

Review Article

Prevalence and associated factors of enuresis among primary school-aged children in China: a systematic review and meta-analysis

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Abstract: Background: Nocturnal enuresis (NE) is a common childhood condition that can cause psychological distress, social isolation, and impaired quality of life for affected children and their families. However, most previous studies have focused on children and adolescents as a whole, with limited evidence specifically for primary school-aged pupils. Purpose: This systematic review and meta-analysis aimed to estimate the prevalence and associated factors of NE among primary school students (5-12 years) in China. Methods: We searched the China National Knowledge Infrastructure, Wanfang Data, the China Science and Technology Journal Database, PubMed, Embase, the Cochrane Library, and Web of Science for cross-sectional studies on the prevalence and associated factors of NE in Chinese primary school children from inception to May 31, 2026. Two reviewers independently performed study selection, data extraction, and quality assessment. A random-effects meta-analysis was used to pool prevalence estimates and odds ratios (ORs). Descriptive subgroup analyses and random-effects meta-regression were performed to explore heterogeneity. Results: Twenty-two studies involving 161,662 participants (11,091 NE cases) were included. The pooled prevalence of NE was 10% (95% CI: 9%-11%), which should be interpreted as a descriptive summary of the available data rather than a precise population estimate, given the substantial heterogeneity across studies ($I^2 = 100\%$). Descriptively, the prevalence was higher in males (9%) than in females (6%) and showed a downward trend with age, decreasing from 16% at age 5 to 2% at age 12. Meta-regression analysis indicated that diagnostic criteria alone did not account for the observed between-study heterogeneity ($R^2 = 0\%$, $I^2_{\text{res}} = 99.16\%$). Significant associated factors included male sex (OR = 1.48), family history of NE (OR = 2.60), constipation (OR = 1.85), attention-deficit/hyperactivity disorder (OR = 2.63), arousal dysfunction (OR = 2.76), bedtime fluid intake (OR = 1.95), daytime symptoms (OR = 1.88), and living in households with three or more children (OR = 2.32), while older age was associated with lower odds of NE (OR = 0.76). Conclusion: NE prevalence among Chinese primary school children is relatively high and influenced by multiple demographic, genetic, physiological, and environmental factors. Enhanced screening and comprehensive management for this population are warranted. However, given the persistent, massive heterogeneity ($I^2 = 100\%$) that remains unexplained by diagnostic criteria, this pooled prevalence should be interpreted with caution as a contextual descriptive summary rather than a single standardized parameter.

Keywords: Enuresis, prevalence, risk factors, primary school-aged children, meta-analysis, China

Introduction

Nocturnal enuresis (NE), or bedwetting, is a relatively common voiding disorder in children aged 5 years and older, characterized by involuntary urination during sleep without any apparent underlying organic disease [1]. The concept of NE varies according to the diagnostic norms used: the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) requires symptoms to occur at least

twice a week for a period of three months, or cause significant emotional distress for the patient [2]; in contrast, the criteria more frequently used in practice include an age of ≥ 5 years and a mean of at least one episode of involuntary nocturnal urination per month for three months or longer [3]. Based on clinical presentation, monosymptomatic nocturnal enuresis (MNE) is characterized by the absence of daytime urinary symptoms, whereas non-monosymptomatic nocturnal enuresis (NMNE)

is accompanied by symptoms such as urinary urgency or daytime urinary incontinence [1]. MNE may be further divided into primary (where the child has never achieved a lasting period of nocturnal dryness) and secondary (where bedwetting recurs after a dry period of six months or more) [4].

NE is a relatively common developmental problem in children worldwide, with a reported prevalence of 4%-16% [5]. Approximately 15% of five-year-olds and almost 10% of seven-year-olds have this condition; around 15% of affected children experience spontaneous resolution each year, but in about 1%-2% of cases, symptoms persist into adolescence [6]. The occurrence is relatively higher among males than among females, and a genetic background is a known risk factor [6]: if one parent has a history of NE, the risk of NE in the child is about 40%; if both parents have a history of NE, the risk exceeds 70% [7]. The pathogenesis of enuresis is complex and involves multiple mechanisms, including delayed maturation of the urinary system, nocturnal polyuria due to insufficient secretion of antidiuretic hormone, detrusor overactivity, reduced functional bladder capacity, and failure to arouse from sleep [8]. Environmental and psychosocial pressures are more frequently associated with secondary enuresis [9].

NE is a frequent problem for children across China that should not be ignored. Previous research shows that the prevalence of enuresis among Chinese children and adolescents is approximately 6.1%, and this rate declines significantly with age; for example, it is around 12% at age 5 and nearly 2% at age 12 [10]. In addition to gender and genetic factors, constipation, previous urinary tract infections, sleep disturbances, daytime urinary incontinence, delayed toilet training, and prolonged use of disposable diapers have all been identified as significant risk factors [10, 11]. Enuresis is also associated with psychological and behavioral problems. Affected children may experience shame, low self-esteem, social isolation, and emotional and behavioral difficulties [12, 13]. However, public awareness of NE in China remains low, at only 62%, and about one-third of affected children are not identified or treated promptly [4]; thus, a considerable number of enuretic children are going undiagnosed or untreated.

Although previous meta-analyses have systematically examined the prevalence and associated factors of enuresis among Chinese children and adolescents, these previous studies have combined “children” and “adolescents” in their evaluations and failed to analyze primary school students as a distinct group [10]. However, the age range of 5-12 years is not only a period during which the prevalence of enuresis declines sharply, but also a crucial period when children begin school, develop peer relationships, and establish their self-concept; therefore, the psychological and social consequences of enuresis may be particularly important during this stage. In recent years, new data on enuresis among primary school children have been reported across different regions of China, creating a need for an updated and systematic synthesis of the available evidence. Therefore, this study aims to assess the prevalence and associated factors of enuresis among primary school students aged 5-12 years in China through a systematic review and meta-analysis, providing evidence to support early identification, targeted management, and the development of public health programs for this population.

Methods

Inclusion and exclusion criteria

Eligibility criteria: (1) Study design: Open-access cross-sectional studies; (2) Study population: Chinese primary school students aged 5-12 years; (3) Studies required to use specific diagnostic criteria for NE; studies using International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10), International Children's Continence Society (ICCS), DSM, or other recognized diagnostic systems were eligible, and the diagnostic criteria were recorded for subgroup and meta-regression analyses; (4) Outcomes included the prevalence of enuresis and/or its associated factors; (5) Publication language was limited to Chinese or English.

Exclusion criteria: (1) Basic research, conference papers or abstracts, meta-analyses, systematic reviews and clinical case reports; (2) Repeated publications; (3) Studies for which the full manuscript is unavailable; (4) Studies with unavailable or insufficient data; (5) Publications not in Chinese or English; (6) Poor-

quality studies [Agency for Healthcare Research and Quality (AHRQ) rating] < 4.

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 statement and registered with International Platform of Registered Systematic Review and Meta-analysis Protocols (INPLASY202680019).

Literature search

A systematic search was conducted in the China National Knowledge Infrastructure, Wanfang Data Knowledge Service Platform, China Science and Technology Journal Database, PubMed, Embase, Web of Science, and the Cochrane Library to identify studies on the prevalence and associated factors of enuresis among primary school children in China. The databases were searched from inception to May 31, 2026, and the reference lists of relevant articles were also screened.

A combination of subject terms and free-text terms was used. English keywords included: Enuresis/Nocturnal Enuresis/Bedwetting/Urinary Incontinence; Child/Children/School-aged children/Primary school children; Prevalence/Epidemiology/Cross-sectional studies. Chinese keywords included: enuresis/bedwetting/nocturnal enuresis/nocturnal urination; children/primary school pupils/school-aged children; prevalence/detection rate/incidence/epidemiology/current status/survey.

Data extraction

EndNote X9 was used to manage the retrieved records and remove duplicates. Two reviewers independently screened the records according to the predefined inclusion and exclusion criteria. First, clearly irrelevant records were excluded based on their titles and abstracts; the full texts of potentially eligible articles were then assessed to determine final eligibility. Any disagreements were resolved through discussion or consultation with a third reviewer. Extracted data included the article title, first author, journal name, publication year, study design, number of participants, age range, sex distribution, prevalence, diagnostic criteria, and associated factors.

Evaluation of study quality

The quality of the included cross-sectional studies was assessed using the appraisal criteria developed by the AHRQ [14]. The AHRQ tool consists of 11 items rated as “yes”, “no”, or “unclear”, with a maximum score of 11. Scores of 0-3 indicated low quality, 4-7 moderate quality, and 8-11 high quality.

Statistical analysis

RevMan 5.3 was used for statistical analysis. Dichotomous outcomes were represented by the odds ratio (OR) and its 95% confidence interval (CI); for continuous data, a mean difference and its 95% CI were used. The I^2 statistic was employed to determine whether there was significant heterogeneity among the studies; a fixed-effects model was used when $P > 0.10$ and $I^2 < 50\%$; otherwise, a random-effects model was used, and sensitivity analyses were conducted. A P value < 0.05 was considered statistically significant. Due to the heterogeneity of diagnostic criteria across the included studies and the unavailability of individual-level data, it was not possible to harmonize the prevalence estimates using a unified diagnostic definition (e.g., the ICCS 2016 criteria). Instead, we performed subgroup analyses and meta-regression stratified by diagnostic criteria to quantitatively assess the impact of different case definitions on the pooled estimates.

Results

Study selection

The initial search identified 737 records. After 414 duplicate records were removed using EndNote X9, 169 records were excluded based on title and abstract screening, and 132 articles were excluded after full-text assessment. A total of 22 studies [15-36] were included-17 Chinese papers [15-31] and 5 English papers [32-36]. The study selection process is shown in **Figure 1**.

Basic characteristics and quality assessment of included studies

Twenty-two studies [15-36] were included in this review, all of which focused on primary school students aged 5-12 years, with a total of 161,662 participants, including 11,091 chil-

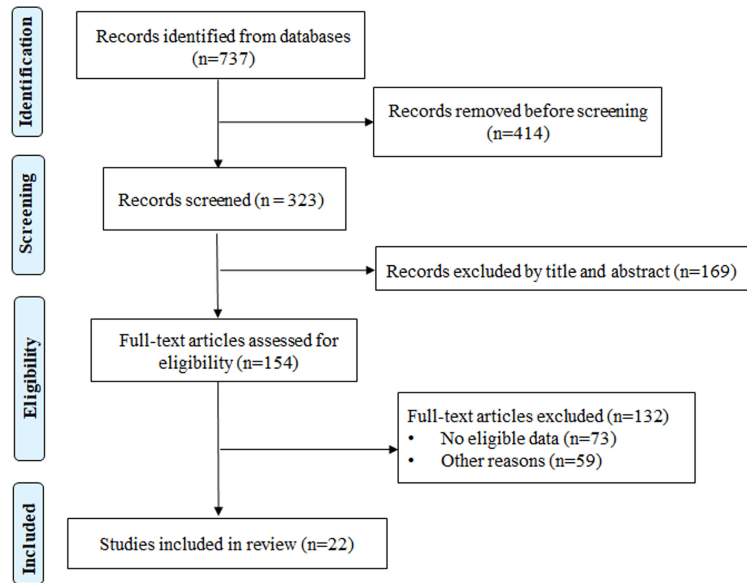


Figure 1. Flow diagram of the study selection process.

dren with NE and 150,571 without NE. The characteristics and quality assessment results of the included studies are shown in **Table 1**.

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Meta-analysis: A total of 22 studies [15-36] reported the prevalence of NE among primary school students in China. Substantial heterogeneity was observed among the included studies ($I^2 = 100\%$, $P < 0.001$); therefore, a random-effects model was used. The pooled prevalence of NE among primary school students in China was 10% (95% CI: 9%-11%), as shown in **Figure 2**. Given the extremely high heterogeneity ($I^2 = 100\%$), this pooled prevalence should be interpreted as a descriptive summary of the available data rather than a precise population estimate.

Subgroup analysis: To explore potential sources of heterogeneity, subgroup analyses were performed according to sex, age, region, diagnostic criteria, ethnicity, and publication year. The subgroup analyses showed that: (1) By sex, the prevalence of NE was 9% (95% CI: 8%-9%) in male students and 6% (95% CI: 6%-7%) in female students; (2) The prevalence of NE showed a downward trend with increasing age, decreasing from 16% (95% CI: 12%-20%) at age 5 to 2% (95% CI: 2%-3%) at age 12, suggesting that ages 5 to 12 may represent a

key window for the rapid decline in NE prevalence; (3) Regionally, The pooled prevalence was 10% (95% CI: 9%-11%) in Southern China and 11% (95% CI: 9%-12%) in Northern China, showing close numerical values; (4) The prevalence of NE varied substantially across diagnostic criteria, ranging from 20% (95% CI: 12%-28%) under ICCS (1998) to 6% under both ICCS (2014) and ICCS (2016); (5) By ethnicity, the prevalence of NE among Han primary school students was 5% (95% CI: 5%-5%), compared to 6% (95% CI: 6%-7%) among ethnic minority students; (6) By publication year, the pooled prevalence was 12% (95% CI: 11%-

13%) in the 13 studies published before 2020 and 6% (95% CI: 6%-7%) in the 9 studies published in 2020 or later. Substantial residual heterogeneity remained within all subgroups ($I^2 = 100\%$, $P < 0.001$ for intra-group tests), and random-effects models were used. The subgroup analysis results are presented in **Table 2**.

Sensitivity analysis: Sensitivity analysis was conducted using the quality effects model, and the leave-one-out method was applied to re-analyze the remaining studies. Under the quality effects model, the overall pooled prevalence was 7% (95% CI: 3%-11%), which differed to some extent from the estimate obtained using the random-effects model (10%, 95% CI: 9%-11%), although the overall conclusion remained unchanged. The quality effects model, which adjusts for study quality differences, provided a more conservative estimate with a wider CI, reflecting the additional uncertainty introduced by between-study methodological heterogeneity. Under the same quality effects model, the leave-one-out analysis showed that after excluding any single study, the pooled prevalence ranged from 6.3% to 6.9% (**Table 3**), which was consistent with the overall quality-effects estimate of 7% and showed no change in the direction of the effect. The I^2 values remained consistently high at 98.8%-99.4%, suggesting that the heterogeneity was not driven by any single study. Overall, the sen-

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Table 1. Basic characteristics and quality assessment of the included studies

Study	Study region	Sample size, n		Prevalence	Age, years	Sex (male/female), n	Diagnostic criteria	Quality score
		NE cases	Participants without NE					
Ban et al. 2015 [15]	Nanning	420	973	30.15%	5-6	789/604	ICD-10 (1993) [37]	8
Huang et al. 2019 [16]	Xi'an	171	3,898	4.20%	5-12	2091/1978	ICCS (2014) [38]	8
Chen et al. 2023 [17]	Jiangmen	154	2563	5.67%	5-12	1,478/1,239	ICCS (2016) [39]	9
Han et al. 2019 [18]	Henan	545	7,972	6.40%	5-12	4594/3923	ICCS (2014)	7
Li et al. 2019 [19]	Henan	198	2575	7.14%	5-12	1445/1328	ICCS (2016)	8
Liu et al. 2023 [20]	Cangzhou	181	2,873	5.93%	5-12	1,703/1,351	Chinese Expert Consensus on the Diagnosis and Treatment of Enuresis in Children (2019) [40]	8
Luo et al. 2020 [21]	Chongqing	449	8,483	5.03%	6-12	4503/4429	ICCS (2016)	7
Wei et al. 2023 [22]	Wuxi	155	965	13.84%	5-6	573/547	Chinese Expert Consensus on the Diagnosis and Treatment of Enuresis in Children (2019) [40]	8
Liao et al. 2020 [23]	China	4426	63,787	6.49%	5-12	35,773/32,440	ICCS (2014)	9
Qian et al. 2018 [24]	Urumqi	82	1189	6.45%	5-12	701/570	ICCS (2014)	9
Wen et al. 2007 [25]	Henan	338	4,749	6.64%	5-12	2628/2459	–	7
Wen et al. 2017 [26]	Zhengzhou	587	5568	9.54%	5-11	3292/2863	ICCS (2016)	8
Zhou et al. 2022 [27]	Maoming	50	1103	4.34%	6-12	643/510	ICCS (1998) [41]	8
Zhang et al. 2022 [28]	Qingdao	101	2007	4.79%	5-12	1121/987	DSM-IV [42]	8
Guo et al. 2017 [29]	Huanggang	511	1907	21.13%	5-7	–	ICCS (1998)	7
Luo et al. 1995 [30]	Hunan	179	5,385	3.22%	5-12	–	DSM-III-R [43]	6
Tang et al. 2021 [31]	Changsha	99	1085	8.36%	6-12	609/575	ICD-10 (1993)	8
Huang et al. 2020 [32]	Xi'an	262	6306	3.99%	5-12	3,409/3,159	ICCS (2016)	8
Zhang et al. 2019 [33]	China	592	12,862	4.40%	5-12	–	–	6
Tai et al. 2007 [34]	Taiwan	560	7,712	6.77%	6-12	4,214/4,058	ICD-10 (1993)	9
Su et al. 2011 [35]	Hong Kong	285	5,862	4.64%	6-11	3115/3032	ICCS (1998)	7
Wang et al. 2007 [36]	Henan	746	747	49.97%	5-12	742/751	ICCS (1998)	8

Note: NE, nocturnal enuresis; ICD-10, International Statistical Classification of Diseases and Related Health Problems, 10th Revision; ICCS, International Children's Continence Society; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition; DSM-III-R, Diagnostic and Statistical Manual of Mental Disorders, Third Edition, Revised; "–" indicates that data were not available.

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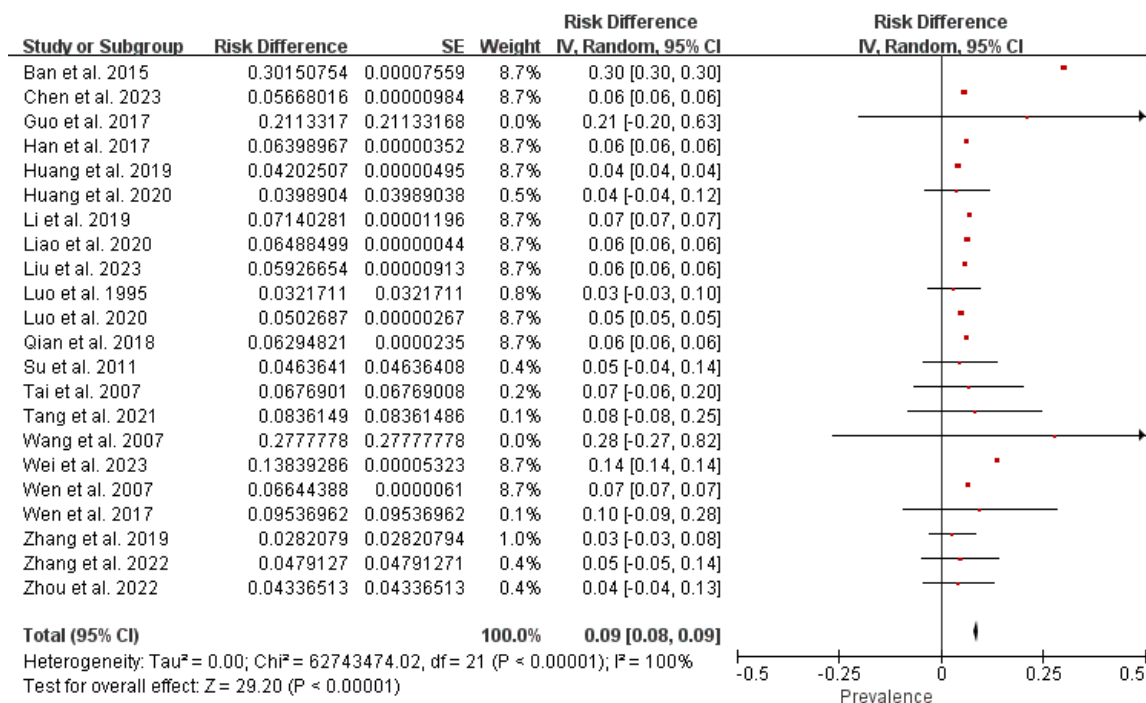


Figure 2. Forest plot of the pooled prevalence of NE among primary school students in China. Note: NE, nocturnal enuresis; SE, standard error; IV, inverse variance; CI, confidence interval; df, degrees of freedom.

sitivity analyses suggested that the pooled estimate was not driven by any single study.

Meta-regression analysis by diagnostic criteria: Meta-regression analysis using diagnostic criteria as a covariate showed that, with ICCS 2016 as the reference category, prevalence estimates were significantly higher for ICD-10 ($\beta = 1.92$, $P < 0.001$) and ICCS 1998 ($\beta = 2.52$, $P < 0.001$), whereas no significant difference was observed between ICCS 2014 and ICCS 2016 ($\beta = 0.00$, $P = 1.000$). The Chinese Expert Consensus criteria also yielded significantly higher prevalence estimates than ICCS 2016 ($\beta = 1.01$, $P < 0.001$). Although prevalence estimates varied across specific diagnostic criteria, overall meta-regression indicated that diagnostic criteria alone did not account for the total between-study heterogeneity ($R^2 = 0\%$, $I^2_{res} = 99.16\%$), suggesting that residual heterogeneity was predominantly driven by other unmeasured methodological or clinical factors. The meta-regression results are presented in **Table 4**. However, given the lack of individual-level data, this meta-analysis could not harmonize all prevalence estimates according to the ICCS 2016 diagnostic criteria. The results should therefore be interpreted

with caution when applied to clinical settings using different diagnostic criteria.

Factors associated with NE in primary school-aged children in China

Meta-analysis: Based on the meta-analysis, the following factors were associated with higher odds of NE among primary school students in China ($P < 0.05$): male sex, lack of toilet training, family history of NE, constipation, attention-deficit/hyperactivity disorder (ADHD), sleep-disordered breathing, arousal dysfunction, fluid intake before sleep, daytime symptoms, and living in households with three or more children (≥ 3). Older age was associated with lower odds of NE; specifically, the odds decreased by approximately 24% with increasing age ($OR = 0.76$, 95% CI: 0.62-0.93, $P = 0.009$). The meta-analysis results, including ORs, 95% CIs, heterogeneity statistics, and the number of studies included for each factor, are presented in **Table 5**.

Sensitivity analysis: A sensitivity analysis was performed by comparing estimates obtained using fixed-effects and random-effects models to assess the robustness of the associations

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Table 2. Subgroup analysis of the prevalence of NE among primary school students in China

Subgroup	Number of studies	Heterogeneity test		Statistical model	Meta-analysis results
		I ² (%)	P value		
Gender					
Boys	18 studies [16-28, 31, 32, 34-36]	100	< 0.001	Random-effects	0.09 (0.08-0.09) < 0.001
Girls	18 studies [16-28, 31, 32, 34-36]	100	< 0.001	Random-effects	0.06 (0.06-0.07) < 0.001
Age (years)					
5	11 studies [15, 17-20, 23, 25, 26, 28-30]	100	< 0.001	Random-effects	0.16 (0.12-0.20) < 0.001
6	13 studies [15-17, 21, 23-26, 28-31, 34]	100	< 0.001	Random-effects	0.13 (0.11-0.15) < 0.001
7	13 studies [17, 18, 20, 21, 23-26, 28-31, 34]	100	< 0.001	Random-effects	0.09 (0.08-0.11) < 0.001
8	11 studies [17, 18, 21, 23-26, 28, 30, 31, 34]	100	< 0.001	Random-effects	0.08 (0.07-0.09) < 0.001
9	11 studies [17, 18, 21, 23-26, 28, 30, 31, 34]	100	< 0.001	Random-effects	0.06 (0.06-0.07) < 0.001
10	11 studies [17, 18, 21, 23-26, 28, 30, 31, 34]	100	< 0.001	Random-effects	0.05 (0.04-0.06) < 0.001
11	11 studies [17, 18, 21, 23-26, 28, 30, 31, 34]	100	< 0.001	Random-effects	0.03 (0.02-0.03) < 0.001
12	8 studies [17, 18, 21, 23, 24, 28, 30, 34]	100	< 0.001	Random-effects	0.02 (0.02-0.03) < 0.001
Region					
South	10 studies [15, 17, 21, 22, 27, 29-31, 34, 35]	100	< 0.001	Random-effects	0.10 (0.09-0.11) < 0.001
North	10 studies [16, 18-20, 24-26, 28, 32, 36]	100	< 0.001	Random-effects	0.11 (0.09-0.12) < 0.001
Diagnostic criteria					
ICD-10 (1993)	3 studies [15, 31, 34]	100	< 0.001	Random-effects	0.15 (0.08-0.23) < 0.001
ICCS (1998)	4 studies [27, 29, 35, 36]	100	< 0.001	Random-effects	0.20 (0.12-0.28) < 0.001
ICCS (2014)	4 studies [16, 18, 23, 24]	100	< 0.001	Random-effects	0.06 (0.05-0.07) < 0.001
ICCS (2016)	5 studies [17, 19, 21, 26, 32]	100	< 0.001	Random-effects	0.06 (0.05-0.08) < 0.001

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Chinese Expert Consensus on the Diagnosis and Treatment of Enuresis in Children (2019)	2 studies [20, 22]	100	< 0.001	Random-effects	0.10 (0.02-0.18) < 0.001
Ethnicity					
Han Chinese	5 studies [15, 20, 21, 23, 24]	100	< 0.001	Random-effects	0.05 (0.05-0.05) < 0.001
Ethnic minority groups	5 studies [15, 20, 21, 23, 24]	100	< 0.001	Random-effects	0.06 (0.06-0.07) < 0.001
Publication year					
Before 2020	13 studies [15, 16, 18, 19, 24-26, 29, 30, 33-36]	100	< 0.001	Random-effects	0.12 (0.11-0.13) < 0.001
2020 or later	9 studies [17, 20-23, 27, 28, 31, 32]	100	< 0.001	Random-effects	0.06 (0.06-0.07) < 0.001

Note: NE, nocturnal enuresis; CI, confidence interval; ICD-10, International Statistical Classification of Diseases and Related Health Problems, 10th Revision; ICCS, International Children's Continence Society. The Qinling-Huaihe Line was used as the boundary between northern and southern China; areas south of the line were classified as southern China, and areas north of the line as northern China. The number of studies included in each subgroup varies because not all studies reported data for every subgroup (e.g., age-stratified, gender-stratified, or regional data). Studies that did not report relevant subgroup data were excluded from the corresponding subgroup analysis.

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Table 3. Sensitivity analysis of the prevalence of NE among primary school students in China

Study excluded	Heterogeneity test		Meta-analysis results	
	I^2 (%)	<i>P</i> -value	Prevalence (95% <i>CI</i>)	<i>P</i> -value
Ban et al. 2015 [15]	99.275	< 0.001	0.064 (0.035-0.100)	< 0.001
Huang et al. 2019 [16]	99.394	< 0.001	0.066 (0.034-0.108)	< 0.001
Chen et al. 2023 [17]	99.402	< 0.001	0.066 (0.034-0.107)	< 0.001
Han et al. 2017 [18]	99.402	< 0.001	0.065 (0.031-0.109)	< 0.001
Li et al. 2019 [19]	99.402	< 0.001	0.065 (0.033-0.107)	< 0.001
Liu et al. 2023 [20]	99.402	< 0.001	0.066 (0.033-0.107)	< 0.001
Luo et al. 2020 [21]	99.396	< 0.001	0.066 (0.032-0.110)	< 0.001
Wei et al. 2023 [22]	99.303	< 0.001	0.065 (0.034-0.105)	< 0.001
Liao et al. 2020 [23]	99.402	< 0.001	0.069 (0.047-0.096)	< 0.001
Qian et al. 2018 [24]	99.402	< 0.001	0.066 (0.034-0.106)	< 0.001
Wen et al. 2007 [25]	99.402	< 0.001	0.065 (0.033-0.108)	< 0.001
Wen et al. 2017 [26]	99.387	< 0.001	0.064 (0.032-0.107)	< 0.001
Zhou et al. 2022 [27]	99.401	< 0.001	0.066 (0.034-0.107)	< 0.001
Zhang et al. 2022 [28]	99.401	< 0.001	0.066 (0.034-0.107)	< 0.001
Guo et al. 2017 [29]	99.303	< 0.001	0.064 (0.035-0.102)	< 0.001
Luo et al. 1995 [30]	99.377	< 0.001	0.066 (0.034-0.108)	< 0.001
Tang et al. 2021 [31]	99.401	< 0.001	0.065 (0.034-0.106)	< 0.001
Huang et al. 2020 [32]	99.386	< 0.001	0.067 (0.033-0.110)	< 0.001
Zhang et al. 2019 [33]	99.379	< 0.001	0.066 (0.031-0.112)	< 0.001
Tai et al. 2007 [34]	99.402	< 0.001	0.065 (0.032-0.109)	< 0.001
Su et al. 2011 [35]	99.395	< 0.001	0.066 (0.033-0.109)	< 0.001
Wang et al. 2007 [36]	98.802	< 0.001	0.063 (0.041-0.091)	< 0.001

Note: NE, nocturnal enuresis; CI, confidence interval.

Table 4. Meta-regression results by diagnostic criteria

Diagnostic criteria	<i>B</i>	<i>P</i> -value	95% <i>CI</i>
ICD-10 (1993)	1.92	< 0.001	(1.56-2.28)
ICCS (1998)	2.52	< 0.001	(2.22-2.82)
ICCS (2014)	0.00	1.000	(-0.28-0.28)
ICCS (2016)	Reference	-	-
Chinese Expert Consensus on the Diagnosis and Treatment of Enuresis in Children (2019)	1.01	< 0.001	(0.65-1.37)

Note: CI, confidence interval; ICD-10, International Statistical Classification of Diseases and Related Health Problems, 10th Revision; ICCS, International Children's Continence Society. Model summary for meta-regression based on diagnostic criteria: $R^2 = 0\%$, $I^2_{res} = 99.16\%$.

between NE and the identified factors. Based on the above results, age, male sex, lack of toilet training, ADHD, arousal dysfunction, day-time symptoms and households with three or more children yielded consistent statistical inferences under the fixed-effects and random-effects models, suggesting that the corresponding meta-analysis results were relatively stable. The statistical significance of several factors, including male sex, household income, snoring, and sleep-disordered breathing, differed between the fixed-effects and random-effects models, indicating that these findings

were sensitive to model selection. There is considerable variation in the research results, so a random-effects model will be applied to the data. The sensitivity analysis results are presented in **Table 6**.

Discussion

Prevalence

A systematic review and meta-analysis was conducted to assess the prevalence of enuresis among primary school students aged 5-12

Prevalence and factors of enuresis in Chinese children

Table 5. Meta-analysis of factors associated with NE among primary school students in China

Factors	Number of studies	Heterogeneity test		Statistical model	Meta-analysis results	
		I^2 (%)	P-value		OR (95% CI)	P-value
Age	7 studies [19-21, 26, 32, 34, 35]	98	< 0.001	Random-effects	0.76 (0.62-0.93)	0.009
Gender (male)	7 studies [19, 20, 22, 26, 34-36]	74	< 0.001	Random-effects	1.48 (1.24-1.76)	< 0.001
Gender (female)	2 studies [32, 35]	93	< 0.001	Random-effects	0.26 (0.04-1.71)	0.16
Lack of toilet training	2 studies [22, 32]	0	0.58	Fixed-effects	1.90 (1.32-2.73)	< 0.001
Annual household income (high)	2 studies [22, 33]	100	< 0.001	Random-effects	1.30 (0.52-3.27)	0.58
Annual household income (low)	2 studies [20, 22]	97	< 0.001	Random-effects	2.17 (0.94-5.02)	0.07
Family history of NE	7 studies [20-22, 26, 32, 34, 36]	96	< 0.001	Random-effects	2.60 (1.55-4.36)	0.0003
Urinary tract infection	2 studies [20, 34]	53	0.15	Random-effects	1.96 (0.57-6.69)	0.28
Constipation	4 studies [20-22, 34]	87	< 0.001	Random-effects	1.85 (1.08-3.17)	0.02
Snoring	2 studies [33, 35]	97	< 0.001	Random-effects	1.29 (0.25-6.60)	0.76
Attention-deficit/hyperactivity disorder	2 studies [20, 33]	0	0.44	Fixed-effects	2.63 (2.12-3.27)	< 0.001
Sleep-disordered breathing	4 studies [20, 21, 32, 35]	90	< 0.001	Random-effects	1.61 (1.03-2.52)	0.04
Arousal dysfunction	3 studies [26, 34, 36]	90	< 0.001	Random-effects	2.76 (1.77-4.31)	< 0.001
Bedtime fluid intake	4 studies [20, 22, 32, 34]	79	0.003	Random-effects	1.95 (1.21-3.16)	0.006
Daytime urinary symptoms	2 studies [35, 36]	0	0.88	Fixed-effects	1.88 (1.44-2.46)	< 0.001
Households with ≥ 3 children	2 studies [20, 22]	0	0.43	Fixed-effects	2.32 (2.06-2.62)	< 0.001

Note: NE, nocturnal enuresis; OR, odds ratio; CI, confidence interval.

Table 6. Sensitivity analysis of factors associated with NE among primary school students in China [OR (95% CI)]

Factor	Fixed-effects model	Random-effects model
Age	0.77 (0.75-0.80)	0.76 (0.62-0.93)
Gender (male)	1.39 (1.28-1.50)	1.48 (1.24-1.76)
Gender (female)	0.54 (0.41-0.72)	0.26 (0.04-1.71)
Lack of toilet training	1.90 (1.32-2.73)	1.90 (1.32-2.73)
Annual household income (high)	1.61 (1.56-1.66)	1.30 (0.52-3.27)
Annual household income (low)	3.18 (3.00-3.37)	2.17 (0.94-5.02)
Family history of NE	2.04 (1.86-2.25)	2.60 (1.55-4.36)
Urinary tract infection	2.03 (0.88-4.71)	1.96 (0.57-6.69)
Constipation	1.52 (1.28-1.80)	1.85 (1.08-3.17)
Snoring	2.58 (2.24-2.98)	1.29 (0.25-6.60)
Attention-deficit/hyperactivity disorder	2.63 (2.12-3.27)	2.63 (2.12-3.27)
Sleep-disordered breathing	1.05 (0.98-1.13)	1.61 (1.03-2.52)
Arousal dysfunction	2.63 (2.29-3.01)	2.76 (1.77-4.31)
Bedtime fluid intake	1.64 (1.38-1.96)	1.95 (1.21-3.16)
Daytime urinary symptoms	1.88 (1.44-2.46)	1.88 (1.44-2.46)
Households with ≥ 3 children	2.32 (2.06-2.62)	2.32 (2.06-2.62)

Note: NE, nocturnal enuresis; OR, odds ratio; CI, confidence interval.

years in China. Twenty-two studies involving a total of 161,662 participants were included, yielding a pooled prevalence of 10% (95% CI: 9%-11%). Given the extremely high heterogeneity ($I^2 = 100\%$) across the included studies, this pooled prevalence should be viewed as a descriptive summary of the available evidence rather than a precise population estimate. In clinical practice, this estimate should be interpreted with caution because it may be influenced by differences in study populations, diagnostic criteria, and geographic settings and should not be regarded as a precise population estimate. This figure is higher than the prevalence of 6.1% reported in a previous meta-analysis of the entire Chinese pediatric and adolescent cohort [10], and is also higher than the aggregated prevalence of 5.59% (95% CI: 4.58%-6.81%) published in another study that combined 38 trials [44]. This difference may partly reflect the narrower age range of the current study, which was restricted to primary school students aged 5-12 years, whereas previous studies also included adolescents, among whom the prevalence of NE is generally lower. Therefore, estimates combining children and adolescents may not accurately reflect the prevalence of NE specifically among primary school-aged children.

Globally, the prevalence estimated in this study is broadly consistent with the reported prevalence of nocturnal enuresis among children and adolescents (7.2%) and is slightly higher than that reported in Asia (6%) [6]. Geographic variation in prevalence may be attributable to differences in diagnostic criteria, sociocultural factors, demographic characteristics, and other population-level factors.

According to the age-based analysis, the prevalence of NE decreased significantly with age, and it was only 2% among twelve-year-olds compared to 16% of five-year-olds. The decline in prevalence was particularly marked between 5 and 9 years of age, suggesting that this period may represent an important stage in the natural course of NE. Gender-based investigation showed that the prevalence was higher among boys (9%) than among girls (6%), consistent with previous research. This difference may be related to sex-specific differences in neurological and bladder maturation, although the underlying mechanisms remain uncertain. The pooled prevalence was similar in southern (10%) and northern China (11%). This similarity may partly reflect the limited geographic representation of the included studies.

Diagnostic Criteria and Temporal Trends: Stratified evaluations show that the investigations

carried out under older diagnostic criteria, such as ICD-10 (1993) and ICCS (1998), had a relatively high prevalence (15%-20%), while those using more recent criteria, such as ICCS 2014 and 2016, showed a lower prevalence (6%). These differences may partly reflect changes in diagnostic definitions and the periods during which the included studies were conducted. On the one hand, changes in diagnostic definitions and classification across different diagnostic systems may have affected case ascertainment and consequently the reported prevalence. On the other hand, a stratified assessment based on the year of publication showed that the frequency was 12% among the 13 articles published before 2020; this dropped to 6% in the nine articles published in 2020 and subsequently, suggesting a lower reported prevalence in more recent studies. Possible explanations include changes in socioeconomic conditions, toilet-training practices, diaper use, and health-seeking behavior; however, these factors were not directly examined in the present meta-analysis. Therefore, comparisons of prevalence estimates across different periods should account for both changes in diagnostic criteria and temporal variation in reported prevalence.

The meta-regression suggested that diagnostic criteria may account for a substantial proportion of the between-study heterogeneity. The included studies used multiple diagnostic definitions, including ICD-10, ICCS 1998/2014/2016, DSM criteria, and the Chinese Expert Consensus. This variability precludes direct harmonization of all prevalence estimates according to a single diagnostic definition, such as the ICCS 2016 criteria. Accordingly, the pooled prevalence of 10% should be interpreted in the context of the diagnostic criteria used, as subgroup estimates varied substantially across diagnostic definitions. These findings support the use of standardized diagnostic criteria and greater attention to children with associated factors identified in this meta-analysis. Further prospective studies are needed to determine how these findings can best be incorporated into screening and management strategies for primary school children in China.

Factors associated with NE

A meta-analysis of 17 potential factors was conducted to identify factors associated with NE among primary school students.

Among the demographic factors studied, for each additional year of age, the odds of NE decreased by approximately 24% (OR = 0.76, 95% CI: 0.62-0.93), indicating that older age was associated with lower odds of NE. Male sex was also associated with higher odds of NE (OR = 1.48, 95% CI: 1.24-1.76), consistent with previous meta-analyses (OR = 1.52).

Among the genetic factors, a family history of NE was associated with higher odds of NE, with an OR of 2.60 (95% CI: 1.55-4.36). Previous studies have shown that the risk of enuresis among offspring is as high as 40% when one parent has it, and more than 70% if both parents are affected [7]; children with hereditary enuresis are also more likely to experience other problems such as emotional problems and hyperactivity [45], and genes may affect the development of enuresis in several ways, including impaired bladder maturation, altered release of antidiuretic hormone, and arousal disorders.

Constipation was associated with higher odds of NE (OR = 1.85, 95% CI: 1.08-3.17). Constipation may indirectly induce or worsen NE through mechanisms such as increased intra-abdominal pressure, reduced bladder emptying efficiency and disturbances in pelvic floor muscle coordination [46]. From a pathophysiological perspective, rectal distension and fecal retention may affect bladder function through the following pathways: (1) Mechanical pathway - a distended rectum directly compresses the posterior bladder wall, reducing effective bladder capacity and causing the bladder to reach the micturition threshold earlier; (2) Neuroreflex pathway - rectal distension enhances involuntary detrusor contractions and induces detrusor overactivity via crossed pelvic reflexes mediated by the pelvic and hypogastric nerves. In addition, recent studies have suggested that chronic constipation-related gut microbiota dysbiosis and local micro-inflammation may potentially reduce bladder sensory thresholds and increase the frequency of unstable contractions through upregulation of transient receptor potential channels (e.g., transient receptor potential vanilloid 1) in the bladder mucosa; however, the causal relationship warrants further basic research validation [46, 47]. In clinical practice, digital rectal examination can be used to assess rectal fecal impaction and anal sphincter tone, the Bristol

Stool Form Scale can be used to classify stool consistency, and the Rome IV criteria can be applied to diagnose functional constipation. A stepped assessment strategy is recommended: routine screening using the Rome IV criteria and the Bristol Stool Form Scale in outpatient settings; for those screening positive, digital rectal examination to evaluate the degree of fecal impaction; and for children with refractory constipation-related NE, plain abdominal radiography or serum inflammatory marker testing may be considered. The pooled result for urinary tract infections was not statistically significant (OR = 1.96, 95% CI: 0.57-6.69), which may be attributable to the limited number of included studies and heterogeneity in definitions.

In terms of sleep factors, dysfunction showed a relatively strong association with NE (OR = 2.76, 95% CI: 1.77-4.31), while sleep-disordered breathing (OR = 1.61, 95% CI: 1.03-2.52) and excessive fluid intake before sleep (OR = 1.95, 95% CI: 1.21-3.16) were also associated with higher odds of NE. Recent research has indicated that children and adolescents with NE may exhibit altered sleep patterns, and children with NE have been reported to experience more sleep problems than controls, particularly parasomnias, breathing disorders, and daytime sleepiness [48]. Sleep-related respiratory problems may increase the risk of NE through pathways such as hypoxemia, disrupted sleep and altered arousal; a combined analysis and meta-analysis have confirmed that sleep-related respiratory problems are an independent risk factor for NE (adjusted OR = 2.85, 95% CI: 2.35-3.45) [49].

Regarding neurodevelopmental and psychological factors, ADHD was associated with higher odds of NE (OR = 2.63, 95% CI: 2.12-3.27), with no observed heterogeneity across the included studies ($I^2 = 0\%$). The comorbid mechanisms between NE and ADHD may involve shared pathways, including delayed central nervous system maturation, dopaminergic system dysfunction, and sleep architecture disturbances [50]. The pathophysiological mechanisms mainly include: (1) Central nervous system maturational delay - children with ADHD exhibit delayed development of the prefrontal cortex and striatum, which affects the regulation of urinary inhibition reflexes and the sleep-wake cycle;

(2) Dopaminergic system dysfunction - dopamine modulates arousal levels and the integration of the micturition reflex via the hypothalamic-pontine-spinal axis, and abnormal receptor signaling may lead to elevated arousal thresholds; (3) Sleep architecture disturbances - children with ADHD show increased light sleep, decreased deep sleep, and elevated arousal thresholds, with concomitant sleep-disordered breathing further reducing the perception of bladder fullness signals [51, 52]. The above multi-level mechanisms suggest that children with ADHD and comorbid NE should receive comprehensive interventions addressing neurodevelopment, sleep assessment, and voiding function. Concomitant daytime symptoms (urinary frequency, urgency, and incontinence) were also identified as a risk factor for NE (OR = 1.88, 95% CI: 1.44-2.46), suggesting that some children with NE have more complex lower urinary tract dysfunction that requires comprehensive evaluation and intervention.

Regarding toilet training, lack of training was associated with higher odds of NE (OR = 1.90, 95% CI: 1.32-2.73). These findings may partly reflect differences in the definitions and implementation of toilet training across studies. Delayed toilet training and prolonged use of disposable diapers may be associated with an increased risk of enuresis [53]. In terms of family and socio-economic factors, households with three or more children were identified as a risk factor for NE (OR = 2.32, 95% CI: 2.06-2.62), which may be related to factors such as reduced parental attention and less consistent toilet training; the combined results for annual household income were not statistically significant, possibly due to differing standards for wealth classification across various studies, and thus their integration might affect the reliability of the combined outcomes. In summary, NE among primary school students is associated with multiple genetic, physiological, neurodevelopmental, behavioral, and family-related factors, highlighting the importance of comprehensive assessment and management.

A major limitation of the risk factor analysis is that most original studies did not report subgroup-specific effect estimates by enuresis subtype (MNE vs. NMNE) or by age group (e.g., 5-7 vs. 8-12 years). Consequently, we were unable to stratify the pooled ORs by these clinical

cally relevant subgroups, which may have masked differential associations of the same risk factor across different phenotypes and age strata. For example, constipation may be more strongly associated with NMNE due to shared pelvic floor dysfunction, while arousal disorders may be more specific to MNE. Future primary studies should report subgroup-specific data to enable more precise meta-analyses. Furthermore, all risk factor analyses in this study relied on self-reported questionnaire data from the original studies, which are subject to recall bias. Clinical measures such as urodynamic assessments, the Bristol Stool Form Scale, and arousal threshold testing were not consistently reported across studies and could not be pooled. We recommend that future research incorporate these objective measures to enhance the clinical utility of risk stratification.

Limitations of this study

The limitations of this study are as follows: (1) There was substantial heterogeneity among the included studies ($I^2 = 100\%$). Despite subgroup analyses and the use of a random-effects model, the sources of heterogeneity could not be fully identified. An I^2 value of 100% indicates extremely high between-study heterogeneity, suggesting that most of the observed variability is attributable to differences among studies rather than sampling error. Therefore, the pooled prevalence of 1% should be interpreted as a descriptive summary rather than a precise population estimate and should be interpreted with caution. Meta-regression indicated that diagnostic criteria did not explain the high between-study variability ($R^2 = 0\%$, $I^2_{\text{res}} = 99.16\%$), confirming that heterogeneity is driven by unmeasured methodological or clinical factors. Sensitivity analysis using the quality effects model yielded a pooled prevalence of 7% (95% CI: 3%-11%), which was directionally consistent with the main analysis but more conservative. (2) Although diagnostic criteria appeared to contribute substantially to the observed heterogeneity, the included studies used multiple diagnostic definitions. Because individual-level data were unavailable, we could not harmonize all prevalence estimates according to the ICCS 2016 diagnostic criteria. (3) For certain associated factors (such as urinary tract infections, annual household income,

and ADHD), the number of included studies was small, and the reliability of the pooled results requires validation through additional primary research. (4) This study only included literature published in Chinese and English, which may have introduced language bias; the included studies were predominantly conducted in eastern and central China, with a marked paucity of research from western and remote areas and an extremely low proportion of ethnic minority samples, limiting the generalizability of the pooled prevalence estimates. (5) Because of the limited number of studies involving ethnic minority populations, further subgroup analyses by specific ethnic group could not be performed. (6) The original studies did not report subgroup-specific effect estimates for associated factors by enuresis subtype (MNE vs. NMNE) or age group. Therefore, we were unable to perform stratified meta-analyses to distinguish differential associations of risk factors across these clinically relevant subgroups. (7) All risk factor analyses relied on self-reported questionnaire data from the original studies, which are subject to recall bias. Clinical measures (e.g., urodynamic assessments, the Bristol Stool Form Scale, and arousal threshold testing) were not consistently reported and could not be pooled, limiting the clinical applicability of the risk stratification findings.

Conclusion

The pooled prevalence of NE among Chinese primary school students aged 5-12 years was approximately 10% (95% CI: 9%-11%), based on a descriptive summary of the available studies. The prevalence was higher among boys than among girls and decreased with age. However, given the substantial heterogeneity across studies and the variation in diagnostic criteria, this estimate should be interpreted with caution and may not represent a precise population parameter. Meta-regression analysis showed that diagnostic criteria alone did not explain the observed heterogeneity ($R^2 = 0\%$, $I^2_{\text{res}} = 99.16\%$). Accordingly, the pooled prevalence should be viewed as a contextual descriptive summary rather than a single standardized parameter. Male sex, family history of NE, constipation, attention-deficit/hyperactivity disorder, arousal dysfunction, bedtime fluid intake, daytime urinary symptoms, and living in households with three or more children were

associated with higher odds of NE, whereas older age was associated with lower odds of NE. Due to the lack of subtype-specific data in the original studies, differential associations of these factors with MNE versus NMNE or across different age groups could not be assessed. These findings highlight the importance of standardized diagnostic criteria, appropriate screening, and comprehensive management of NE among primary school children, with particular attention to children with associated factors identified in this meta-analysis.

Disclosure of conflict of interest

None.

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