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Panel 6: Otitis media and associated hearing loss among disadvantaged populations and low to middle-income countries

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Abstract

Objective: Summarise the published evidence on otitis media and associated hearing loss in low to middle-income countries (LMIC) and disadvantaged populations.

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AJL Chaired Panel 6, wrote the microbiology section, provided general oversight, editing and collating. PH (co-Chair of Panel 6) wrote the risk factor section and provided general oversight, CC and PSM wrote the diagnosis section, AJL, HG, and SKD wrote the epidemiology section, MB and SOT wrote the treatment section, RGJ wrote the prognosis section, KK provided general oversight. All authors read the final version.

Data sources: PubMed and other databases.

Review methods: Firstly, sensitive search strategy using 'otitis media', combined with specific key words for each topic of the review, from January 2015 to June 2019. Then, restriction to LMIC and disadvantaged populations. Topics covered included prevention, epidemiology, risk factors, microbiology, prognosis, diagnosis, and treatment.

Conclusions: There was a high degree of methodological heterogeneity and high risk of bias. The majority of studies were school-based. In Africa, Asia and Oceania (e.g., Australian Aboriginal populations) the prevalence of OM was respectively 8% (range 3–16%), 14% (range 7–22%) and 50% (4–95%). Prevalence of any hearing loss in these regions was 12% (range 8–17%), 12% (range 3–24%), and 26% (range 25–28%) respectively. Risk factors in LMIC and disadvantaged populations included age, gender, exposure to smoke and pollution. Microbiology was reported for otitis media with effusion at time of surgery or ear discharge (acute otitis media with perforation or chronic suppurative otitis media). Specimen handling and processing in hospital laboratories was associated with low detection of *S. pneumoniae* and *H. influenzae*. Case series described complicated cases of OM due to M. tuberculosis, multidrug resistance and HIV. QOL studies identified discrimination of persons with OM and hearing loss. Diagnostic methods varied greatly, from naked eye to tympanometry. Treatment interventions were reported from four RCTs. Non-RCTs included evaluations of guidelines, surgery outcomes, access to ENTs.

Implications for Clinical Practice: Chronic suppurative otitis media, otitis media with effusion and conductive hearing loss are common in LMIC and disadvantaged populations. Paucity of research, poor regional representation, non-standardised methods and low-quality reporting preclude accurate assessment of disease burden in LMIC and disadvantaged populations. Awareness and adherence to reporting Guidelines should be promoted.

Keywords

Otitis media; Low to middle income countries; Disadvantaged populations; Epidemiology; Aetiology; Risk factors; Microbiology; Diagnosis; Prognosis; Treatment

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1. Epidemiology

1.1. Introduction

PREVALENCE OF OM (Table 1) and HL (Table 2): In the previous ISOM Epidemiology Panel report, almost all new studies on OM prevalence were from developing countries Turkey, China, Bangladesh, Kenya, Nepal, and India. Prevalence of OME was 16% in Turkey ~4% in China, 12% in Egypt. The prevalence of CSOM in the entire population varies by geography as has been noted in past literature reviews and was reported among school children in Bangladesh (5.6%), and Kenya (3.3%) where prevalence was higher in rural (6%) than urban areas, and similar in boys and girls. Hearing loss was reported from Nepal (4%–27% among those with OME), Brazil (30%), Egypt (19%), Greenland (2.5–50%), Bangladesh (20%) and Columbia (2–6%). Prevalence was highly dependent on threshold for age.

1.2. Methods

Search strategy: Key words were *conductive hearing loss, otitis media, epidemiology, prevalence, incidence, survey, and cross sectional*. The search retrieved 2828 articles of which 2801 studies were rejected, and 27 studies from LMIC or disadvantaged populations (Fig. 1 were included. Of the 27 studies, 11 were from African, 12 from Asia and 4 from Oceania (including Australia). All but five prospective studies followed a cross-sectional design or survey. Ten studies reported only prevalence of otitis media (OM), seven studies reported only prevalence of hearing loss (HL), two studies reported incidence of OM, eight studies reported prevalence of both OM and HL, and one study reported both prevenance of HL and incidence of OM. Most of the study participants were children and adolescents (younger than 19 years); five studies included the general population (three from Asia, and one each from Africa and Oceania and Australia). All but one study reported the diagnostic technique and who performed the ear examination or hearing assessment, although sufficient details of hearing assessment were rarely provided. Nine studies were conducted in 2015 or later, fourteen studies were conducted earlier, and four studies did not report dates (see Fig. 2).

1.3. Discussion

A total of 18 studies (7 Africa, 8 Asia and 3 Oceania) representing 35,173 participants (17,521 from Africa, 16,182 from Asia and 1,470 from Oceania) provided a pooled prevalence of any type of OM of 16% (95% Confidence Interval (CI) 0.10–0.24) (Fig. 2). Region specific OM prevalence rates (Fig. 3) were 8% (0.03–0.16), 14% (0.07–0.22) and 50% (0.04–0.95) in Africa, Asia and Oceania respectively. The overall, pooled prevalence of OME was 10% (0.05–0.16), CSOM 6% (0.03–0.09), and other types of OM (OME with or without perforation and others) was 0.6% (0.03–0.10) (Fig. 4) [1–16].

Data from 15 studies (9 Africa, 4 Asia and 2 Oceania) representing 278,329 study participants (20,293 from Africa, 9,144 from Asia and 248,892 from Oceania) provided a pooled prevalence of any HL (conductive, sensorineural and mixed) was 14% (95% CI 0.11–0.18) (Fig. 3). Region specific prevalence rates for any level of HL were 12% (0.08–0.17), 12% (0.03–0.24), and 26% (0.25–0.28) in Africa, Asia, and Oceania, respectively (Fig. 3). The overall prevalence of sensorineural, conductive, or mixed HL was 5% (0.02–0.07), 8% (0.03–0.14) and 1% (0.0–0.03), respectively (Fig. 4) [1–4,7,10,13,14,17–23].

Studies which reported the incidence of OM estimated between 400 and 410 per 1000 population in Oceania and between 128 and 138 per 1000 population in Asia.

1.4. Implications for clinical practice and future research goals

High quality data are needed from LMICs (Lower to Middle Income Countries) and disadvantaged populations to determine disease burden at local, regional and country levels. These data would raise awareness and inform policy and practice augmentation in ear and hearing services for of children, particularly Indigenous and disadvantaged children.

2. Risk factors

2.1. Introduction

Our aim was to determine whether previously established risk factors for OM were consistent with those identified specifically among low to middle-income countries or disadvantaged populations.

2.2. Methods

The search string used was ("otitis media"[MeSH Terms] OR ("otitis"[All Fields] AND "media"[All Fields]) OR "otitis media"[All Fields]) AND ("humans"[MeSH Terms] OR "humans"[All Fields] OR "human"[All Fields]) AND English[All Fields] AND (aetiology[All Fields] OR ("risk factors"[MeSH Terms] OR ("risk"[All Fields] AND "factors"[All Fields]) OR "risk factors"[All Fields] OR ("risk"[All Fields] AND "factor"[All Fields]) OR "risk factor"[All Fields])) AND (has abstract[text] AND ("2015/06/01"[PDAT]: "2019/06/01"[PDAT]))

2.3. Discussion

There were 214 studies of which 60 remained after title screening, 16 after abstract reading and finally eight were included after text reading. These eight studies are shown in Table 3 with identified risk factor associations. The studies are from India [24], Brazil, Mozambique [25], Malawi [3], China [26], Philippines [27] and Fiji [28]. All studies are rated as having high risk of bias due to diagnostic methodology, lack of definitions, small sample sizes, lack of control groups, selection bias and use of univariate statistics etc.

2.4. Implications for clinical practice and future research goals

The methodological limitations described decrease the level of confidence in the findings, however, the risk factors identified are consistent with the evidence in other populations. We have also included some factors that are of local interest due to special local circumstances that cannot be generalized to other areas. Additional high-quality studies are needed to accurately identify risk factors associated with OM in LMIC populations.

3. Microbiology

3.1. Introduction

Previous ISOM reports have not specifically addressed aetiology, risk factors or microbiology in disadvantaged populations or LMIC. Whist there has been reports of studies of CSOM, these have not identified disadvantaged populations or LMIC separately. Microbiology panels have provided excellent reviews of laboratory and animal model studies of microbial pathogenesis, molecular epidemiology, genomics, virology, and polymicrobial interactions of the organisms known to cause OM. However, the microbiology of the middle ear was not included.

3.2. Methods

("otitis"[MeSH Terms] OR "otitis"[All Fields] OR conductive hearing loss) AND microbiology Filters: Publication date from 2015/01/01 to 2019/06/01 AND Human AND English = = 597. Title, abstract and full text search for studies that included middle ear fluid or ear disharge microbiology. Studies known to the author included.

3.3. Discussion

Twenty-two studies met inclusion criteria (Table 4). Seven studies were reviews or retrospective analyses, and 14 were original studies. Studies published between 1/1/2015 and 1/6/2019 reported that data were originally collected over a long time-period (reviews) and often ten or more years ago. Data collection dates were reported in seven reviews and retrospective analyses [29–35] and 14 original studies [16,36–47]. 2016 was the most recent data collection. Twenty-one countries were included. Data from 9 countries or populations were reported in reviews only and include Alaska Natives [35], Greenlandic [35], Chile [29], Columbia [29], Mexico [29], Venezuela [29], Ethiopia [31], India [31], Turkey [31]). Original surveillance or case series studies were reported from 10 countries: Angola [36], Nigeria [48,49], Nepal [39], Pakistan [30], Thailand [40], Indigenous Australians [16,44,47], Israel Bedouins [32,34], South Africa [42], China [45] and Malawi [46]. Several reports focussed on single pathogens [38] or pneumococcal serotypes [41,43]. All studies included children. Some included all ages [36,38], the mean age being 12 years. Twelve original studies were case series in hospitals. Community-based surveillance was reported from the Australian Indigenous population [16,47] and Papua New Guinea [43]. Diagnoses included OM [31], CSOM [16,33,34,36,38,39, 43,46–49], AOMwiP [16,29,33,40,42,43,45,47,49], any TMP [30,34,35, 37], OME [33,44,50], and AOM [29,32,34,41,42]. Twenty studies reported ear discharge (ED) findings from CSOM, any tympanic membrane perforation (TMP) (not defined), or AOMwiP. Tympanocentesis (OME cases) was reported in the three reviews([29,33,35]) and three original studies of AOMwoP [41,42]or OME [44]. Few studies described method of canal cleaning. The World Health Organisation technical advisory group on pneumococcal nasopharyngeal carriage studies recommend methods for specimen collection (including ED and MEF) and laboratory processing [51]. Most studies failed to report methods used or reported other methods [29,32,41]. We assumed that WHO methods were followed if recommended methods for transport and storage were reported [16,35–38,47]. No details were provided in reviews. One microbiome study reported otopathogens [44] Almost all studies used hospital laboratory standard culture methods and non-selective culture media [30,32,35,37,39,40,46]. Few studies used selective media [34,36], qPCR for density [33,35], or PCR for detection of A.o [33] or other pathogens [29,35]. Where pneumococcal serotypes were reported, the Quellung method was used [29,34].

Original studies: In Angola, CSOM was associated with ear discharge culture positive for Proteus (15%), Pseudomonas (13%), enterococci (9%), 87 species were identified, and pneumococcal serotype 19F was found in 4 cases, serotypes 6A and 17F were found in fewer than 4 cases each [36]. Also in Angola, 11% of 188 CSOM cases were co-colonised with *Alcaligens faecalis*, attributed to a cultural practice of using bird faeces to prevent ear secretions [38]. In Nepal, 240 patients with acute or chronic pus cultured *Staphylococcus* *aureus* (Sa)(36%), *Pseudomonas aeruginosa* (Ps.a)(33%) and no *Streptococcus pneumoniae* (Spn) nor non-typeable *Haemophilus influenzae* (NTHi) were found [39]. Sa (31%), Proteus spp. (25%) and Ps.a (23%) dominated in Nigerian children (53% of low SES) with ear discharge, 91% of whom were culture positive [37]. Among HIV-positive and HIV-negative Nigerian children with CSOM, Pseudomonas spp. was more prevalent among HIV-positive children. Cases of AOMwiP (n = 40) in Thailand were all culture positive for any of 13 organisms, with Hi (36%), Sa (26%), Spn (9%) and Ps.a (11%). Pneumococcal serotypes were not reported [40]. In 352 Pakistani children with ear pus, aspirate or MEF, 79% were culture positive. Of these around 70% were monomicrobial. Pneumococcus was present in 56% children <2 years of age, and 18% older children, and Hi was detected in 38% and 17%, respectively. Sa and pseudomonas spp. were predominant, especially in older children. Pneumococcal serotypes were not reported [52]. Australian Indigenous PHiD-CV10-vaccinated children with AOMwiP or CSOM were less likely to be culture positive for NTHi (36%) compared to PCV13-vaccinated children (64%). Proportions for Spn were 17% and 43%, Mc 8% and 7%, and Sa 40%–7%, respectively. Serotypes were reported [16]. Some studies in Israel reported findings for pneumococcal OM in the Bedouin population. One study focussed on vaccine-type and non-vaccine-type pneumococci in MEF obtained by tympanocentesis from children with AOM, but individual serotypes were not reported, nor NTHi [41].

3.4. Implications for clinical practice and future research goals

Overall, reports provided few details of microbiological methods or clinical diagnoses. The majority of studies were of ear discharge from children with CSOM presenting at hospitals. The microbiology of CSOM appears to be similar across countries and populations with a dominance of Pseudomonas and Staphylococcus, but up to 87 species have been identified. Ear discharge from AOM in younger children is more likely to identify classic otopathogens, but results are highly dependent on specimen handling and laboratory methods. If CSOM is to be prevented, a better understanding of the aetiology of AOM, particularly the role of pneumococcus and NTHi, and potential benefit of vaccines, is needed.

4. Diagnosis

4.1. Introduction

Our aim was to describe the studies of otitis media diagnostic methods that are currently used Table 5a or may be relevant to low and middle income countries (LMIC) and disadvantaged populations that live within middle and high income countries (Table 5b). We only included studies that have been published since the 2015 International Symposium for Otitis Media conference.

4.2. Methods

We searched the PubMed database using the following strategy: ("otitis"[MeSH Terms] OR "otitis"[All Fields]) AND Diagnosis/Broad [filter] AND ("2015/01/01"[PDat]:"2019/06/01" [PDat]). The Diagnosis/Broad[filter] uses the following terms: (sensitiv*[Title/Abstract] OR sensitivity and specificity[MeSH Terms] OR diagnose [Title/Abstract] OR diagnosed[Title/Abstract] OR diagnoses[Title/Abstract] OR diagnosing[Title/Abstract] OR diagnosis[Title/

Abstract] OR diagnostic[Title/Abstract] OR diagnosis[MeSH:noexp] OR diagnostic * [MeSH:noexp] OR diagnosis, differential[MeSH:noexp] OR diagnosis[Subheading:noexp]).

The search was repeated on the June 8, 2019 with 1492 articles identified. The titles and abstracts were reviewed to identify studies that were either: i) systematic reviews of diagnostic tests; ii) randomized controlled trials of diagnostic tests; iii) diagnostic comparisons with a reference standard (reporting sensitivity and specificity); or iv) describing a new diagnostic method; or v) describing a diagnostic method being used in a low or lower middle income countries or disadvantaged populations (including studies of agreement and reliability). Studies of agreement and reliability that were conducted in upper middle income and high income countries were not included unless they targeted a recognised disadvantaged population.

4.3. Discussion

Using this approach, the following were identified: i) 0 systematic reviews of diagnostic tests; ii) 2 randomized controlled trials of diagnostic tests (diagnostic training) [53,54]; iii) 12 diagnostic comparisons with a reference standard (reporting sensitivity and specificity) [55–64]; iv) 16 studies describing a new diagnostic method [56,65,66]; and v) 7 studies describing a diagnostic method being used in a low or middle income country or disadvantaged population [53,55,58,61, 67,68,69].

The evidence table is limited to include the first 3 categories (systematic reviews of diagnostic tests, randomized controlled trials of diagnostic tests, and diagnostic comparisons with a reference standard (reporting sensitivity and specificity)-see Tables 5a and 5b. To be eligible for inclusion in the evidence table, diagnostic accuracy studies needed to recruit participants who were: i) undifferentiated prior to testing; and ii) typical of individuals at risk of otitis media. Other reports of diagnostic accuracy (eg. reports from case-control comparisons) may be included in the text.

Several new technologies to identify otitis media have been described in the last 4 years (Table 5b). These include quantitative pneumatic otoscopy using a light-based ranging technique [65], red-green-blue (RGB) values of tympanic membrane (TM) images [70], store and forward of video-otoscopy images (telemedicine) [55,68], smart phone otoscopy [56,71,72], automated image analysis [73,69], tympanic membrane temperature (for unilateral AOM) [74], mean platelet volume (for cholesteatoma) [75], ultrasound (for MEE) [76], wideband acoustic absorbance testing (for MEE) [77–79], shortwave infrared otoscopy [66,80], and optical detection using spectroscopic techniques [66,80].

Finally, there were several papers describing either a new condition associated with otitis media or conditions without an agreed diagnostic reference standard. These conditions included amblyaudia, Eustachian tube dysfunction, and auditory processing disorder. Further research is needed to establish the clinical importance of these conditions and whether improvement in health outcomes is possible after the condition has been identified. For systems or geopraghic areas where there are limited resources for healthcare services, efforts to increase diagnostic capacity for OM should consider the balance of the benefit of improved diagnostic accuracy with the likelihood of achieving widespread implementaton of such efforts.

4.4. Implications for clinical practice and future research goals

Further research is needed to establish the sensitivity and specificity of new diagnostic approaches. For low-income and low middle-income countries, studies assessing the sensitivity and specificity of simple otoscopy using the available equipment in these settings are needed. In many countries, the otoscopes used in middle-income and high-income countries are too expensive to be widely available to primary healthcare workers. A better understanding of the potential health benefits of all the equipment currently in use is long overdue (Table 5a).

5. Prognosis

5.1. Introduction

OM especially in the severe form as CSOM with or without cholesteatoma can lead to hearing loss (mainly conductive), intra- and extra-cranial complications and death. In this section, recent publications have been identified describing prognosis and specifically severe complications. It is acknowledged that the majority of this research is Level V research (Case reports and reviews) and that with the Level of research it is difficult to make substantive recommendations. With this acknowledgement, there is a clear need for those with adequate resources and data to construct, where possible, broader longitudinal studies to capture additional data and to develop Level III and Level IV evidence with additional systematic reviews and consensus panels.

5.2. Methods

(((((((((“language development disorders”[MeSH Terms] OR “speech disorders”[MeSH Terms]) OR “learning disorders”[MeSH Terms]) OR “hearing loss”[MeSH Terms]) OR “facial paralysis”[MeSH Terms]) OR “labyrinthitis”[MeSH Terms]) OR “meningitis”[MeSH Terms]) OR “mortality”[MeSH Terms]) OR “cholesteatoma”[MeSH Terms]) AND “otitis media”[MeSH Terms]) OR “mastoiditis”[MeSH Terms] AND ((“2015/01/01”[PDAT]: “2019/07/01”[PDAT]) AND “humans”[MeSH Terms]). Added to search after reading:2. Complications have been broadened to anything that can contribute to the understanding of burden of OM in developing countries and indigenous populations. All study designs have been included.

434 articles identified, 366 excluded on title, 68 abstracts screened and 19 studies included (Table 6). Two studies were after reading references added.

5.3. Discussion

Complications have been broadened to anything that can contribute to the understanding of burden of OM in developing countries and indigenous populations. All study designs have been included. OM, especially in the severe form as CSOM with or without cholesteatoma, can lead to hearing loss (mainly conductive), intra- and extra-cranial complications and death.

Several studies investigated sensorineural hearing loss (SNHL) as a sign of permanent damage to the cochlea after COM. A nationwide register based study in Taiwan identified 10248 cases with COM and found a 3 times increased risk of sudden sensorineural hearing loss compared with age and sex matched controls [81]. Cochlear infection, even after AOM was described in multiple case series [82–86].

An important documentation of the variation of burden of OM and HL within a country was done in a large school based study of 1526 children in different regions of Columbia [87]. It is the only study that demonstrated a variation of perforations, sequelae and conductive HL between regions and ethnic groups.

A population-based cohort study in Greenland found a high level of OM related hearing loss and out of the 223 participants one child had OM related meningitis leading to mental retardation and bilateral deafness underlining the risk of severe intracranial complications in high risk areas [88].

Limited access to treatment of OM complications was only described in one case report from Zimbabwe where a child diagnosed with CSOM and Gradenigo's syndrome later developed meningitis with a fatal outcome [89]. Lack of funding on several steps of contact with the hospital delayed diagnosis and treatment.

Tuberculous OM, previously reported from South Africa [90] and China [91] More recently in India a case of tuberculous mastoiditis with Bezolds abscess was described [92] and a large case series with 502 patients undergoing mastoidectomy, found M. Tuberculosis in 5% of all cases [93]. The authors were concerned of a resurgence of tuberculous OM in India and made suggestions for diagnostic criteria based on clinical criteria and diagnostic tests. Tuberculous OM was associated with a higher level of severe complications than other CSOM forms.

In Nigeria a study on CSOM and its complications in a tertiary center over 20 year time period found a reduction in the prevalence of CSOM and a shift of more adults presenting in the resent years [94]. There was also a reduction in incidence of intracranial complications of CSOM, but complication rates remained largely unchanged. A new aspect of the long-term effects of untreated OM was shown in a Nepalese questionnaire based study, where 71% responded that people with OM and HL were discriminated in society [95]. A semi-structured interview among aboriginal Australians found that parents ranked OM and it's complications as the highest health concern [96]. A case series from Tanzania highlighted the impact of multidrug resistance and HIV on OM in Africa [97]. The majority of patients with prolonged illness from OM were infected with multi drug resistant bacteria and those with positive HIV status poorly responded to treatment and tended to present with complications. Cases with unusual complications or lethal outcomes can be seen in the prognosis Table [98–103]. Death from OM occurs not infrequently in low resource settings, whether due to meningitis, brain abscess or other causes [101,104].

5.4. Implications for clinical practice and future research goals

As noted above, several studies point out that CSOM leads to sensorineural hearing loss as a sign of permanent cochlear damage. Investigators in India suspect a possible rise of tuberculous otitis media leading to more complications. Reports from Africa gave concern to the impact of multidrug resistance and HIV on complicated and recalcitrant OM. In Nepal QOL studies showed the negative impact of CSOM but also demonstrated problems with discrimination of persons with OM and hearing loss. Finally, in the study from Columbia great variation of OM complications was found between regions and ethnic groups within the country. Thus, demonstrating the importance of collecting data in several regions within a nation to estimate the burden of disease. Prognostic studies in LMIC or disadvantaged populations are needed.

6. Treatment

6.1. Introduction

Treatment of otitis media in developing countries or disadvantaged populations is subject to factors that may differ from developed countries. This includes higher burden and severity of disease, lack of access to healthcare, and variations in how healthcare is delivered. We were particularly interested in research that may help us understand the impact of such factors.

6.2. Methods

A systematic review of all published studies was performed in PubMed between 01 January 2015 and 01 June 2019 with the following key words used for searching were; *treatment, therapy, surgery, antibiotic, surveillance, steroid, hearing aid, rehabilitation, clinical trial and otitis, otitis media or mastoiditis*. We retrieved 2823 titles, of which 2695 were excluded because they were case reports, studies not related to treatment, or not relevant to low resource settings or indigenous populations. After screening of abstracts, a further 85 were excluded for the same reasons, and 6 were excluded as they were not in the English language (4 in Russian, 2 in Chinese) This left 37 studies for inclusion (Table 7)..

6.3. Discussion

There are concerns about under and over treatment of acute otitis media (AOM) in low resource settings. For example, easy availability of antibiotics in some settings, and the high cost or poor accessibility of doctors, may favour self-medication with antibiotics, with potential over-treatment and development of antibiotic resistance. Conversely, low socio-economic conditions and a lack of access to healthcare may mean that AOM presenting to medical services is more severe than that seen in high resource settings and so under-treated.

Guidelines can help to target treatment of AOM. A review by Ovnat Tamir et al. [105] found that whereas watchful waiting was the standard of care for mild to moderate OM in high resource countries, this was an option in only 3 of 7 guidelines from low resource countries. A recent guideline for AOM developed by an expert panel in Brazil (Level IV evidence) was based upon data and guidelines from the USA, but it is unclear if this is or is not appropriate. In Jordan, a questionnaire study found that most physicians had good diagnostic skills for AOM, and were aware of treatment guidelines, but only half of them said they regularly adhered to these guidelines [106]. A separate study from Jordan using data from a variety of health settings found that almost all patients diagnosed with AOM were prescribed antibiotics [107]. Similarly, in Lebanon, Nasrallah et al. [108] reported that the majority of physicians were able to diagnose AOM, and many knew the criteria for treatment, but a separate study found that parents in Lebanon would often buy antibiotics directly from a pharmacy without a prescription, and that pharmacists had variable knowledge of the indications for antibiotic treatment of AOM. A survey in Turkey by Buyukcam et al. [109] found that the majority of paediatricians did not adopt a policy of watchful waiting for AOM.

For chronic serous otitis media (SOM), or ‘glue ear’, three studies in high risk populations suggest the disease behaves similar to other settings. A study of 40 patients from Pakistan showed that in 2/3rds there was resolution on conservative management [110]. In Turkey ventilation tube insertion was found to improve quality of life [111]. In New Zealand no difference was found in clinical characteristics between Maori and non-Maori children undergoing ventilation tube surgery [112].

In chronic suppurative otitis media (CSOM), there have been several reports on bacteriology and potential therapy. *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Proteus* were the most commonly isolated pathogens in South Africa, Angola, Bangladesh, Nigeria, and Yemen [36,113–115]. Resistance to common topical antibiotics such as quinolones was 2–30% depending upon setting and bacterial strain. Bareega et al. argued that in most low resource settings, empirical rather than culture directed therapy is preferable [116]. Correct administration of treatment is also critical: a trial from Egypt showed that parental education on techniques for ear wicking, and indications for antibiotic use, led to greater resolution of disease [117]. Surgical treatment for CSOM can be challenging to deliver where human, physical or financial resources are constrained. Maile et al. showed that surgical treatment for CSOM in Nepal was associated with large improvements in quality of life [118]. Smith et al. described a program for training surgeons in Cambodia, using teaching fellows who were resident in country for 4–6 months, with good learner outcomes and clinical success [119].

In recent years there has been an increasing focus on health services research and in particular in programmes utilizing community health workers (CHWs) or telemedicine to deliver ear and hearing care. A report from Malawi showed that training CHWs in ear and hearing care was feasible and effective [120]. Another from India demonstrated that it was possible to train CHWs in a cleft palate program to capture otoscopy or audiology data with simultaneous expert assessment, although this model was not without challenges [120]. An analysis of services for OM for remote Aboriginal populations in Australia showed that using telemedicine for consultation and a visiting service for surgery is at a lower cost than using a visiting service for both diagnosis and surgery, or transporting patients to a distant centre for such services [121]. Other researchers have used stake-holder engagement to evaluate important components of the ideal model for service delivery for OM. In the Pacific region, advocacy, funding and a long-term vision were identified as important [122]. For the Aboriginal population of Queensland (Australia), appropriate governance structures, shared goals, and mechanisms for feedback were identified [123]. In 2017 an expert panel defined a set of indicators that could be used to evaluate primary care programmes for OM [124]. However, the lack of a service is not the only barrier to care: in a survey from Rwanda, patients treated for CSOM reported a lack of awareness or financial constraints as the most common barriers to access to ear and hearing care [125].

6.4. Implications for clinical practice and future research goals

Very few randomized controlled trials have been undertaken in LMIC or disadvantaged populations during this time period. Researchers in these settings should be encouraged to apply high quality methods to answer the clinical questions of importance to practice in their region.

7. ISOM 2019 recommendations for reporting cross-sectional epidemiological studies on otitis media and hearing loss

7.1. Introduction

Reporting on otitis media research is complicated due to a lack of consensus on diagnostic definitions of otitis media conditions, best practice diagnostic techniques and cut-off values for normal vs. disease, the definition of hearing loss (best ear vs. any ear, average loss and number of frequencies tested for average or other method, cut-off dB threshold), and unit of analysis (ear vs. child).

7.2. Implications for clinical practice and future research goals

The Panel recommends otitis media researchers should use the STROBE checklist [126] (https://www.strobe-statement.org/index.php?id=available-checklists) for reporting of cross-sectional studies (Table 8).

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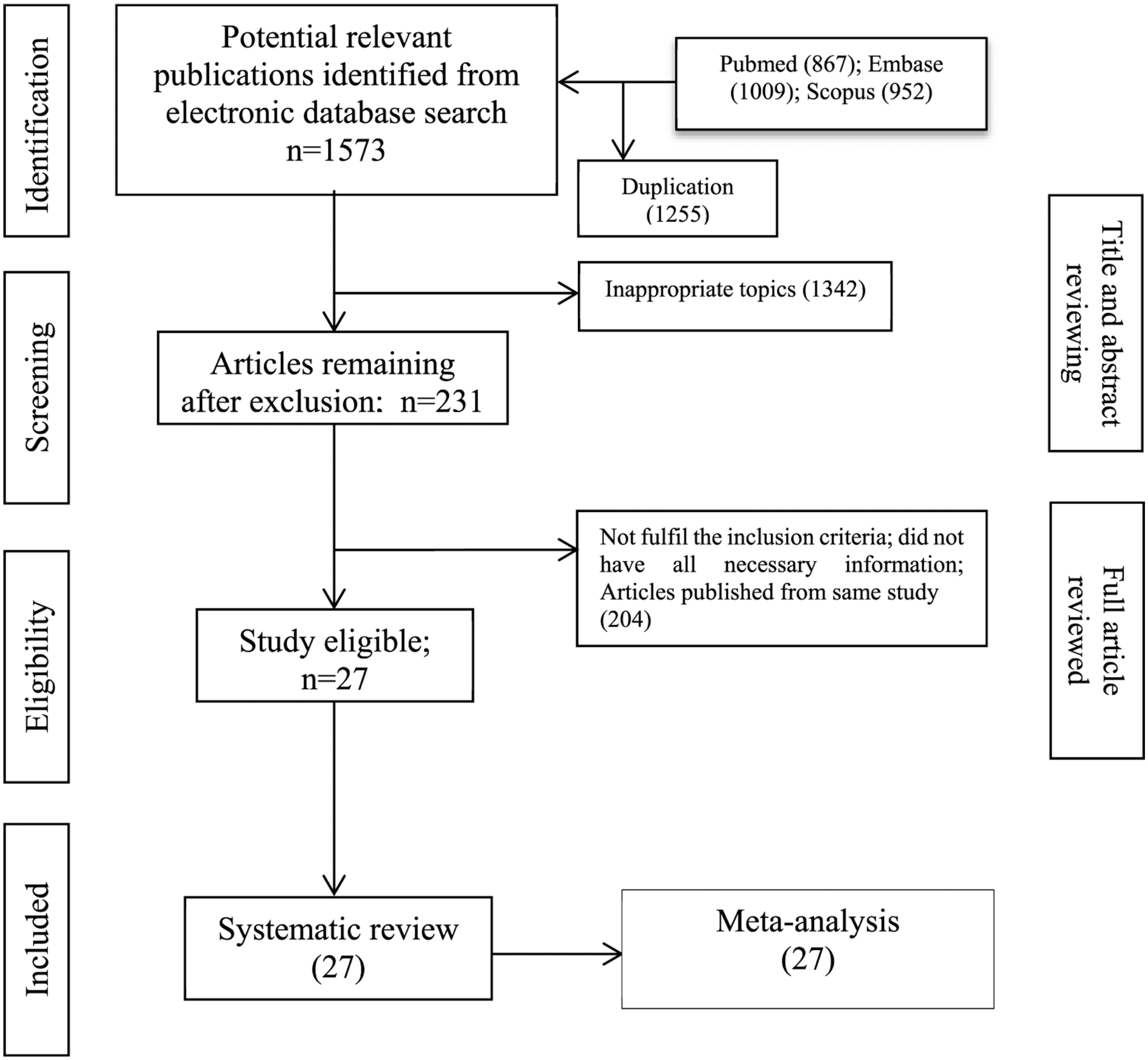


Fig. 1.

Selection framing of literature for systematic review and meta-analysis.

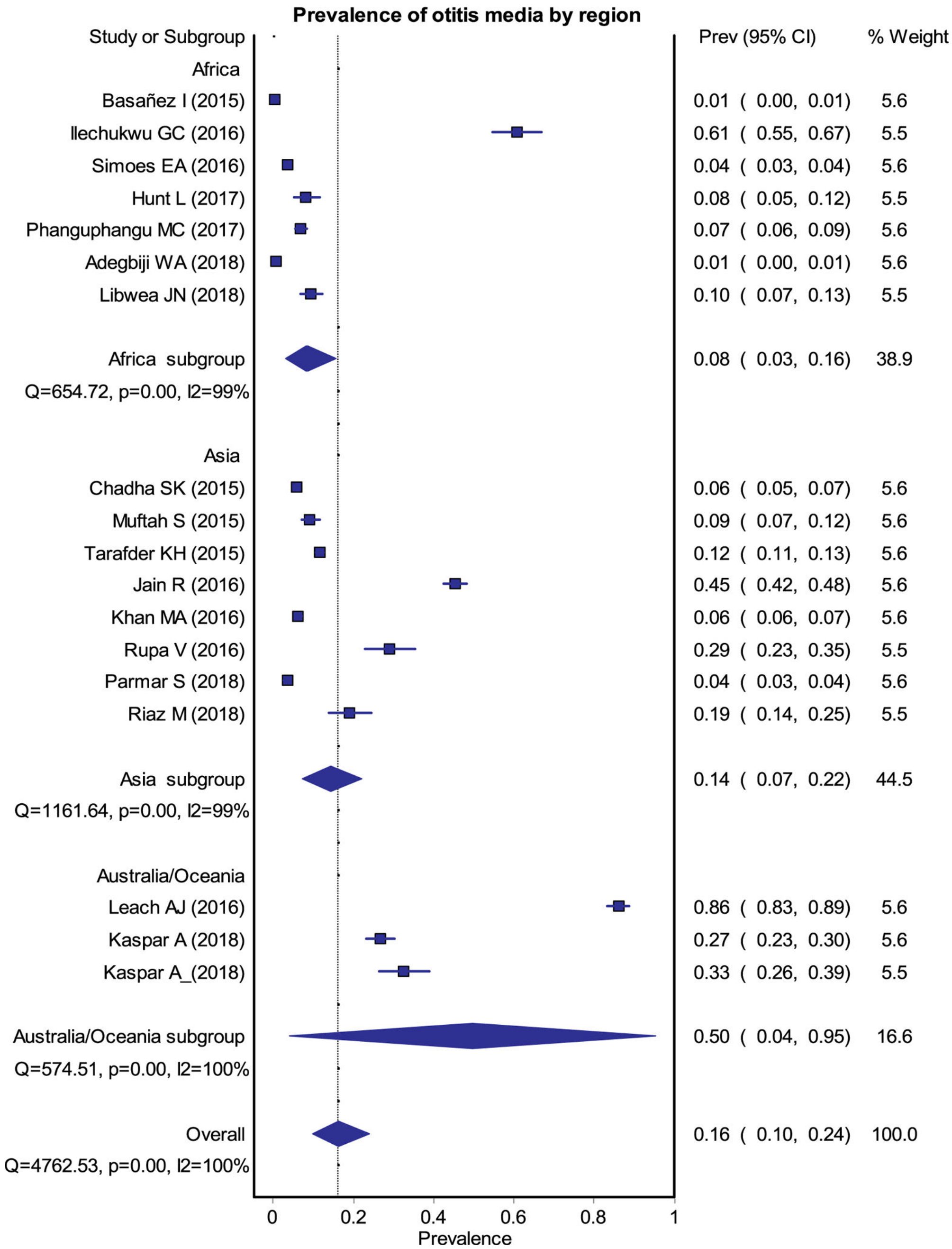


Fig. 2.

Forest plot for the pooled estimates of prevalence of any OM.

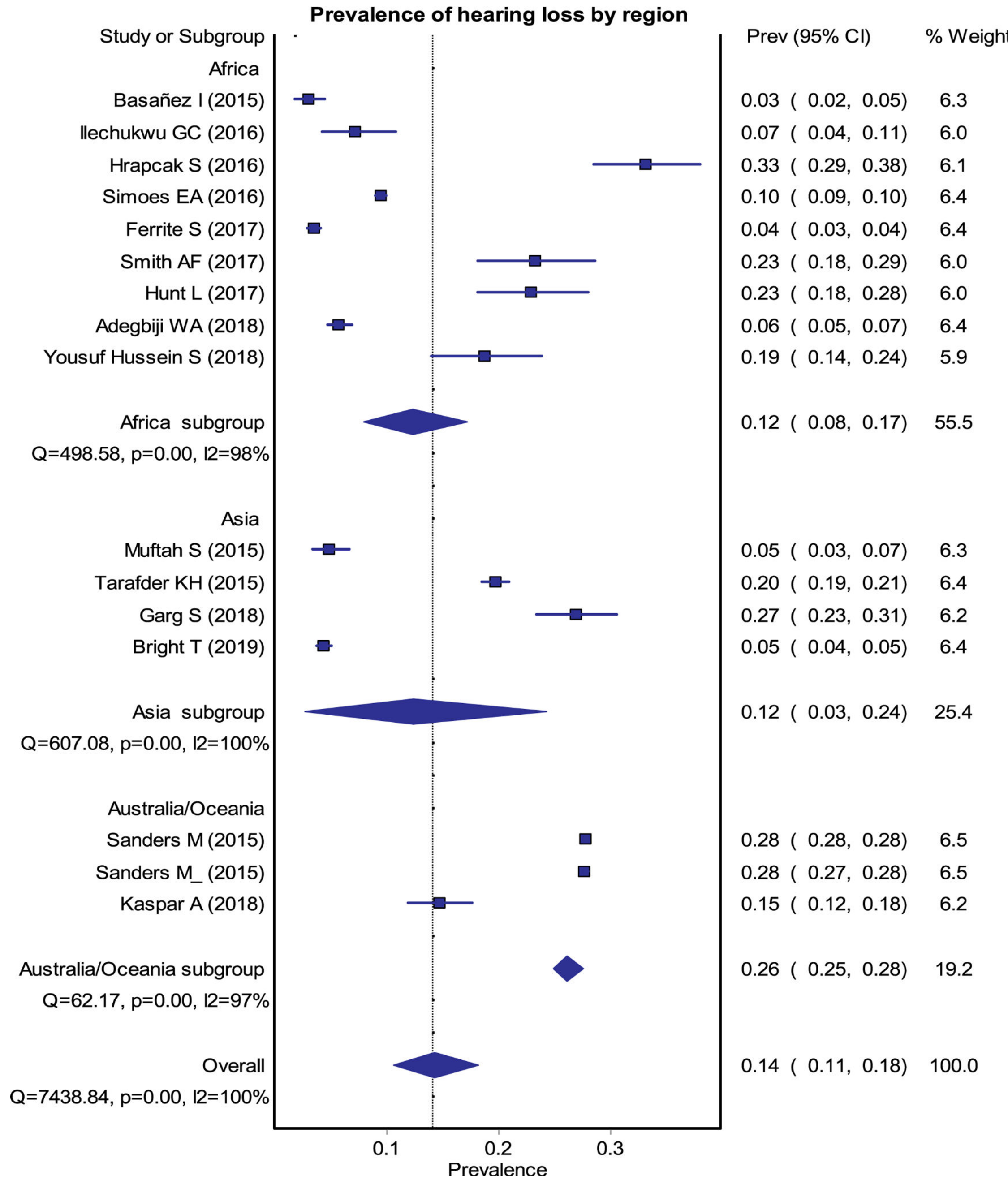
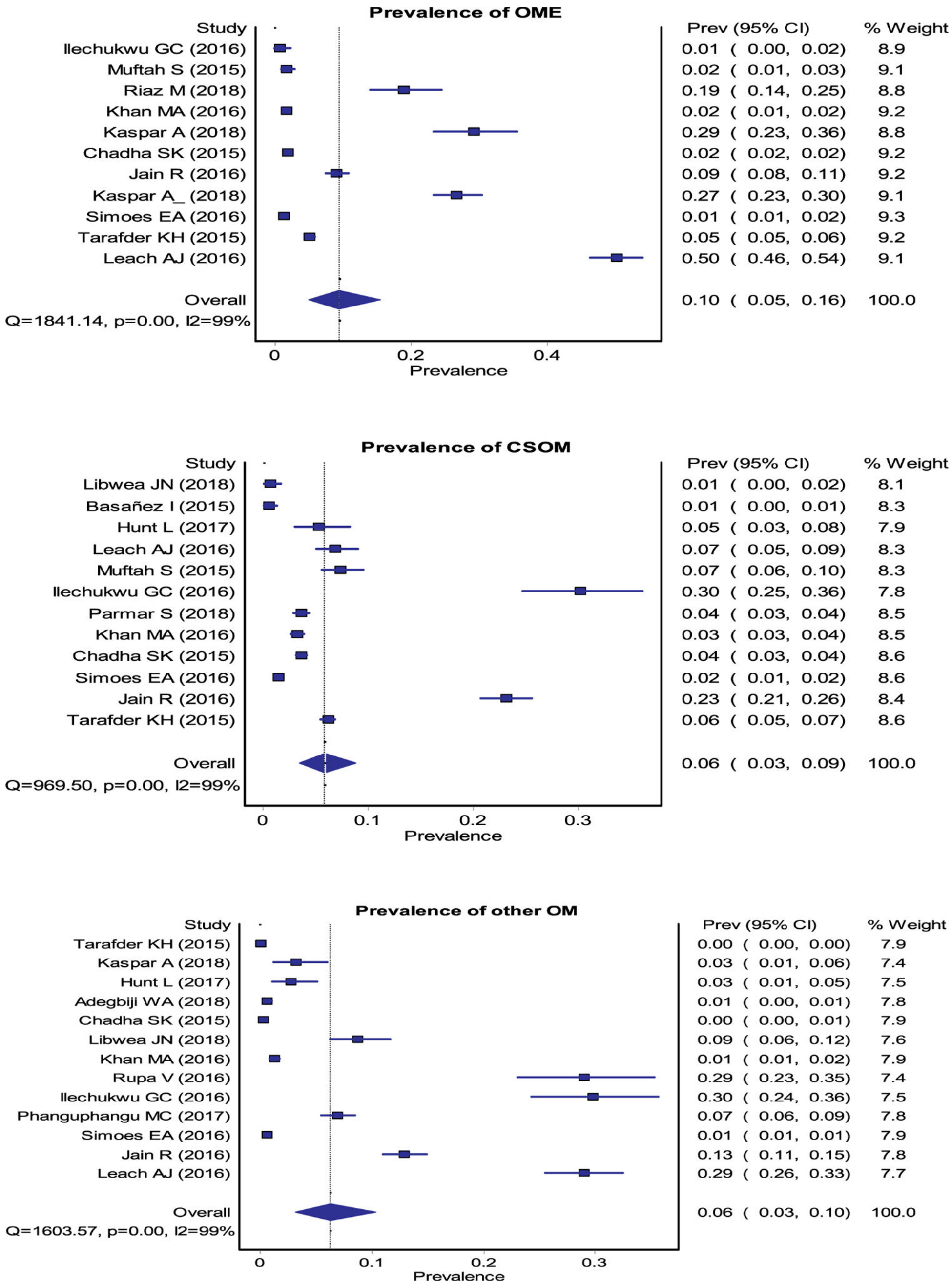


Fig. 3.

Forest plot for the pooled estimates of prevalence of any HL.


Prevalence of OME
Study
Prev (95% CI)
% Weight
Ilechukwu GC (2016) 0.01 (0.00, 0.02) 8.9
Muftah S (2015) 0.02 (0.01, 0.03) 9.1
Riaz M (2018) 0.19 (0.14, 0.25) 8.8
Khan MA (2016) 0.02 (0.01, 0.02) 9.2
Kaspar A (2018) 0.29 (0.23, 0.36) 8.8
Chadha SK (2015) 0.02 (0.02, 0.02) 9.2
Jain R (2016) 0.09 (0.08, 0.11) 9.2
Kaspar A_ (2018) 0.27 (0.23, 0.30) 9.1
Simoes EA (2016) 0.01 (0.01, 0.02) 9.3
Tarafder KH (2015) 0.05 (0.05, 0.06) 9.2
Leach AJ (2016) 0.50 (0.46, 0.54) 9.1
Overall 0.10 (0.05, 0.16) 100.0
Q=1841.14, p=0.00, I2=99%
0
0.2
0.4
Prevalence
Prevalence of CSOM
Study
Prev (95% CI)
% Weight
Libwea JN (2018) 0.01 (0.00, 0.02) 8.1
Basañez I (2015) 0.01 (0.00, 0.01) 8.3
Hunt L (2017) 0.05 (0.03, 0.08) 7.9
Leach AJ (2016) 0.07 (0.05, 0.09) 8.3
Muftah S (2015) 0.07 (0.06, 0.10) 8.3
Ilechukwu GC (2016) 0.30 (0.25, 0.36) 7.8
Parmar S (2018) 0.04 (0.03, 0.04) 8.5
Khan MA (2016) 0.03 (0.03, 0.04) 8.5
Chadha SK (2015) 0.04 (0.03, 0.04) 8.6
Simoes EA (2016) 0.02 (0.01, 0.02) 8.6
Jain R (2016) 0.23 (0.21, 0.26) 8.4
Tarafder KH (2015) 0.06 (0.05, 0.07) 8.6
Overall 0.06 (0.03, 0.09) 100.0
Q=969.50, p=0.00, I2=99%
0
0.1
0.2
0.3
Prevalence
Prevalence of other OM
Study
Prev (95% CI)
% Weight
Tarafder KH (2015) 0.00 (0.00, 0.00) 7.9
Kaspar A (2018) 0.03 (0.01, 0.06) 7.4
Hunt L (2017) 0.03 (0.01, 0.05) 7.5
Adegbiji WA (2018) 0.01 (0.00, 0.01) 7.8
Chadha SK (2015) 0.00 (0.00, 0.01) 7.9
Libwea JN (2018) 0.09 (0.06, 0.12) 7.6
Khan MA (2016) 0.01 (0.01, 0.02) 7.9
Rupa V (2016) 0.29 (0.23, 0.35) 7.4
Ilechukwu GC (2016) 0.30 (0.24, 0.36) 7.5
Phanguphangu MC (2017) 0.07 (0.06, 0.09) 7.8
Simoes EA (2016) 0.01 (0.01, 0.01) 7.9
Jain R (2016) 0.13 (0.11, 0.15) 7.8
Leach AJ (2016) 0.29 (0.26, 0.33) 7.7
Overall 0.06 (0.03, 0.10) 100.0
Q=1603.57, p=0.00, I2=99%
0
0.1
0.2
0.3
Prevalence

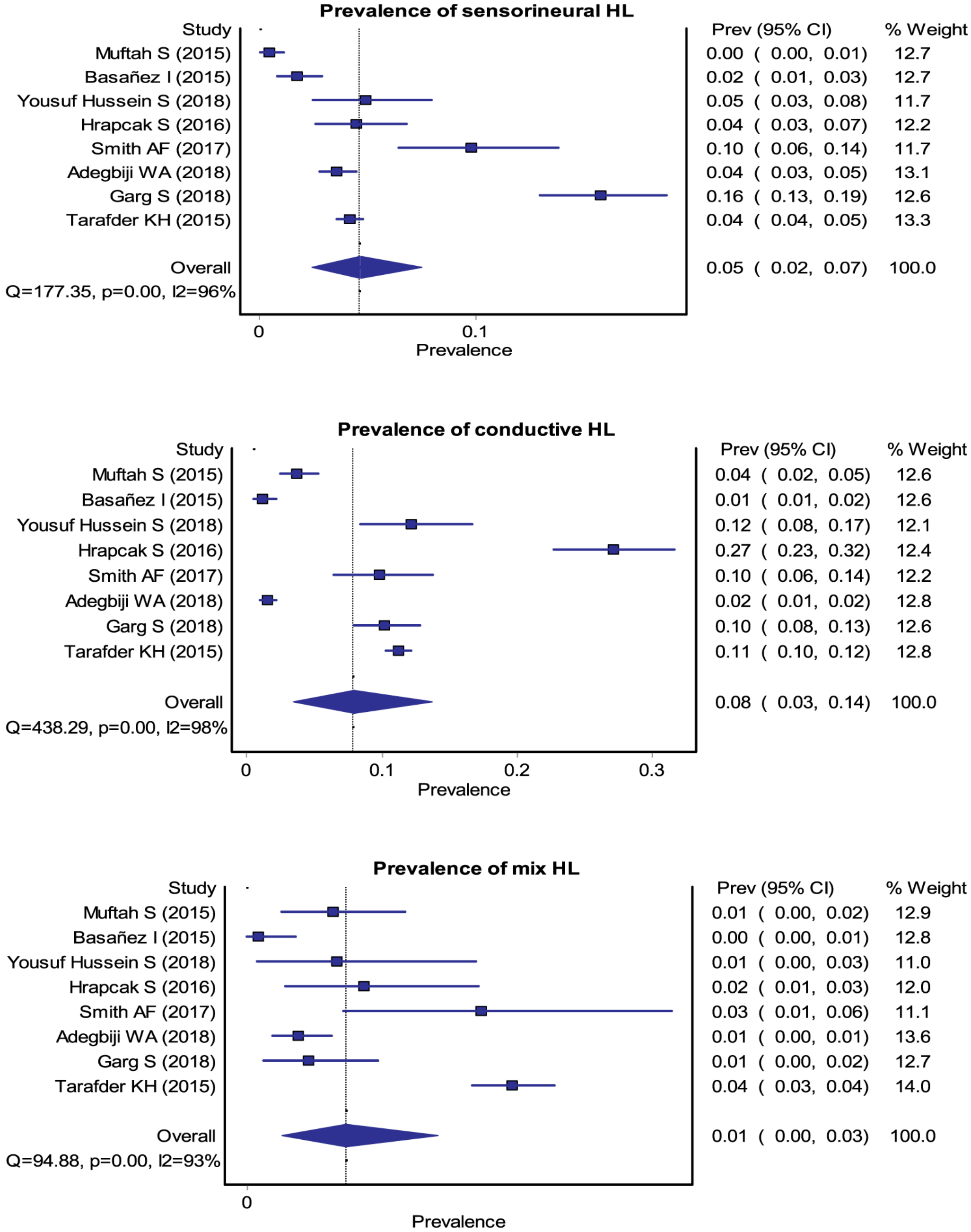


Fig. 4.

Forest plots for the pooled estimates of prevalence of OME, CSOM, SNHL, CHL and mixed HL.

Table 1

Prevalence of OM.

SI	Author (Year of publication) and date of study	Age	Study design; Sample (Country)	Methods; personnel performed examination	N	Any OM (n)	%	OME	%	CSOM	%	Other OME*	%
1	Adegbiji WA (2018), Feb 2016-Jan2018	1–5 years	Prospective; preschool children with complaints of hearing impairment (Nigeria)	Otoscope, tympanometry, otoacustic emission and auditory brain stem response audiometry; Not mentioned	1726	13	0.75	-	-	-	-	13	0.75
2	Basañez I (2015), NM	5–14 years	Cross-sectional; school-aged children in Mbarara municipality (Uganda)	Otoscopy, Tuning fork testing, Battery powered, portable Earscan 3 screening audiometer; Principal investigator	639	4	0.63	-	-	4	0.63	-	-
3	Hunt L (2017), May-Jun 2016	4–6 years	Community-based cross-sectional; school-entry age children from 10 villages in Chikhwawa district; (Malawi)	Otoscopy; Clinical Health Officer and otolaryngologists	281	23	8.19	-	-	15	5.34	8	2.85
4	Ilechukwu GC (2016), Jun-Aug 2006	0–17 years	Cross-sectional; Children presenting at the University of Nigeria Teaching Hospital ear-related problems (Nigeria)	Auroscopy, Paediatricians and otolaryngologist	248	151	60.89	2	0.81	75	30.24	74	29.84
5	Libwea JN (2018), Mar-Jun 2013	2–3 years	Community-based cross-sectional; Randomly selected children form the pneumococcal disease sentinel surveillance sites at Yaounde (Cameroon)	Pneumatic otoscop, Tympanometry (Middle Ear Analyser Grason Stadler tympanometer), Study physician	429	41	9.56	-	-	3	0.70	38	8.86
6	Phanguphangu MC (2017), Mar-Jun 2015	5–7 years	Cross-sectional retrospective study; 11 primary schools in the Waterberg District of Limpopo, Mokopane and Mookgophong, were selected for the school health campaign (South Africa)	Otoscopic examinations on pupils; Audiologists	1089	76	6.98	-	-	-	-	76	6.98
7	Simoes EA (2016), Jun-Dec 2012	2–15 years	Prospective study; preschool, elementary, and secondary school (Kenyan)	Otoscopic, Interacoustics handheld tympanometers, pure-tone audiometry; Clinical officers	13109	488	3.72	193	1.47	203	1.55	92	0.70
8	Chadha SK (2015), 2010 to 2011	18 days and 15	Pilot study, Children from non-slum urban areas, urban slums and rural area (India)	Otoscope, Oto-acoustic emission tests, loss; examining the external ear; Persons trained in ear examination and diagnoses were verified by an ENT specialist	4626	279	6.03	93	2.01	168	3.63	18	0.39

SI	Author (Year of publication) and date of study	Age	Study design; Sample (Country)	Methods; personnel performed examination	N	Any OM (n)	%	OME	%	CSOM	%	Other OME*	%
9	Jain R (2016), Jan-Jun 2013	≤18 years	Prospective study; Pediatric patients attending ENT OPD (India)	History, clinical examination and otoscopic examination	1140	517	45.35	105	9.21	264	23.16	148	12.98
10	Khan MA (2016), May–Jul 2014	5–16 years	Community based cross-sectional; 8 schools for the poor and most underdeveloped/deprived Shangla district (Pakistan)	History of ENT examination by Physicians and oto-rhino-laryngologists	2882	186	6.45	54	1.87	93	3.23	39	1.35
11	Muftah S (2015), Apr 2011–Jun 2011	6–16 years	Community-based survey cross-sectional survey; Healthy school-age children for selected 30 schools from urban and rural areas of Socotra Island (Yemen)	Clinical and otoscopic examinations, Tuning Fork examination, KAMPLEX diagnostic audiometer; **NM**	686	64	9.33	13	1.90	51	7.43	-	-
12	Parmar S (2018), NM	5–15 years	Cross-sectional survey; Randomly selected students from primary schools in rural and urban areas of Muzaffarnagar (India)5.3%	Pure tone audiometry; Otoscopic examination; **NM**	2158	78	3.61	-	-	78	3.61	-	-
13	Riaz M (2018), Dec 2016-Nov 2017	4–14 years	Cross-sectional; Children visited outdoor of ENT Sir Ganga Ram Hospital Lahore with allergic rhinitis (Pakistan)	Tympanometry; NM	220	42	19.09	42	19.09	-	-	-	-
14	Rupa V (2016), Feb-Aug 2009	0–26 months	Cohort; Rural K.V Kuppam Vellore district of Tamil Nadu state (India)	Otoscopy; Doctor or nurse	210	61	29.05	-	-	-	-	61	29.05
15	Tarafder KH (2015), 2013	≥ 0–60 years	Nationally representative cross-sectional survey; 11 urban and 41 rural areas (Bangladesh)	Tuning fork tests, Pure tone audiometry, Tympanometry, Otoacoustic emissions testing, Research physician	4260	495	11.62	226	5.31	264	6.20	5	0.12
16	Kaspar A (2018), NM	4–15 years	Cross-sectional; Primary school students in the capital city Honiara (Solomon Islands)	Tuning fork test, audiometry; Audiologist, Registered Nurses	604	162	26.82	162	26.82	-	-	-	-
17	Kaspar A (2018), Aug 2017	≥ 0–24 months	Cross-sectional; Eight Child Welfare Clinics (CWCs) in the capital city Honiara (Solomon Islands)	Vorotek-O-Scope equipment; Senior ENT Registered Nurse	215	70	32.56	63	29.30	-	-	7	3.26
18	Leach AJ (2016), Feb 2010-Aug 2013	0–6 years	Cross sectional survey; 25 Top End remote communities (Australia)	Tympanometer, pneumatic otoscopy, and a video-otoscope; Ear health research nurses	651	561	86.18	327	50.23	45	6.91	189	-

NM: Not mentioned; Other OME: OM/AOM, AOM with/without perforation: OM: Otitis media; AOM: Acute Otitis media; CSOM: chronic supportive otitis media.

Table 2

Prevalence of hearing loss.

SI	Author (Year of publication) and date of study	Age	Study design; Sample (Country)	Methods; personnel performed examination	Hearing proof/ treated; Other	Condition	N	n	%	Sensorineural	%	Conductive	%	Mixed	%
1	Adegbiji WA (2018), Febr 2016-Jan 2018	1–5 years	Prospective; preschool children with complaints of hearing impairment (Nigeria)	Otoscope, tympanometry, otoacustic emission and auditory brain stem response audiometry; Not mentioned	Not mentioned	Overall Moderate Severe Severe Profound	1726	101 3 21 48	5.85 0.17 1.22 2.78	62 -	3.59	27	1.56	12	0.70
2	Basañez I (2015), Not mentioned	5–14 years	Cross-sectional; school-aged children in Mbarara municipality (Uganda)	Otoscopy, Tuning fork testing, Battery powered, portable Earscan 3 screening audiometer; Principal investigator	The school library		639	20	3.13	11	1.72	8	1.25	1	0.16
3	Ferrite S (2017), Aug-Oct 2013	≥ 0–80 years	Population-based survey (Cameroon)	Otoacoustic emission (OAE) test in both ears; manual pure-tone audiometry (PTA) screening, Ear-Nose-Throat nurses	Conducted in the field in the quietest space available; The degree of hearing impairment was graded as 'moderate' when 41–60 dB (18+ years) or 35–60 dB (4–17 years); 'severe' when 61–80 dB and 'profound' when ≥ 81 dB.	Overall Moderate (>4 Years) Moderate (>4 Years) Moderate (> 4 Years)	3567 3092 3092 3092	127 76 15 9	3.56 2.46 0.49 0.29	-					
4	Hrapcak S (2016), Dec 2013-Mar 2014	4–14 years	Cross-sectional, HIV-infected children attending antiretroviral therapy clinic in	Otoscopy, tympanometry, transient evoked otoacoustic emissions (TEOAE), and	Portable testing van containing two sound proof booths or at Largeer	Overall Mild Moderate Severe Profound	380	126 84 26 9 7	33.16 22.11 6.84 2.37 1.84	17 6 1 3 7	4.47 1.58 0.26 0.79 1.84	103 77 24 2 0	27.11 20.26 6.32 0.53 0.00	6 1 1 4 0	1.58 0.26 0.26 1.05 0.00

SI	Author (Year of publication) and date of study	Age	Study design; Sample (Country)	Methods; personnel performed examination	Hearing proof/ treated; Other	Condition	N	n	%	Sensorineural	%	Conductive	%	Mixed	%
			Lilongwe between(Malawi)	audiometry.; Trained audiology staff	booths at African Bible College; Categories of hearing loss were defined as follows: normal (up to 20 dB), mild (21–40 dB), moderate (41–65 dB), severe (66–90 dB), and profound (≥91 dB)										
5	Hunt L (2017), May-Jun 2016	4–6 years	Community-based cross-sectional; school-entry age children from 10 villages in Chikhwawa district; (Malawi)	Otoscopy; Clinical Health Officer and otolaryngologists	Quietest available room in each community. Ambient noise levels were monitored and tests repeated if maximum permissible noise levels were exceeded		279	64	22.94	-					
6	Ilechukwu GC (2016), Jun-Aug 2006	0–17 years	Cross-sectional; Children presenting at the University of Nigeria Teaching Hospital ear-related problems (Nigeria)	Auroscopy, Paediatricians and otolaryngologist	NM		248	18	7.26	-					
7	Simoes EA (2016), Jun 2012-Dec 2012	2–15 years	Prospective study; preschool, elementary, and secondary school (Kenyan)	Otoscopic, Interacoustics handheld tympanometers, pure-tone audiometry; Clinical officers	Semi sound proof room	Overall Mild Moderate Severe	12985	1243 952 243 48	9.57 7.33 1.87 0.37	-					

SI	Author (Year of publication) and date of study	Age	Study design; Sample (Country)	Methods; personnel performed examination	Hearing proof/ treated; Other	Condition	N	n	%	Sensorineural	%	Conductive	%	Mixed	%
8	Smith AF (2017), Nov 2015-Apr 2016	7–20 years	Cross-sectional; school age children in Addis Ababa with HIV positive (107) and 147 HIV unknown (147) (Ethiopia)	Pure-tone audiometry	Circumaural headset; hearing loss greater than 25 dB		254	59	23.23	25	9.84	25	9.84	8	3.15
9	Yousuf Hussein S (2018), NM	3–6 years	Early childhood development (South Africa)	Innitial screening by HearScreen™ smartphone application, Handheld Welch Allyn or Heine mini 3000, Interacoustics Impedance Audiometer; Audiologist	NM	Overall Mild Mild to moderate Moderate Moderate to severe Severe Mild to sever	245	46 25 5 5 4 1 2	18.78 10.20 2.04 2.04 1.63 0.41 0.82	12 -	4.90	30	12.24	3	1.22
10	Bright T (2019), 2014	≥ 6 months	Population-based cross-sectional survey; (India)	Otoacoustic emissions (OAE) test,.Audiologist	Aged 6 months to 3 years 11 months: participants who failed OAE in both ears; ≥4 years: pure-tone average of thresholds at 0.5, 1, 2, and 4 kHz in the better ear of ≥41 dB HL in adults (≥18 years of age) and ≥31 dB HL in children (4–17 years of age	Overall Mild Moderate Severe Profound	3573	313 160 104 34 15	8.76 4.48 2.91 0.95 0.42	-					
11	Garg S (2018), Jan-Jun 2017	≥3 months (32.17 ± 20.85)	Community-based cross-sectional, rural and urban areas of Delhi (India)	Handheld oto-acoustic emission (OAE) in children <5 years of age and pure tone audiometry (PTA) in persons	Mild (26–40 dB), Moderate (41–60 dB), Severe (61–80 dB), Profound (>81 dB)	Overall Mild Moderate Severe Profound	595	160 48 22 82 5	26.89 8.07 3.70 13.78 0.84	94 -	15.80	61	10.25	5	0.84

SI	Author (Year of publication) and date of study	Age	Study design; Sample (Country)	Methods; personnel performed examination	Hearing proof/ treated; Other	Condition	N	n	%	Sensorineural	%	Conductive	%	Mixed	%
				>5 years; Not mentioned											
12	Muftah S (2015), Apr-Jun 2011	6–16 years	Community-based survey cross-sectional survey; Healthy school-age children for selected 30 schools from urban and rural areas of Socotra Island (Yemen)	Clinical and otoscopic examinations, Tuning Fork examination, KAMPLEX diagnostic audiometer; Not mentioned	Soundproof headphones; normal (<30 dB), mild (31 dB-40 dB), moderate (41 dB-60 dB), severe (61 dB-80 dB), and profound (>80 dB), **Prevalence of Hearing loss among children with disabling hearing impairment*	Overall Mild Moderate Severe	686	34 16 13 2	4.95 2.33 1.90 0.29	3* -	0.44	26*	3.79	5*	0.73
13	Tarafder KH (2015), 2013	≥ 0–60 years	Nationally representative cross-sectional survey; 11 urban and 41 rural areas (Bangladesh)	Tuning fork tests, Pure tone audiometry, Tympanometry, Otoacoustic emissions testing, Research physician	No impairment (0–25 dB), mild impairment (26–40 dB), moderate impairment (41–60 dB), severe impairment (61–80 dB) and profound impairment (greater than 80 dB)	Overall Mild Moderate Severe Profound	4260 4260	1215 1112 258 53 49	28.52 26.10 6.06 1.24 1.15	178 -	4.18	478	11.22	152	3.57
14	Kaspar A (2018), NM	4–15 years	Cross-sectional; Primary school students in the capital city Honiara (Solomon Islands)	Tuning fork test, audiometry; Audiologist, Registered Nurses	Non-sound-treated room		604	89	14.74	-					

SI	Author (Year of publication) and date of study	Age	Study design; Sample (Country)	Methods; personnel performed examination	Hearing proof/ treated; Other	Condition	N	n	%	Sensorineural	%	Conductive	%	Mixed	%
15	Sanders M (2015), 2008	≥5 years	Census data (Soma)	Not mentioned	Not mentioned	Overall 20–34 dBHL 35–49 dB 50–64 dB 65–79 dB 80–94 dB ≥95 dB	160987	44754 29783 10303 3220 966 322 161	27.80 18.50 6.40 2.00 0.60 0.20 0.10	-					
		≥5 years	Census data (Tonga)	Not mentioned	Not mentioned	Overall 20–34 dBHL 35–49 dB 50–64 dB 65–79 dB 80–94 dB ≥95 dB	87301	24182 15801 5675 1833 524 175 175	27.70 18.10 6.50 2.10 0.60 0.20 0.2	-					

Table 3

Risk factors for OM.

Author, Year of study, Year of publication, Journal/Conference	Country, Population	Study design	Population - risk group, age	Diagnostic method	Outcome	Study period	Risk of bias	Results and Conclusions
T. Bandyopadhyay; E. V. Raman 2018 Indian J Otolaryngol Head & Neck	Indian urban children	Case-control Selection method of controls not mentioned	Children 1–10 years old. 50 from tertiary care and 50 controls	Otoscopy, tymp, history recording,	Describe epidemiological characteristics and risk factors for OME	2012–2014	High Only univariate statistics	**Not significant:** Birth order, maternal age >30, prematurity, perinatal complication, Nose block, allergy, siblings, family structure, accommodation pattern **Significant:** NICU attendance, Bottle feeding, passive smoking, daycare,
Bowatte et al., 2018 Int J Environment Research and Public Health	Mozambique Bhopal Sao Paulo	Systematic review	Children various ages	Systematic review	Air pollution and OM	Older studies from 1990’s	High (rely on cross-sectional studies and case-control)	Higher risk with charcoal or wood use in houses (OR 3.09–3.18), living close to coking works, and air polluted areas
Hunt et al., 2018 PlosOne	Malawi	Cross-sectional with clinical examination	281 children aged 4–6 years	Video-otoscopy and hearing test	Chronic OM and risk factors	2016	High Cross-sectional	No significant associations
Deng et al., 2017 Chemosphere	Changsha, China	Retrospective	1617 children aged 3–4 years	Parental questionnaire	Lifetime prevalence of OM and pre- and postnatal pollution	2011–12	High Retrospective - parental questionnaire	adjusted OR (95% CI) = 1.44 (1.09–1.88) for a 27 μg/m^3 increase in SO_2 and postnatal exposure to indoor renovations with OR (95% CI) = 1.62 (1.05–2.49) for new furniture and 1.81 (1.12–2.91) for redecoration
Santos-Cortez et al., 2016 Otolaryngol Head Neck Surg	Philippines, community	Cross-sectional clinical study	All ages (n = 187)	Otoscopy, interviews, genetic testing	Identification of genetic and environmental determinants for OM	?	High Cross-sectional small survey	no association between otitis media and age, gender, body mass index, breastfeeding, tobacco exposure or deep swimming Association with A2ML1 genotype (OR 3.7 (95%CI: 1.3, 10.8; p = 0.005)
Fang et al., 2016 Int J Ped Otorhinolaryngol	Fiji	Cross-sectional clinical study	Children 0–18 years (n = 467)	Otoscopy and tympanometry	Examine prevalence, clinical features and QoL	2015	High Cross-sectional, wide age-range	**Significant:** Age (OR 0.53, 95% CI: 0.36–0.77) is a significant predictor of AOM, whereas male gender (OR 2.46, 95% CI: 1.13–5.37), smoke exposure (OR 2.81, 95% CI: 1.01–7.82), and concomitant chronic sinusitis (OR 6.05, 95% CI: 2.31–15.88) are significant predictors of OME.
Wang J et al., 2016 Acta Otolaryngol	China	Case-control Age-matched	Adults - Han Chinese - 206 cases and 210 controls	Otoscopy and standardized questionnaire	Risk factors for CSOM	?	High Case-control. Controls not described. Not validated questionnaire	male (OR1/40.42; 95% CI: 0.21–0.83), BMI increasing (OR1/40.85; 95% CI: 0.77–0.93), URTI (OR1/4152.85; 95% CI: 34.11–684.93), smoke/passive smoke (OR1/47.11; 95% CI: 3.36–15.07), residential location (urban area) (OR1/40.27; 95% CI: 0.13–0.56), serum calcium increasing (OR1/40.09;

Author, Year of study, Year of publication, Journal/Conference	Country, Population	Study design	Population - risk group, age	Diagnostic method	Outcome	Study period	Risk of bias	Results and Conclusions
								95% CI: 0.01–0.71) were prime risk factors for CSOM
Orji et al., 2014 EAORL	Nigeria	Consecutive series of cases presenting at tertiary hospital	All ages 128 non-healing 58 healing	Not mentioned	Risk factor difference between healing (within 6 months) and non-healing (>24 months) CSOM	2010–2012	High Hospital selected cases Methods not mentioned	**Significant:** by logistic regression analysis: rural residence, multidrug-resistant bacteria, and bilateral CSOM (P = 0.001, 0.001, and 0.008, respectively). Others were onset of ear discharge before the age of 10 years, diabetes mellitus, persistent rhinorrhoea, home [10 miles away from hospital, and [7 persons in a family (P = 0.012, 0.041, 0.013, 0.010, and 0.043, respectively

Table 4

Microbiology of ear discharge (ED) or middle ear fluid (MEF).

Author, Year of publication, Year of data,	Country, Population	Study design	Study Question Population - risk group, age	Diagnostic method	Specimen collection and transport method	Culture conditions, PCR included, serotype method	Results
Coleman 2018 [2] Data 1972 to 2016 Search to 15/8/17	Australian Aboriginal communities (22) Alaskan (1) Greenlandic (2)	Review [PRISMA] See additional file for search strategy. Quality	Microbiology of OM in Indigenous children < 18 yo	NP at time of OM ED of CSOM MEF if OME	Table 2. Mostly culture. WHO methods not mentioned in review.	Culture Pathogens, some PCR	ED - Less otopathogens cultured cf molecular methods ED (CSOM): Ps.a and Sa MEF (OME): otopathogen < 20% NP: high otopathogen in both AOM & OME (no controls) = = 75%
Van Dyke 2017 [3] GSK Data 2006 to 2011	Including (%PCV7): Chile (2%) Columbia (18%) Mexico (42%) Sth Africa (9%) Thailand (0%) Venezuela (74%)	Pooled analysis of observational studies	Review of AOM Spn serotypes and NTHi. Children < 5yo with AOM	AOM: otoscopy and tympanometry. OME: type B tymp CSOM > 2w or > 6w	Tympanocentesis (AOMwoP) Ear discharge (AOMwiP) Amies <48hr.	Selective agars. Culture ± PCR. Quellung	Countries very similar. MEF or ED: Spn & NTHi ≫ S.pyogenes & Mcat 2006 to 2011: Spn: PCV_{VT+6A} dec NTHi inc relative risk Sth Africa, Spain, Venezuela: NTHi < Spn
Lewnard 2017 [4] (2004 to 2016)	Bedouin population survey	Retrospective analysis of clinical and microbiology data	Rates of clinical progression from NP carriage to MEF culture + ve in PCV-vaccinated vs PCV-non-vaccinated	ED MEF if required Chronic and acute cases	See Dagan 2000, Ben-Shimol 2016	Quellung	Progression from NPcarr to ED/MEF < 12 mo old: dec by 92% (Bedouin), 80% (Jewish) > 12 mo old: dec by 32% (Bedouin) 61% (Jewish)
Jervis-Bardy 2017 [5] 2004 to 2016	Australian Indigenous Remote communities	Review of OME surgeries in hospital and published data on ED microbiology.		ED from cases of AOMwiP CSOM MEF from OME	Mainly WHO methods for culture	Selective and non-selective media. qPCR	Culture: ED (AOMwiP): NTHi 31–57%, & Spn 4–35% ≫ Mcat 0–6%, Sa, Spy Bacterial Load predicts severity PCR: A. otitidis co-infection in OME (10/22 + ve for Aboriginal & non-Aboriginal children). PCR inc detection of NTHi, Spn & Mcat in ED. ED (CSOM): Ps.a 62%. NTHi (greater in << 6yo) MEF (OME in surgery canal sterilised): Ps.a, Sa 3 to 42% culture + ve. (1985, 2003, 2007)
Ilechukwu 2017 [6] Data July & Sept 2007	Nigeria Hospital	Consecutive case series	Children 1mo to 17yo. N = 100 Exclusion: foreign bodies, Antibiotics < 2 weeks, OE	Any ED	Otoscopy, canal clean EtOH, swab. No STGG, no −70 °C.	Aerobic culture. Choc agar (candle jar). Cystine-Lactose-Electrolyte deficient (CLED) agar	53% Low SES. ED: 91% culture + ve. Acute ED: Sa 31% Proteus 25% Ps.a 23% Chronic ED: Proteus 39% Sa 28%. No Spn or Hi

Author, Year of publication, Year of data,	Country, Population	Study design	Study Question Population - risk group, age	Diagnostic method	Specimen collection and transport method	Culture conditions, PCR included, serotype method	Results
Filipe 2017 [7] Data 2016	Angola Hospital	Case series. Patient selection methods not specified	Traditional use of bird faeces to prevent ear secretions caused by primary ear infection All ages N = 188	ED related to OM	ED: Clean canal w EtOH. Swab in STGG −70 °C to Sweden	Culture (online techappendix - NA)	ED (CSOM): Alcaligens faecalis co-colonisation in 11%, mostly with Ps.a (50%) Fluoroquinolone R? Recommendation - change to colistin ±oral amoxi-clav
Basnet 2017 [8] Data May 2015 to Jan 2016	Nepal Hospital ENT.	Prospective case series. Patient selection not specified.	N = 263 pus samples from 240 patients	Pus present - 151 chronic 65 acute pus	Hospital lab using standard protocol. Swab in peptone water.	BA, CA, Mannitol, MacConkey agars.	ED: 216 culture + ve Sa 36%, Ps.a 33%. All sens to Gent. All Ps.s sens to Imipenem. All Sa sens to Amikacin (co-trimox 55%) No Spn nor Hi -(even in acute type OM)
Sonsuwan 2016 [9] Data 2008	Thailand Hospital Dept ORL	Prospective = = consecutive AOMwiP cases	Age 3mo – 5yo (mean 24mo) with AOMwiP N = 40	AOMwiP = = fever, pain, non-chronic. Exclusion: antibiotic treatment, tympanostomy tubes, pneumococcal or NTHi vaccine	ED swab	Culture & sensitivity Chocolate, Blood and MacConkey agars	ED: 100% culture + ve 13 organisms Hi 36%, Sa 26%, Spn 9% (no serotypes), Ps.a 11% Hi sensitivity amp 74% co-tri 47% Excluded coag -ve Staph
Shakoor 2016 [10] Data 2004 to 2013	Pakistan Hospital laboratory data	Retrospective case series	Pre-Hib (2004 to 2008) versus post-Hib (2009 to 2013) vaccination. Children 0–24mo (n = 179) and 25–58mo (n = 98)	None. Ear pus, aspirate, MEF ear fluid.	Ear pus. Methods not specified.	Standard methods across multiple labs. No Hib test!	ED: 277/352 (79%) children were pathogen + ve. AGE: 0–24mo (n = 179), 134 (75%) monomicrobial, Spn 56% Hi 38% 25–58mo (n = 98), 68 (69%) monomicrobial, Spn 18% Hi 17%. Sa, Ps.a most common in both age groups, esp older. Post-Hib: n = 159. 33% polymicrobial. Sa 38%, Psa. 26%. Spn 27%, Hi 25%, Spy 6%
Ofogbu 2016 [11] Abstract only, no date of data collection	SE Nigeria Hospital	Prospective. HIV+ vs age and sex-matched HIV-ve children mean age ~7yo & ~8yo	HIV+ vs HIV-ve micro of CSOM	Chronically discharging ears	ED swabs culture and sensitivity. No detail in abstract	NA	ED: Ps.a most prevalent in HIV + ve Fungal elements more common in HIV-ve
Leach 2016 [12] Data Feb 2010 to Aug 2013	Northern Territory Aboriginal and Torres Strait Islander remote communities	Cross sectional comparison of vaccine groups. PHiD-CV10 vs PCV13	Children < 6yo	AOMwiP < 6w & perf < 6w CSOM > 6w & perf >2% Dry Perf Any TMP Otoscopy	WHO methods STGGB −70 °C	Selective and non-selective agar. Quellung	ED swabs collected from 51/511 children in PHiD-CV10 & 11/140 in PCV13 PHiD-CV10:PCV13 NTHi 36%:64% Spn 17%:43% Mc 8%:7% Sa 40%:7% Serotypes in ED:

Author, Year of publication, Year of data,	Country, Population	Study design	Study Question Population - risk group, age	Diagnostic method	Specimen collection and transport method	Culture conditions, PCR included, serotype method	Results
							PHiD-CV10 = = 11A, 15A, 16F, 19F, 21, 22A, 35F PCV13 = = 33F, 1, 9N, 35B
Flasche 2016 [13] Data 2009	Israel Bedouin. Hospital	Prospective daily first 4 patients in paediatric emergency. < 2yo	Value of NP carriage in < 5yo to monitor serotypes causing OM in < 2yo OM incidence.	acute symptoms (<7 days) necessitating a visit to clinic or hospital and resulting in MEF culture	NP swab in < 5yo MEF in < 2 yo via tympanocentesis. Swabs of MEF into Amies processed within 16hrs	Gent BA. Quellung	NP: in < 5yo - inc non-vaccine types (non-VT replacement). ED: in < 2yo - smaller inc in non-VT OM Suggests non-VT are less virulent than VT. Bedouin and Jewish - same trend. No NTHi reported No individual serotypes reported.
DeAntonio 2016 [14] Data 2002 to 2011	Developing and newly industrialised. Assume hospitals	Systematic Review Epidemiology and aetiology.	Children < 6yo	Any OM Studies reporting pathogens causing OM	No details	No details	TABLE 3 ED 2002 Nigeria: AOM n = 53. Spn 9%, Hi 7%, Sa 25% 2001 Ethiopia: CSOM n = 63 Sa 8% 2004 India: CSOM n = 278 Ps.a 10% (<2yo) 2006 Turkey; AOM n = 120 Spn 36–38%, Hi 16–24%
Ben-Shimol 2016 [15] Data 2004 to 2015	Israel Bedouin Population based	active surveillance	< 3 yo N = 7475	All OM episodes submitted for MEF.	See Ben-Shimol 2014, Dagan 2000. Amies processed within 12hrs	Non-selective agar for Spn, NTHi, Mc, GAS, culture -ve.	MEF: 64% culture + ve. Spn 30%. NTHi 26%. Spn+NTHi 12%. Other 5% Spn-OM incidence dec in both Bedouin & Jewish children (−22%,−36%) NTHi-OM dec in Bedouins (−17%) OM-other inc (53%) OM-ve dec in Bedouin (−29%)
Madhi 2016 [17] Data May 2009 to April 2010	Sth Africa Hospital	Primary Health Care prospective	AOM in HIV ± in 3mo to 5yo, n = 260 episodes in 248 children	AOM symptoms + bulging… or otorrhoea	NPA - Viral PCR MEF - ED or tympanocentesis culture. Amies transport < 16hrs.	Selective agar. Quellung.	ED or MEF: Bacteria 54%. Hi 31%. Spn 20%, Sa 16%, Mc 5%, GAS 1.5%. Spn non-sus 64% 19F 23%>19A 11% = 15B11%. Resp viruses 74% cases. Rhinovirus 38% ± bacteria HIV + ve = = HIV-ve
Aho 2016 [18] Data 2005 to 2009	Papua New Guinea Community	RCT of PCV7 in neonatal, infant and control groups.	Birth to 18 months of age Spn infection in ED of 49 episodes of AOMwiP or CSOM (n = 13, 20, 16) in 36 children (all fully vaccinated)	Purulent ear discharge on examination	WHO method in STGGB −70 °C	WHO methods. Selective agar. Semi-Q. Quellung	ED: Spn isolates in ED 46% (6/13), 65% (13/20) and 50% (8/16) in neonatal, infant and control vaccine groups. 27 Spn isolates. VT = 1,1, & 3. Non-VT 6,10,4. 19A in 7/33 PCV7 gps vs 1/16 controls.
Nwokoye 2015 [16] Data no date	Nigeria Hospital (13mo)	Prospective case series	212 children 6mo to 10y with OM requiring treatment. 130 AOM (61%) 82 CSOM	AOM acute pain +fluid+opaque+dec mobility. Probably AOMwiP and	No details	ED aerobic + anaerobic culture. Refer to Nwokoye 2012 (not on Pubmed)	< 1 yo peak incidence of AOM & CSOM. ED: AOM = 55%, CSOM = 45% Aerobes in AOMwiP: Hi (12), Mc (8), Sa (66), Spn (32) GAS (6)

Author, Year of publication, Year of data,	Country, Population	Study design	Study Question Population - risk group, age	Diagnostic method	Specimen collection and transport method	Culture conditions, PCR included, serotype method	Results
				CSOM current and previous ED			
Leach 2015 [19] Data 2008 to 2011	Northern Territory Aboriginal and Torres Strait Islander. Remote community.	Cross-sectional survey. ED from AOMwiP or CSOM in PCV7 vs PHiDCV10 era	PCV7: 60 children, 85 perforations. PHiD-CV10: 47 children, 59 perforations.	Otoscopy and tympanometry	WHO method in STGGB	CNA, BVCCA. Filter if swarming Proteus spp. Spn, NTHi, Mcat, Sa	ED: PCV7 : PHiD-CV10 Spn 25% : 18% NTHi 61% : 34% (p = 0.008) Serotypes in ED 12 serotypes in the PCV7 group: 10A (n = 4), 7F (n = 2), 11C (n = 2) and one each of 10F, 12F, 16F, 17F, 19A, 19F, 23F, 6A and 6C. The hierarchy of 7 serotypes in the PHiD-CV10 group: 11A(n = 2) and one each of 15A, 16F, 19F, 21, 22A and 35F.
Jervis-Bardy 2015 [20] May-June 2014	Australian Aboriginal Alice Springs General Hospital ENT	Baseline for OME RCT	Mean age 5.4 yrs	Bilateral OME + HL + type B tympanogram. NP, MEF, Adenoid N = 11	WHO method in STGGB −80 °C	16S rRNA No culture	3 sites. N = 8 with sufficient bacterial biomass for microbiome analysis. Si variation in microbial diversity by site. Common to all sites: Mc, Hi, Sp. MEF: less diversity Ao & HI. Ao not in NP or adenoid.
Ding 2015 [21] Jan 2011 to Dec 2013	China, Suzhou Hospital	Prospective cases	All children < 18yrs with AOMwiP N = 229. CSOM excluded	AOM confirmed by Otolaryngologist	MEF culture. Immediate plating.	Gentamicin BA, CA only	ED or MEF: 159(69%) + ve for bact pathogens. Spn 47%, Sa 19%, Hi 7% 19F>19A predominant = = 80%
Chirwa 2015 [22] July-Sept 2013	Malawi Hospital (ENT)	Cross sectional descriptive CSOM random sampling	Mean age 18 yrs. 2 to 64 yo. N = 104	CSOM > 2w mostly purulent, scant in 53%	ED. Transported in anaerobic jar	Aerobic - BA, MacConkey, CA. no details for Spn, NTHi or Mc Anaerobic	ED: P. mirabilis 29%, Sa 20%, Ec 8% Anaerobes 35%

Table 5a

Diagnostic studies conducted in LMIC or disadvantaged populations.

Country	Study Population	Method of diagnosis	Reference
Australia (Aborigine populations)	1699 children (aged 0–17years)	Age appropriate audiometry, tympanometry, standard and pneumatic video-otoscopy	Gunasekera 2018
Philippines	47 children (aged less than 18 years)	Operating otoscope, video otoscope, tympanometry, distortion product otoacoustic emission, audiometry screening using noise cancelling headphones and a handheld Android device	Chan 2019
Ethiopia	173	Ear discharge, otoscope with headlights where available otherwise naked eye was employed	Gorems 2018
Indonesia	36 (17–50 years)	Persistent or recurrence of ear discharge for more than 2 months, perforated tympanic membrane and negative findings of cholesteatoma from physical examination or radiological examination	Darmawan 2018
India	3000 patients	(ENTraview A store-and-forward telemedicine device that integrates a camera-enabled smart phone with an otoscope)	Gupta 2017
		Commercial video otoscopes	Myburgh 2016
Yemen	150 children	Ear discharge	Bin Mohanna 2016
India	30 patients (15–45 years)	History taking, clinical examination, pure tone audiometry, X-ray examination of mastoids	Santesh 2016
Nigeria	3021 Children (less than 18 years)	Medical history and auroscopy	Ilechukwu 2016
Malawi	104 patients with mean age 17.8	Detailed clinical history, including duration of discharge	Chirwa 2015
Iran	62 adults	Thorough medical history, physical examination including anterior rhinoscopy and otoscopy. History of chronic otorrhoea (persisting for at least 3 months), accumulation of mucopurulent exudates in the external canal or middle ear and/or perforated tympanic membrane on otoscopy.	Nemati 2015
Tanzania	301 adult patients	Medical history, otoscopy, Rinne’s test, Weber’s test for assessment of hearing loss. Discharge for more than 6 weeks, tympanic membrane perforation	Mushi 2016
India	502 patients	tympanomastoidectomy	Kameswaran 2017

Table 5b

Evidence table of relevant diagnostic studies.

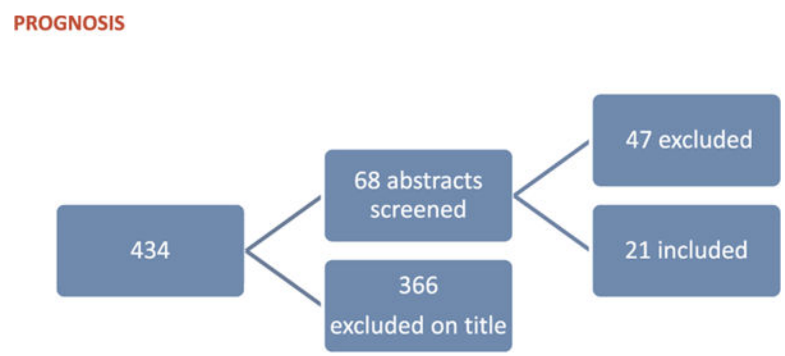
Study	Methods	Results	Comments
Mulwafu et al., 2017	Cluster RCT in Malawi comparing 3 days of training in primary ear and hearing care in 5 intervention health centres (29 CHWs) compared to 5 control health centres (28 CHWs). The primary outcome was knowledge of ear and hearing care.	The average overall correct answers increased from 55% to 68% (95% CI 65 to 71) in the intervention group ($p < 0.001$).	The study cannot determine whether the increase in knowledge was translated into an improvement in clinical assessment. Since a large proportion of people identified did not attend for formal assessment, the accuracy of the identification process is unclear.
Stepniak et al., 2017	RCT in USA of standard otology lectures plus 1 week access to a web-based otitis media diagnosis simulator (OtoTrain) in 21 2nd year medical students compared to standard otology lectures alone in 20 2nd year medical students.	With the standard otology lectures, the control group had a 31% improvement in their post-test score (mean ± standard error of the mean, 30.4 ± 1.5) compared with their pretest score (23.3 ± 1.8) ($P < 0.001$). The simulator group had the addition of OtoTrain to the otology lectures, and their score improved by 71% on their post-test (37.8 ± 1.6) compared to their pretest (22.1 ± 1.9) ($P < 0.001$). Comparing the post-test results, the simulator group had a 24% higher score than the control group ($P < 0.002$).	The study cannot determine whether the increase in knowledge was translated into an improvement in clinical assessment. It is currently unclear what level of ability in the correct recognition of OM images is needed to ensure competent clinical examination. Technical ability is not asses in this study.
Gunasekera et al., 2018	A diagnostic agreement and accuracy study of 5 audiologists compared to 3 ENT specialists (reference standard). 1310 of 1669 SEARCH participants (78.5%; mean age, 7.0 years; SD, 4.4 years) were assessed. and received a diagnosis using video otoscopy and tympanometry. Test results (but not case histories) were forwarded to one of three otolaryngologists for blinded independent assessment. Paired diagnoses by audiologists and otolaryngologists were available for 863 children at the child level and 1775 ears (989 children) at the ear level.	Agreement between audiologists and otolaryngologists for OM at the ear level was 92.2% ($\kappa = 0.78$; 95% CI, 0.74–0.82), and at the child level 91.7% ($\kappa = 0.81$; 95% CI, 0.77–0.85).	The reference standard was ENT specialist diagnosis but this relied on information provided by the audiologist. The audiologist also had additional information available from the clinical assessment. While the high level of agreement is encouraging, diagnostic accuracy estimates may be biased.
Erkkola-Anttinen et al., 2017	A diagnostic accuracy study of spectral gradient acoustic reflectometry (SG-AR) by parents in Finland. 185 children (age 6–35 months) whose parents were willing to use the SG-AR at home daily. Measurement pairs of parental home SG-AR examination results were generated and analyzed. We defined the SG-AR level as increasing when the difference between two measurements was ≥2 levels from a lower to a higher level, suggesting development of AOM.	361 paired SG-AR home measurements were obtained. The reference measurement was related to a healthy middle ear as determined by pneumatic otoscopy. Increasing SG-AR levels (59/361), were 63% (95% CI 50%−74%) sensitive and 94% (91%−97%) specific for deterioration of a healthy middle ear to AOM. The positive predictive value was 71% (58%−82%) and the negative predictive value was 92% (88%−95%).	Diagnostic tools that suitable to be used by parents are likely to great potential if they are accurate. To date, the accuracy of SG-AR has been assessed for the detection of OME. The development of a new MEE does not always indicate AOM if you require otoscopic features of acute inflammation to make the diagnosis.
Erkkola-Anttinen et al., 2017	359 children (age 6–35 months) whose parents were willing to use SG-AR at home. The parents were asked to perform bilateral SG-AR daily on their child. In this study, we included children who had undergone successful parental home SG-AR examination performed on the same day that a physician had also performed successful SG-AR examination and pneumatic otoscopy at the study clinic. We compared the parental and study physician SG-AR examination results to the study physicians' pneumatic otoscopy, which served as the diagnostic standard.	We analyzed 571 successful parental home SG-AR examinations performed on the same day that a study physician had performed a successful SG-AR examination and pneumatic otoscopy at the study clinic. None of the evaluated SG-AR level combinations resulted in both high sensitivity and specificity. For symptomatic visits, the negative predictive value of a parental SG-AR level 1 to detect MEE was 64%. For parental SG-AR levels 4–5, the positive predictive value to detect MEE was 88%. However, for asymptomatic visits, the negative predictive value of a parental SG-AR level 1 to detect MEE was 83%.	Diagnostic tools that suitable to be used by parents are likely to great potential if they are accurate. In this study, while parents were not as successful in achieving SG-AR reading as clinicians, their results were similar ie. the accuracy appears to be determined by the method itself rather than the user.

Study	Methods	Results	Comments
Chan et al., 2019	The presence of middle ear fluid is a key diagnostic marker for two of the most common pediatric ear diseases: acute otitis media and otitis media with effusion. We present an accessible solution that uses speakers and microphones within existing smartphones to detect middle ear fluid by assessing eardrum mobility. We conducted a clinical study on 98 patient ears at a pediatric surgical center in the USA.	The abstract reports 85% sensitivity and 82% specificity, comparable to published performance measures for tympanometry and pneumatic otoscopy. Similar results were obtained when testing across multiple smartphone platforms. Parents of pediatric patients (n = 25 ears) demonstrated similar performance to trained clinicians when using the smartphone-based system.	This is interesting adaption of smart phones to detect the presence of MEE. Need to check the full methods as I only currently have access to the abstract.
Bathla et al 2017	The aim of this study was to evaluate the routine use of HRCT of temporal bone in such cases. This study was a prospective study done at LG hospital, AMC MET Medical College, Ahmedabad to evaluate and compare the temporal bone findings in HRCT and intraoperative findings in 100 patients with atticoantral CSOM. All patients underwent HRCT screening followed by surgical exploration of middle ear cleft.	HRCT showed very high sensitivity and specificity for epitympanum (100, 94%) and mesotympanum (98, 98%) areas. It gave valuable information of disease extent in hidden areas like sinus tympani and facial recess of mesotympanum. HRCT satisfactorily delineated malleus and incus erosion but had 75% sensitivity for detecting erosion of stapes suprastructure, though specificity was of 97%. For bony anatomical landmarks HRCT showed very high sensitivity and specificity for detecting erosion of lateral semicircular canal, tegmen tympani and sinus plate. Detection of facial canal erosion on HRCT had moderate sensitivity of 75%.	This study provides useful information about how HRCT can assist in planning surgery for CSOM. However, it does not assess whether this information results in any differences in the type of surgery performed or whether the outcomes are improved.
Karki et al., 2017	To evaluate the role of high resolution computed tomography temporal bone in Chronic suppurative otitis media atticoantral disease and to compare preoperative computed tomographic findings with intra-operative findings. Method Prospective, analytical study conducted among 65 patients with chronic suppurative otitis media atticoantral disease in Department of Radiodiagnosis, Kathmandu University Dhulikhel Hospital between January 2015 to July 2016. The operative findings were compared with results of imaging. The parameters of comparison were erosion of ossicles, scutum, facial canal, lateral semicircular canal, sigmoid and tegmen plate along with extension of disease to sinus tympani and facial recess.	High resolution computed tomography temporal bone offered sensitivity (Se) and specificity (Sp) of 100% for visualization of sigmoid and tegmen plate erosion. The performance of HRCT in detecting malleus (Se = 100%, Sp = 95.23%), incus (Se = 100%,Sp = 80.48%) and stapes (Se = 96.55%, Sp = 71.42%) erosion was excellent. It offered precise information about facial canal erosion (Se = 100%, Sp = 75%), scutum erosion (Se = 100%, Sp = 96.87%) and extension of disease to facial recess and sinus tympani (Se = 83.33%,Sp = 100%). high resolution computed tomography showed specificity of 100% for lateral semicircular canal erosion (Sp = 100%) but with low sensitivity (Se = 53.84%).	See comments above.
Nash et al., 2017	To determine the diagnostic performance of diffusion-weighted magnetic resonance imaging in the assessment of patients with suspected, but not clinically evident, cholesteatoma. A retrospective analysis of a prospectively collected database of non-echo-planar diffusion-weighted magnetic resonance imaging studies (using a half-Fourier single-shot turbo-spin echo sequence) was conducted. Clinical records were retrospectively reviewed to determine indications for imaging and operative findings. Seventy-eight investigations in 74 patients with suspected cholesteatoma aged 5.7–79.2 years (mean, 41.7 years) were identified. Operative confirmation was available in 44 ears. Diagnostic accuracy of the imaging technique was calculated using operative findings as a ‘gold standard’.	The accuracy of diffusion-weighted magnetic resonance imaging in assessment of suspected cholesteatoma was 63.6 per cent. The imaging technique was significantly less accurate in assessment of suspected cholesteatoma than clinically evident disease ($p < 0.001$).	This study highlights the limitations of MRI in patients who have suspected cholesteatoma that is not clinically evident.
Sarmento et al., 2017.	High-frequency conductive hearing loss (HfCHL) has been considered a hallmark of incomplete ossicular discontinuity. This study aims to evaluate the use of HfCHL as a preoperative predictor of IOD in patients with non-cholesteatomatous chronic suppurative otitis media. The HfCHL test was defined as the preoperative air-bone gap (ABG) at 4 kHz minus the average of the ABG at 0.25 and 0.5 kHz. The test was applied in 328 patients before surgery and compared to intraoperative findings as the gold standard.	At surgery, 201 (61.3%) patients had an intact ossicular chain, 44 (13.4%) had a complete ossicular discontinuity, and 83 (25.3%) exhibited an IOD. The best cutoff level was calculated as 10 dB. The HfCHL test to diagnose IOD had a sensitivity of 83% and a specificity of 92% with a post-test probability of 78% and a likelihood ratio of 10.2.	This is a useful study describing an additional role for hearing assessment prior to surgery for CSOM. This information may affect the use of additional imaging or assist in places that do not routinely have access to additional imaging. This study does not assess whether this information results in any differences in the type of surgery performed or whether the

Study	Methods	Results	Comments
			outcomes are improved. Further studies testing the usefulness of the proposed 10dB threshold are needed.
Anwar et al., 2016	The diagnostic accuracy of tympanometry in detecting fluid in the middle ear space in children with otitis media with effusion by comparing its findings with those of myringotomies. This prospective study was conducted at the Department of ENT& Head and Neck Surgery, Postgraduate Medical Institute Hayatabad Medical complex, Peshawar from July 1, 2012 to April 30, 2015. Patients with suspicion of OME underwent tympanometry and later myringotomies. Using Jerger's classification, Type B tympanogram with normal canal volume was considered as conclusive evidence of fluid in the middle ear space. Its findings were compared with those of the respective myringotomies.	A total 117 ears of 63 patients were operated. The age range was 3 to 12 years. The commonest age group (58.7%) affected by OME was 6–8 years. Type B tympanogram with flat curve and normal canal volume was obtained in 71.4% of the ears. Comparison with myringotomy findings showed TP 85, TN 13, FP 5 and FN 14. The diagnostic value of tympanometry was; Sensitivity 85.85%, Specificity 72.22%, PPV 94.44%, NPV 48.14% and Accuracy of 83.76%.	This study indicates that tympanometry in Pakistan has a similar accuracy to the studies conducted in other populations. The age of the children having surgery was older than the children in other studies and this may affect the results.
Tuzcu et al., 2015	This study aims to report the significance of echo-planar diffusion-weighted imaging (EP-DWI) in preoperative magnetic resonance imaging of patients with surgically corrected cholesteatoma and granulation tissue according to DWI and apparent diffusion coefficient (ADC) values. Ninety-one patients (52 males, 39 females; mean age 40.7 ± 15.8 years; range 3–77 years) who admitted to radiology clinic of our hospital between December 2009 and May 2011 with a pre-diagnosis of chronic otitis media with primary acquired cholesteatoma and assessed preoperatively in our clinic by ear magnetic resonance imaging and DWI were included in the study. Diffusion-weighted imaging results were compared with operative findings and pathology results.	According to the results of operations, 50 patients had cholesteatoma and 41 patients had granulation tissue. The mean DWI values of patients with cholesteatoma were significantly higher than patients with granulation tissue ($p < 0.05$). The mean ADC values of patients with cholesteatoma were significantly lower than patients with granulation tissue ($p < 0.05$). The sensitivity and specificity of EP-DWI in detection of cholesteatoma were 97.6% and 92.0%, respectively.	Currently only have access to abstract. The article is in Turkish. This study does not assess whether this information results in any differences in the type of surgery performed or whether the outcomes are improved.
Park et al., 2015.	This study validated the 1000-Hz probe tone and evaluated the age at which it should be used in Korean infants. METHODS: Data from 83 infants (43 males, 40 females; mean age 9.2 ± 6.2 (range 1–30) months, 165 ears) were analyzed. Tympanograms were classified according to Baldwin's modification of the method of Marchant et al. and correlated with results based on combined diagnostic tests, including an endoscopic examination of the tympanic membrane, myringotomy findings, and the air and bone conduction auditory brainstem response (ABR) thresholds. Data were analyzed in five age groups, each covering a 3-month range. The traces were measured for both 226- and 1000-Hz probe tones.	For the 226-Hz probe tone, the tympanograms showed normal traces for most ears with otitis media effusions in infants younger than 12 months. By contrast, the tympanograms using the 1000-Hz probe tone showed abnormal traces in most of the infants with otitis media effusions in all age groups. In infants with no otitis media effusion, the tympanograms using both 226- and 1000-Hz probe tones were interpreted as normal in most cases in all age groups. In infants younger than 12 months, the sensitivity of the 226-Hz probe tone was very low (0–6.6%), whereas that of the 1000-Hz probe tone was very high (90–100%). In infants older than 13 months, however, the sensitivities of the 226- and 1000-Hz probe tones were 76.2% and 85.7%, respectively. Regarding specificity, the difference between the two probe tones was not significant for any age group.	These results are interesting. The finding in children 4–12mo are not consistent with previous studies. Further research in this area is appropriate. Need to check of this study as there was ePub at end of 2014.
Fischer et al., 2019.	This study aimed to evaluate readout-segmented echo-planar DWI for the detection of cholesteatoma and compare the results with surgical validation. MATERIALS AND METHODS: Fifty patients with chronic otitis media (24 females and 26 males; range, 12–76 years of age; mean age, 41 years) who underwent MR imaging before an operation of the middle ear (1–169 days) were included. The MR imaging protocol consisted of axial and coronal readout-segmented echo-planar DWI with b-values of 0 and 1000 s/mm^2 and 3-mm slice thickness. The readout-segmented echo-planar diffusion-weighted images were fused with standard T2-weighted sequences for better anatomic assignment.	Readout-segmented echo-planar DWI detected 22 of the 25 cases of surgically proved cholesteatoma. It has an accuracy of 92% (95% confidence interval, 80.8%−97.8%), a sensitivity of 88%, a specificity of 96%, a positive predictive value of 96%, and a negative predictive value of 89%. In 1 case, a positive finding for cholesteatoma with readout-segmented echo-planar DWI could not be proved by histology, and in 3 cases, histology yielded a cholesteatoma that was not detected with MR imaging.	This study does not assess whether this information results in any differences in the type of surgery performed or whether the outcomes are improved.

Table 6

Prognostic studies conducted in LMIC or disadvantaged populations.



Author	Year of publication	Country region	Study design	Participants	Age	Diagnostic methods	Study question	Study period	Results	Comments
Yen	2015	Taiwan	Retrospective cohort, register study	10248 diagnoses with COM		ICD codes in Taiwan's national health insurance program (covers 98% of population)	what is the risk of developing sudden SNHL if you have COM	2001–2008	Incidence of sudden sensorineural HL (sSNHL) was 3 times higher among pt'ens with COM compared to age and sex matched control group. The risk of sSNHL was 101/10248 among COM = 0,01 and non-COM 103/30744 = 0,003	Large population, Side of COM and later sSNHL was not included. The relative risk is higher but the absolute risk is still small.
Yehudai	2015	Israel	Tertiary centre, retrospective, preoperative audiograms, for COM or cholesteatoma. normal ear BC vs COM ear BC.	124 with unilateral COM	7–18	otomicroscopy, audiometry 500–4000 Hz	Is SNHL in COM ears clinically significant, and what are the risk factors	1997–2012	Difference in mean BC at 1000, 2000 and 4000 Hz, 1.3 dB 4.3 dB and 7.2 dB. Statistically significant meaning COM ear showed SNHL	Small difference within the insecurity of an audiogram, maybe not clinically significant finding.

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Author	Year of publication	Country region	Study design	Participants	Age	Diagnostic methods	Study question	Study period	Results	Comments
									compared to the healthy ear. Age >10 and presence of cholesteatoma increased the risk of SNHL	The postop BC could have been evaluated too.
Orji	2015	Nigeria	retrospective, register, tertiary centre	203 CSOM cases from 2009 to 10 compared with 343 cases from 1990 to 91	mean age 27 and 21 years	otoscopy	incidence of CSOM at the centre, complication rate	1990–2010	CSOM incidence lowered, cases tended to be older, fewer intracranial complications in newest time period, but overall complication rate unchanged	
Touati	2015	Morocco	retrospective case series, tertiary centre,	30	9–15 years	otoscopy, otomicroscopy?	describe COM with cholesteatoma, clinical and presentations and surgical intervention	jan 2009 to 2013	86% had conductive HL, 60% had airbone gap over 30 dB	
Peñaranda	2015	Colombia different regions	school based	1526	5–14	otoscopy, audiometry	prevalence of AOM, perforation, sequelae, HL		Perforation variation between regions and races from 0 to 1.4%. Variation in	Demonstrates challenges in OM prevalence in countries with large differences in access to

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Author	Year of publication	Country region	Study design	Participants	Age	Diagnostic methods	Study question	Study period	Results	Comments
									sequelae and conductive HL	healthcare and racial heterogeneity
Maile	2015	Nepal	questionnaire	242	all ages	Glasgow health Status Inventory and Glasgow benefit inventory	Adapt QOL instruments to Nepal. Quantify burden of disease. Determine QoL alterations associated with surgery for CSOM or Cholesteatoma.	2012–2013	CSOM associated with reduced QoL, same degree as cholesteatoma. Surgical intervention is associated with increased QoL	
Penido	2015	Brazil	retrospective register, case series tertiary centre	51	mean 31 years	Unclear for ear examination, but imaging modalities were available. CT; MR, MRA	describe epidemiological aspects of OM related ICC (intracranial complication)		80% of complications were due to COM while 20 % were due to AOM. 4 died to ICC. Mean age ICC from AOM 30 years, but bifasic (majority under 15 or over 60) mean age icc from CSOM was 26 years. Mean time of hospitalization was 34 days permanent	

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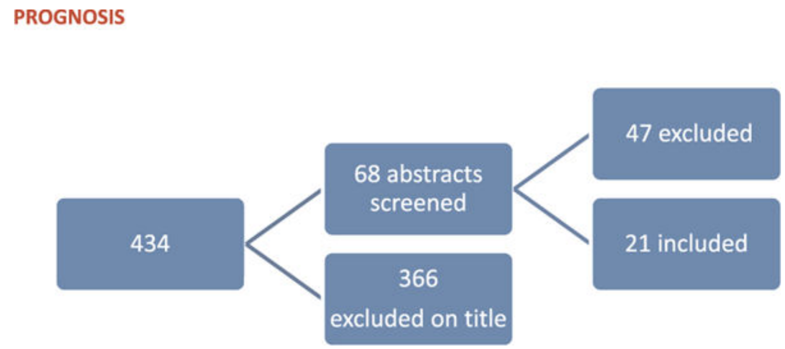
Author	Year of publication	Country region	Study design	Participants	Age	Diagnostic methods	Study question	Study period	Results	Comments
									neurological sequelae were seen in 29% of all ICC cases. 4 patients died	
Avsntorp	2016	Greenland	follow-up on population based cohort	223 children	4–10 years	Video-otoscopy, tympanometry, audiometry	prevalence of CSOM and OM related hearing loss	2010	5.8% CSOM, 13.9% OME, 55% sequelae. CSOM median PTA high/low 34/31 dB, OME 23/23, normal ears 12/13 dB	High prevalence of CSOM, 1 case meningitis, mental retardation and bilateral severe HL.
Maranhão	2016	brazil	retrospective case series, register based, tertiary centre	14 pts labyrinthitis secondary to OM	mean 40		clinical factors and hearing level among pt'ens with OM related labyrinthitis	1987–2013	43% had cholesteatoma, 43% AOM 14% had CSOM associated with facial paralysis, meningitis. Intracranial abscess, one death	
Poole	2016	Nepal	questionnaire, case-control	N = 153. 82 non-OM vs 71 CSOM/AOM/HL recruited from waiting room health care centre	mean 39 vs 48 years	history of OM	Investigate knowledge, beliefs, attitude and practice regarding CSOM and HL		Interestingly 70 % responded that people with HL were discriminated in society	



Author	Year of publication	Country region	Study design	Participants	Age	Diagnostic methods	Study question	Study period	Results	Comments
Zaidi	2016	Pakistan	Case series (described as cross sectional?) tertiary centre	CSOM	6–45 years	audiometry average of 3 speech frequencies, bone conduction?	What is the frequency of SNHL in CSOM	2013–2014	52% had SNHL	frequencies not reported, use of bone conduction not reported
Mushi	2016	Tanzania	prospective cross sectional tertiary centre	301 CSOM cases with 6 weeks otorrhoea	All over 1 year	otoscopy and tuning fork tests, cultures. HIV tests	find predictors of complications in CSOM, evaluate treatment outcome and anti-microbiological susceptibility	2013–2014	Majority of patients with prolonged illness duration, otalgia, infected with multi drug resistant bacteria and those with positive HIV status poorly respond to treatment and tend to present with disease complications	632 attends the clinic annually. 48% of patients present with CSOM at the clinic
Mushi	2016	Tanzania	Case series, tertiary centre	410 CSOM cases	Median age 29.5 in cases with fungi. Age not stated in overall group		Prevalence of fungal infection		44 (11%) of cases had fungi	There was an association but not significant between co-infection with fungi and poor treatment outcome. Causality cannot be

PROGNOSIS

Author	Year of publication	Country region	Study design	Participants	Age	Diagnostic methods	Study question	Study period	Results	Comments
										established. High risk of bias
Dobriansky	2017	Brazil	Cross-sectional, register. Tertiary centre	158 patients. 98 CSOM with otorrhoea and contralateral normal ear. 60 CSOM with dry perforation	median 26 years in otorrhoea group, unknown range	otoscopy, audiometry	is otorrhoea associated with SNHL		otorrhoea is associated with SNHL	
Jensen PV	2017	Zimbabwe	case report	1 fatal	8				fatal complication to AOM Gradenigo syndrome. Lethal outcome due to inaccessibility diagnosis and treatment	
Toros	2017	Turkey	case	1	45 years	otoscopic			mastoiditis, bezold, paraspinal abscess, sinus thrombosis. Survived with hemiparesis	first description of paraspinal abscess due to OM
Qin	2017	China	case report	1	10 year				Zygomatic root abscess and fistula, after 6 months of low grade infection	

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Author	Year of publication	Country region	Study design	Participants	Age	Diagnostic methods	Study question	Study period	Results	Comments
Singh	2017	India	prospective case series tertiary centre	46 CSOM/ cholesteatoma patients	7–50	otomicroscopy, surgery	Occurrence of fungal infection		All had otorrhoea, 43% had fungal co-infection, 15% extra-cranial complications, no intracranial complications	Causal relation between chronic otorrhoea and fungal infection cannot be established. Highlights the importance of testing for fungal infection in recalcitrant cases. Prevalence rates are very high, high risk of selection bias. Authors hypothesis that it could be due to increased availability of AB in India
Kameswaran	2017	India, Tamil nadu	case series, tertiary centre	502 patients undergoing tympanoplasty with mastoidectomy		otomicroscopy, surgery, CT		2011–2012	25 (5%) patients had M tuberculosis in ear samples. Authors suspect TB OM to be	tuberculous otitis media higher risk of complications due to delayed diagnosis as

PROGNOSIS

Author	Year of publication	Country region	Study design	Participants	Age	Diagnostic methods	Study question	Study period	Results	Comments
									under reported in India	many patient dont have coincident pulmonary symptoms. More severe hearing loss and presence of complication.
Cordeiro	2018	Brazil	Prospective case series with follow-up. Tertiary centre.	82 with AOM at first visit .41 followed- up	5–65, median 38 years	Extended high frequency audiometry 8 to 16 KHz. Otoscopy, tympanometry	impact of first episode of AOM on hearing after 14,28,49 and 180 days	2015–2016	First OM episode led to high frequency elevated thresholds at 6 months follow-up in the affected ear. At 14 days follow-up standard audiometry did not show any HL	
Singh	2018	India	case				description of case		tuberculosis middle ear, mastoid, zygomatic and Bezold abscess	tuberculosis OM pathogen in India
Jones	2018	Australia	semi-structured interviews	9 caregivers to 12 children with bilateral OM, some with		Medical history	what is the parents view on the program.		Parents were positive towards the	The more OM concerned

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Author	Year of publication	Country region	Study design	Participants	Age	Diagnostic methods	Study question	Study period	Results	Comments
				CSOM, participating in a program speech, language, hearing loss and school readiness					program for various reasons. Parents ranked OM as the highest health concern	parents more likely to participate in the program. May not be representative for the community. High risk of bias. But only study that asked parents to rank "burden of disease"
Singer	2018	Egypt	prospective, case series (patient own control) tertiary centre	200 unilateral CSOM, using contralateral as control-ear	10–60	Otomicroscopy, tympanometry audiometry 500–4000. BC average 25 dB or	occurrence of SNHL in CSOM	2016–2017	10 % had SNHL, CSOM associated with SNHL but other predisposing factors e.g.	

Table 7

Treatment.

Author, Year of study, Year of publication, Journal/Conference	Country, Population	Study design	Study Question Population - risk group, age	Treatment method/Study method	Study Question Outcome	Study period	Risk of bias
Dave et al., 2019 Indian J Otolaryngol Head Neck Surg.	Urban Indian	Case series	All ages (n = 90) Tertiary referral centre	Tympanoplasty ± mastoidectomy for CSOM	Graft uptake rate in relation with ET function	2016–2017	High - tertiary hospital based
Miyake et al., 2019 Einstein (Sao Paulo)	Brazil	Controlled Open-label randomized	All ages (n = 80)	Incidence of post- MVTI otorrhoea in patients with no water precaution	Protection should be recommended during the first month after surgery but not further on	July 2013–May 2015	Low - lost to follow up, selection
Toman et al., 2019 Trop Med Infect Dis.	Rural South Africa	Case series	Adults (n = 14)	Antibiotic prescription according to culture results	Culture oriented treatment for better disease control	6 week	High -selection, low numbers
Ramkumar et al., 2018 Am J Audiol.	Rural India - cleft palate patients	Case series	Children and adults (3–35 years)	Identifying and managing middle ear disorders through video-otoscopy and Telemedicine	Directing patients to appropriate therapy using video otoscopy and Telemedicine	13 months	High-selection, low numbers
Zahreddine et al., 2018 Pharm Pract (Granada)	Lebanon	Cross -sectional study	Pharmacists and parents	Assessing the correct use of antibiotics for AOM	Necessary to implement educational campaigns to increase awareness of antibiotic misuse and resistance among pharmacists and patients	June-August 2017	High - selection, small numbers
Kouhi et al., 2018 Ear Nose Throat J	Iran	Randomized controlled	All (n = 59)	Assess the influence of corticosteroids on tympanoplasty outcomes	No effect was found on graft uptake following corticosteroid treatment	2013–2014	High - selection, size
Jacups et al., 2018 J Eval Clin Pract.	Australia Indigenous population	Costing Evaluation	Children	Identifying the least costly model of delivery of ENT surgery	Low-risk ENT surgery from a state funded hospital in remote setting with high use of videoconference technology it the most cost effective	2017	Low risk
Udden et al., 2018 Infect Dis Poverty	Angola	Case series	All (n = 152)	Identification of aerobic pathogens in CSOM	The most common pathogens were *Enterococcus spp*, *Pseudomonas aeruginosa* and *Proteus spp*. Resistance rates to quinolones ranged 6–30% and suggested topical therapy with quinolones should be the mainstay	-	High - selection
Nasrallah et al., 2018 Int J Pediatr Otorhinolarngol	Lebanon	Anonymous survey	Physicians (n = 75)	Assessing physician knowledge of AOM diagnosis, management and treatment	Interventions for improving awareness of clinical guidelines should be taken	2017	High - questionnaire
Johnston et al., 2018 ANZ J Surg	New Zealand	Case series	Maori and non-Maroi children (n = 11941)	Compare incidence and outcomes of children with MVTI	No difference in the post-operative course between Maroi and non-Maroi children	January 1996–June 2016	Low - case series, high number

Author, Year of study, Year of publication, Journal/Conference	Country, Population	Study design	Study Question Population - risk group, age	Treatment method/Study method	Study Question Outcome	Study period	Risk of bias
Yazici et al., 2018 Clin Otolaryngol	Turkey	Case series	Children (n = 50)	Compare QOL using OM6 post MVTI	Improvement in QOL following MVTI	December 2016–April 2017	High - case series, small number
Nshimirimana et al., 2018 Int J Otolaryngol	Rawanda	Cross-sectional	All (n = 109)	Determine factors for delayed care seeking in CSOM treatment	Low knowledge of disease and use of traditional medicine	2017	High - tertiary hospital
Smith et al., 2018 J Laryngol Otol	Cambodia	Case series (n = 124)	All	Measuring tympanic membrane closure rate at six weeks and PTA at three months after local surgeon performed surgery	Local training of surgeons shows high success rate in tympanoplasty results	2016–2017	High - case series
Piltcher et al., 2018 Braz J Otorhinolaryngol	Brazil	Literature review	-	Medical management of AOM	Periodic revisions on guidelines and recommendations for treatment should be performed	-	Low
Durham et al., 2018 PLoS One	Australia - Aboriginal and Torres Strait Islander	Online survey and face to face or phone interview	Documents (n = 20) Interview (n = 27)	Driving sustained improvement in OM care in children	A holistic systemic approach is needed for OM care improvement	-	High - interview, survey
Master et al., 2018 Otolaryngol Clin North Am.	Developing countries	Overview	-	Seeking the difficulties in treating CSOM	Surgical management may be warranted and training of local surgeons is required	-	High
Jones et al., 2018 BMC Pediatr	Australia - Indigenous population	In depth semi-structured interviews (n = 21)	Children 0–3 years	Assessing the LiTTLE Program effect on Aboriginal community health	Positive views about the LiTTLe Program possible areas of improvement		High - interviews
Buyukcam et al., 2018 Int J Pediatr Otorhinolaryngol	Turkey	Questionnaire (n = 977)	Paediatricians	Assess paediatricians' attitude toward AOM treatment and pain management	Educational interventional strategies are needed to improve compliance with EBG for AOM treatment and management, watchful waiting should be applied when appropriate	January 2015-December 2016	High - interviews, university hospital and research hospital paediatricians
Kong et al., 2017 J Paediatr Child Health	Australia - Indigenous and non-Indigenous	Review	Children	Identifying children with OME who need simple ENT surgery	Advancing children who meet surgical criteria to surgery		High - review
Hussein et al., 2017 J Laryngol Otol	Egypt	Prospective randomized study	Children 2–11 years of age (n = 290)	Evaluate the effects of oral steroids alone or followed by intranasal steroids versus WW for OM resolution	Oral steroids lead to a quick resolution of OM with no long term benefits. Intranasal steroids non useful		Low - no randomization, not blinded
Kaya et al., 2017 Eur Arch Otorhinolarngol	Turkey	Prospective randomized controlled	All (n = 13)	Compare the audiologic outcomes of the patients who underwent endoscopy on one ear and microscopic tympanoplasty on the other, and to investigate the operative time, graft success,	Endoscopic approach for type 1 tympanoplasty offers shorter surgery time, better health status and lower postoperative pain than microscopic surgery as well as comparable improvement in air-bone gap and graft success	February 2015-September 2016	High -selection, size

Author, Year of study, Year of publication, Journal/Conference	Country, Population	Study design	Study Question Population - risk group, age	Treatment method/Study method	Study Question Outcome	Study period	Risk of bias
				postoperative pain and health status			
Jacups et al., 2017 Int J Pediatr Otorhinolaryngol	Cape York Indigenous children	Case series	Children (n = 16)	Improving accessibility to ENT surgery through usage of private health care facilities	Private health care provided quicker surgical access and well as good post-operative hearing results		High - small case series
Akhtar et al., 2017 Mymensingh Med J	Bangladesh - tertiary center	Cross sectional prospective study	All (n = 117)	Identify the common microorganism involved and the antibiogram of CSOM patients	*Staphylococcus aureus* and *Pseudomonas aeruginosa* most common with sensitivity to gentamycin and ciprofloxacin, respectively		High - selection
Khreesha et al., 2017 Int J Pediatr Otorhinolaryngol	Jordan	Survey	Physicians (n = 71)	Assess AOM treatment trends as well as adherence to guidelines	Encouraging awareness of AOM guidelines	-	High - survey
Ababneh et al., 2017 Int Health	Jordan	Prospective cross-sectional	Children	Assessing antibiotic prescription rate for URTI	Broad spectrum antibiotics are prescribed often for AOM and health policy initiatives should be taken to minimize such prescripitions	-	High
Demant et al., 2017 Trials	Greenland	Investigator initiated multicenter, randomized, blinded superiority trial	Children 9–36 months	Detection of a decrease of 2 visits to a health clinic during 2 years	On going	-	Low - selection bias
Sibthorpe et al., 2017 Aust J Prim Health	Australia - Aboriginal and Torres Strait Islanders	Expert Consensus		Detecting evidence based indicators for continuous quality improvement in the prevention and management of OM and its sequelae	Seven evidence - based indicators were developed from electronic health records	-	High - consensus, selection
Sharma et al., 2016 Indian J Otolaryngol Head Neck Surg	India	Case series	-	Evaluate the outcome of type I tympanoplasty ± mastoidectomy for CSOM	Type I tympanoplasty with cortical mastoidectomy had better graft uptake and audiological results then tympanoplasty alone	One and a half years	High - selection, small series
Yousaf et al., 2106 J Auyb Med Coll Abbottabad	Pakistan	Randomized controlled	Children ages 4–12 years (n = 82)	Evaluate laser myringotomy for the resolution of OME	Laser myringotomy is less effective in clearance of mucoid effusion in long standing and recurrent OME	February 2012-January 2015	High - selection, statistics
Singh et al., 2016 J Laryngol Otol	India	Prospective randomised	Adults (n = 100)	Evaluate the success rate of dry and wet temporalis fascia grafts in type I underlay tympanoplasty.	A dry or wet temporalis fascia graft does not influence the outcome of tympanoplasty type I.	-	?
Silveira et al., 2016 Braz J Otorhinolaryngol	Brazil	Randomized controlled	All (n = 40)	Effect on healing of direct application of a bacterial cellulose graft on the tympanic membrane	Bacterial cellulose grafts promoted the closure of the tympanic membrane perforations	-	?

Author, Year of study, Year of publication, Journal/Conference	Country, Population	Study design	Study Question Population - risk group, age	Treatment method/Study method	Study Question Outcome	Study period	Risk of bias
				compared to the conventional approach with autologous fascia			
Amer et al., 2016 Int Arch Otorhinolaryngol	Egypt	Case series	Children (n = 42)	Determine the usefulness of adjuvant IT steroids of OME after MVTI	IT steroids is safe we lower incidence of recurrent OME, tympanosclerosis and otorrhea		High - selection, small series
Bin Mohanna et al., 2016 J Ayub Med Coll Abbottabad	Yemen	Cross - sectional with parental questionnaires	Children 1–15 years of age (n = 150)	Identify the bacterial etiologic agents of OM and determine their sensitivity patterns	Bacterial cultures are essential for guiding antibiotic therapy. Bacterial isolates were *Staphylococcus aureus* and *Pseudomonas aeruginosa* most common with sensitivity to cefotaxime and azithromycin as well as amoxicillin - clavulanic acid.	January-October 2015	High - selection, tertiary centre
Maile et al., 2015 Trop Med Int Health	Nepal	Case series	All (n = 242)	Assessing the impact of ear disease and the effect of ear surgery on QoL as well as adapt the GHSI and GBI into relevant questionnaires for Nepali patients	Ear disease is associated with reduced QoL while surgical intervention is associated with an improved QoL. It is essential to invest in measures of QoL in developing nations	-	High - selection
Elsayed et al., 2015 Int J Otolaryngol	Questionnaire	Case series	Children < 2 year old (n = 100)	Assess the impact of educational program on the management of children with CSOM	Education of parents leads to a higher percentage of cure in patients with CSOM	September 2013-May 2014	High - recall

AOM - Acute otitis media; ENT - Ear, nose and throat; CSOM - Chronic suppurative otitis media; ET - Eustachian tube; MVTI - myringotomy plus ventilation tube insertion; OM6 - Otitis media 6 -item questionnaire; QOL - Quality of life; PTA - Pure tone audiometry; OM - Otitis media; LiTTLE Program - Learning to Talk, Talking to Learn; EBG - Evidence based guidelines; CHW - Community health worker; URTI - Upper respiratory tract infection; OME - otitis media with effusion; IT - intratympanic; QoL - Quality of life; GHSI - Glasgow Health Status Inventory; GBI - Glasgow Benefit Inventory.

Table 8

Recommended reporting items and justification for studies of otitis media and associated hearing loss in LMIC or disadvantaged populations.

STROBE item	Recommendation	Justification
Setting	Specify: • Urban vs. rural setting * • Season • Smoking rates * • Breastfeeding rates *	• Variation by urban • Variation by season, incl. wet vs. dry • Smoking risk association • Breastfeeding protection association
Participants	• Specify selection method • Describe your assessment of generalisability	• Population-based vs. healthcare attendance very different • OM varies by multiple factors and readers not familiar with your setting will not know the prevalence of risk factors (e.g., breastfeeding, smoking)
Variables	• Define each condition you are reporting	• No consensus on definitions
Measurement	• Specify diagnostic technique(s) used • Specify cut-off • Specify examiner (e.g., role and experience)	• No consistency with techniques and sensitivity varies by technique • No consistency with cut-off (e.g., Type B or Type B + C tympanograms) • Examiners varied experience/expertise
Descriptive data	• Specify age range, mean and SD of participants	• OM prevalence significantly different by age categories
Outcome data for OM	• Specify results for each diagnostic technique (e.g., frequency of each tympanogram type) • Report prevalence by both child and ear separately • Specify diagnostic hierarchy used. **Suggested hierarchy:** - Cholesteatoma - CSOM - AOM with perforation - TTO - Dry perforation - recurrent AOM - other AOM - chronic OME	• Reporting the frequency of each type of Tympanogram enables comparison with studies using different definitions • No consensus on reporting and important to differentiate child level vs. ear level hearing impairment • Most clinical decisions are determined at the child level not ear level • When reporting by child, the reader needs to know how children with different conditions in each ear were categorised

STROBE item	Recommendation	Justification
	- other OME - Wax - Other - Normal	
Outcome data for hearing	• Report prevalence by both child and ear separately • Use WHO definitions • Report loss by each frequency tested • Report loss in some other way (e.g., 3FAHL) please also report as above	• High variability in HL reporting makes it hard to compare samples
Generalisability	• Specify age range, mean and SD of participants (and/or median age if not a normal distribution)	• OM prevalence significantly different by age categories so a range alone is not sufficient to enable comparisons with other datasets

* report best available local data if you do not know the precise rates for your specific sample