BMC Pediatrics

RESEARCH Open Access

Prevalence and risk factors for childhood asthma: a systematic review and meta-analysis

Weijun Zhou[1*] and Jia Tang[1]

Abstract

Background This study aimed to systematically review and perform a meta-analysis on epidemiological studies in order to estimate the global and regional prevalence and to identify risk factors associated with childhood asthma.

Methods A comprehensive search of the PubMed, Embase, and Cochrane Library electronic databases was conducted for relevant literature published from their inception to March 31, 2023. The primary endpoint was the prevalence of childhood asthma. Secondary endpoint focused on the identification of risk factors associated with childhood asthma.

Results A total of 1,547,404 children participated in the 164 studies selected for the meta-analysis. The overall prevalence of childhood asthma was 10.2% (95% CI: 9.5-11.0%), while the prevalence of childhood asthma in Asia, Europe, Latin America, North America, Oceania, Africa, or Eurasia were 10% (95%CI: 7-13%), 9% (95%CI: 7-12%), 14% (95%CI: 9-20%), 13% (95%CI: 12-14%), 23% (95%CI: 19-28%), 11% (95%CI: 7-19%), and 8% (95%CI: 2-27%), respectively. Moreover, the identified risk factors for childhood asthma included older age, male sex, obesity, parental smoking, high education of the mother, premature birth, cesarean section, no breastfeeding, family history of asthma, rhinitis, eczema, pets, high density of road traffic, meat, margarine, fast food, paracetamol use, and antibiotic use.

Conclusion Childhood asthma is common, and the prevalence of asthma is highest in Oceania, with a lower prevalence in Eurasia. Moreover, the risk factors for childhood asthma were comprehensively identified, and health education should be provided to prevent modifiable factors.

Keywords Prevalence, Risk factors, Childhood, Asthma, Systematic review, Meta-analysis

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Background

Asthma is a common chronic disease of the respiratory tract characterized by wheezing, coughing, and airflow obstruction [1]. The detection rate of asthma in children has reached 10%, making it a global public health problem [2]. In recent decades, the global prevalence, morbidity, and economic burden of asthma have increased [3]. Currently, the pathogenesis of asthma is not fully understood, and the main causes of asthma progression include decreased lung function, allergic disorders, and bacterial and viral infections [4–8]. Furthermore, asthma is significantly associated with lower lung activity from the prenatal stage which persists in childhood and adulthood, and can accelerate the progression of chronic obstructive pulmonary disease [9].

Asthma can be caused by complex gene-environment interactions that precede preschool symptoms [10, 11]. The International Study of Asthma and Allergies in Childhood (ISAAC) reported the prevalence of asthma in the Asia-Pacific region was lower in 1998, while this trend increased in 2007 [12]. The global epidemiology of asthma needs to be updated, and the risk factors for asthma in children should be thoroughly explored to inform future asthma prevention and management strategies [11]. A systematic analysis conducted by Song et al. identified 220 population-based studies and found that the prevalence rates of current wheezing, ever wheezing, current asthma, and ever asthma were 11.5%, 17.9%, 5.4%, and 9.8%, respectively. However, this analysis, while comprehensive, did not fully address the evolving nature of asthma risk factors in pediatric populations. Additionally, there is a need to incorporate more recent data and to consider regional and demographic variations that may influence the prevalence and risk factors of asthma [13]. Moreover, Sio et al. performed a meta-analysis of 289 studies and found that asthma-associated risk factors included family history of allergy-related conditions, presence of mold, mold spots, mold odor, cockroaches, water damage, incense burning, male sex, cigarette smoking, body mass index, air pollution, low birth weight, preterm birth, and cesarean Sect. [14]. However, the meta-analysis includes multiple studies that involve the same population of participants, which may lead to data duplication and bias. Additionally, the study includes both children and adults, which may affect the interpretation of the results, as different age groups may have significant differences in the pathogenesis and risk factors of asthma. Therefore, we performed a systematic review and meta-analysis to determine the prevalence and risk factors of childhood asthma.

Methods

Data sources, search strategy, and selection criteria

This study was performed following a Meta-analysis of Observational Studies in Epidemiology [15]. This study was registered in INPLASY platform (no: INPLASY202350116). Epidemiological studies that have reported the prevalence and risk factors for asthma in children were eligible for our study, and no restrictions were placed on the publication language and status. We systematically searched the PubMed, Embase, and Cochrane Library databases to identify potential studies published from their inception to March 31, 2023, and the following search terms were applied: (Asthma*[Title]) AND (epidemiology[Title/Abstract] OR risk[Title/Abstract]) and restricted them to Child: birth-18 years. The details of search strategy in each data are shown in Supplemental File 1. Reference lists of relevant reviews and original articles were manually searched to identify eligible patients who met the inclusion criteria.

Two reviewers independently performed the literature search and screening, and conflicts between the reviewers were resolved by an additional reviewer after full-text evaluations. Studies were included if they met the following criteria: [1] Population: age of individuals less than 18.0 years; [2] Definition: clear definition of asthma; [3] Outcome: prevalence of asthma or a specific risk factor for asthma was reported in at least three studies; and [4] Study design: cross-sectional studies. The details of exclusion criteria are listed as follows: [1] studies that included individuals aged 18 years or older; [2] studies that did not provide a clear and consistent definition of asthma; [3] studies that did not report the prevalence of asthma or specific risk factors for asthma fewer than three studies; and [4] studies that were not cross-sectional in design.

Data extraction and quality assessment

Data collection was independently performed by two reviewers, and the abstracted information included the first author's name, publication year, country, sample size, age range, male proportion, asthma definition, number of asthma cases, and investigated outcomes. These two reviewers assessed the methodological quality of the included studies using the Newcastle-Ottawa Scale (NOS). The NOS scale contains items based on selection (4 items), comparability (1 item), and outcome (3 items), and the "staring system" ranged from to 0–9 [16]. Inconsistent results regarding data extraction and quality assessment between the reviewers were resolved by an additional reviewer referring to the original article.

Statistical analysis

The prevalence of childhood asthma was analyzed based on the number of children with asthma included in the individual studies, while the odds ratio (OR) with a 95%

confidence interval (CI) was applied as an effect estimate for the identified risk factors for asthma. Then, the random-effects model was applied to calculate the pooled prevalence of childhood asthma and effect estimates for risk factors because it could consider the various underlying factors across the included studies [17, 18]. Heterogeneity across the included studies was assessed using the I^2 and Cochran Q statistics, and significant heterogeneity was defined as $I^2 > 50.0\%$ or $P < 0.10$ [19, 20]. Sensitivity analysis was performed to determine the risk factors for childhood asthma by sequentially removing individual studies [21]. Subgroup analysis was performed to determine the prevalence of childhood asthma by country and outcome definition. Publication bias was assessed using funnel plots and Egger and Begg tests [22, 23]. The *P* value for the pooled conclusion was two-sided and the inspection level was set at 0.05. All analyses were conducted using STATA software, version 14.0, from Stata Corporation, College Station, TX, USA.

Results

Search of the literature

A total of 10,934 articles were identified from the initial electronic search, and 4,159 articles were retained after duplicate articles were removed. Subsequently, 3,615 irrelevant articles were removed through title and abstract reviews. The remaining 544 articles were retrieved for full-text evaluation, and 380 studies were removed because of their retrospective design ($n = 261$), including adult individuals ($n = 89$), or no clear definition for asthma ($n = 30$). None of the studies retrieved through the manual review yielded new eligible studies. Finally, 164 cross-sectional studies were included in the final systematic review and meta-analysis (Fig. 1).

Study characteristics

Supplemental File 1 summarizes the baseline characteristics of the included studies and involved individuals. A total of 1,547,404 children were identified in the 164 studies, and the sample sizes ranged from 299 to 134,646. Sixteen studies defined asthma based on reports from parents or guardians, 69 studies defined asthma based on the ISAAC questionnaire, 32 studies defined asthma based on physician-confirmed data, and 47 studies defined asthma based on self-reports. Furthermore, the methodological quality of the included studies was assessed using the NOS scale: there were 39 studies with 7 stars, 86 studies with 6 stars, and the remaining 39 studies had 5 stars.

Prevalence of childhood asthma

After pooling all included studies, we noted that the overall prevalence of asthma in children was 10.2% (95% CI: 9.5-11.0%). The prevalence of childhood asthma in Asia, Europe, Latin America, North America, Oceania, Africa, and Eurasia were 10% (95%CI: 7-13%), 9% (95%CI: 7-12%), 14% (95%CI: 9-20%), 13% (95%CI: 12-14%), 23% (95%CI: 19-28%), 11% (95%CI: 7-19%), and 8% (95%CI: 2-27%), respectively (Fig. 2). In Asia, the prevalence of childhood asthma was highest in Qatar (prevalence: 21%; 95%CI: 19-22%) and lowest in Kuwait (prevalence: 2%; 95%CI: 2-3%). In Europe, the prevalence of childhood asthma was the highest in the UK (prevalence: 14%; 95%CI: 13-15%) and lowest in Greece (prevalence: 4%; 95%CI: 4-5%). In Latin America, the prevalence of childhood asthma is higher in Brazil than in Ecuador (prevalence: 17%; 95%CI: 10-24% vs. prevalence: 12%; 95%CI: 9-15%). In North America, the prevalence of childhood asthma in Mexico was the highest (prevalence: 15%; 95%CI: 8-22%), whereas it was the lowest in the USA (prevalence: 12%; 95%CI: 10-14%). In Oceania, the prevalence of childhood asthma was higher in Australia than in New Zealand (prevalence: 28%; 95%CI: 18-39% vs. prevalence: 22%; 95%CI: 21-23%). In Africa, the prevalence of asthma was the highest in Angola (prevalence: 16%; 95%CI: 11-20%) and lowest in Nigeria (prevalence: 6%; 95%CI: 4-8%). Finally, among Eurasian countries, we noted that the prevalence of childhood asthma in Turkey was higher than that in Russia (prevalence: 15%; 95%CI: 10-19% vs. prevalence: 4%; 95%CI: 2-5%). When stratified by outcome definition, we noted the prevalence of childhood asthma in care-defined asthma, asthma-based on self reports, asthma defined by ISAAC questionnaire, and physician-confirmed asthma were 11% (95%CI: 9-13%), 10% (95%CI: 9-12%), 10% (95%CI: 9-12%), and 10% (95%CI: 8-11%).

Risk factors for childhood asthma

Summary results for the risk factors for childhood asthma are shown in Fig. 3 and Supplemental File 3. Firstly, we noted older age (OR: 1.28; 95%CI: 1.14–1.43; $P < 0.001$), obesity (OR: 1.30; 95%CI: 1.21–1.39; $P < 0.001$), and parents' smoking (OR: 1.21; 95%CI: 1.16–1.26; $P < 0.001$) were associated with with an increased risk of childhood asthma. Female gender (OR:0.75; 95%CI:0.71–0.79; $P < 0.001$), and low education in mother (OR:0.85; 95%CI:0.73–0.99; $P = 0.043$) were associated with a reduced risk of childhood asthma. However, socioeconomic status, and father's education were not associated with childhood asthma risk. Secondly, premature birth (OR: 1.49; 95%CI: 1.24–1.79; $P < 0.001$), and cesarean section (OR: 1.36; 95%CI: 1.18–1.57; $P < 0.001$) were associated with an increased risk of childhood asthma, while breastfeeding (OR:0.83; 95%CI:0.73–0.96; $P = 0.010$) was associated with a reduced risk of childhood asthma. Thirdly, family history of asthma (OR: 2.98; 95%CI: 2.73–3.25; $P < 0.001$), rhinitis (OR: 3.73; 95%CI: 2.73–5.10; $P < 0.001$), and eczema (OR: 2.40; 95%CI: 1.80–3.21;

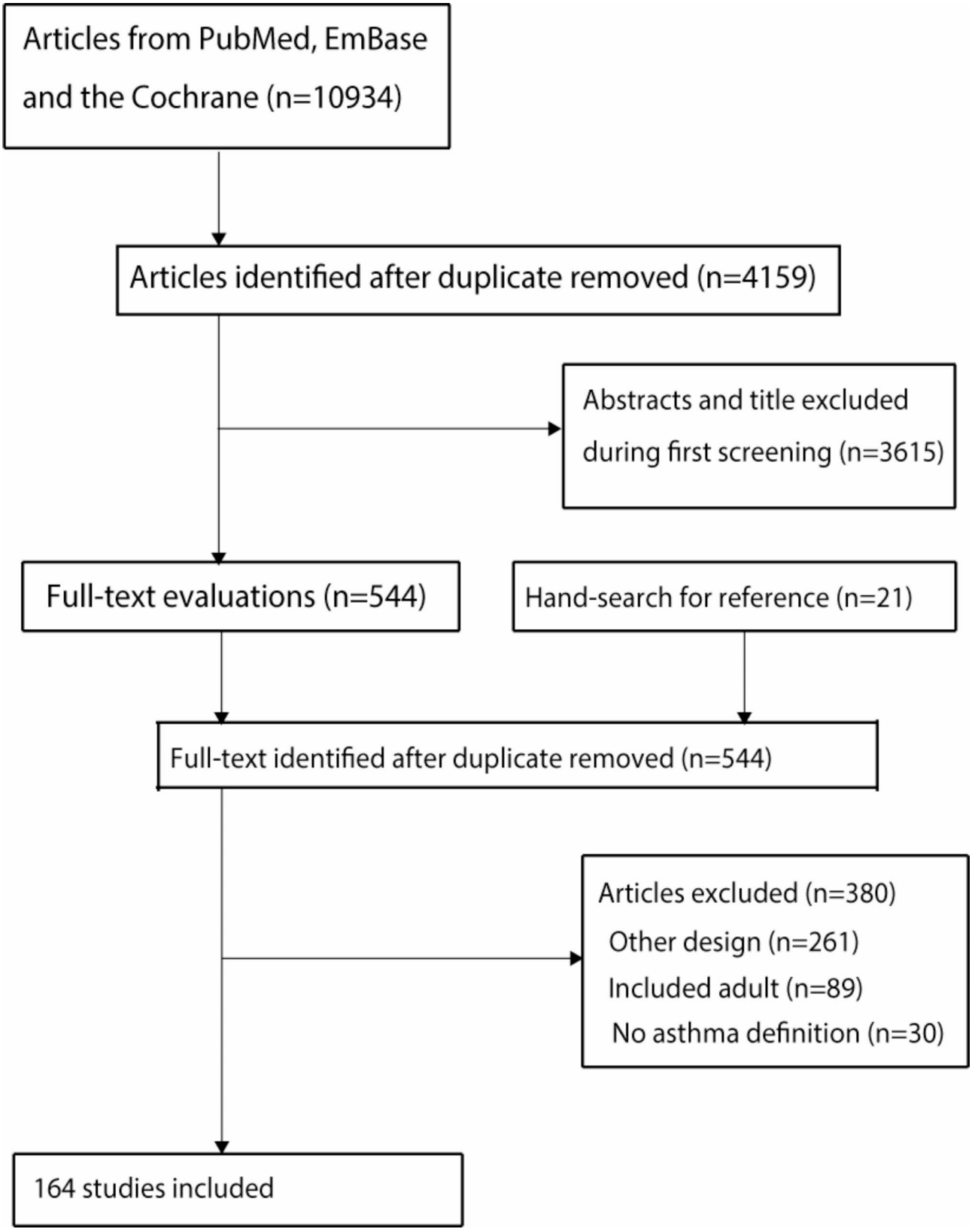

Fig. 1 Flow diagram of the literature search and study selection process

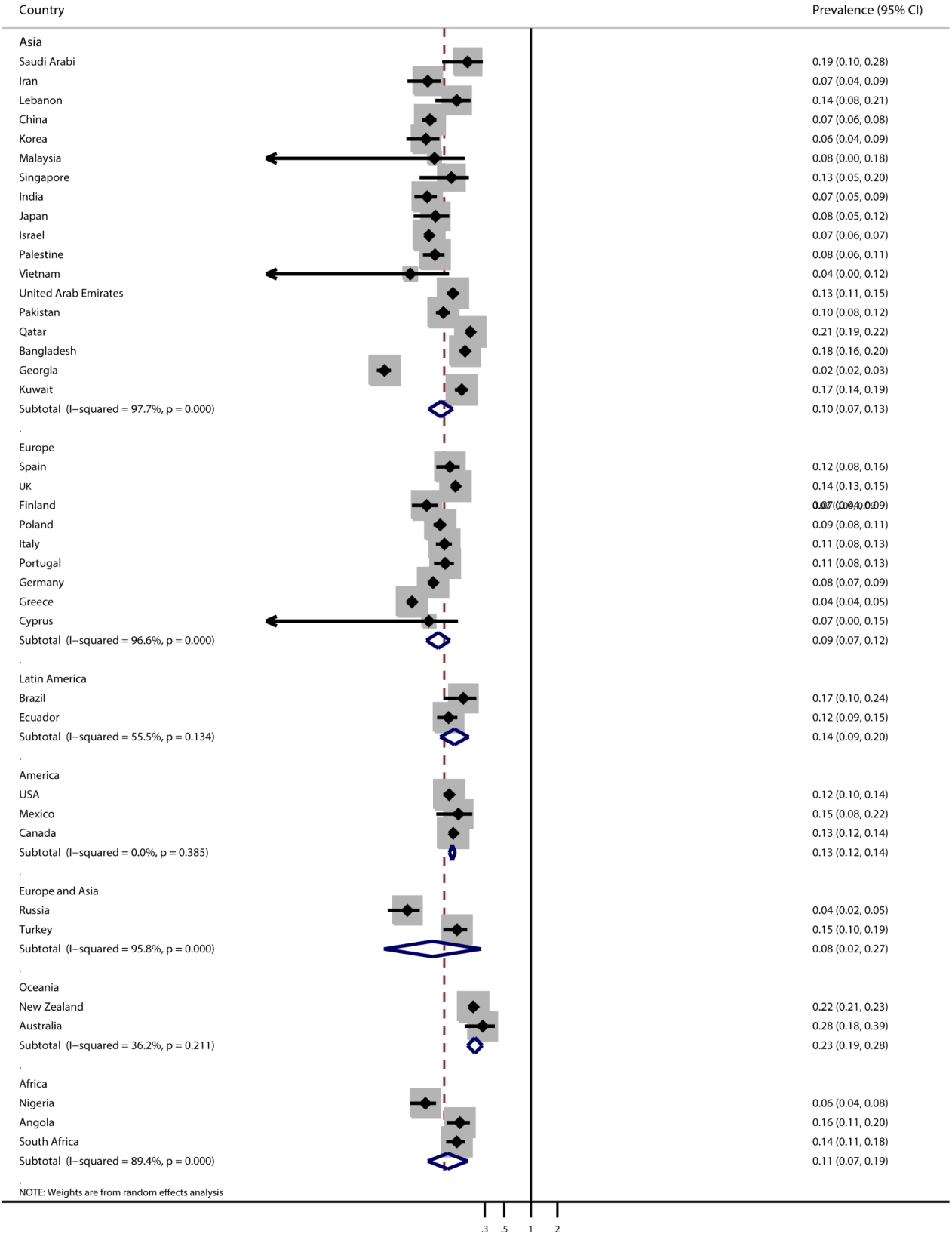

Fig. 2 The overall prevalence of childhood asthma

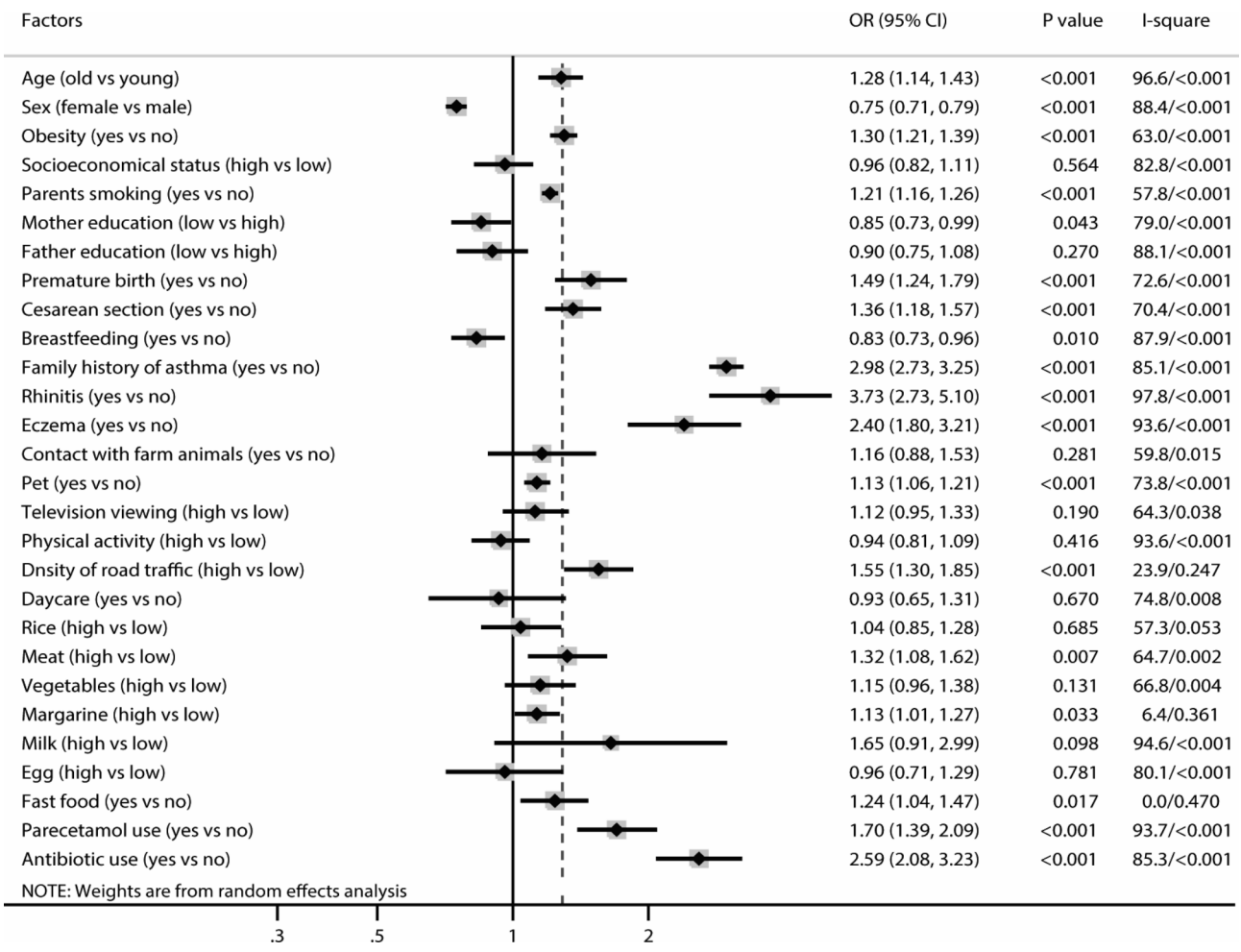

Fig. 3 Identified risk factors for childhood asthma

$P<0.001$) were associated with an increased risk of childhood asthma. However, contact with farm animals was not associated with childhood asthma risk. Fourthly, living with a pet (OR: 1.13; 95%CI: 1.06–1.21; $P<0.001$), high density of road traffic (OR: 1.55; 95%CI: 1.30–1.85; $P<0.001$), consumption of meat (OR: 1.32; 95%CI: 1.08–1.62; $P=0.008$), consumption of margarine (OR: 1.13; 95%CI: 1.01–1.27; $P=0.033$), and consumption of fast food (OR: 1.24; 95%CI: 1.04–1.47; $P=0.017$) were associated with an increased risk of childhood asthma. However, physical activity, day care, and rice, vegetables, milk, and egg consumption were not associated with childhood asthma risk. Fifthly, paracetamol use (OR: 1.70; 95%CI: 1.39–2.09; $P<0.001$), and antibiotic use (OR: 2.59; 95%CI: 2.08–3.23; $P<0.001$) were associated with an increased risk of childhood asthma. In addition, there was significant heterogeneity in risk factors across all studies except in the intensity of road traffic, consumption of margarine and fast food.

The results of the sensitivity analysis are presented in Supplementary File 4. We noted that the pooled conclusions for age, sex, obesity, socioeconomic status, parental smoking, paternal education, premature birth, cesarean section, breastfeeding, family history of asthma, rhinitis, eczema, contact with farm animals, pets, physical activity, density of road traffic, daycare, rice, meat, milk, egg, paracetamol use, and antibiotic use with the risk of childhood asthma were robust and were not altered by removing any single study. However, the pooled conclusions regarding the associations of maternal education, television viewing, vegetables, margarine, and fast food with the risk of childhood asthma vary.

Supplementary File 5 presents the publication bias for the risk factors for childhood asthma. There was no significant publication bias for sex, socioeconomic status, parental smoking, mother's education, father's education, premature birth, breastfeeding, eczema, contact with farm animals, pets, television viewing, physical activity, density of road traffic, daycare, rice, meat, vegetables, margarine, milk, egg, fast food, or antibiotic use with the risk of childhood asthma. There was a significant publication bias for age, obesity, cesarean section, family history

of asthma, rhinitis, and paracetamol use with the risk of childhood asthma. These conclusions did not change after adjusting for publication bias using the trim-and-fill method [24].

Discussion

The current systematic review and meta-analysis were based on cross-sectional studies that assessed the prevalence and risk factors of childhood asthma. This large quantitative study included1,547,404 children from 164 studies with a wide range of individual characteristics. We noted that the overall prevalence of childhood asthma was 10.2% (95% CI: 9.5-11.0%), and the prevalence of childhood asthma was the highest in Oceania, with a lower prevalence in Europe and Asia. Moreover, the identified risk factors for childhood asthma included older age, male sex, obesity, parental smoking, high education of the mother, premature birth, cesarean section, no breastfeeding, family history of asthma, rhinitis, eczema, presence of a pet, high density of road traffic, consumption of meat, margarine, or fast food, paracetamol use, and antibiotic use.

The prevalence of childhood asthma was consistent with a previous study that reported that the prevalence of asthma in people aged 5–69 years was 9.8% [13]. However, this study reported that the prevalence of asthma was highest in Africa and lowest in Southeast Asia [13]. In contrast, we noted that the prevalence of childhood asthma was the highest in Oceania, including New Zealand (22%) and Australia (28%). The prevalence of childhood asthma in New Zealand was reported to be 10,873 cases amongst 6- to 7-year-old children [25]. They discovered that ethnic minorities showed an increased prevalence of asthma symptoms in New Zealand, which could be explained by inequalities in access to health services [26]. Moreover, two of the included studies reported the prevalence of childhood asthma in Australia [27, 28]. Skinner et al. applied carer-reported survey data for 1290 urban Aboriginal children aged 2–17 years and found that the prevalence of asthma was 33.9% [27], while the study conducted by Shahunja et al. analyzed data from the Longitudinal Study of Australian Children and found that the prevalence of asthma was 23.1% [28]. This difference can be explained by area-level socioeconomic disadvantage [29]. In addition, the prevalence of childhood asthma in Europe and Asia was lower, which was mainly attributed to Russia, which reported a prevalence of 4% in 581 Russian schoolchildren aged 7–16 years [30].

Despite the different definitions, the observed prevalences of childhood asthma are relatively close, with all estimates falling within a narrow range of 10–11%. Several factors may contribute to this similarity: [1] the different definitions, while varying in their specific criteria, often overlap in the types of symptoms and conditions they capture. For example, a child with asthma who requires medical attention (care-defined) is also likely to be diagnosed by a physician and may report their condition in a survey; [2] the overall prevalence of childhood asthma in the studied populations may be relatively stable, meaning that even with different definitions, the underlying burden of the disease remains consistent. This suggests that the core population of children with asthma is being captured across the different definitions; and [3] the clinical practice of diagnosing and managing asthma may be well-established, leading to consistent reporting and management practices. This can result in similar prevalence rates across different definitions, as the same children are likely to be identified regardless of the method used.

The current study found that the risk factors for childhood asthma included older age, male sex, obesity, parental smoking, high education of the mother, premature birth, cesarean section, no breastfeeding, family history of asthma, rhinitis, eczema, pet, high density of road traffic, meat, margarine, fast food, parecetamol use, and antibiotic use. Several risk factors have already been identified in prior meta-analyses, including male sex, obesity, parental smoking, premature birth, cesarean section, and family history of asthma, rhinitis, and eczema, which are risk factors for asthma in both children and adults. However, several other risk factors were identified in our study, including older age, higher education in mothers, lack of breastfeeding, presence of pets, high-density road traffic, consumption of meat, margarine, or fast food, and paracetamol or antibiotic use. The potential reasons for these risk factors include: [1] the prevalence of asthma is significantly related to age-associated hormonal changes, especially in women [31–33]; [2] the education level of mothers was considered a non-traditional metric for seeking professional advice, which could detect mild asthma symptoms [34]; [3] breastfeeding could protect against the risk of early life infections, especially for respiratory infections, which is significantly related to the risk of asthma [35]; [4] early-life pet exposure significantly increases allergen exposure, which is associated with more severe asthma and increases the frequency of asthma exacerbations [36–39]; [5] traffic-related air pollution has a larger impact on children owing to the immature respiratory system and immune system in children, while the unit weight ventilation and outdoor activities in children are higher than in adults [40, 41]; [6] increased meat consumption or fast food is significantly related to a lack of antioxidants, which play an important role in asthma prevention [42]; [7] margarine consumption is significantly related to fatty acids, which are involved in immune and inflammatory processes [43]; and [8] the onset of childhood asthma could be affected by the balance of pathogenic and beneficial

bacteria, and the use of paracetamol or antibiotics could affect microbiota in the birth canal and skin, which could be transmitted to the infants during delivery [44, 45].

Several shortcoming of this study should be mentioned: [1] all of the included studies were designed as cross-sectional, and the causality cannot be established; [2] the heterogeneity across included studies for investigated outcomes was substantial, which was not fully explained by sensitivity analysis; [3] the asthma definition across included studies differed, which could affect the effect estimates for the prevalence and risk factors of childhood asthma. Many of the included studies relied on self-reported questionnaires to assess the presence of asthma. This method is subject to recall bias, where participants may not accurately remember or report their symptoms or exposures. Additionally, there can be social desirability bias, where respondents may provide answers they believe are more socially acceptable rather than their true experiences. Furthermore, the validity and reliability of the questionnaires used varied across studies, which could introduce measurement error; [4] the adjusted factors for the risk factors of childhood asthma varied among the included studies, which could affect the effect estimates of risk factors; [5] the variability in the definition of age groups across the included studies can affect the association between age and asthma prevalence, particularly when considering the differences in prevalence between boys and girls from childhood to adolescence; and [6] the analysis was based on published articles, and unpublished data were not available. This limitation might introduce potential publication bias.

Conclusions

This study reported the overall prevalence of childhood asthma, and we noted the prevalence of childhood asthma was highest in Oceania, and lowest in Europe and Asia. Moreover, risk factors for childhood asthma were identified, including older age, male sex, obesity, parental smoking, high education in the mother, premature birth, cesarean section, no breastfeeding, family history of asthma, rhinitis, eczema, presence of a pet, high density of road traffic, consumption of meat, margarine, or fast food, and paracetamol or antibiotic use. The identified risk factors for childhood asthma should be verified through further meta-analyses using prospective cohort studies.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12887-025-05409-x.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

Supplementary Material 5

Author contributions

WJZ and JT conceived and designed the study, analyzed the data, wrote the paper, contributed reagents/materials/analysis tools and approved the final version of this manuscript.

Funding

There was no funding relating to this review.

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 14 March 2024 / Accepted: 7 January 2025
Published online: 20 January 2025

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