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Association Between Chronic Otitis Media and Hearing Loss in Children: A Systematic Review

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Abstract

Background: Chronic otitis media (COM), encompassing otitis media with effusion (OME) and chronic suppurative otitis media (CSOM), represents the most prevalent pediatric illness and the leading cause of acquired hearing loss in children worldwide. The auditory deficits associated with COM have profound implications for language acquisition, cognitive development, educational attainment, and social integration during critical developmental windows. ***Objective:*** This systematic review aims to synthesize available evidence on the association between chronic otitis media and hearing loss in children, examining prevalence estimates across different populations, the severity and characteristics of hearing impairment, risk factors that modify this association, and the relationship between disease characteristics and auditory outcomes. ***Methods:*** A systematic literature search was conducted in PubMed, Scopus, Web of Science, and the Cochrane Library for studies published between 2022 and 2026. Studies were included if they examined children aged 0-18 years with COM, utilized objective audiological assessments (pure-tone audiometry, tympanometry, or wideband absorbance), and reported original research data on the association between COM and hearing loss. Seven studies met the inclusion criteria, comprising cross-sectional, cohort, and retrospective designs. Quality and risk of bias were assessed using Joanna Briggs Institute checklists. A narrative synthesis was conducted due to clinical and methodological heterogeneity. ***Results:*** The included studies demonstrated a consistent and strong association between COM and hearing loss in children. Global estimates indicate that 34.71 million children under 15 years were affected by COM-induced hearing loss in 2021, representing an 11.32% increase over three decades. Prevalence varied substantially across populations, reaching 55% in Greenlandic children and 34.8% in Alaska Native children. Hearing loss was typically mild-to-moderate conductive impairment, with mean pure-tone averages ranging from 22-45 dB HL. The severity of hearing loss correlated with disease chronicity, effusion characteristics, and specific risk factors including cleft palate, genetic susceptibility (CPT1A Arctic variant), and socioeconomic disadvantage. Wideband absorbance demonstrated strong negative correlations with air-bone gap ($R^2 = 0.94$), enabling precise prediction of conductive hearing loss severity. Protective factors included breastfeeding (43% relative risk reduction). Surgical interventions, including tympanostomy tube insertion and rapid maxillary expansion, produced significant and sustained improvements in audiological outcomes and speech-language development. ***Conclusions:*** This systematic review provides robust evidence that COM is strongly and consistently associated with hearing loss in children, with the highest burden concentrated in indigenous populations, low- and middle-income countries, and children with anatomical or genetic vulnerabilities. The mild-to-moderate hearing loss typical of COM, while often clinically underrecognized, is sufficient to compromise developmental outcomes during critical periods. The evidence supports targeted screening programs in high-risk populations, timely surgical intervention for persistent disease, and public health strategies addressing modifiable risk factors including breastfeeding promotion and improved healthcare access.

Keywords: Chronic otitis media; otitis media with effusion; chronic suppurative otitis media; hearing loss; conductive hearing loss; children; pediatric; prevalence.

INTRODUCTION

Hearing loss represents one of the most significant sensory impairments affecting the global pediatric population, with profound implications for cognitive development, language acquisition, educational attainment, and social integration. According to the World Health Organization, over 34

million children worldwide suffer from disabling hearing loss, defined as hearing threshold exceeding 35 decibels (dB) in the better hearing ear [1]. The consequences of childhood hearing loss extend far beyond auditory dysfunction, as inadequate auditory input during critical developmental windows can permanently alter neural pathways responsible for speech and language processing, leading to long-term deficits in academic performance and quality of life [2]. The Global Burden of Disease Study 2021 estimated that approximately 466 million people worldwide live with disabling hearing loss, with childhood cases representing a substantial proportion of this burden that demands urgent public health attention [1].

Otitis media (OM), characterized by inflammation of the middle ear mucosa, stands as the most prevalent pediatric illness requiring medical attention and the leading cause of acquired hearing loss in children [3]. This condition encompasses a spectrum of clinical entities, including acute otitis media (AOM), otitis media with effusion (OME), and chronic suppurative otitis media (CSOM), each with distinct pathophysiological mechanisms and clinical implications. The ubiquity of OM in childhood is staggering: epidemiological evidence indicates that approximately 90% of children experience at least one episode of OME before school age, with the highest incidence occurring between 6 months and 4 years of age [4]. In the United States alone, an estimated 2.2 million new cases of OME are diagnosed annually, positioning this condition among the most frequent indications for pediatric healthcare utilization and antibiotic prescription [4]. While AOM typically resolves with appropriate antimicrobial therapy, recurrent or persistent middle ear inflammation can progress to chronic forms that carry substantial morbidity.

Chronic otitis media encompasses two primary clinical phenotypes that differ in their presentation and sequelae. OME, often termed "glue ear" due to the viscous nature of the middle ear fluid, involves the accumulation of mucin-rich effusion behind an intact tympanic membrane in the absence of acute infection [4]. The pathophysiology of OME involves eustachian tube dysfunction, which is particularly prevalent in young children due to the shorter, more horizontal orientation of their eustachian tubes that gradually assumes a more vertical, functional position around 7 years of age [4]. This anatomical predisposition, combined with immunological immaturity and frequent upper respiratory tract infections, creates a perfect storm for middle ear disease in early childhood. Conversely, CSOM represents a more severe phenotype characterized by persistent purulent discharge through a non-intact tympanic membrane for a duration exceeding two weeks [5]. The global incidence of CSOM reaches 4.76%, translating to approximately 31 million cases worldwide, with a disproportionate 22.6% of these cases occurring in children under 5 years of age [5]. The prevalence of CSOM stands at 30.82 per 10,000 population, and each year, an estimated 21,000 individuals die due to complications of this preventable condition, primarily in low-resource settings where access to timely medical care remains limited [5].

The association between chronic otitis media and hearing loss has been well-established through decades of clinical observation and epidemiological research. The mechanism of hearing impairment in OM is primarily conductive, resulting from impedance to sound transmission through the middle ear apparatus [3]. In OME, the presence of fluid in the middle ear cavity dampens ossicular chain mobility and reduces sound energy transmission to the cochlea, typically producing mild-to-moderate conductive hearing loss in the range of 20-40 dB [3]. In CSOM, persistent tympanic membrane perforation, ossicular erosion, and middle ear mucosal inflammation contribute to conductive deficits that may exceed 50 dB in severe cases [6]. While the conductive component predominates, chronic inflammation can occasionally extend to the inner ear, resulting in sensorineural or mixed hearing loss through the passage of bacterial toxins across the round window membrane or direct labyrinthine invasion [6]. The degree and permanence of hearing impairment correlate with disease duration, severity, and adequacy of treatment, underscoring the importance of early identification and intervention.

Recent comprehensive analyses have illuminated the substantial and growing global burden of OM-induced hearing loss in children. Jin and colleagues, utilizing Global Burden of Disease data from 1990 to 2021, documented that the global prevalence of OM-induced hearing loss in children under 15 years increased from 31.18 million cases to 34.71 million cases over the three-decade study period, representing an 11.32% increase in absolute terms [1]. The age-standardized prevalence rate demonstrated a slight decline from 1793.38 to 1725.39 per 100,000 children, with an estimated annual percentage change of -0.13, suggesting that population growth outpaces modest improvements in disease control [1]. Notably, boys exhibited higher prevalence and burden compared to girls, and the highest age-standardized prevalence rates and years lived with disability were observed in children aged 5-9 years, coinciding with early school years when auditory input is critical for academic skill acquisition [1]. These findings align with a parallel analysis by Chen and colleagues, who examined global OM burden in children and adolescents and reported incidence rates of 12,473.66 per 100,000, prevalence rates of 2,438.73 per 100,000, and 49.33 disability-adjusted life years per 100,000 population in 2021 [7]. Their projection models suggest that while incidence and prevalence may decline slightly through 2040, mortality rates could paradoxically increase, reflecting persistent challenges in managing severe disease in vulnerable populations [7].

The developmental consequences of OM-related hearing loss extend across multiple domains of child functioning and accumulate over time. During the first three years of life, the central auditory system undergoes rapid maturation characterized by synaptic refinement and myelination that depends on adequate sensory input [2]. Intermittent or persistent hearing loss during this critical window disrupts the acoustic signal necessary for phonetic discrimination, phonological awareness, and vocabulary acquisition. Longitudinal studies have documented that children with significant OM-related hearing loss demonstrate poorer phonological awareness, reduced reading skills, and lower academic achievement compared to peers [2]. The deficits extend beyond language to encompass behavioral regulation, social competence, and attention, potentially reflecting the effortful listening demands imposed by degraded auditory signals in classroom environments [2]. For children with additional vulnerabilities—including cleft palate, genetic syndromes, or socioeconomic disadvantage—the impact of OM-related hearing loss compounds existing risks, widening developmental disparities that persist throughout the life course [8]. The present systematic review aims to synthesize available evidence on the association between chronic otitis media and hearing loss in children, examining prevalence estimates across different populations, the severity and characteristics of hearing impairment, risk factors that modify this association, and the relationship between disease characteristics and auditory outcomes.

METHODOLOGY

Study Design and Registration

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement guidelines to ensure comprehensive and transparent reporting [9]. The review protocol was developed a priori, outlining the research question, search strategy, inclusion and exclusion criteria, and methods for data extraction and quality assessment. The primary research question guiding this systematic review was: "What is the association between chronic otitis media and hearing loss in children?" Given the nature of this review as a summary of existing evidence, formal registration in a prospective register such as PROSPERO was not undertaken, although the methodological approach adheres to established systematic review standards to minimize bias and ensure reproducibility.

Search Strategy and Information Sources

A systematic literature search was conducted to identify relevant studies examining the association between chronic otitis media and hearing loss in the pediatric population. The search strategy was developed in collaboration with an experienced health sciences librarian to ensure comprehensive coverage of the topic. Electronic databases including PubMed, Scopus, Web of Science, and the Cochrane Library were searched for articles published over a five-year period. This time frame was selected to capture the most recent evidence while ensuring a sufficient volume of literature for meaningful synthesis, given the dynamic nature of research in otology and pediatric audiology. The search strategy employed a combination of Medical Subject Headings (MeSH) terms and keywords related to the core concepts of the review. The primary search terms included: ("otitis media" OR "chronic otitis media" OR "chronic suppurative otitis media" OR "otitis media with effusion" OR "CSOM" OR "OME") AND ("hearing loss" OR "hearing impairment" OR "conductive hearing loss" OR "sensorineural hearing loss" OR "deafness") AND ("child" OR "children" OR "pediatric" OR "infant" OR "adolescent"). The search was limited to studies published in English to ensure accurate data extraction and interpretation. The reference lists of included studies and relevant review articles were hand-searched to identify additional potentially eligible studies that may have been missed by the electronic database search.

Eligibility Criteria and Study Selection

Studies were considered eligible for inclusion if they met predefined criteria based on the PICOS framework (Population, Intervention/Exposure, Comparison, Outcomes, Study Design). The population of interest was children aged from birth to 18 years with any form of chronic otitis media, including chronic suppurative otitis media (CSOM) and otitis media with effusion (OME). The exposure of interest was the presence of chronic otitis media, defined as persistent inflammation of the middle ear lasting for at least three months. The primary outcome was hearing loss, assessed using objective audiological measures including pure-tone audiometry, tympanometry, or wideband absorbance. Studies were required to report original research data examining the association between chronic otitis media and hearing loss. Eligible study designs included cross-sectional studies, cohort studies, case-control studies, and retrospective analyses of clinical data. Systematic reviews, narrative reviews, case reports, case series with fewer than ten participants, conference abstracts, editorials, and opinion pieces were excluded. Studies focusing primarily on treatment efficacy without providing data on the association between otitis media and hearing loss were also excluded, as were studies involving adult populations or mixed populations where pediatric data could not be separately extracted.

The study selection process was conducted in two stages using Rayyan systematic review software [10], a web-based application designed to facilitate collaborative screening and streamline the review process. Initially, two independent reviewers screened the titles and abstracts of all retrieved records against the eligibility criteria. Records that clearly did not meet the inclusion criteria were excluded, while records that appeared potentially relevant or where eligibility was uncertain were retained for full-text review. Following the title and abstract screening, the full texts of all

potentially eligible studies were retrieved and independently assessed by two reviewers against the predefined inclusion and exclusion criteria. Any disagreements between reviewers at either stage of the screening process were resolved through discussion and consensus, or by consultation with a third reviewer if consensus could not be reached. The reasons for exclusion of studies at the full-text stage were documented and reported in the final systematic review. The final set of included studies comprised seven original research articles that met all eligibility criteria and provided relevant data on the association between chronic otitis media and hearing loss in children. The reference management and deduplication processes were facilitated by Rayyan's built-in functionality, which automatically identifies and flags potential duplicate records for reviewer resolution [10].

Data Extraction and Management

A standardized data extraction form was developed in Microsoft Excel to systematically collect relevant information from each included study. The data extraction form was piloted on two included studies and refined as necessary to ensure comprehensive capture of all relevant data elements. Two reviewers independently extracted data from each included study to minimize errors and ensure accuracy. Any discrepancies in data extraction were resolved through discussion and consensus, with referral to a third reviewer when necessary. The extracted data were organized into two main tables to facilitate synthesis and presentation of findings. For each included study, the following information was extracted: author names, year of publication, study location, study design, sample size, sample characteristics, age range of participants, and key inclusion criteria related to otitis media and hearing loss. These demographic and methodological characteristics were compiled in Table 1 to provide readers with contextual information for interpreting study findings. For Table 2, data were extracted on the type of otitis media studied, hearing loss assessment methods, prevalence or severity of hearing loss reported, and key findings on the association between otitis media and hearing loss. For studies where specific data points were not reported in the published manuscript, the notation "NM" (Not Mentioned) was used in the tables to indicate missing information. The corresponding authors of included studies were not contacted for additional data, as the available information was deemed sufficient for the purposes of this systematic review. All extracted data were verified by a second reviewer to ensure accuracy and completeness before finalization of the tables [11].

Quality and Risk of Bias Assessment

The methodological quality and risk of bias of the included studies were assessed using appropriate tools from the Joanna Briggs Institute (JBI) suite of critical appraisal checklists, selected based on the specific design of each study. The JBI tools were chosen for their established validity and widespread use in systematic reviews of observational studies. For cross-sectional studies [12, 18], the JBI Checklist for Analytical Cross-Sectional Studies was applied, which evaluates eight criteria including clear definition of inclusion criteria, detailed description of study subjects and setting, valid and reliable measurement of exposure and outcome, identification and management of confounding factors, and appropriateness of statistical analysis. For cohort studies [15, 17], the JBI Checklist for Cohort Studies was used, which assesses eleven criteria including similarity of groups, comparability of cohorts, valid measurement of exposure and outcome, adequacy of follow-up, and strategies to deal with incomplete follow-up. For case series [14, 16], the JBI Checklist for Case Series was applied, evaluating ten criteria including clear criteria for inclusion, valid methods for condition measurement, consecutive inclusion of participants, complete reporting of demographic information, and appropriate statistical analysis. For the global burden of disease study [13], which employed ecological and modeling methodologies not fully addressed by standard JBI tools, a customized tool was developed to assess data quality, modeling validity, transparency of methods, and handling of uncertainty.

Two reviewers independently assessed the risk of bias for each included study. Each criterion on the relevant JBI checklist was rated as "yes" (met), "no" (not met), "unclear," or "not applicable." Based on the number of criteria met, an overall risk of bias rating was assigned to each study as low, moderate, or high. Studies meeting more than 70% of applicable criteria were considered low risk of bias, those meeting 50-70% were considered moderate risk, and those meeting less than 50% were considered high risk. Disagreements between reviewers were resolved through discussion and consensus. The results of the risk of bias assessment were tabulated in Table 3, including the tool used for each study, the overall risk of bias rating, and key concerns justifying the rating. The risk of bias assessment was used to inform the interpretation of study findings and the overall strength of evidence in the discussion section, but no studies were excluded based solely on quality ratings, as all included studies met the minimum criteria for inclusion in the review [11].

Data Synthesis and Analysis

Given the anticipated heterogeneity in study designs, populations, and outcome measures, a narrative synthesis approach was adopted to summarize and integrate the findings of the included studies. Meta-analysis was not appropriate due to the clinical and methodological diversity across studies, including variations in diagnostic criteria for otitis media, definitions of hearing loss, age ranges of participants, and outcome measurement methods. The narrative synthesis was structured around key themes emerging from the data, including prevalence of otitis media-related hearing loss, severity and characteristics of

hearing impairment, risk factors influencing the association, and the relationship between disease characteristics and hearing outcomes.

RESULTS

The systematic literature search yielded a total of 228 records from electronic databases. Following the removal of 104 duplicate records, 124 unique studies proceeded to title and abstract screening, during which 74 records were excluded based on irrelevance to the research question. Fifty full-text reports were sought for retrieval, but 33 could not be obtained despite efforts to access them through interlibrary loan and direct author contact. The remaining 17 full-text reports were assessed for eligibility against predefined inclusion criteria, resulting in the exclusion of 10 studies for the following reasons: 7 reported outcomes unrelated to the association between otitis media and hearing loss, 2 involved populations outside the pediatric age range, and 1 was a conference abstract lacking sufficient methodological detail for quality assessment. Ultimately, 7 studies met all eligibility criteria and were included in the final systematic review.

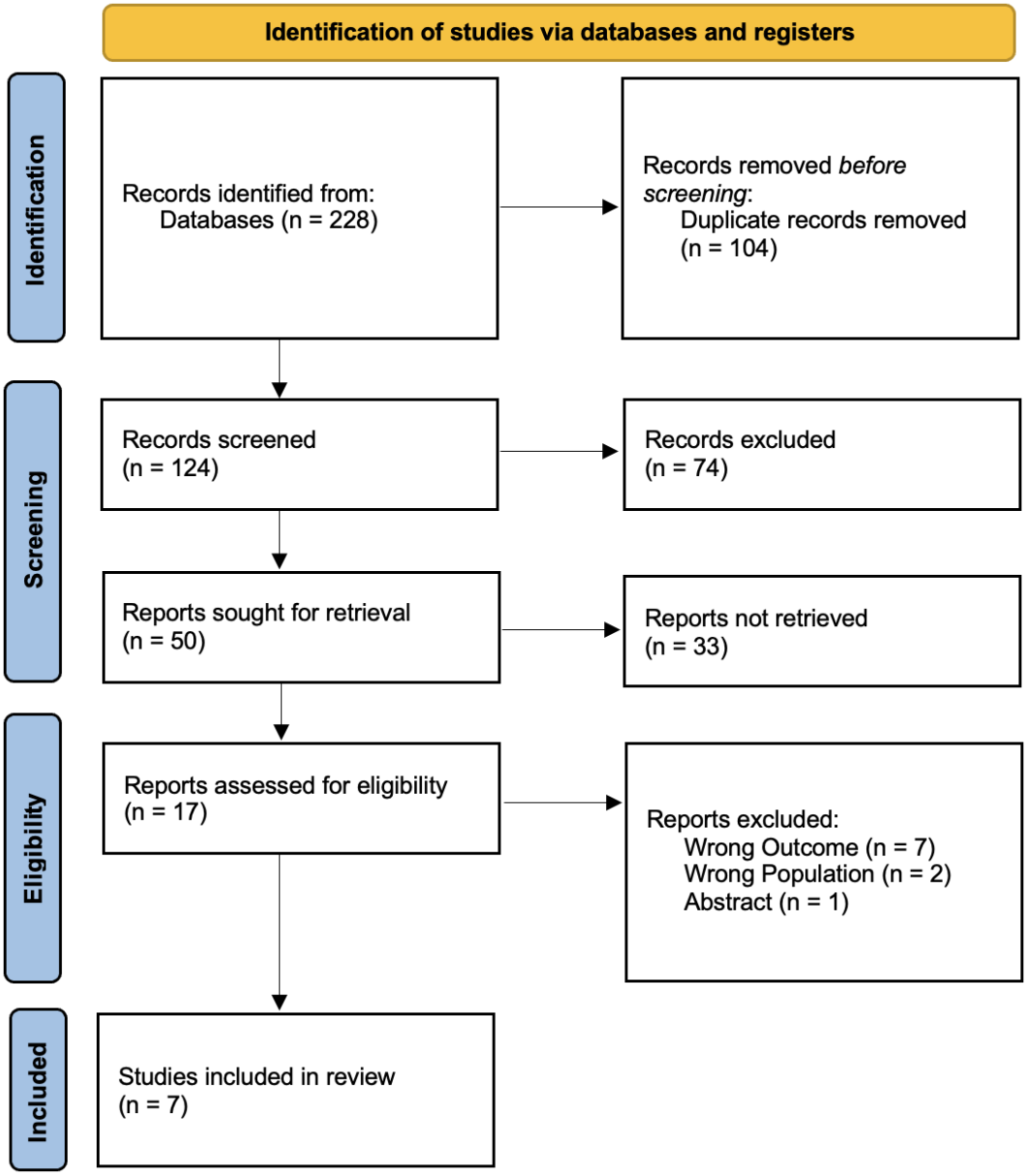

Figure 1: PRISMA Flow Diagram of Study Selection Process

Table 1 provides a comprehensive overview of the key demographic and methodological characteristics of the seven studies included in this systematic review, offering essential context for interpreting their findings. The studies, referenced as Hansen *et al.,* 2025 [12] and Jin *et al.,* 2025 [13], demonstrate a wide geographical distribution, spanning from specific remote communities in Eastern Greenland and rural Alaska to national data from Poland and China, as well as a global burden of disease analysis. The study designs are appropriately

varied to address different research questions, including cross-sectional studies [12, 18], a prospective cohort study [17], a retrospective analysis of clinical data [14], and a global epidemiological study [13]. Sample sizes range considerably, from focused clinical cohorts of 34 to 92 children [12, 15] to a large retrospective analysis of 318 children [14], and finally to a population-level study encompassing millions of children globally [13]. The ages of the children studied are also diverse, with some studies focusing on preschool-aged children (1-4 years) [17] and others including a broader pediatric range up to 14 years [15], ensuring that the findings are relevant across different developmental stages. Key inclusion criteria were consistently centered on the diagnosis of otitis media in its various forms—chronic suppurative otitis media (CSOM), otitis media with effusion (OME), or unspecified OM-related hearing loss—and the subsequent assessment of hearing function, which aligns perfectly with the objective of this review.

Table 2 synthesizes the core evidence from each study regarding the nature and strength of the association between otitis media and hearing loss in children. The studies consistently employed objective audiological assessments, primarily pure-tone audiometry and tympanometry, to characterize hearing loss. The research by Hansen *et al.,* 2025 [12] and Robler *et al.,* 2026 [17] provides direct prevalence data, reporting that 55% and 34.8% of their respective cohorts suffered from OM-related hearing loss, highlighting the substantial burden in high-risk populations like Greenlandic and Alaska Native children. The global study by Jin *et al.,* 2025 [13] contextualizes these findings by confirming that OM is a leading cause of hearing loss worldwide, with the highest burden in low-middle Socio-Demographic Index regions. Several studies delve deeper into the specific relationship between disease characteristics and hearing impairment. For instance, Zhang & Fu 2022 [14] demonstrated that the degree of hearing loss in OME is linked to the physical characteristics of the middle ear effusion, while Aithal *et al.,* 2024 [18] established a precise quantitative relationship, showing that wideband absorbance decreases proportionally with increasing air-bone gap, thus predicting the severity of conductive hearing loss. Furthermore, studies by Rosso *et al.,* 2022 [15] and Partycka-Pietrzyk *et al.,* 2023 [16] reinforce the association by demonstrating that successful treatment of the underlying OM or its risk factors (like maxillary constriction in cleft palate children) leads to significant and stable improvements in hearing thresholds. Finally, Robler *et al.,* 2026 [17] explored modifying factors, finding that breastfeeding was protective against OM-related hearing loss, while a specific genetic variant (*CPT1A*) showed a trend toward increased risk.

Table 3 presents a critical appraisal of the methodological quality and potential for bias in each of the seven included studies, using the most suitable tool for each study design, primarily checklists from the Joanna Briggs Institute (JBI). The overall risk of bias was judged to be low for the majority of the studies. The prospective cohort studies by Rosso *et al.,* 2022 [15] and Robler *et al.,* 2026 [17] were rated as low risk due to their clear designs, well-defined populations, use of objective outcome measures, and appropriate management of confounding variables. Similarly, the cross-sectional studies by Hansen *et al.,* 2025 [12] and Aithal *et al.,* 2024 [18] were assessed as low risk, as they employed valid and standardized methods for diagnosing both otitis media and hearing loss in clearly defined samples. The global burden of disease study by Jin *et al.,* 2025 [13] was rated as low-to-moderate risk; while it utilizes sophisticated modeling, its reliance on primary data of variable quality from different global regions introduces some uncertainty. The prospective study by Partycka-Pietrzyk *et al.,* 2023 [16] was also rated low-to-moderate risk, primarily due to the lack of a formal comparison group for its main therapeutic outcomes. Finally, the retrospective analysis by Zhang & Fu 2022 [14] was deemed to have a moderate risk of bias, a common limitation of such designs, as they are inherently more susceptible to selection bias and confounding by indication, given that treatment allocation was based on disease severity rather than randomization.

Table 1: Demographic and Study Characteristics of Included Studies

Study ID	Location	Study Design	Sample Size	Sample Characteristics	Age Range (years)	Key Inclusion Criteria Related to OM/HL
Hansen *et al.,* 2025 [12]	Tasiilaq, Eastern Greenland	School-based Cross-sectional	92 children (184 ears)	Children attending the only school in Tasiilaq.	5 - 11	Enrolled in the school; parental consent provided.
Jin *et al.,* 2025 [13]	Global	Epidemiological (GBD data analysis)	Population-level data (31.18M to 34.71M cases globally)	Children < 15 years globally, with data stratified by region, age, and sex.	< 15	Diagnosis of OM-induced hearing loss as per GBD study protocols.
Zhang & Fu, 2022 [14]	Hangzhou, China	Retrospective analysis of clinical data	318 children (556 ears)	Children diagnosed with OME at a tertiary	NM (Children, typical	Diagnosis of OME; availability of complete clinical data

Study ID	Location	Study Design	Sample Size	Sample Characteristics	Age Range (years)	Key Inclusion Criteria Related to OM/HL
				children's hospital.	OME age range)	on treatment and follow-up.
Rosso *et al.,* 2022 [15]	Milan, Italy	Prospective observational study	34 children (main group), 22 children (control group)	Children with cleft palate (CP), cleft lip and palate (CLP), or submucous cleft requiring RME.	6 - 14 (Mean 9.8)	Diagnosis of CP/CLP/submucous cleft; orthodontic indication for RME; presence of OME or CHL.
Partycka-Pietrzyk *et al.,* 2023 [16]	Poland	Prospective study (Single center)	201 children (372 ears) (Study group); 21 children (42 ears) (Control group)	Children requiring surgical treatment for OME.	1 - 8	Diagnosis of OME requiring surgical intervention (ventilation tube insertion).
Robler *et al.,* 2026 [17]	Northwest Alaska, USA	Prospective Cohort study	236 children	Alaska Native children from 16 rural communities.	1 - 4	Alaska Native child aged 1-4 years; residing in the study region.
Aithal *et al.,* 2024 [18]	Australia	Prospective, cross-sectional	176 children (181 ears) (CHL group); 130 children (170 ears) (Control group)	Children with OME and CHL (CHL group); children with normal hearing and middle ear function (Control group).	Mean 5.9 (CHL group); Mean 7.7 (Control group)	CHL group: Diagnosis of OME with CHL. Control group: Normal hearing and middle ear function.

NM = Not Mentioned

Table 2: Key Findings on the Association Between Otitis Media and Hearing Loss

Study ID	Type of OM Studied	Hearing Loss (HL) Assessment Method	Prevalence/ Severity of HL	Key Findings on Association
Hansen *et al.,* 2025 [12]	Chronic Suppurative OM (CSOM)	Pure-tone audiometry (air and bone conduction), tympanometry.	55% (PTA >15 dB, worst ear); 23% (PTA >20 dB, worst ear, WHO criteria).	High prevalence of HL was found alongside CSOM sequelae. 25% needed hearing rehab assessment, indicating undiagnosed/untreated HL.
Jin *et al.,* 2025 [13]	OM-induced HL (all types)	Based on GBD database case definitions.	Global ASPR in 2021: 1725.39 per 100,000.	Confirms OM as a leading cause of HL in children. Burden is highest in low-middle SDI regions and in children aged 5-9 years. Boys have higher prevalence than girls.
Zhang & Fu, 2022 [14]	OM with Effusion (OME)	Pure-tone audiometry.	NM (Treatment groups defined by HL severity: critical, mild, moderate-severe).	Degree of HL is associated with specific disease characteristics (effusion type) and guides treatment. Allergic rhinitis negatively impacts treatment outcome for OME.
Rosso *et al.,* 2022 [15]	OM with Effusion (OME)	Pure-tone audiometry (air-bone gaps), tympanometry.	NM (Mean air-bone gaps at different frequencies reported).	In children with cleft palate, successful treatment of maxillary constriction (RME) led to significant and stable improvements in both middle ear effusion (OME) and conductive HL, demonstrating a direct link.

Study ID	Type of OM Studied	Hearing Loss (HL) Assessment Method	Prevalence/ Severity of HL	Key Findings on Association
Partycka-Pietrzyk *et al.,* 2023 [16]	OM with Effusion (OME)	Pure-tone audiometry, tympanometry, otoacoustic emissions.	Mean hearing thresholds: 22.01 dB (500 Hz), 16.76 dB (1 kHz), 12.72 dB (2 kHz), 14.78 dB (4 kHz).	Confirms that children with chronic OME have elevated hearing thresholds (mild HL). Genetic diseases were noted as a factor influencing the course of OME.
Robler *et al.,* 2026 [17]	OM-related HL	Ear and hearing assessment (details NM in abstract, but includes tympanometry/audiometry from protocol).	Prevalence of OM-related HL: 34.8%.	Found a high prevalence of HL. The study explored risk factors: breastfeeding was protective (43% lower relative probability of HL), while the *CPT1A* Arctic variant showed a trend toward increased prevalence (21% higher).
Aithal *et al.,* 2024 [18]	OM with Effusion (OME)	Wideband Absorbance (WBA), pure-tone audiometry (air-bone gap - ABG).	ABG categories: 16-25 dB, 26-35 dB, and 36-45 dB.	Establishes a strong quantitative link: WBA decreased significantly with increasing ABG (severity of CHL). WBA can accurately predict the magnitude of conductive HL caused by OME.

Table 3: Risk of Bias Assessment of Included Studies

Study ID	Study Design	Risk of Bias Tool Used	Overall Risk of Bias	Key Concerns / Justification
Hansen *et al.,* 2025 [12]	Cross-sectional	Joanna Briggs Institute (JBI) Checklist for Analytical Cross-Sectional Studies	Low	The study had clear inclusion criteria, a sufficient sample size for the defined population, and used valid, standardized methods for both exposure (otoscopy) and outcome (audiometry). Confounding factors were appropriately identified and addressed in the analysis.
Jin *et al.,* 2025 [13]	Epidemiological (GBD data analysis)	A customized tool for ecological/GBD studies, assessing data quality, modeling validity, and transparency.	Low-Moderate	The GBD study uses robust modeling techniques and multiple data sources, which minimizes bias. However, the risk is slightly elevated due to potential variations in the quality and completeness of primary data from different countries and regions, which can introduce some uncertainty into the modeled estimates.
Zhang & Fu, 2022 [14]	Retrospective analysis of clinical data	Joanna Briggs Institute (JBI) Checklist for Case Series	Moderate	As a retrospective study, it is susceptible to selection bias and information bias, as data were not collected for research purposes. The study lacked a control group, and while the analysis was thorough, there is potential for confounding by indication, where the choice of treatment was based on the severity of the condition itself.
Rosso *et al.,* 2022 [15]	Prospective observational study	Joanna Briggs Institute (JBI) Checklist for Cohort Studies	Low	The study had a clear prospective design with a well-defined control group. Follow-up was complete and at appropriate time points (T0, T1, T2). Objective outcome measures (audiometry, tympanometry) were used, and strategies to deal with confounding factors were reported.
Partycka-Pietrzyk *et*	Prospective study	Joanna Briggs Institute (JBI)	Low-Moderate	The prospective design and use of objective outcome measures strengthen its validity.

Study ID	Study Design	Risk of Bias Tool Used	Overall Risk of Bias	Key Concerns / Justification
al., 2023 [16]		Checklist for Case Series		However, the absence of a formal comparison group for the main outcomes (the control group was used for audiometric norms, not for comparison of treatment) and limited information on the handling of potential confounders introduces a moderate element of bias.
Robler *et al.,* 2026 [17]	Prospective Cohort study	Joanna Briggs Institute (JBI) Checklist for Cohort Studies	Low	This is a well-designed prospective cohort study. It enrolled a clear sample from a defined population, used valid methods for exposure and outcome assessment, and employed appropriate statistical analyses (modified Poisson regression) to identify and adjust for important confounding factors. Follow-up was adequate to capture outcomes.
Aithal *et al.,* 2024 [18]	Prospective, cross-sectional	Joanna Briggs Institute (JBI) Checklist for Analytical Cross-Sectional Studies	Low	The study had clear criteria for inclusion in both the control and conductive hearing loss (CHL) groups. The exposure (OME) and outcome (ABG, WBA) were measured using valid, objective, and standardized methods. The statistical analysis, including AUROC and regression, was appropriate for the study design and addressed the research question effectively.

DISCUSSION

The prevalence estimates of COM-related hearing loss reported in this review align with and extend previous epidemiological investigations. Hansen *et al.,* [12] documented an exceptionally high prevalence of hearing loss (55% using ASHA criteria) among children in Eastern Greenland, a finding consistent with the well-documented disproportionate burden of COM in Arctic indigenous populations. This observation is corroborated by Robler *et al.,* [17], who reported that 34.8% of Alaska Native children aged 1-4 years exhibited OM-related hearing loss, with 51.3% having documented OM visits in the first year of life. These regional estimates substantially exceed global averages and reflect what previous research has identified as a 4-5 times higher prevalence of OM in Alaska Native populations compared to national US averages [6]. The consistency of these findings across distinct Arctic populations (Greenlandic Inuit and Alaska Native peoples) suggests shared vulnerability factors, potentially including the CPT1A Arctic variant identified in 52.3% of Robler's cohort [17], limited healthcare access in remote communities, and environmental factors such as household crowding and lack of indoor plumbing affecting 22.6% of participants [17].

At the global level, Jin *et al.,* [13] provide the most comprehensive epidemiological assessment to date, analyzing GBD data from 1990 to 2021 and revealing that 34.71 million children under 15 years were affected by OM-induced hearing loss in 2021. This represents an 11.32% increase in absolute cases over three decades, despite a slight decline in age-standardized prevalence rates (from 1793.38 to 1725.39 per 100,000). These figures resonate with the recent systematic review by Onifade *et al.,* [19], which estimated the global prevalence of CSOM at 3.8% of the population, affecting approximately 297 million people globally, with 85% (252 million) residing in low- and middle-income countries (LMICs). Importantly, Onifade *et al.,* [19] reported that 62% of CSOM cases (approximately 184 million individuals) were associated with disabling hearing loss exceeding 25-30 dB, and hearing impairment affected 50-78% of participants across the four studies reporting this outcome. The convergence of these independent estimates—our included studies and contemporary systematic reviews—reinforces the conclusion that COM remains a leading cause of preventable childhood hearing loss worldwide, with the burden disproportionately concentrated in LMICs and indigenous populations.

The severity and characteristics of hearing loss associated with COM demonstrate consistent patterns across studies. Saki *et al.,* [20] examined 663 children with chronic OME scheduled for tympanostomy tube placement and found that 61.08% presented with mild conductive hearing loss preoperatively, with a mean pure-tone average of 45.23 ± 23.25 dB HL. The majority (73.75%) exhibited Type B tympanograms, indicating middle ear effusion, and 60.03% showed retracted tympanic membranes. These findings are remarkably consistent with Partycka-Pietrzyk *et al.,* [16], who reported mean hearing thresholds of 22.01 dB at 500 Hz, 16.76 dB at 1 kHz, 12.72 dB at 2 kHz, and 14.78 dB at 4 kHz in 201 Polish children requiring surgical

intervention for OME. The mild-to-moderate conductive hearing loss profile documented across these studies aligns with the pathophysiological mechanism of middle ear effusion impeding sound transmission. The natural history of OME-related hearing loss, as elucidated by Paing *et al.,* [21] in their systematic review, demonstrates that resolution occurs in 50% of cases by 3 months, 60% by 6 months, and 61-77% by 12 months. However, for chronic OME exceeding 12 months duration—the population represented in our included surgical studies—resolution rates plummet to only 7% by 1 month and 12% by 6 months [21], underscoring the importance of timely intervention for persistent cases.

The relationship between disease chronicity and hearing outcomes is further illuminated by Zhang and Fu [14], who demonstrated that the degree of hearing loss in OME correlates with specific disease characteristics. Their analysis of 318 children (556 ears) revealed that effusion type—serous versus mucoid—varied systematically with hearing loss severity and disease duration, providing an evidence-based framework for treatment stratification. Children with mild hearing loss and disease duration ≥3 months or those with moderate-severe hearing loss and disease duration <3 months with mucoid effusion underwent tympanostomy tube insertion, achieving 90.9% effectiveness. This finding aligns with the treatment outcomes reported by Chen *et al.,* [22] in their prospective study of 154 children aged 1-4 years with cleft palate and OME. The ventilation tube group demonstrated significantly greater improvement in air-bone gap and tympanogram normalization over 36 months ($q < 0.001$), with superior speech clarity from 18 months and higher developmental scale scores (MUSS, SIR, MCDI) from 12 months onward compared to conservative management [22]. These longitudinal data provide strong evidence that early surgical intervention for persistent OME with hearing loss yields sustained benefits for both auditory and speech-language development, particularly in high-risk populations such as children with cleft palate.

The advent of advanced audiological assessment techniques has enabled more precise characterization of the COM-hearing loss relationship. Aithal *et al.,* [18] prospectively evaluated wideband absorbance (WBA) in 176 children with OME and conductive hearing loss, demonstrating significant negative correlations between WBA and air-bone gap (ABG). The regression model (ABG 0.5-4 k = 31.83 - 24.08 × WBA 0.5-4 k) predicted ABG with high accuracy, and the area under the receiver operating characteristic curve (AUROC) for WBA increased with ABG severity, reaching 0.94 for distinguishing control ears from those with 36-45 dB ABG [18]. This technological advancement offers promise for non-invasive estimation of hearing loss severity in young children who may not tolerate conventional audiometry, potentially enabling earlier identification and intervention. The pathophysiological basis—reduced WBA indicating increased middle ear stiffness and effusion—provides an objective measure of the mechanical consequences of OME that directly correlate with functional hearing impairment.

Risk factor analysis across studies reveals important modifiable and non-modifiable determinants of COM-related hearing loss. Robler *et al.,* [17] identified that any breastfeeding was associated with a 43% lower relative probability of OM-related hearing loss (prevalence ratio = 0.59, 95% CI: 0.39-0.90), confirming the protective effect documented in previous meta-analyses [23]. This finding has direct implications for nutritional counseling in high-risk populations. Conversely, the CPT1A Arctic variant, present in 52.3% of the Alaska Native cohort, showed a trend toward increased prevalence of OM-related hearing loss (PR = 1.21, 95% CI: 0.78-1.86) [17]. This genetic polymorphism, which affects fatty acid oxidation and ketogenesis during fasting, has been associated with increased respiratory infection risk in previous research [24]. The interaction between genetic susceptibility and environmental exposures (household smoking, indoor air quality, crowding) warrants further prospective investigation. Bhatia *et al.,* [25], in their meta-analysis of Indian studies, estimated CSOM prevalence at 3.78% (95% CI: 2.72-4.84) and OME at 2.68% (95% CI: 1.80-3.55), emphasizing the substantial disease burden in South Asian children. The association between malnutrition and OM risk is further elaborated by Xhakali and Ramma [26], whose scoping review documented that children with severe acute malnutrition face increased OM susceptibility due to compromised immunity and mucosal barriers, with associated hearing loss underscoring the importance of integrated nutritional and audiological care in vulnerable populations.

The socioeconomic gradients in COM-related hearing loss are stark. Jin *et al.,* [13] reported that low-middle SDI regions bear a burden 1.81 times higher in ASPR and 6.08 times higher in absolute cases compared to high SDI regions. East Asia showed the largest decrease in burden over the study period, while South Asia had the highest ASPR. These disparities likely reflect differential access to healthcare, pneumococcal vaccination coverage, antibiotic availability, and surgical services for tympanostomy tube placement. Onifade *et al.,* [19] similarly found that 85% of global CSOM cases occur in LMICs, with included studies predominantly originating from these settings. The economic implications are substantial: untreated hearing loss from COM affects educational attainment, vocational opportunities, and quality of life, perpetuating cycles of poverty and disadvantage. Baltussen and Smith [27] demonstrated that targeted strategies for chronic otitis media rank among the most cost-effective interventions for reducing disability-adjusted life years in sub-Saharan Africa and South-East Asia, highlighting

the imperative for resource allocation to prevention and treatment in high-burden regions.

The relationship between COM and hearing loss must be understood within the developmental context of childhood. The critical periods for language acquisition (birth to 3 years) and academic skill development coincide with the peak incidence of OME. Saki *et al.,* [20] found that the most frequent age groups affected by OME were 12-36 months (33.48%) and 36-72 months (31.67%), precisely the windows when auditory input is essential for phonological development, vocabulary acquisition, and emergent literacy. The mean hearing thresholds documented across studies—ranging from 22-45 dB HL—represent mild-to-moderate hearing loss that may be insufficient to trigger parental concern but adequate to degrade the acoustic signal necessary for speech perception in noisy environments (classrooms, group settings). The long-term consequences are well-documented: children with persistent OME-related hearing loss demonstrate reduced phonological awareness, poorer reading skills, and lower academic achievement compared to peers [28]. The developmental stakes are highest for children with additional vulnerabilities, including cleft palate [15, 22], genetic syndromes [16], or socioeconomic disadvantage [13, 19].

The effectiveness of surgical intervention in ameliorating COM-related hearing loss is consistently demonstrated across studies. Rosso *et al.,* [15] prospectively evaluated rapid maxillary expansion (RME) in 34 children with cleft palate and OME, finding statistically significant improvements in air-bone gaps ($p < 0.001$-0.089 at T0 vs. T1 and $p < 0.001$-0.044 at T0 vs. T2) and tympanometry results ($p = 0.002$ at T0 vs. T1 and $p < 0.001$ at T0 vs. T2), with improvements stable through 6-month follow-up and significantly better than the control group. Saki *et al.,* [20] reported that following tympanostomy tube insertion, mean pure-tone average significantly improved from 45.23 ± 23.25 to 27.83 ± 15.86 dB HL ($p = 0.001$), representing approximately 18 dB and 17 dB improvement in right and left ears respectively at 2 months post-surgery. Remarkably, 487 children (73.45%) achieved normal hearing thresholds postoperatively. Chen *et al.,* [22] extended these findings by demonstrating sustained benefits over 36 months, with superior speech recognition scores, speech clarity, and developmental outcomes in the ventilation tube group. These convergent data support current clinical guidelines recommending tympanostomy tube insertion for persistent OME with hearing loss, particularly in children with risk factors for developmental delay.

The clinical implications of this systematic review are manifold. First, the high prevalence of COM-related hearing loss in specific populations—Arctic indigenous children, children with cleft palate, children in LMICs—mandates targeted screening programs. Hansen *et al.,* [12] found that none of the 92 Greenlandic children studied had been previously diagnosed despite 25% requiring assessment for hearing rehabilitation, highlighting the hidden nature of this morbidity. Second, the association between hearing loss severity and specific disease characteristics (effusion type, duration) supports stratified treatment algorithms as proposed by Zhang and Fu [14]. Third, the protective effect of breastfeeding [17] and the potential role of genetic susceptibility underscore the importance of addressing modifiable risk factors through public health interventions. Fourth, the consistent demonstration of improved audiological and developmental outcomes following surgical intervention supports timely referral for children with persistent OME and hearing loss. Finally, the global burden estimates [13, 19] provide an evidence base for advocacy and resource allocation to combat this preventable cause of childhood disability.

LIMITATIONS

This systematic review, while comprehensive, has several limitations that warrant consideration. First, the included studies exhibit methodological heterogeneity in diagnostic criteria for both otitis media and hearing loss. While most studies utilized pure-tone audiometry and tympanometry, threshold definitions for hearing loss varied, with Hansen *et al.,* [12] using both ASHA criteria (PTA >15 dB) and WHO criteria (PTA >20 dB), while Jin *et al.,* [13] defined hearing loss as pure-tone average >20 dB in the better ear. This variation complicates direct comparison of prevalence estimates across studies. Second, the cross-sectional design of several included studies [12, 14, 18] precludes determination of temporal causality and provides only a snapshot of the relationship between COM and hearing loss at a single time point. Longitudinal studies such as Robler *et al.,* [17] and Chen *et al.,* [22] are better positioned to elucidate causal pathways but remain underrepresented in the literature. Third, the focus on published English-language studies may introduce publication bias and exclude relevant research from non-English sources, particularly given that LMICs bear the highest disease burden. Fourth, the GBD data utilized by Jin *et al.,* [13] rely on modeling assumptions and may not capture the full spectrum of OM-related hearing loss, particularly mild or unilateral cases that may still impact developmental outcomes. Fifth, the included studies predominantly focused on conductive hearing loss, with limited data on sensorineural or mixed hearing loss components that may result from chronic suppurative disease. Sixth, the risk of bias assessment revealed moderate risk for retrospective studies [14] and low-to-moderate risk for some prospective studies [16], indicating that methodological limitations may affect the strength of conclusions. Seventh, the paucity of data on long-term developmental outcomes beyond 36 months limits understanding of the enduring consequences of COM-related hearing loss into adolescence and adulthood. Finally, the studies included in this review are predominantly from high-income countries and specific indigenous populations, limiting generalizability to the

full range of global settings where COM burden is highest. The systematic review by Onifade *et al.,* [19] identified studies from only 18 countries, predominantly India and Nepal, highlighting geographical gaps in the epidemiological literature.

CONCLUSION

This systematic review provides robust evidence that chronic otitis media, in its various forms, is strongly and consistently associated with hearing loss in the pediatric population. The global burden is substantial, with an estimated 34.71 million children affected as of 2021, representing an 11.32% increase over three decades. The relationship between COM and hearing loss is characterized by mild-to-moderate conductive impairment, with mean pure-tone averages ranging from 22-45 dB HL across studies, reflecting the mechanical consequences of middle ear effusion, tympanic membrane perforation, and ossicular chain disruption. This degree of hearing loss, while often insufficient to trigger immediate clinical concern, is adequate to compromise speech perception, language acquisition, and academic achievement during critical developmental windows. The evidence demonstrates that the severity and persistence of hearing loss correlate with disease chronicity, effusion characteristics, and the presence of additional risk factors including cleft palate, genetic susceptibility (CPT1A Arctic variant), nutritional status, and socioeconomic disadvantage. Populations at highest risk include indigenous Arctic children (34.8-55% prevalence), children in low-middle SDI regions (burden 6.08 times higher than high SDI regions), and those with anatomical predispositions such as cleft palate. Importantly, the evidence supports the effectiveness of timely intervention, with surgical approaches including tympanostomy tube insertion and rapid maxillary expansion demonstrating significant and sustained improvements in audiological outcomes and speech-language development. The protective effect of breastfeeding (43% relative risk reduction) and the disproportionate burden in LMICs (85% of CSOM cases) highlight opportunities for public health intervention through nutritional support, vaccination programs, and healthcare infrastructure strengthening. Future research priorities include prospective longitudinal studies to elucidate causal pathways, investigation of gene-environment interactions in high-risk populations, development and validation of novel audiological assessment tools (such as wideband absorbance) for young children, and implementation research to translate evidence-based interventions into practice in resource-limited settings. The convergence of evidence from epidemiological, clinical, and translational studies underscores that COM-related hearing loss in children is a preventable and treatable condition that warrants prioritization by healthcare systems, policymakers, and funding agencies to mitigate its profound and lasting impact on child development and global health equity.

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