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Non-exclusive breastfeeding is associated with pneumonia and asthma in under-five children: an umbrella review of systematic review and meta-analysis

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Abstract

Background Despite numerous reviews examining the impact of exclusive breastfeeding on preventing childhood pneumonia and asthma, a comprehensive and up-to-date synthesis is lacking. This umbrella review aims to consolidate the current evidence on the link between non-exclusive breastfeeding and the risk of pneumonia and asthma in under-five children.

Methods A comprehensive search was conducted in PubMed, Embase, Scopus, Web of Science, the Cochrane Database of Systematic Reviews, and Google Scholar to identify systematic review and meta-analysis (SRM) studies evaluating the effect of exclusive breastfeeding on preventing childhood pneumonia and asthma globally. The latest search was conducted on January 25/2025. The quality of the included studies was assessed using the Assessment of Multiple Systematic Reviews Two (AMSTAR-2) tool. A weighted inverse variance random-effects model was employed to generate pooled estimates. Summary effect estimates were expressed using odds ratios (OR) with 95% confidence intervals (CI). We evaluated the quality of evidence for each association using the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) framework, categorising it as convincing (class I), highly suggestive (class II), suggestive (class III), and weak (class IV).

Results Twelve SRMs, including 270 primary studies with over ten million participants, were analysed. The random-effects model revealed a highly suggestive association between non-exclusive breastfeeding and an increase in the risk of pneumonia (OR 2.34; 95% CI 1.89, 2.78, GRADE: highly suggestive). Similarly, there was highly suggestive evidence that non-exclusive breastfeeding was associated with a 29% higher risk of childhood asthma (OR 1.21; 95% CI 1.07, 1.34, GRADE: highly suggestive).

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Conclusion Our results highlighted that non-exclusive breastfeeding is associated with an increased risk of pneumonia and asthma in under-five children. These findings emphasise the critical role of exclusive breastfeeding in reducing the risk of respiratory health issues, highlighting the need for policies and initiatives that promote breastfeeding as a key strategy for improving children's health outcomes.

Keywords Exclusive breastfeeding, Asthma, Pneumonia, Umbrella review, Under-five children

Background

Respiratory diseases, including childhood pneumonia and asthma, remain significant causes of mortality and morbidity among under-five children worldwide [1–4]. Despite a decline in global mortality rates, these conditions continue to represent a substantial health burden [5]. In 2019, pneumonia accounted for 45 million global episodes among under-five children and resulted in over 700,000 deaths, making it the leading cause of mortality in this age group [6]. Childhood asthma also contributed considerably, with 12,900 deaths and 5.1 million new cases reported globally in 2019 [7].

Researchers have identified numerous early factors that influence the likelihood of childhood pneumonia and asthma [8–11]. Exclusive breastfeeding is a critical protective factor, providing several mechanisms that reduce the risk of these conditions [12, 13]. Breast milk contains immunoglobulins, particularly IgA, which coat the mucosal surfaces of the respiratory tract, offering direct protection against pathogens [14]. Additionally, breastfeeding supports the establishment of a healthy gut microbiome, which plays a vital role in modulating the immune response and reducing systemic inflammation [15]. The presence of anti-inflammatory cytokines and bioactive components in breast milk further enhances the infant's immune system, reducing susceptibility to respiratory infections and inflammation associated with asthma [16].

To date, more than 270 primary studies and numerous systematic reviews and meta-analyses, have investigated the impact of exclusive breastfeeding on the risk of childhood pneumonia and asthma in children under five [11, 17–26]. Despite this substantial body of evidence, an up-to-date comprehensive review is lacking to inform the development of current prevention strategies, as most existing reviews are over a decade old. Additionally, findings from available meta-analyses have been inconsistent. For example, a 2020 meta-analysis by Karmany et al. reported a fourfold increase in the risk of pneumonia among non-exclusively breastfed children [20]. In contrast, meta-analyses by Brew et al. suggested that non-exclusive breastfeeding was not associated with an increased risk of childhood asthma [22]. This umbrella review aims to consolidate the findings from existing systematic reviews and meta-analyses, provide the most current evidence, and offer practical recommendations for researchers, clinicians, and policymakers based on the synthesised results.

Methods

Research design

This umbrella review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations [27]. A predefined protocol guided the search, selection, data extraction, and analysis of relevant articles. The protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) (ID: CRD42025640880) [28]. To ensure the study's quality, we also followed the PRIOR statement, a reporting guideline for overviews of reviews on healthcare interventions [29].

Searching strategy and information sources

Studies were identified through searches in PubMed, Embase, Web of Science, Google Scholar, and Scopus, focusing on Systematic Review and Meta-Analysis (SRM) studies that reported the effect of exclusive breastfeeding on preventing childhood pneumonia and asthma globally. The latest search was conducted on January 25/2025. The search strategy included MeSH terms, keywords, their combinations, and snowball searching of reference lists from articles identified in the database search to retrieve additional relevant studies. For each condition, five key concepts and search terms were developed: Concept 1 (Exclusive breastfeeding), Concept 2 (childhood pneumonia and asthma respiratory problems), Concept 3 (SRM): 'meta-analysis,' 'systematic review,' and 'review,' and Concept 4 (Children): 'Under Five Children,' 'Childhood.

The literature search was conducted independently by two reviewers, with any discrepancies resolved through consensus. The search terms were used both independently and in combination, employing 'OR' and 'AND' operators. In addition to systematic database searches, article retrieval was supplemented by reviewing the reference lists of included studies and using the 'cited by' and 'related articles' features on PubMed.

Study selection/eligibility criteria

The retrieved articles were exported to EndNote reference management software (version 8) to remove duplicates. Two investigators (BBA and MA) independently screened the studies based on titles and abstracts before

retrieving the full-text papers. Pre-specified inclusion criteria were then applied to further assess the full-text articles. Included studies were Systematic Reviews and Meta-Analyses (SRM) that reported the effect of exclusive breastfeeding on the prevention of childhood pneumonia and asthma. Only articles published in English and addressing the Population, Intervention, Control, and Outcome (PICO) framework in a global context were considered.

Population Under five children.

Intervention Exclusive breastfeeding.

Control Non-exclusive breastfeeding.

Outcome Childhood pneumonia and asthma.

To be considered a systematic review or meta-analysis, studies had to meet the following predefined criteria: (a) have a defined literature search strategy, (b) appraise the quality of included studies using a relevant tool, and (c) use a standard method to pool the study's results and providing summary estimates. Studies were excluded for any of the following reasons: (a) failure to report the measures of interest for this study, (b) language other than English, and (c) narrative reviews, editorials, correspondence, abstracts, and methodological studies. The screening and selection process was conducted in two stages: first, title and abstract screening, followed by full-text review. Any disagreements were resolved through consensus discussions with other reviewers to ensure the final selection of studies for inclusion in the umbrella review.

Quality assessment

We used the AMSTAR-2 checklist to assess the quality and transparency of the included systematic reviews and meta-analyses. It evaluates 16 domains, including research question clarity, protocol registration, risk of bias, study selection, data extraction, funding sources, statistical methods, and addressing heterogeneity and publication bias [30–32]. Each review was rated as high, moderate, low, or critically low quality based on adherence to AMSTAR-2 criteria. Two independent reviewers assessed the quality of the included studies, with disagreements resolved through consensus or consultation with a third author as needed.

Data extraction

Data from the included Systematic Review and Meta-Analysis (SRM) studies were extracted using a standardized data abstraction form, developed in an Excel spreadsheet. For each SRM study, the following data were extracted: (a) identification details (first author's last name, publication year), (b) number of primary studies included, (c) number of study participants, (d) effect size with 95% confidence intervals, and (e) types of respiratory diseases.

Statistical analysis

After data extraction using Microsoft Excel, the data were imported into STATA version 17.0 statistical software for further analysis. Both narrative and quantitative approaches were employed to summarise the estimates from the included reviews. Summary effect estimates were re-calculated using random-effects models to account for expected heterogeneity across studies. The effect estimates were expressed using odds ratios (OR) with 95% confidence intervals (CI). Heterogeneity among studies was assessed using Cochrane's Q statistic (Chi-square), inverse variance (I^2) statistic, and *p*-values [40]. An I^2 value of zero indicated homogeneity, while values of 25%, 50%, and 75% were considered low, moderate, and high heterogeneity, respectively [32, 33]. For heterogeneous data, we applied the DerSimonian-Laird random-effects model. To assess the impact of individual studies on the overall effect size, a leave-one-out sensitivity analysis was performed by sequentially excluding each study and recalculating the pooled effect estimates based on the remaining studies. Publication bias was assessed using a funnel plot and, more objectively, through Egger's regression test [34].

Credibility/GRADE assessment of each pooled analysis

We used the GRADE system to assess the quality of evidence for each pooled analysis, classifying it as *convincing*, *highly suggestive*, *suggestive*, or *weak* [35]. GRADE evaluates five criteria: risk of bias, inconsistency, indirectness, imprecision, and publication bias, with evidence from observational studies initially rated as low quality. Downgrades occur based on high risk of bias, inconsistency (I^2 values), indirectness (multiple control comparisons), imprecision (wide confidence intervals or small sample size), and publication bias (significant Egger test *p*-value). *Convincing associations* (Class I) required a *p*-value $< 10^{-6}$, over 1,000 participants, low-to-moderate heterogeneity (I^2 < 50%), a 95% prediction interval excluding the null, and no small-study bias. *Highly suggestive associations* (Class II) involved over 1,000 participants, a *p*-value $< 10^{-6}$, and a 95% prediction interval excluding the null. *Suggestive evidence* (Class III) required over 1,000 participants and a *p*-value ≤ 0.001, while *weak associations* (Class IV) needed a *p*-value ≤ 0.05, with $p > 0.05$ considered non-significant [35].

Results

Study selection

A total of 4,607 studies were identified from different databases. After duplication was removed, 2,444 articles remained. Finally, 219 studies underwent full-text review, and 12 SRMs comprising 270 independent primary studies were included in the final analysis [11, 17–26, 36] (Fig. 1).

Characteristics of included studies

The characteristics of the included studies are presented in Table 1. Twelve SRMs, including 270 primary studies and over ten million participants, were included in the analyses. The number of studies included in each systematic review ranged from 9 [18] to 46 [25]. The effect of non-exclusive breastfeeding on the risk of pneumonia and asthma ranged from 1.1 (1.16, 1.02) [23] to 4.0 (2.75,5.81) [20]. Seven of the included reviews were conducted before 2020 [11, 17, 19, 23–26] while five reviews were conducted after 2020 [18, 20–22, 36].

Quality assessment

Based on AMSTAR-2 criteria, the majority of the SRMs (7 out of 12) [17–19, 21, 23, 24, 26] were assessed as low quality, while 5 out of 12 [11, 20, 22, 25, 36] were rated as high quality (Table S1). The five most common reasons why many included SRMs are rated as low quality based on the AMSTAR-2 checklist are: failure to register the protocol in PROSPERO [11, 17, 19–21, 23–26], lack of justification for excluded studies [17, 23], absence of an evaluation of the risk of bias in the meta-analysis [11, 17, 18, 21–24], insufficient explanation of heterogeneity [17–19, 26], and failure to assess publication bias [11, 18, 19, 21].

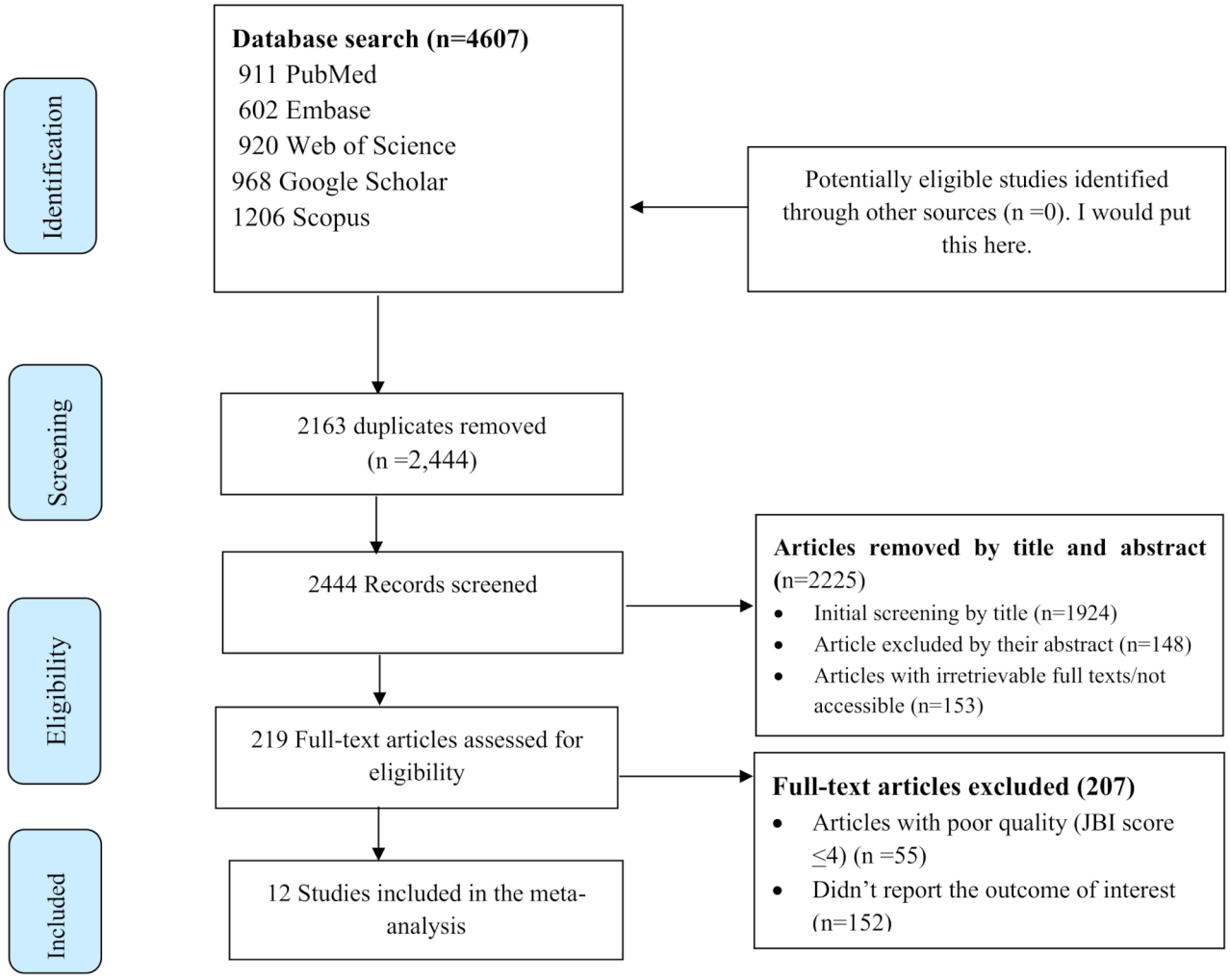

Fig. 1 PRISMA–adapted flow diagram showed the search results and reasons for exclusion

Table 1 Characteristics of the included studies

SrNo	Author	Year	No of studies	No of participants	OR (95% CI)	Types of respiratory diseases	Heterogeneity (I^2 &*P* value)	Evidence hierarchy
1.	Harvey et al. [18]	2020	9	25,208	1.47 (1.14,1.89)	Asthma	I^2 = 53%, *P* = 0.00	Class II
2.	Brew et al. [23]	2011	31	417,880	0.96 (0.86,1.06)	Asthma	I^2 = 54%, *P* = 0.01	Class II
3.	Lodge et al. [24]	2015	30	4,894,277	1.10 (1.03,1.19)	Asthma	I^2 = 62.9%, *P* = 0.00	Class II
4.	Dogaru et al. [25]	2014	46	832,013	1.28 (1.19, 1.35)	Asthma	Not reported	Class II
5.	Gdalevich et al. [26]	2001	12	8,183	1.43 (1.23, 1.67)	Asthma	I^2 = 11.3%, *P* = 0.74	Class II
6.	Xue et al. [38]	2021	23	3,630,230	1.23 (1.10–1.39)	Asthma	I^2 = 44%	Class II
7.	Jackson et al. [11]	2013	36	460,591	2.34 (1.42, 3.88)	Pneumonia	I^2 = 89.6%, *P* = 0.00	Class II
8.	Bernardo et al. [17]	2013	18	Not reported	2.33 (1.82, 3.03)	Pneumonia	Not reported	Class II
9.	Lamberti et al. [19]	2013	10	No reported	1.93 (1.39, 2.69)	Pneumonia	Not reported	Class II
10.	Karmany et al. [20]	2020	9	2,837	4.00 (2.75,5.81)	Pneumonia	I^2 = 60%, *P* = 0.01	Class II
11.	Alamneh et al. [21]	2020	12	4,598	2.46 (1.35, 4.47)	Pneumonia	Not reported	Class II
12.	Biruk et al. [22]	2020	34	87,984	2.47 (1.79, 3.16)	Pneumonia	I^2 =65.0%, *P* = 0.01	Class II

CI: Confidence Interval, OR: Odds ratios

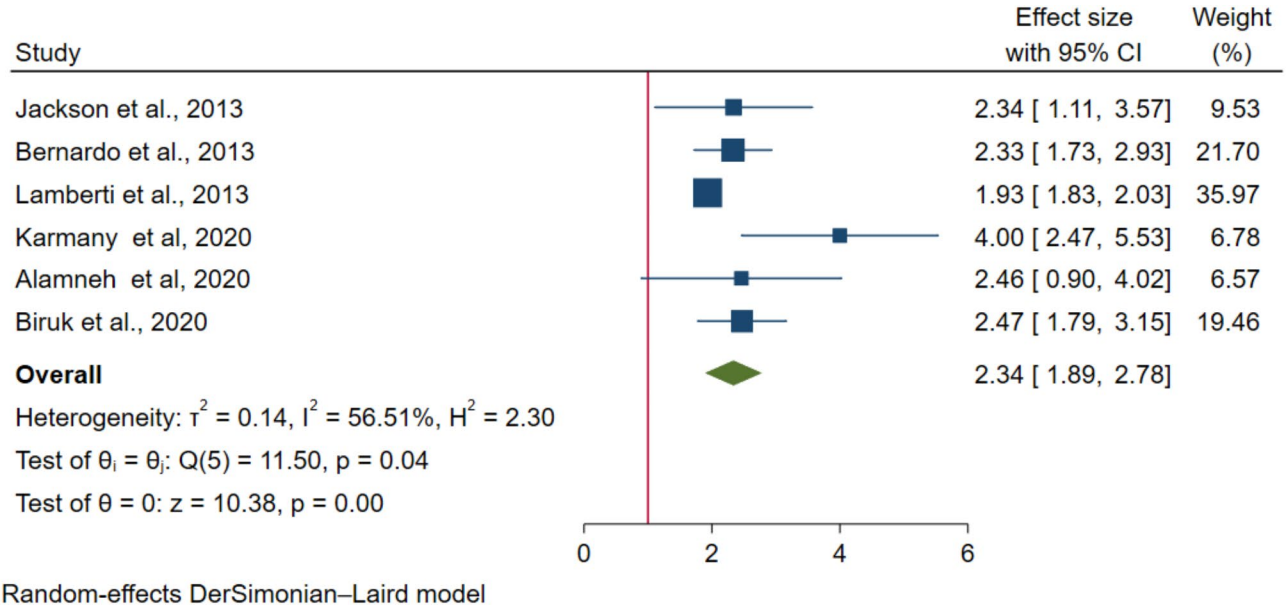

Fig. 2 Forest plot shows the effect of non-exclusive breastfeeding on the risk of childhood pneumonia

The effect of non-exclusive breastfeeding on the risk of childhood pneumonia and asthma

Of the twelve SRMs included, six examined the effect of non-exclusive breastfeeding on the risk of childhood pneumonia [11, 17, 19–22], while the other six focused on its impact on the risk of childhood asthma [18, 23–26, 36]. The random-effects model revealed a highly suggestive association between non-exclusive breastfeeding and an increase in the risk of pneumonia (OR 2.34; 95% CI 1.89; 2.78, GRADE: highly suggestive (Class II) (Fig. 2). Similarly, there was highly suggestive, that non-exclusive breastfeeding was associated with a 21% higher risk of childhood asthma (OR 1.21; 95% CI 1.07, 1.34, GRADE: highly suggestive) (Fig. 3).

Sensitivity analysis

The results of this sensitivity analysis showed that the findings were not dependent on a single study. The pooled estimated risk associated with non-exclusive breastfeeding ranged from 2.05 (95% CI 1.12, 2.98) [20] to 2.50 (95% CI 2.10, 2.90) [23] for pneumonia and from 1.26 (95% CI 1.12, 1.40) to 1.33 (95% CI 1.21, 1.44) [24] for asthma, following the exclusion of each included study during the sensitivity analysis (Table 2).

Publication bias

A funnel plot showed an asymmetrical distribution (Figure S1). The Egger's regression test value was < 0.001, which indicated that, the presence of publication bias (Figure S2). To address this, a trim-and-fill analysis was

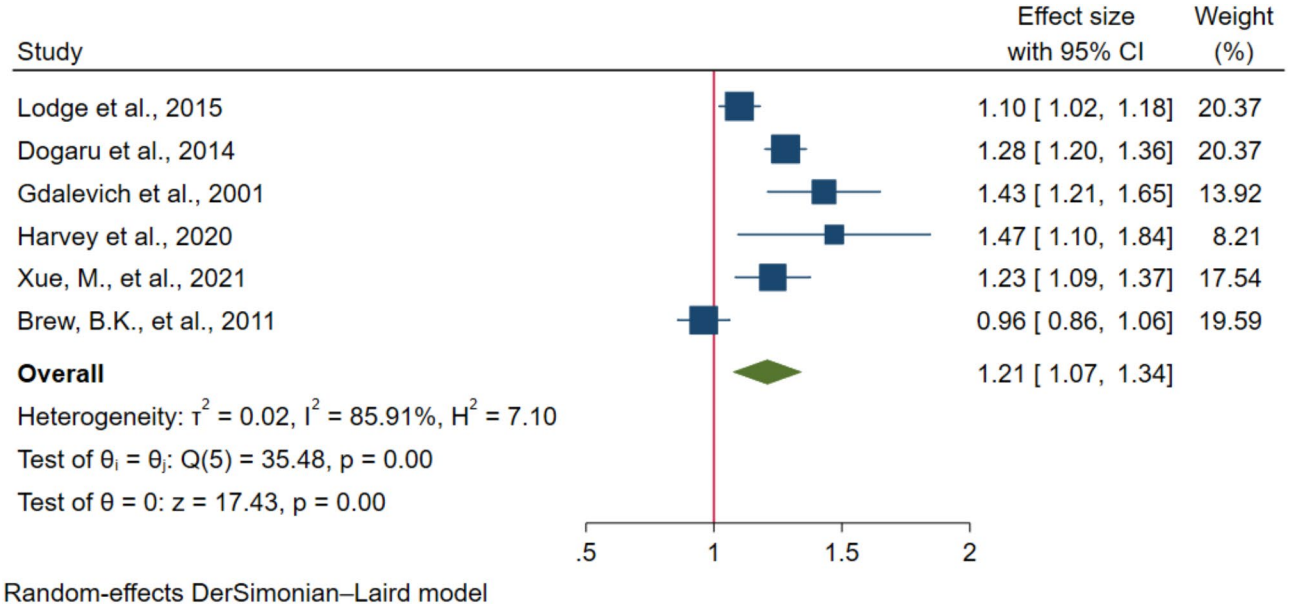

Fig. 3 Forest plot shows the effect of non-exclusive breastfeeding on the risk of childhood asthma

Table 2 Sensitivity analysis of the effect of non-exclusive breastfeeding on the risk of childhood pneumonia and asthma

Study omitted	OR	95% CI
Reviews on the risk of pneumonia		
Jackson et al. (2013)	2.32	1.27–3.37
Bernardo et al. (2013)	2.33	1.20–3.46
Karmany et al. (2020)	2.05	1.12–2.98
Alamneh et al. (2020)	2.30	1.27–3.33
Biruk et al. (2020)	2.29	1.22–3.36
Brewet al. (2011)	2.50	2.10–2.90
Reviews on the risk of asthma		
Lamberti et al. (2013)	1.26	1.14–1.38
Lodge et al. (2015)	1.33	1.21–1.44
Dogaru et al. (2014)	1.31	1.13–1.50
Gdalevich et al. (2001)	1.26	1.12–1.40
Harvey et al. (2020)	1.27	1.13–1.40
Xue et al. (2021)	1.31	1.15–1.48

CI: Confidence Interval, OR: Odds ratios

performed, which imputed four additional studies (Figure S3).

Quality of evidence/credibility according to GRADE evidence assessment

Overall, the quality of evidence, as assessed using the GRADE framework, indicates a highly suggestive evidence for the pooled analysis of pneumonia and asthma. Both analyses were downgraded based on two criteria: (1) inconsistency/heterogeneity, with I^2 values of 77.28%, and $P = 0.00$ for asthma and 87.04% for pneumonia, both reflecting high heterogeneity ($I^2 > 75\%$), and (2) publication bias, detected in both analyses (Egger test $p = 0.0074$ for asthma, $p = 0.0007$ for pneumonia). However, both analyses performed well in the other three GRADE criteria: (1) no serious indirectness, (2) no serious imprecision, and (3) risk of bias assessment, where 3/4 of the AMSTAR questions were answered "yes" and 1/4 were rated "unclear" or "no." As a result, the overall certainty of evidence for both pneumonia and asthma remains highly suggestive (Class II) (Table S2).

Discussion

This umbrella review evaluated the effect of non-exclusive breastfeeding on the risk of respiratory diseases, specifically childhood pneumonia and asthma, on a global scale, drawing data from 12 SRMs. The analysis revealed that children who were not exclusively breastfed had a 2.34-fold higher risk of developing pneumonia and a 21% increased risk of experiencing childhood asthma.

Exclusive breastfeeding, which involves providing only breast milk to infants under 6 months, has a significant positive impact on a child's immunity, growth, and development. It is associated with a reduced risk of childhood asthma, Sudden Infant Death Syndrome (SIDS), and other conditions, although multiple factors contribute to these outcomes [37, 38]. Research has consistently shown that exclusive breastfeeding lowers morbidity and mortality rates in children under five, as well as the risk of allergies and respiratory conditions due to the protective components in breast milk [39–42]. Not breastfeeding has been identified as a risk factor for acute respiratory infections, particularly pneumonia, which is a leading cause of hospitalization and death in children [11, 21, 43, 44]. Some of the included SRMs examined the impact of breastfeeding duration on child health outcomes, emphasising that longer durations of breastfeeding are

associated with a significantly reduced risk of respiratory issues, such as asthma and pneumonia [24, 36]. Furthermore, some studies indicated that both exclusive and non-exclusive breastfeeding provide more substantial protection against respiratory health problems compared to non-breastfeeding, highlighting the health advantages of any form of breastfeeding over none [18, 19, 25]. This underscores the importance of promoting breastfeeding in all its forms as a key public health strategy to reduce the burden of childhood respiratory diseases.

Childhood pneumonia and asthma continue to be major causes of mortality and morbidity among under-five children worldwide. One of the Sustainable Development Goals (SDGs) is to reduce mortality in children under five, which can be achieved by improving child nutrition and preventing diseases. Several reviews suggest that exclusive breastfeeding can help prevent respiratory diseases, including pneumonia and asthma/wheezing, though the exact extent of this protective effect is not fully demonstrated in the literature [18, 20, 24, 45].

Breastfeeding is linked to a lower risk of respiratory problems through several physiological mechanisms. First, breast milk contains bioactive components like immunoglobulins (IgA), lactoferrin, and lysozyme, which strengthen the infant's immune defences and reduce the risk of infections, such as pneumonia and bronchitis, that may lead to chronic respiratory issues [46, 47]. Second, breastfeeding promotes the development of the infant's respiratory system, supporting optimal lung growth and function, which can enhance lung capacity and resilience to respiratory challenges [48, 49]. Third, the anti-inflammatory properties of breast milk help reduce airway inflammation, a key factor in respiratory conditions [50]. Finally, exclusive breastfeeding supports the development of the gut microbiome, which plays a crucial role in immune function and offers further protection against respiratory illnesses [51, 52].

Exclusive breastfeeding for the first six months is strongly recommended for its many benefits, including providing an ideal nutrient balance for growth, immune protection (particularly through colostrum), and support for digestive development [53, 54]. Longer exclusive breastfeeding is associated with a reduced risk of asthma and related complications. A dose-response effect was observed, with breastfeeding for 2–4 months reducing asthma outcomes by 64%, for 5–6 months by 61%, and for more than 6 months by 52%, compared to breastfeeding for less than 2 months [55].

The meta-analysis, which synthesizes data from eight published studies encompassing a total of 16,862 children and adolescents aged 7 to 15 years, suggests a positive association between longer durations of exclusive breastfeeding (specifically, more than 6 months) and higher cardiorespiratory fitness during childhood and adolescence [56]. This finding implies that extended breastfeeding may contribute to better cardiovascular health and physical endurance later in life. Furthermore, the analysis also highlights that respiratory problems may hurt cardiorespiratory fitness, indicating that children who experience respiratory issues may show diminished cardiorespiratory capacity [57]. These two findings suggest a potential link between breastfeeding duration, respiratory health, and overall physical fitness, which could inform future research on how early nutrition and health conditions interact to affect long-term fitness outcomes.

Strengths and limitations of the study

This umbrella review has several strengths. It draws from a wide range of data sources, including numerous systematic reviews and meta-analyses, providing a comprehensive analysis of exclusive breastfeeding's effect on preventing pneumonia and asthma in children. The research adheres to PRISMA guidelines, ensuring high-quality, relevant studies, and uses the AMSTAR-2 tool for quality assessment. Subgroup analyses further enhance the study's depth. Addressing a timely issue, we conducted multiple statistical tests to assess the evidence level, including contour-enhanced funnel plots, Egger's regression tests, and the trim-and-fill technique, to evaluate publication bias and potential overstatement in the meta-analyses.

Despite its strengths, the study has several limitations. The included studies do not cover all countries, limiting the generalizability of the results. The high heterogeneity remained despite efforts to reduce it using a random-effects model and subgroup analysis. Missing data in some meta-analyses prevented the calculation of key metrics, such as small study effects and I^2, limiting our ability to fully evaluate the evidence. Additionally, observed heterogeneity may be influenced by sociocultural, economic, and political factors affecting vaccine hesitancy across regions. Future research, particularly cohort studies or RCTs, is needed to address residual confounding factors. Moreover, the majority of the included SRMs primarily focused on evaluating the impact of exclusive breastfeeding on the prevention of asthma and pneumonia in children under five. However, they did not provide sufficient insights on two key areas: (1) the effect of non-exclusive breastfeeding compared to no breastfeeding at all, and (2) the relationship between the duration of breastfeeding and child health outcomes. Therefore, future research should aim to assess the effects of both exclusive and non-exclusive breastfeeding, as well as the duration of breastfeeding, on various child health outcomes.

Conclusion

Our results highlight the increased risk of pneumonia and asthma associated with non-exclusive breastfeeding in children under five. These findings underscore the importance of breastfeeding as a critical strategy for reducing the incidence of respiratory health issues. These results support the existing recommendations for breastfeeding for at least six months since they are consistent with the theory that breastfeeding has a lasting protective impact against respiratory tract infections.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13006-025-00712-w.

Additional files: **Supplementary Table 1**: Shows quality appraisal of included SRM using AMSTAR-2 checklist. **Supplementary Table 2**: Quality assessment using the GRADE framework of each pooled analysis assessing associations Between non-exclusive breastfeeding and the risk of pneumonia and asthma. **Supplementary Figure 1**: Funnel plot on the pooled exclusive breastfeeding for the prevention of respiratory problems. **Supplementary Figure 2**: Publication bias on the pooled exclusive breastfeeding for the prevention of respiratory problems. **Supplementary Figure 3**: Trim-and-fill analysis on the pooled exclusive breastfeeding for the prevention of pneumonia and asthma

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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