



ORIGINAL ARTICLE

Prevalence of Ear Infections in Children (0 to 15 Years) of India: A Systematic Review and Meta-Analysis

Ragini Bhatia¹, Anil Chauhan², Kulbir Kaur³, Monika Rana⁴, Pranita Pradhan⁵ and Meenu Singh^{6*}



¹Scientist C, Department of Paediatrics, Post Graduate Institute of Medical Education and Research, Chandigarh, India

²Consultant, Department of Telemedicine, Post Graduate Institute of Medical Education and Research, Chandigarh, India

³Senior research fellow, Department of Paediatrics, Post Graduate Institute of Medical Education and Research, Chandigarh, India

⁴Biostatistician, Department of Paediatrics, Post Graduate Institute of Medical Education and Research, Chandigarh, India

⁵Librarian, Post Graduate Institute of Medical Education and Research, Chandigarh, India

⁶Professor, Department of Paediatrics, Post Graduate Institute of Medical Education and Research, Chandigarh, India

*Corresponding author: Professor Meenu Singh, Department of Paediatrics, Post Graduate Institute of Medical Education and Research, Chandigarh, India

Abstract

Objectives: Ear ailments in children are a major public health problem in India. This systematic review and meta-analysis aim to quantitatively pool the epidemiologic evidence on the prevalence of ear diseases and related morbidities in children (0 to 15 years) of India.

Methods: In this review PRISMA guidelines (preferred reporting items for systematic reviews and meta-analysis) were followed. We did extensive literature search in PubMed, Embase, Cinahl and Web of Science to identify relevant community based cross sectional studies that investigated the prevalence of ear diseases in children in India. We used STATA version 16.0 software to perform meta-analysis.

Results: In this review 8 major community based observational studies were finalized that included 29,756 participants from urban and rural areas in various states of India. In the analysis part, doing random effect meta-analysis the pooled estimated prevalence of 11.66 % (95%CI 4.81-18.50) was found for ear ailments in India. When sub-group analysis was done, prevalence of Cerumen impaction was found to be 13.98% (95%CI 9.45-18.51), Chronic suppurative otitis media 3.78% (95%CI 2.72-4.48), Otitis media with effusion in 2.68 per% (CI 1.80-3.55), foreign body in the ear in 0.37 % (95%CI 0.29-0.45) and Acute suppurative otitis media in 0.55% (95%CI 0.32-0.78).

Conclusion: The findings of the review resulted in the pooled estimated prevalence of ear diseases of 11.66% in

children of India which is substantial to lead to high disease burden. Therefore, it is imperative to promote more epidemiological studies that will aid policy makers in recommendation of preventive, diagnostic and treatment strategies.

Keywords

Prevalence, Ear diseases, Ear morbidity, Otic ailments in children, Systematic review, Meta-analysis

Introduction

Ear diseases in children are a major public health problem in developing countries [1]. Diseases of the middle ear have inflicted a significant burden on the health system and accounts for almost one third of healthcare visits made to paediatricians especially in the child's first five years of life [2,3].

The term "Otitis Media" (OM) includes a range of conditions, mostly characterized by inflammation of the middle ear with common symptoms of pain, irritability and fever. Infections, allergies and environmental factors contribute to the occurrence of otitis media with bacterial or viral aetiology [4]. Many risk factors can predispose children to develop acute otitis media

like preceding upper respiratory tract infection [5] and genetic factors [6]. Acute otitis media can occur at any age, but it is most common in the age group of 6 to 24 months [7]. Around 80 per cent of all children would experience a case of otitis media during their life course [8,9].

The different forms of ear diseases are: 1) Suppurative otitis media (ear pain or discharge that lasts for less than two weeks); 2) Acute suppurative otitis media (ASOM, pain in the ear); 3) Chronic suppurative otitis media (CSOM, persistent purulent discharge that lasts for more than 2 weeks); 4) Non-suppurative otitis media (NSOM) including acute and chronic NSOM; 5) Impacted cerumen (wax plug that obstructs the tympanic membrane); 6) Serous otitis media (retracted and dull tympanic membrane). All these conditions are interrelated and may lead to the development of severe form. Suppurative otitis media is associated with life-threatening complications. ASOM leads to hearing loss (mild or greater). Disabling hearing loss corresponds to hearing loss greater than 30 dB in the better hearing ear in children (0 to 14 years). In India six per cent of the population is reported to have hearing loss [5]. In children hearing loss can negatively impact many aspects of life such as communication, the development of language and speech cognition, education and mental health. Cost-effective interventions can alleviate these overwhelming costs associated with hearing loss. Some 10% of children have impacted cerumen [10]. CSOM is one of the commonest infectious diseases of childhood [11].

In 2013, the evidence-based guidelines for the diagnosis and management of acute otitis media were updated by the American Academy of Pediatrics, accentuating the role of clear visualization of the tympanic membrane in the diagnosis of ear infections [12]. Otitis media is clinically diagnosed through physical exam (otoscopy) combining the history of the patient with presenting signs and symptoms. The diagnostic tools for Otitis Media available are pneumatic otoscope, acoustic reflectometry and tympanometry. Pneumatic otoscopy is considered better than other modalities to facilitate diagnosis [8]. Suppurative otitis media can result in complications such as tympanic membrane (TM) perforation, meningitis, brain abscess, mastoiditis, hearing loss and others [13]. Children having recurrent episodes with severe symptoms or complications of AOM may require immediate otolaryngologic evaluation and surgical treatment [14]. Antibiotics are prescribed for AOM more frequently than for any other illness of childhood [15].

There is a paucity of reliable population-based data on the prevalence of preventable ear disorders in the developing countries [16]. Few community based observational studies done in Indian context including children (0 to 15 years) have shown the prevalence of otic

ailments in the range of 4.5 per cent to 25.78 per cent. It is imperative to support more research on disability caused by ear infections in children and contemplate accurate diagnostic and treatment techniques.

Materials and Methods

Search strategy

For this review, an extensive literature search was done as per the guidelines of reporting systematic review and meta-analysis (PRISMA). The protocol has been submitted in Prospero with registration ID CRD42022309217. Published literature on the prevalence of ear morbidities using the following major databases was reviewed: Pubmed Central, Embase, Web of Science and Cinahl. All published articles from 2005 up to 2021 were included in the systematic review and meta-analysis. The search in Pubmed Central was conducted using the following terms: "children or child or infant or "preschool children" AND ear infection OR ear infections OR (middle ear infection OR ear inflammation OR otitis OR acute otitis OR "Otitis" AND India.

Eligibility criteria

The title and abstract were evaluated of the relevant studies done before recouping of full-text articles to be screened further by the two reviewers. A predefined inclusion and exclusion criteria were approved for the screening of the retrieved full articles and any disagreements in the process were resolved through discussion with a third reviewer. Cross-sectional and other observational studies from 2005 and onwards that assessed the prevalence of ear infections in children (0 to 15 years) in various parts of India and only those published in English language were included in this review. Only community based cross sectional studies done through surveys or screenings in schools were included. Hospital or healthcare based observational studies were excluded. The literature excluded were duplicate studies, commentaries, short communications, editorials, reviews and letters.

Methods for data extraction and quality assessment

A preformed data extraction format was utilized for the extraction of data from the studies included in this systematic review. The information extracted from each study was the name of the study, first author, year of publication, study setting, study design, sample size, mode of examination and assessment method, age of participants and prevalence of ear morbidity. Data was extracted from included studies by two reviewers and disagreements were resolved through discussion with third reviewer. Hoy, et al. (2012) [17] scale was used to assess the quality of prevalence studies with 9 indicators of risk of bias.

Data synthesis and analysis

STATA version 16.0 software was used to do random effect meta-analysis to estimate the overall pooled estimated prevalence of ear morbidities in children of India. The Q and I^2 -statistics depicted the heterogeneity among the studies included in the review. The funnel plot and Egger's regression tests were reviewed to assess publication bias.

Insert [Figure 1](#) here

Results

The electronic search engine and strategies resulted in a total of 995 articles after removing duplicate articles. We excluded 941 articles after reading the abstracts where inclusion criteria were not met. We read full text of 54 articles and after full evaluation 14 articles were selected for further review. Out of 14 articles 2 articles did not have sample size exclusively for children, and 4 articles were based on observational study where

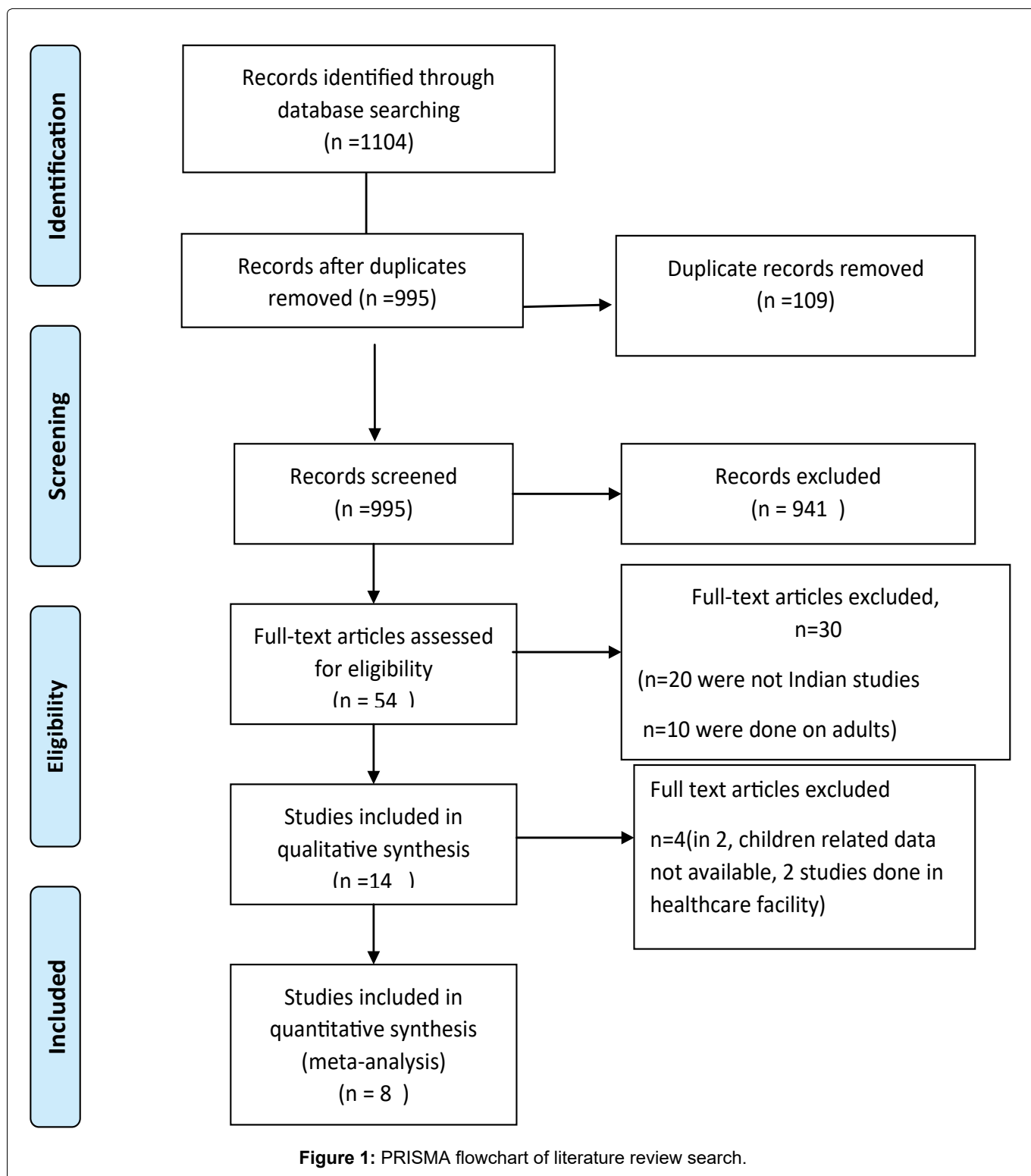


Table 1: Characteristics of studies included in the systematic review and meta-analysis.

Study ID	State	Type of study design	Age of participants (in years)	Ear morbidity assessment method	Sample size (Total)	Prevalence(n)	Overall prevalence (%)	Prev. in Males (%)	Prev. in Females (%)	Prev. in Urban	Prev. in Rural	Hoy et al quality score
Chadha, et al. [18]	New Delhi	Community based cross-sectional study in schools	5-12	1. Head light 2. Otoscope 3. Hand held, Portable tympanoscope for tympanometry 4. hand held audio scope	3000	652	21.73%	No association	No association	2.13%	19.60%	2 Low risk 0-3 Moderate risk 4-6 High risk 7-9
Siddhartha, et al. [19]	Karnataka	Community based cross-sectional study in schools	5-10	Clinical examination and tympanometry	1020	46	4.5%	43%	57%	No association	No association	4
Sophia, et al. [20]	Tamil Nadu	Community based cross-sectional study, case-control study design	11 months-7	Study questionnaire and tympanometry	800	69	8.6%	59.4%	40.6%	No association	10.6%	4
Chadha, et al. [16]	New Delhi	Community based cross-sectional study in schools	5-12	Headlight and an Otoscope	15718	4052	25.78%	No association	No association	4.79%	No association	2
Bright, et al. (2014)	Telangana	Community based cross-sectional study	0 - 3	Hearing screening with otoacoustic emissions.	280	5	1.8%	No association	No association	No association	No association	4
Kumar, et al. [21]	Karnataka	Community based cross-sectional study in schools	4 - 14	Pure tone Audiometry	1312	116	8.8%	No association	No association	No association	No association	4
Chadha, et al. [2]	New Delhi	Community based cross-sectional study, door to door survey	18 days - 15	Clinical examination, otoscopic examination and tympanometer	3000	213	7.1%	No association	No association	14.5%	7%	2
Chadha, et al. (2015)	New Delhi	Community based cross-sectional study, door to door survey	0-15	1. Otoscopy 2. Impedance audiometry 3. Hearing Screening	4626	685	14.8%	No association	No association	91.2%	8.7%	2

data was collected in primary, secondary or a tertiary healthcare facility. Therefore 6 more studies were excluded resulting in 8 studies for systematic review and meta-analysis.

Characteristics of the included studies

In this review, a total of 8 studies were included which were community based cross-sectional studies. Data was collected either in schools or in the form of door-to-door surveys. The studies included were from the states of Karnataka, Telangana, New Delhi and Tamil Nadu. Four major studies were done in New Delhi. A total 29,756 participants in the age group 0 to 15 years were included in these 8 studies of the review. The demographic characteristics of the study population included in this study are shown in Table 1. The studies included in this review were published from 2005 to 2021.

Pooled estimate of prevalence

Eight studies reporting the prevalence of ear morbidities in children were included in the final analysis. Based on the results of the random-effects meta-analysis model, the pooled estimated prevalence of ear disease among children of India was 11.66 per cent (95%CI 4.81-18.50) as shown in Figure 2. When subgroup analysis was done keeping risk factors constant, prevalence of Cerumen impaction was found to be 13.98 per cent (95%CI 9.45-18.51), Chronic suppurative otitis

media 3.78 per cent (95%CI 2.72-4.48), Otitis media with effusion in 2.68 per cent (CI 1.80-3.55), foreign body in the ear in 0.37 per cent (95%CI 0.29-0.45), Acute suppurative otitis media in 0.55 per cent (95%CI 0.32-0.78) as shown in Figure 3. Due to variable sample size and population demographics, we found significant heterogeneity for this analysis. Meta-analyses of prevalence usually present high I^2 values and not always synonymous with high heterogeneity [22].

Publication bias

The funnel plot was found to be symmetrical around the null vertical line indicating absence of publication bias. The calculated Egger's statistic ($p = 0.210$) also depicted no significant bias.

Quality of included studies

The Hoy, et al. scale (2012) [17] for prevalence studies was used to assess the quality of studies which included 9 indicators. The overall risk of bias had three levels of low risk, moderate risk and high risk of bias. Four studies had low risk of bias and four studies had moderate risk of bias (Table 1).

Discussion

The studies done in four parts of the country with substantial sample size revealed that India has high ear infections related disease burden. With the recent developments in public health and healthcare sector,

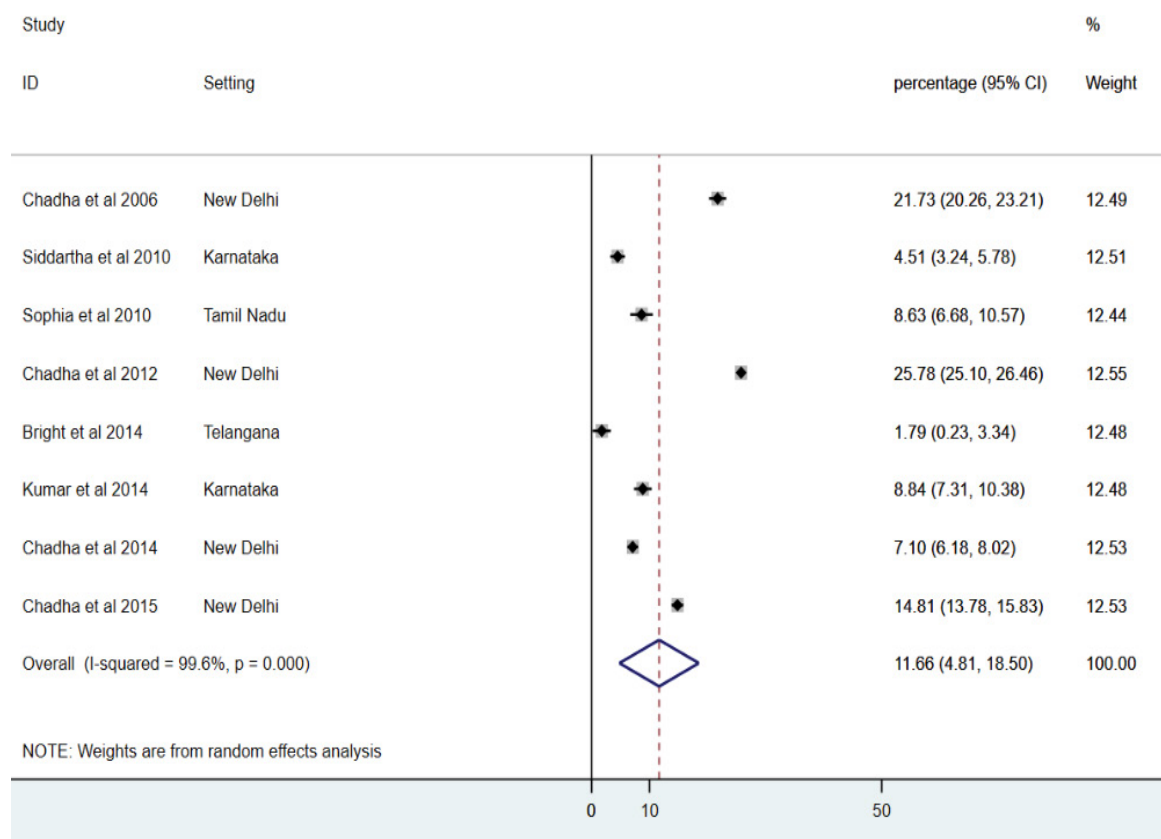


Figure 2: Forest plot of the prevalence of ear morbidity in children in India: a meta-analysis.

Keys: High ($I^2 = 99.6\%$, $P < 0.0001$): Random effect meta-analysis.

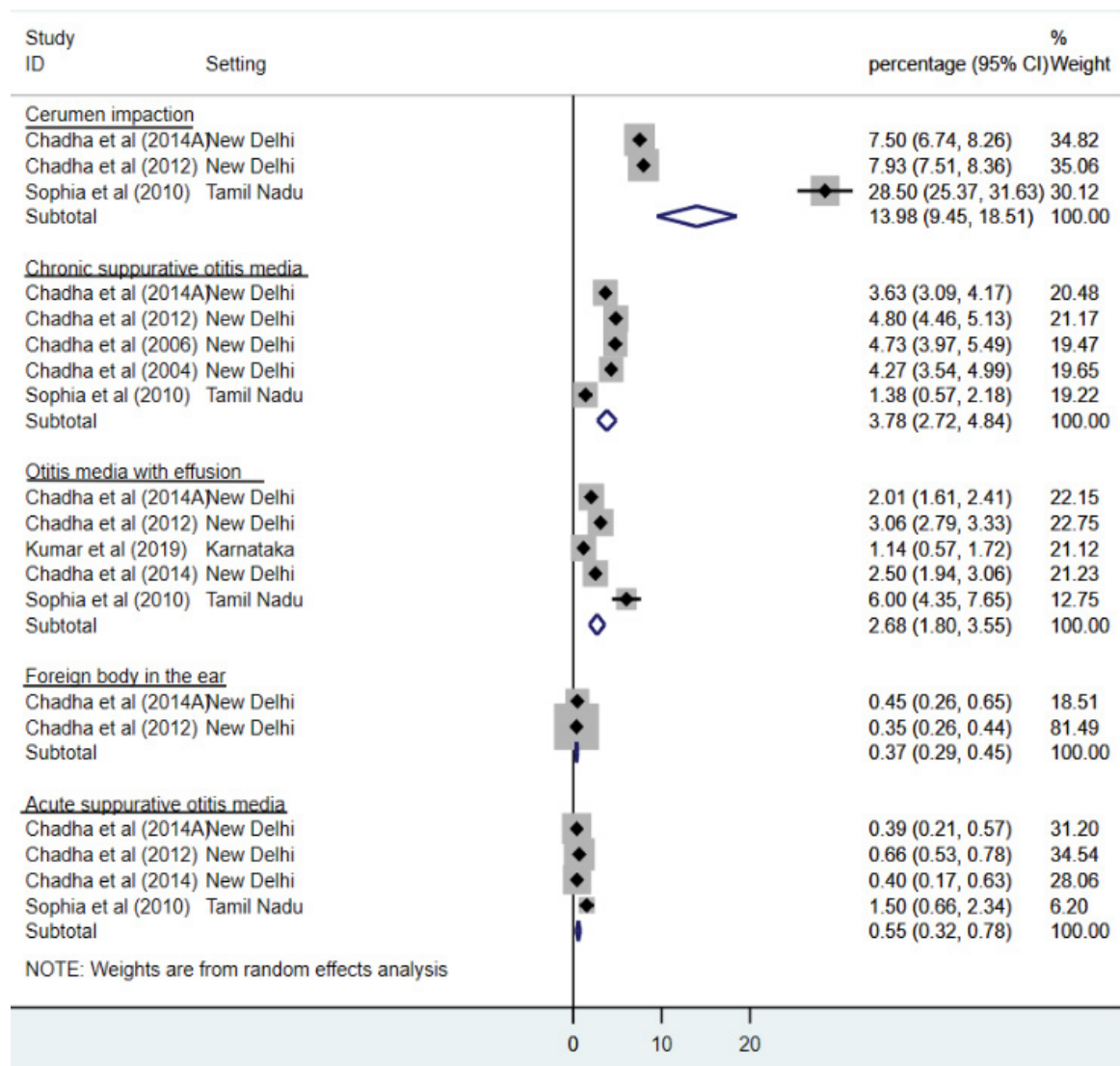


Figure 3: Sub group analysis for prevalence of ear disease type.

ear disorders in children are still prevalent in many parts of the country. Yet there is paucity of research in many parts of India that would indicate the prevalence of ear disorders and its implications. In this systematic review and meta-analysis for the prevalence of ear morbidity among children in India resulted in the pooled estimated prevalence of ear diseases of 11.66 per cent. This is a significant proportion of the children having ear disorders that can affect their psychological and physical development. The studies included showed prevalence in the range of 4.5 per cent to 25.78 per cent. The variations might be because of the difference in age groups of children included, socio-economic factors, context and sample size used in the study.

The paper by Rettig E, et al. illustrates that in the United States, 8.8 million children (11.8 per cent) under the age of 18 were reported to have ear infections in 2006, leading to an estimated total treatment cost of \$2.8 billion [14,15]. These estimates are similar to our review results (11.66 per cent). We can compare our analysis of sub-types of the ear diseases with a systematic review done by Mahadevan M, et al. to assess

burden of disease in Asia Pacific region, in school going children where OM prevalence varied between 3.25 per cent in Thailand and 12.23 per cent in Philippines. Otitis Media with Effusion varied between 1.14 per cent in Thailand and 13.8 per cent in Malaysia. It was 2.68 per cent as per our review. CSOM prevalence was 15 per cent in Aboriginal Australian children and 2-4 per cent in Thailand, Philippines, Malaysia and Vietnam [23]. In our review the point estimate for CSOM was 3.78 per cent. In the review by Mahadevan M, et al. OM prevalence/incidence and service utilization were highest in children of the age group 2-5 years. Streptococcus pneumoniae and Haemophilus influenzae were labelled as the primary cause in this review [23].

In a systematic review done by Antonio R, et al. on the epidemiology of Otitis media in children from developing countries enumerates the results of many studies including results from Sophia, et al. study (2010) [20] from India. Few studies were included from other Asian countries but the sample size was not relevant [24]. In a systematic review done by Monasta L, et al. (2012) data were available from 15 of the 21 WHO

regions and showed OM incidence rate to be 10.85 per cent (new episodes per 100 people per year) with 51 per cent of these occurring in under-fives. Global incidence rate is highest in the age group 1 to 4 years and in the first year of life. Globally, CSOM incidence rate is highest in the first year of life [25].

The methods and tools for diagnosis of ear infections and related morbidities used in the observational studies were the same. The assessment methodology for all studies included otoscopy, tympanometry, audiometry and clinical examination. All the studies were community based observational studies in the form of door-to-door surveys or clinical examination in the schools. The observational study done by Chadha, et al. (2012) [16] 15,718 school children (5-12 years of age) in New Delhi showed a high ear disease prevalence of 25.78 per cent. Another study conducted by Chadha, et al. (2006) [18] compared the prevalence of ear diseases in 1500 school children of lower and higher socioeconomic strata in New Delhi. In this study 19.6 per cent prevalence of ear disease in the lower strata of that society compared with 2.13 per cent in higher socioeconomic group. This study associates the prevalence of ear diseases in children to socioeconomic status. Children from a deprived area attending government schools were compared to those attending elite private schools. Children of lower socioeconomic status had a higher prevalence of otitis media. This study confirmed childhood ear disease is linked with poverty. The study [16] also enumerated some risk factors attributed to the high rates of chronic otitis media such as lack of breast feeding, overcrowding, poor hygiene, poor nutrition, pathogenic bacteria, passive smoking and inadequate healthcare. Inappropriate care of the infected ear was another reason for the increased prevalence of chronic otitis media. Cerumen impaction, otitis media with effusion and chronic suppurative otitis media were found to be the most common morbidity of the ear. The study done by Chadha, et al. (2014) [2] revealed the presence of otitis media in 9.9% of children in urban slums as compared to 4.6% in non-slum areas of the city and 7% in rural areas.

In the study done by Kumar S, et al. (2019) [21] showed prevalence of 8.8 per cent which is similar to the Global prevalence of hearing loss in children which is 9 per cent as per the WHO report on hearing loss [10]. This study found impacted wax and Retracted Tympanic Membrane amenable for the hearing loss. The case-control study done by Siddartha, et al. [19] found association of socio-economic status with ear ailments. They found higher prevalence of ear diseases in lower socio-economic status. The Sophia et al case control study [20] showed that snoring, persistent rhinorrhoea, seasonal rhinitis and passive smoking were significant factors for otitis media in children aged eleven months to seven years. This study also showed high prevalence of soft and impacted wax in children of rural area of

Vellore, Tamil Nadu. All the studies done by Chadha, et al. showed no association of sex with the prevalence [16,18].

Four studies had low risk of bias whereas four studies had moderate risk of bias. In all the studies the target population represented the National population, subjects were randomly selected and non-response was taken into consideration. The mode of data collection was same for all the subjects in all the studies. The studies with lower quality lacked randomization of subjects, case definitions and the instruments used to measure prevalence were not shown to have reliability and validity.

Strength and Limitation

Extensive literature search was done for this systematic review using various data bases, including studies done from 2005 to 2021 thus considering the latest trends in the prevalence of ear diseases in children in India. The quality of the studies was carefully reviewed and risk of bias was low to moderate for most of the studies. The results for point prevalence were obtained with confidence intervals and weights using random effect meta-analysis. Sub-group analysis was done for different categories of Otitis Media. This adds to strength of the review. The limitation of this review is that the studies included in this review were majorly from four parts of the Nation, therefore the results have less external validity and cannot be generalized. Subgroup analysis for different age groups, for urban rural and slum population was not done due to insufficient data and absence of uniformity in the results of the studies. The risk factors for ear related morbidities were not evaluated in detail.

Conclusion

The findings of this paper suggested that the pooled estimated prevalence of ear diseases is 11.66 per cent in children in India leading to high disease burden and related social and economic costs. Therefore, there is a need for well-planned epidemiological studies of prevalence of ear diseases as well as associated risk factors in India. There should be regular screening of children in the schools and those with positive findings should be referred to otolaryngologist for diagnosis and treatment. Significant investment is needed in India to provide facilities for detection and treatment of otic ailments in children.

Conflict of Interest

There is no conflict of interest related to this study.

Role of Funding Sources

The study was funded by the Indian Council of Medical Research, New Delhi with grant number 5/7/1668/CH/CAR/2019-RBMCH date - 3/01/2019.

Acknowledgements

The authors thanks for the support provided by Evidence Based Medicine (EBM-Phase 2), Indian Council of Medical Research, New Delhi.

Conflict of Interest

None.

References

- Kohli C, Kadirvelu U, Garg S, Sharma N (2016) Burden of ear morbidities among children in primary care setting in Delhi. *Clin Epidemiol Glob Health* 4: S12-S16.
- Chadha SK, Gulati K, Garg S, Agarwal AK (2014) Comparative prevalence of otitis media in children living in urban slums, non-slum urban and rural areas of Delhi. *Int J Pediatr Otorhinolaryngol* 78: 2271-2274.
- Teele DW, Klein JO, Rosner B (1989) Epidemiology of otitis media during the first seven years of life in children in Greater Boston: A Prospective, Cohort Study. *J Infect Dis* 160: 83-94.
- Ubukata K, Morozumi M, Sakuma M, Takata M, Mokuno E, et al. (2018) Etiology of acute otitis media and characterization of pneumococcal isolates after introduction of 13-valent pneumococcal conjugate vaccine in Japanese children. *Pediatr Infect Dis J* 37: 598-604.
- Fireman P (1997) Otitis media and eustachian tube dysfunction: Connection to allergic rhinitis. *J Allergy Clin Immunol* 99: s787-s797.
- Mittal R, Robalino G, Gerring R, Chan B, Yan D, et al. (2014) Immunity genes and susceptibility to otitis media: A comprehensive review. *J Genet Genomics* 41: 567-581.
- Meherali S, Campbell A, Hartling L, Scott S (2019) Understanding Parents' Experiences and Information Needs on Pediatric Acute Otitis Media: A Qualitative Study. *J Patient Exp* 6: 53-61.
- Danishyar A, Ashurst JV (2022) Acute Otitis Media. *StatPearls*.
- Usonis V, Jackowska T, Petraitiene S, Sapala A, Neculau A, et al. (2016) Incidence of acute otitis media in children below 6 years of age seen in medical practices in five East European countries. *BMC Pediatr* 16: 108.
- WHO (2021) World report on hearing.
- WHO (2004) Chronic suppurative otitis media: Burden of illness and management options.
- Lieberthal AS, Carroll AE, Chonmaitree T, Ganiats TG, Hoberman A, et al. (2013) The diagnosis and management of acute otitis media. *Pediatrics* 131: e964-e969.
- García Carretero R (2017) Cerebellar abscesses, infective endocarditis and bacteraemia due to a rare pathogen: *Streptococcus constellatus*. *BMJ case reports* 2017.
- Rettig E, Tunkel DE (2014) Contemporary Concepts in management of acute otitis media in children. *Otolaryngol Clin North Am* 47: 651-672.
- Soni A (2008) Ear Infections (Otitis Media) in Children (0-17): Use and Expenditures, 2006. Medical Expenditure Panel Survey STATISTICAL BRIEF #228.
- Chadha SK, Sayal A, Malhotra V, Agarwal AK (2013) Prevalence of preventable ear disorders in over 15,000 schoolchildren in northern India. *J Laryngol Otol* 127: 28-32.
- Hoy D, Brooks P, Woolf A, Blyth F, March L, et al. (2012) Assessing risk of bias in prevalence studies: Modification of an existing tool and evidence of interrater agreement. *J Clin Epidemiol* 65: 934-939.
- Chadha SK, Agarwal AK, Gulati A, Garg A (2006) A comparative evaluation of ear diseases in children of higher versus lower socioeconomic status. *J Laryngol Otol* 120: 16-19.
- Siddartha, Bhat V, Bhandary SK, Shenoy V, Rashmi (2012) Otitis media with effusion in relation to socio economic status: A community based study. *Indian J Otolaryngol Head Neck Surg* 64: 56-58.
- Sophia A, Isaac R, Rebekah G, Brahmadathan K, Rupa V (2010) Risk factors for otitis media among preschool, rural Indian children. *Int J Pediatr Otorhinolaryngol* 74: 677-683.
- Kumar S, Aramani A, Mathew M, Bhat M, Rao V (2019) Prevalence of hearing impairment amongst school going children in the rural field practice area of the institution. *Indian J Otolaryngol Head Neck Surg* 71: 1567-1571.
- Migliavaca CB, Stein C, Colpani V, Barker TH, Ziegelmann PK, et al. (2022) Meta-analysis of prevalence: I 2 statistic and how to deal with heterogeneity. *Res Synth Methods* 13: 363-367.
- Mahadevan M, Navarro-Loocsin G, Tan HKK, Yamanaka N, Sonsuwan N, et al. (2012) A review of the burden of disease due to otitis media in the Asia-Pacific. *Int J Pediatr Otorhinolaryngol* 76: 623-635.
- DeAntonio R, Yarzabal JP, Cruz JP, Schmidt JE, Kleijnen J (2016) Epidemiology of otitis media in children from developing countries: A systematic review. *Int J Pediatr Otorhinolaryngol* 85: 65-74.
- Monasta L, Ronfani L, Marchetti F, Montico M, Brumatti L, et al. (2012) Burden of disease caused by otitis media: Systematic review and global estimates. *PLoS ONE* 7: e36226.