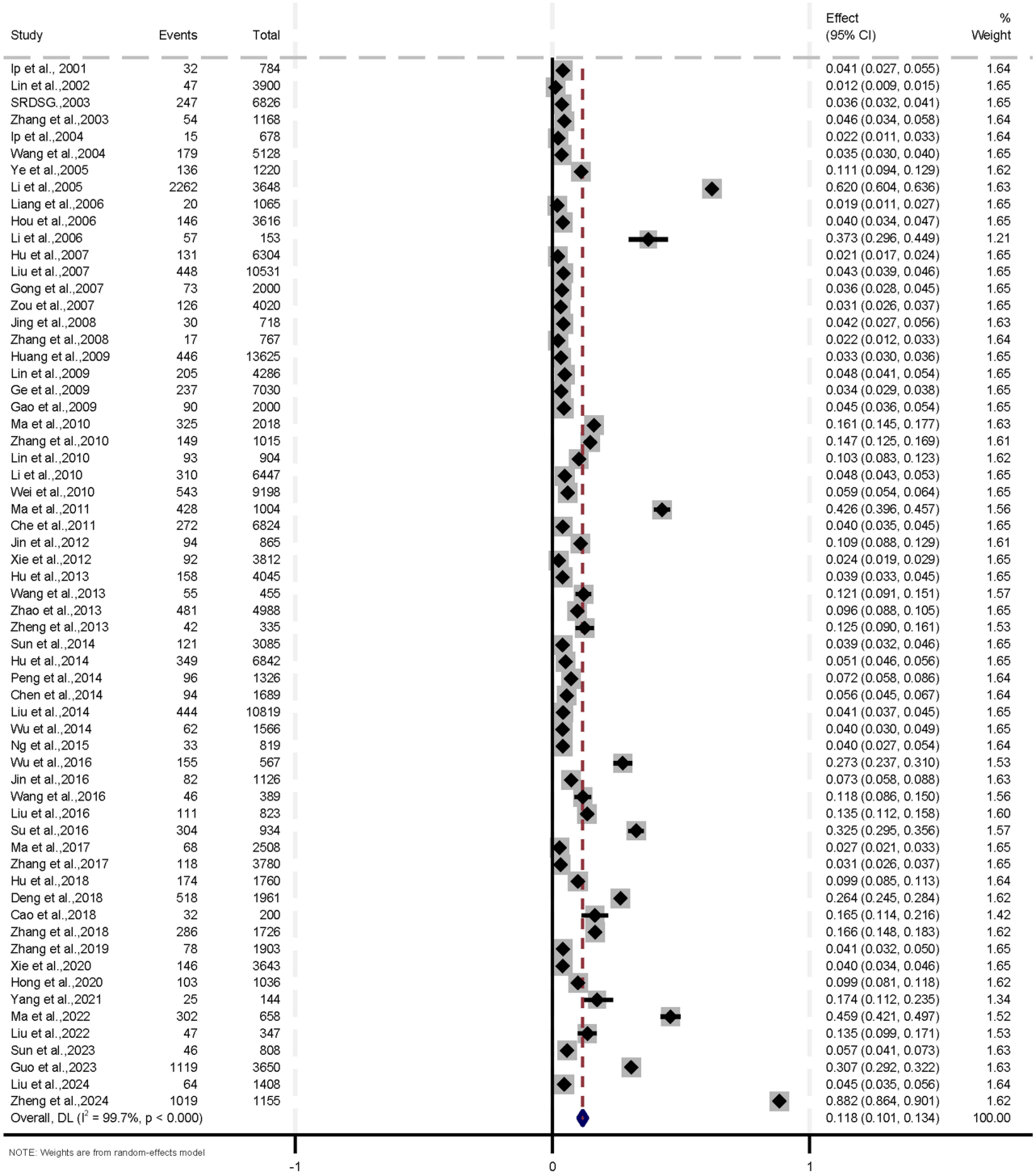

Figure 2 Forest plot of OSA prevalence in China.

Subgroup Analysis (Table 3)

Gender and Age

The results of our analyses demonstrated a significantly higher prevalence of obstructive sleep apnoea (OSA) in males compared to females (11.1% vs 6.0%, P < 0.001) (Supplementary Figure S2). Furthermore, the prevalence of OSA increased with age in all age groups (Supplementary Figure S5), as follows: the prevalence in the ≤12 years group was 6.0% (95% CI: 3.5–9.0%), and the prevalence in the 13–17 years group was 7.1% (95% CI: 3.4–12. The prevalence of

Table 3 Subgroup Analysis of the Source of Heterogeneity of Included Studies

Study characteristics	Number of Studies	N with OSA	Total Sample Size	Heterogeneity, I^2 (%) (P)	Pooled Prevalence (95% CI), %	Q	P
Survey period							
2000–2005	8	2972	23.352	99.9 (<0.001)	8.1 (0.7, 22.5)	6635.056	<0.001
2006–2010	20	3876	86.566	97.9 (<0.001)	5.5 (4.4, 6.6)	915.966	<0.001
2011–2015	13	2391	37.605	99.1 (<0.001)	8.2 (5.4, 11.4)	1291.221	<0.001
2016–2020	14	2221	22.356	99.2 (<0.001)	11.8 (7.3, 17.2)	1701.372	<0.001
2021–2024	7	2622	8170	99.8 (<0.001)	26.9 (7.4, 53.0)	3151.441	<0.001
Overall	62	14,082	178.049	99.7 (<0.001)	11.8 (10.1, 13.4)	18.245.607	<0.001
Sub-groups						14.518	0.006
Sex (M/F)							
Male	48	11,908	140,458	99.7 (<0.001)	11.1 (8.1, 14.5)	17,102.830	<0.001
Female	40	9061	143.758	99.6 (<0.001)	6.0 (4.2, 8.1)	9267.235	<0.001
Overall	88	20.969	284.216	99.7 (<0.001)	8.6 (6.9, 10.5)	26.626.375	<0.001
Sub-groups						7.781	0.005
Region of Study							
Urban	37	9149	105.620	99.6 (<0.001)	8.3 (5.7, 11.4)	10.220.355	<0.001
Rural	2	357	2218	Not applicable	16.0 (14.5, 17.6)	Not applicable	Not applicable
Mixed	23	4576	70.211	99.7 (<0.001)	11.7 (7.5, 16.6)	7492.273	<0.001
Overall	62	14,082	178.049	99.7 (<0.001)	11.8 (10.1, 13.4)	18.245.60	<0.001
Sub-groups						19.670	<0.001
Geographic Area							
NC	14	2805	30,108	99.1 (<0.001)	11.8 (8.1, 16.1)	1380.548	<0.001
NEC	2	2393	9952	Not applicable	16.9 (16.2, 17.7)	Not applicable	Not applicable
EC	22	4205	77,924	99.6 (<0.001)	7.4 (4.5, 10.8)	5839.005	<0.001
CC	4	836	9986	99.6 (<0.001)	9.7 (2.2, 21.8)	782.091	<0.001
SC	12	2793	37.443	99.5 (<0.001)	9.2 (5.3, 14.0)	2046.748	<0.001
SW	6	574	10.218	98.1 (<0.001)	6.9 (3.7, 10.9)	256.509	<0.001
NW	2	476	2418	Not applicable	17.8 (16.3, 19.3)	Not applicable	Not applicable
Overall	62	14.082	178.049	99.7 (<0.001)	11.8 (10.1, 13.4)	18.245.607	<0.001
Sub-groups						57.943	<0.001
Age Range							
≤12	11	2066	38.742	99.2 (<0.001)	6.0 (3.5, 9.0)	1244.818	<0.001
13–17	6	1692	34.998	99.6 (<0.001)	7.1 (3.4, 12.0)	1175.662	<0.001
18–39	46	10.631	143.076	99.7 (<0.001)	9.1 (6.5, 12.1)	15.123.745	<0.001
40–64	45	11.733	127.845	99.7 (<0.001)	11.3 (8.0, 15.0)	17.483.055	<0.001
65–85	32	10.328	111.200	99.8 (<0.001)	12.3 (8.2, 17.1)	16.069.149	<0.001
≥86	14	2424	53.231	96.8 (<0.001)	6.0 (4.9, 7.3)	407.532	<0.001
Overall	154	38,874	509.092	99.7 (<0.001)	11.8 (10.1, 13.4)	52.650.652	<0.001
Sub-groups						18.595	0.002
Careers							
Civil Servants	3	534	9004	Not applicable	7.3 (4.6, 10.5)	Not applicable	Not applicable
Drivers	6	550	3476	91.5 (<0.001)	15.3 (11.3, 19.8)	58.850	<0.001
Clerks	2	602	8073	Not applicable	7.2 (6.6, 7.8)	Not applicable	Not applicable
Pilots	1	20	1065	Not applicable	1.9 (1.2, 2.9)	Not applicable	Not applicable

(*Continued*)

Table 3 (Continued).

Study characteristics	Number of Studies	N with OSA	Total Sample Size	Heterogeneity, I^2 (%) (P)	Pooled Prevalence (95% CI), %	Q	P
Soldiers	2	238	7455	Not applicable	3.1 (2.8, 3.6)	Not applicable	Not applicable
Not reported	48	12.138	148.976	99.7 (<0.001)	10.0 (7.2, 13.1)	17.469.920	<0.001
Overall	62	14.082	178.049	99.7 (<0.001)	11.8 (10.1, 13.4)	18.245.607	<0.001
sub-groups						218.151	<0.001
Sleep monitoring methods							
In-lab	43	9508	126.821	99.7 (<0.001)	8.7 (6.0, 11.8)	13.996.658	<0.001
Portable	19	4574	51.228	99.6 (<0.001)	12.2 (8.0, 17.0)	4113.820	<0.001
Overall	62	14.082	178.049	99.7 (<0.001)	11.8 (10.1, 13.4)	18.245.607	<0.001
sub-groups						1.683	0.195
RoB score							
8–9	20	6954	70.365	99.8 (<0.001)	10.2 (5.8, 15.7)	8750.664	<0.001
6–7	30	5699	93.538	99.6 (<0.001)	7.6 (5.1, 10.5)	7036.249	<0.001
3–5	12	1429	14.146	99.4 (<0.001)	15.0 (7.8, 23.9)	1850.873	<0.001
Overall	62	14.082	178.049	99.7 (<0.001)	11.8 (10.1, 13.4)	18.245.607	<0.001
sub-groups						3.775	0.151
Sampling Strategy							
Both high- and low-risk	25	8338	72.712	99.8 (<0.001)	13.6 (8.1, 20.3)	13.800.369	<0.001
Only high-risk	37	5744	105.337	98.9 (<0.001)	7.4 (5.9, 9.0)	3320.444	<0.001
Overall	62	14.082	178.049	99.7 (<0.001)	11.8 (10.1, 13.4)	18.245.607	<0.001
sub-groups						4.609	0.032

Abbreviations: NC, North China; NEC, Northeast China; EC, East China; CC, Central China; SW, Southwest China; NW, Northwest China; SC, South China;

OSA was 9.1% (95% CI: 6.5–12.1%) in the 18–39 years age group, 11.3% (95% CI: 8.0–15.0%) in the 40–64 years age group, 12.3% (95% CI: 8.2–17.1%) in the 65–85 years age group, and 6.0% (95% CI: 4.9–7.3%) in the ≥86 years age group. It is noteworthy that the lowest prevalence was observed in the ≤12 years age group (6.0%), while the highest prevalence was observed in the 65–85 years age group (12.3%). This age-related pattern was further corroborated by subgroup analyses excluding pediatric studies (n=7/62). The pooled prevalence in adults reached 13.0% (9.0–17.0%), significantly exceeding the 5.0% (4.0–6.0%) observed in children (Psubgroup difference < 0.001). Detailed forest plots of age-stratified estimates are provided in Supplementary Figure S5.

Year of Investigation

The results of the meta-analysis indicated a tendency for the prevalence of obstructive sleep apnoea to increase annually throughout the study period (Supplementary Figure S1). Specifically, the prevalence was 8.1% (95% CI: 0.7–22.5%) between 2000–2005; 5.5% (95% CI: 4.4–6.6%) between 2006–2010; 8.2% (95% CI: 5.4–11.4%) between 2011–2015; and increased significantly to 11.8% between 2016–2020 (95% CI: 7.3–17.2%); and 26.9% (95% CI: 7.4–53.0%) in 2021–2024, indicating a notable rise in the prevalence of OSA in recent years.

Geographic Location and Study Setting

In the geographic analysis, the pooled prevalence of obstructive sleep apnoea (OSA) was 8.3% (95% CI: 5.7–11.4%) in the urban population, whereas the mixed urban-rural population exhibited a relatively elevated prevalence of 11.7% (95% CI: 7.5–16.6%). The two studies conducted in rural areas demonstrated a prevalence of 16.0% (95% CI: 14.5–17.6%), thereby further emphasizing the impact of urban-rural differences on the prevalence of OSA (see Supplementary Figure S3). The lowest prevalence was observed in the South West (6.9%, 95% CI: 3.7–10.9%), while the highest was seen in

the North West (17.8%, 95% CI: 16.3–19.3%). The prevalence rates in other regions were as follows: 11.8% (95% CI: 8.1–16.1%) in North China, 16.9% (95% CI: 16.2–17.7%) in Northeast China, 7.4% (95% CI: 4.5–10.8%) in East China, 9.7% (95% CI: 2.2–21.8%) in Central China, and 9.2% (95% CI: 5.3–14.0%) (see Supplementary Figure S4).

Occupation

With regard to occupational differences, the prevalence of obstructive sleep apnoea (OSA) was 7.3% (95% confidence interval (CI): 4.6–10.5%) for civil servants, while drivers exhibited a significantly higher prevalence of 15.3% (95% CI: 11.3–19.8%). In contrast, the prevalence among clerks was 7.2% (95% CI: 6.6–7.8%), while pilots and soldiers exhibited relatively low prevalence rates of 1.9% (95% CI: 1.2–2.9%) and 3.1% (95% CI: 2.8–3.6%), respectively. The group prevalence without reported occupation was 10.0% (95% CI: 7.2–13.1%) (see Supplementary Figure S6).

Analyses According to Sleep Monitoring Modality

A subgroup analysis of different sleep monitoring modalities revealed that studies utilizing laboratory and portable sleep studies exhibited comparable combined prevalence rates of 8.7% (95% CI: 6.0–11.8%) and 12.2% (95% CI: 8.0–17.0%), respectively. This suggests that the prevalence trend of OSA remained consistent irrespective of the monitoring modality (see Supplementary Figure S7).

Analysis Based on Quality Assessment Results

Following the categorization of the quality of the studies, it was observed that the combined prevalence rates were comparable for studies with quality assessment results of high, medium, and low quality, at 10.2% (95% CI: 5.8–15.7%), 7.6% (95% CI: 5.1–10.5%), and 15.0% (95% CI: 7.8–23.9%), respectively. Please refer to Supplementary Figure S9 for further details.

Analyses According to Sampling Strategy

The proportion of studies that included both high- and low-risk groups was significantly higher than the proportion of studies that included only high-risk groups (13.6% vs 7.4%, $P < 0.001$) (Supplementary Figure S8).

Significance Tests for Subgroup Analyses

Please refer to Supplementary Table S8 for details of the significance tests applied to subgroup analyses of the prevalence of obstructive sleep apnoea (OSA) in China.

Sensitivity Analyses

Sensitivity Analysis of Methodological Quality Influence

Sensitivity analysis excluding low-quality studies (n=12) reduced the pooled prevalence from 11.8% (95% CI: 10.1–13.4%) to 8.6% (95% CI: 6.3–11.3%), with heterogeneity decreasing from I^2=99.7% to 99.3%. Restricting analysis to high-quality studies (n=20) further lowered the estimate to 8.1% (95% CI: 5.8–10.8%). (Figures 3 and 4) This quality-prevalence gradient primarily stemmed from methodological flaws in low-quality studies. This reduction underscores the importance of methodological quality in prevalence estimates and confirms that lower quality studies have the potential to bias the overall findings.

Sensitivity Analysis Excluding Extreme Outliers

To assess the robustness of our estimates, we conducted sensitivity analyses excluding studies with prevalence values beyond ±3 SD from the pooled mean (Zheng et al, 2024; Li et al, 2005; Ma et al, 2022). The revised analysis incorporated 59 studies, reduced heterogeneity (I^2=99.7%→99.1%) and modestly lowered the estimate to 7.8% (95% CI: 6.5–9.2%), suggesting these studies disproportionately influenced the upper confidence limit. (Supplementary Figure S11)

Sensitivity Analysis Excluding Studies Restricted to High-Risk Populations

In conducting sensitivity analyses, studies in which sleep studies were conducted exclusively in high-risk populations identified by questionnaire were excluded (Figure 5). Following the analysis of studies encompassing both high- and low-

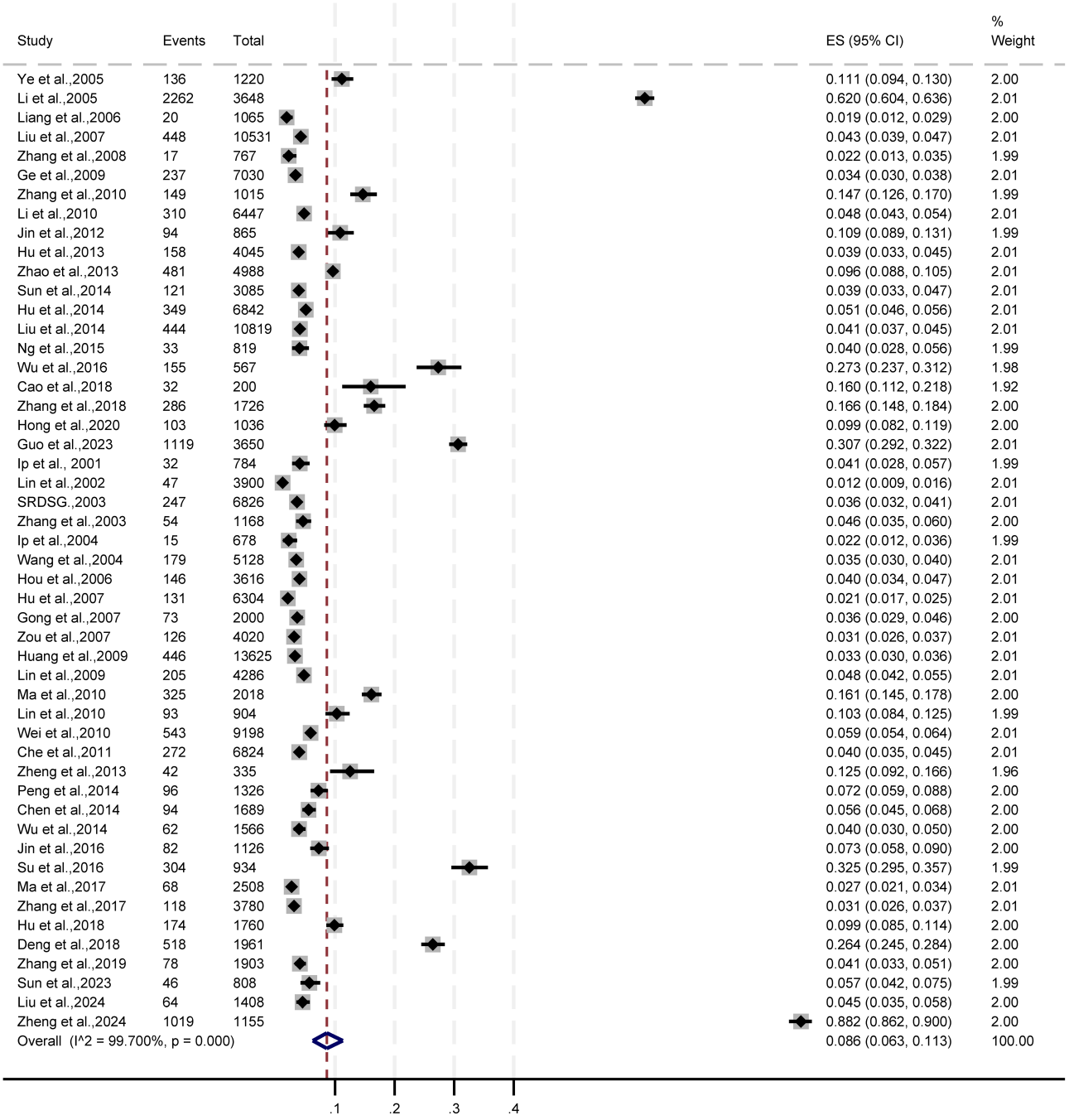

Figure 3 Sensitivity Analysis Excluding Low-Quality Studies.

risk subjects, a pooled prevalence of obstructive sleep apnoea (OSA) of 16.8% (95% CI: 12.7%-20.8%) was observed, which was significantly higher than the overall pooled prevalence of 11.8%.

Meta-Regression Analysis

Meta-regression analyses identified several covariates significantly associated with heterogeneity in OSA prevalence estimates (Table 4). The survey period demonstrated a positive temporal trend, with a 0.036-unit increase in prevalence per time unit (95% CI: 0.005–0.067; P=0.025). Sex-based differences were significant, showing a 0.062-unit reduction in prevalence among females compared to males (95% CI: −0.123–-0.001; P=0.047). Geographic variations (95% CI:

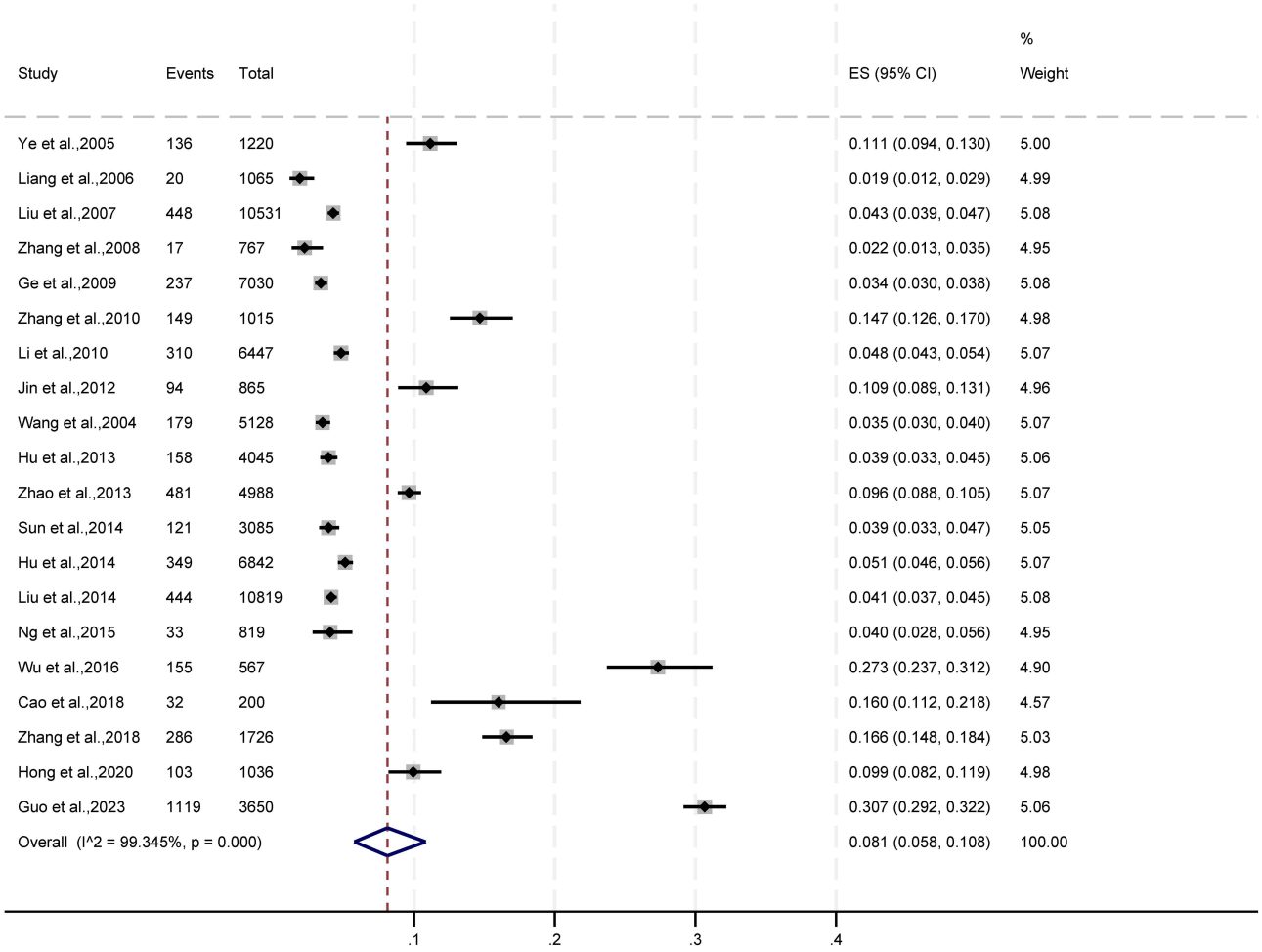

Figure 4 Sensitivity Analysis Restricting to High-Quality Studies.

0.002–0.534; P=0.035), Occupational factors (95% CI: 0.002–0.047; P = 0.047), sampling strategies (95% CI: −0.162–-0.021; P=0.012), were identified as potential sources. Methodological rigor, as reflected by RoB scores, reduced prevalence estimates by 0.027 units per score increment (95% CI: −0.095–-0.008; P =0.022). In contrast, region of study (P=0.336), age range (P=0.187), and sleep monitoring methods (P=0.874) exhibited no significant association with OSA prevalence heterogeneity.

Discussion

In recent years, studies on obstructive sleep apnea (OSA) conducted by Chinese researchers have been limited in number, and the findings show substantial variability attributable to a myriad of factors such as geographic differences, study design, and population characteristics. This systematic evaluation and meta-analysis aimed to elucidate the prevalence of obstructive sleep apnoea (OSA) and its associated influencing factors in China. By integrating data from multiple studies, we were able to gain a more comprehensive perspective and provide important baseline information for understanding this complex disease.

The findings suggest that the prevalence of OSA in China ranges from 1.2% to 88.2%, with an overall prevalence of 11.8%. This finding is consistent with the results of several international studies,[6,75] which may be closely related to the effects of population aging, lifestyle changes and environmental factors in China. However, considerable heterogeneity was observed across studies due to differences in survey year, gender, and sampling method.[76,77]

In accordance with the findings of the global literature, our study revealed a markedly elevated prevalence of obstructive sleep apnoea (OSA) in males compared to females (11.1% vs 6.0%). This disparity may be attributed to

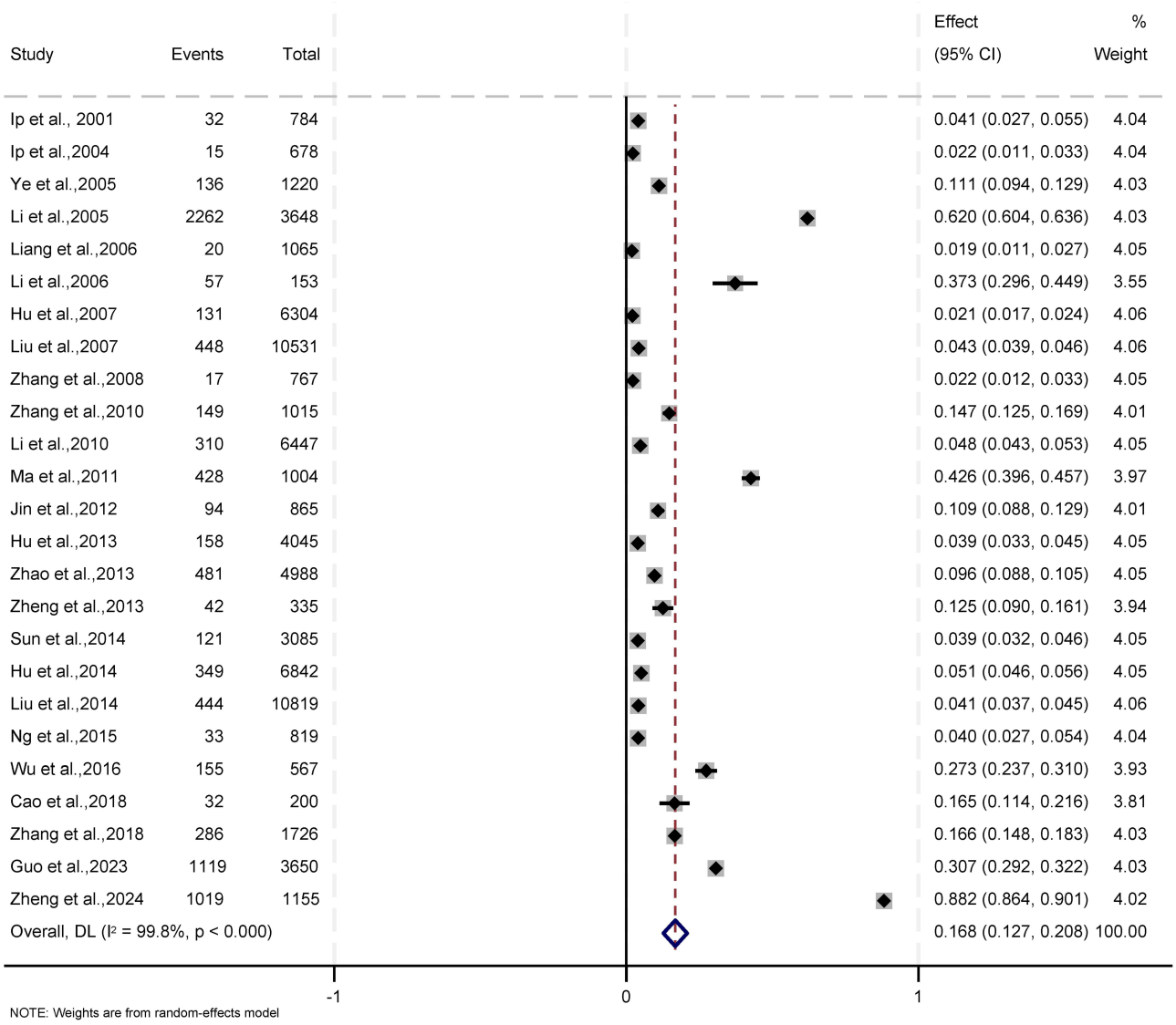

Figure 5 Forest plot of sensitivity analysis including only studies that assessed the prevalence of OSA through sleep studies in both high- and low-risk subjects.

the influence of male physiology and lifestyle habits, including but not limited to obesity, smoking, and hormonal imbalances.[78] Furthermore, age was found to have a significant impact on the prevalence of OSA, with the highest rates observed in individuals aged 65–85 years.[79] This finding indicates that as the population ages, the necessity for management and intervention for OSA will increase significantly, thereby underscoring the urgent need for the

Table 4 Results of Meta-Regression Analysis for Prevalence of OSA

Covariate	Meta-Regression Coefficient	95% CI	*P*
Survey period	0.036	0.005 to 0.067	0.025
Sex	−0.062	−0.123 to −0.001	0.047
Region of Study	−0.114	−0.031 to 0.011	0.336
Geographic Area	0.268	0.002 to 0.534	0.035
Age Range	0.170	−0.041 to 0.207	0.187
Careers	0.254	0.002 to 0.047	0.047
Sleep monitoring methods	0.018	−0.071 to 0.084	0.874
RoB score	−0.027	−0.095 to −0.008	0.022
Sampling Strategy	−0.029	−0.162 to −0.021	0.012

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development of more appropriate screening and treatment options for older adults. The results of the meta-analysis demonstrated a notable increase in the prevalence of OSA on an annual basis between 2000 and 2024, particularly during the period between 2021 and 2024, when it exhibited a significant rise to reach 26.9%. It is essential to recognize that the observed increase in prevalence may be partially attributed to advancements in public awareness of obstructive sleep apnoea (OSA) and improvements in diagnostic methodologies over the years. The Healthy China 2030 initiative, launched in 2010, placed a significant emphasis on sleep health, which, in turn, has led to a marked increase in both public and clinical awareness of sleep disorders, including OSA. This shift in awareness has likely facilitated more widespread screening and diagnosis, thereby contributing to the higher prevalence rates reported in recent years. The heightened recognition of sleep disorders has been bolstered by various public health campaigns and an increasing acknowledgment of the importance of sleep health within both the medical community and the general public. Additionally, it is crucial to consider the evolution of sleep medicine in China over the 24-year study period. The expansion of sleep medicine services, marked by a growing number of sleep disorder specialists and an increase in diagnostic facilities, has likely played a significant role in the rising identification of OSA cases.[80] As the capacity for diagnosing OSA has improved, the prevalence rates may reflect these enhancements in diagnostic infrastructure. However, granular data regarding the number of specialists and the expansion of diagnostic facilities were not available in the majority of the included studies, preventing us from directly adjusting for these potential confounding factors.

The present analysis also revealed a significant effect of geographic location on the prevalence of obstructive sleep apnoea (OSA), with higher prevalence rates observed in the northwestern and northeastern regions of China and relatively lower rates in the eastern and southwestern regions. This discrepancy may be closely associated with synergistic interactions between dietary habits, environmental, socioeconomic, and healthcare. The significantly elevated prevalence of obstructive sleep apnoea (OSA) in Northwest China (17.8%) and Northeast China (16.9%) can be partially attributed to region-specific dietary habits.[81] These regions typically consume calorie-dense and meat-heavy foods, contributing to higher obesity rates. Given that obesity is a well-established risk factor for OSA due to fat deposition in the pharyngeal area, the increased prevalence of obesity in these areas likely underlies the higher OSA rates observed. Both Northwest and Northeast China exhibit substantial hypertension rates.This correlation may partly explain the elevated OSA prevalence, as hypertension frequently coexists with sleep-disordered breathing.[81] Geoclimatic extremes compound biological vulnerabilities. Additionally, particulate matter levels in industrial cities like Lanzhou (Northwest) and Shenyang(Northeast) far exceed WHO guidelines, and air pollution, inducing airway inflammation that worsens OSA severity.

Socioeconomic factors further complicate these dynamics. Northwest China's polysomnography availability lower, compounded diagnostic delays in communities. Northeast China's aging industrial workforce faces higher occupational OSA risks, yet routine health screenings rarely address sleep-related issues. These systemic gaps contrast sharply with coastal regions like East China, where better income levels and specialist availability facilitate earlier intervention.

Our analysis indicated that drivers exhibit a significantly higher prevalence of OSA (15.3%, 95% CI: 11.3–19.8%) compared to other occupational groups such as civil servants (7.3%) and clerks (7.2%). This finding is consistent with previous studies that have highlighted the increased risk of OSA in drivers due to prolonged sitting, fragmented sleep due to shift work, and exposure to traffic-related stressors.[82,83] It is critical to recognize that while we can attribute higher rates of OSA prevalence among drivers to their occupational environment and lifestyle, other demographic and health-related confounders must also be considered. For example, the prevalence of obesity in occupational populations can vary significantly. Future research should aim to control for these confounding factors more rigorously. Stratifying analyses by body mass index (BMI), sleep habits, and comorbid conditions such as hypertension and diabetes can help isolate the true effect of occupational exposure on OSA prevalence.

The pronounced prevalence of OSA in low-quality studies compared to high-quality studies suggests that methodological deficiencies may inflate estimates. Frequently, these studies lack standardized diagnostic criteria, appropriate sampling methods, or adequate sample sizes, which could consequently lead to either over-diagnosis or misdiagnosis of OSA. Several low-quality studies utilized convenience sampling or targeted specific populations, which can lead to selection bias. High-quality studies, on the other hand, employed stratified sampling methods that enhance representativeness across geographic and demographic spectra. This methodological rigor is reflected in their comparatively lower prevalence estimates, which likely provide a more accurate picture of OSA distribution across China. In conclusion, the

quality disparities across the included studies are likely to result in biased prevalence estimates, demonstrating the necessity for methodological standardization in future research to ensure accurate depiction of OSA prevalence and epidemiology. Furthermore, the combined prevalence of laboratory and portable monitoring modalities was found to be similar, indicating that the prevalence of obstructive sleep apnoea (OSA) remains consistent across monitoring settings.[84] Despite the absence of significant differences between monitoring modalities, portable testing has been subject to criticism for underdiagnosing cases of mild OSA.[85] It is therefore recommended that future studies investigate the potential impact of different monitoring modalities on outcomes in order to improve the detection rates and diagnostic accuracy of OSA. The extreme prevalence estimates in three studies highlight critical methodological challenges. Zheng et al's[74] 88.2% prevalence—the highest reported—likely reflects their exclusive focus on snoring patients identified through respiratory clinics, violating basic epidemiological sampling principles. Similarly, Li et al's[20] otolaryngology clinic-based recruitment and Ma et al's[69] non-standard diagnostic thresholds exemplify how sampling frame and measurement variability can distort burden estimates. While these studies met our inclusion criteria, their design limitations reduce comparability with population-based investigations. Their exclusion in sensitivity analyses produced a more conservative estimate (7.8%) that better reflects general population risk.

Our stratified analyses revealed that sampling methodology significantly influenced prevalence estimates. Studies employing two-step designs (screening both high- and low-risk populations) higher OSA prevalence than single-step designs (13.6% vs 7.4%, $p<0.001$). This discrepancy is a result of single-step studies not testing low-risk subjects due to funding or resource constraints thereby underestimating undiagnosed cases in the general population. These findings align with global meta-analyses demonstrating that selective sampling of high-risk cohorts underestimates OSA prevalence.[6] Standardizing risk-stratified sampling frameworks is thus critical for future epidemiological studies.

Given the identified methodological disparities among studies, there is a clear necessity for standardization in future research to ensure more accurate prevalence estimates. We recommend that subsequent studies prioritize larger, multi-center cohorts utilizing harmonized diagnostic protocols and geographically stratified sampling frameworks, as such approaches are vital for enhancing public health strategies and effectively addressing the increasing burden of OSA.

Limitations

While this multilevel meta-analysis provides valuable insights into the prevalence of obstructive sleep apnea (OSA) across China, several methodological constraints must be carefully considered. The high heterogeneity observed in our analysis (I^2=99.7%) can be attributed to a variety of factors, including differences in sample selection, geographic diversity, and the range of diagnostic and measurement tools employed. This significant heterogeneity introduces uncertainty in our overall prevalence estimates and complicates the comparability of results across studies.

Firstly, although our study encompassed 178,049 participants from a broad range of geographic regions, the uneven distribution of studies introduces potential selection bias. Most studies were focused on urban populations in the developed eastern provinces, while only two studies specifically targeted rural populations in Northwest and Southwest China—regions that are undergoing rapid dietary and lifestyle changes, which could have a disproportionate impact on OSA risk. This urban-rural imbalance, coupled with the underrepresentation of 11 provincial-level administrative divisions, limits the generalizability of our geographic stratification results and may obscure emerging epidemiological trends in China's rapidly developing interior regions. We emphasize the need for more research in rural regions to obtain a more accurate national prevalence estimate.

Additionally, variations in diagnostic criteria and methodologies across studies further complicate the interpretation and comparison of prevalence rates among different populations. While our age-stratified analysis captured developmental trends, the differential AHI thresholds between pediatric and adult OSA diagnoses may introduce measurement variability. Future studies employing age-specific diagnostic criteria across the lifespan could enhance precision. The increase in the prevalence rate over the years may reflect both changes: on the one hand, it may be that the actual number of people with the disease is indeed increasing, and on the other hand, it may be that the increase in the detection rate has been brought about by the spread of diagnostic technology over the years. This interdependence may confound relevant epidemiological trends.

Given the considerable heterogeneity, we advise caution in interpreting our findings across various subgroups, such as age, gender, and geographic region. The limitations outlined above may influence the implications of our study for

policy-making and intervention strategies targeting high-risk groups. We recommend that future research adopt more standardized methodologies and consistent diagnostic criteria to enhance the comparability and reliability of epidemiological data across diverse populations.

Conclusions

This systematic evaluation and meta-analysis revealed the prevalence of obstructive sleep apnoea (OSA) and its associated influencing factors in China. The findings indicated that the overall prevalence of OSA was 11.8%, a figure that may be conservative and is likely to increase in the coming decades as the median age and prevalence of obesity rise. The present study demonstrates that the prevalence of obstructive sleep apnoea (OSA) exhibits significant gender and age-related differences. In particular, the data indicate that men have a significantly higher prevalence of OSA than women, with the highest prevalence observed in older age groups (65–85 years). Geographic location, lifestyle factors, and occupational exposures significantly influence OSA prevalence, particularly in the northwestern and northeastern regions of China. The prevalence among high-risk occupations, especially drivers, is markedly elevated. These findings underscore the urgency of integrating OSA screening into routine health assessments for high-risk groups (eg, male drivers, aging populations) and prioritizing resource allocation to Northwest China, where dietary transitions and hypertension epidemics exacerbate OSA burden.

Additionally, the rising OSA burden parallels the rapid advancements in sleep medicine infrastructure in China since 2000; however, disparities persist, particularly in rural and low-income areas. Strengthening specialist training programs and equitable resource distribution remains critical to mitigating diagnostic delays. Policymakers should advocate for standardized diagnostic protocols and rural healthcare capacity-building to address underrepresentation in current studies.

OSA is not only prevalent in China, but is also associated with impaired quality of life, reduced productivity, increased traffic accidents and an increased risk of cardiovascular and metabolic diseases. Future research should focus on longitudinal designs to explore causal pathways linking urbanization and obesity to OSA. There is also a need for cost-effectiveness analyses of targeted screening programs to better understand their impact on population health. By enhancing public awareness and education regarding OSA, we can lay the groundwork for comprehensive public health strategies to mitigate this significant health issue in China.

Data Sharing Statement

The original contributions presented in the study are included in the article files, further inquiries can be directed to the corresponding author.

Ethical Approval Statement

This study was a secondary analysis based on published literature and did not involve the direct participation of human subjects and therefore did not require ethics committee approval. All included studies declared compliance with ethical norms in their original publications.

Author Contributions

YQ N: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing - Original Draft.

SW S: Methodology, Validation, Investigation, Data Curation, Formal Analysis, Visualization, Writing - Review & Editing.

YL W: Software, Validation, Formal Analysis, Resources, Writing - Review & Editing.

LL C: Conceptualization, Methodology, Supervision, Writing - Review & Editing.

YF S: Conceptualization, Methodology, Supervision, Writing - Review & Editing.

XC Z: Supervision, Validation, Funding acquisition, Project Administration, Writing - Review & Editing.

All authors have approved the final version of the manuscript for publication, agreed to submit this work to the current journal, and accept full accountability for all aspects of the research.

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Disclosure

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

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