Children hearing impairment and its associated factors in sub-Saharan Africa in the 21st century: A systematic review and meta-analysis

Assefa Desalew, Tilayie Feto Gelano, Agumasie Semahgn, Biftu Geda and Tilahun Ali

Abstract

Background: Childhood hearing impairment is still a significant cause of disability in the 21st century in developing countries. Particularly, the burden is more severe in sub-Saharan Africa, where the majority of children with hearing problems is living. There are great variations and inconsistencies of available findings conducted in sub-Saharan Africa. Hence, the aim of this review was to determine the pooled prevalence of childhood hearing impairment and its associated factors in sub-Saharan Africa.

Methods: Studies were searched from main databases (PubMed, CINAHL, and African Journals Online), Google Scholar, and other relevant sources using electronic and manual techniques. All observational studies, written in English and conducted among participants (aged less than 18 years) from 2000 to 2018, were eligible. Heterogeneity between included studies was assessed using I², and publication bias was explored using visual inspection of the funnel plot. Statistical analysis was carried out to determine pooled prevalence using Stata version 14. In addition, subgroup analysis was carried out for the normality criteria of hearing thresholds and characteristics of the study populations.

Results: The pooled prevalence of hearing impairment was 10% (95% confidence interval (CI): 9%–11%). The magnitude of hearing impairment varies with the normality criterion used. The most commonly used threshold was 25 and 30 dB hearing level. The prevalence of hearing impairment based on normality criterion (>20 dB, >25 dB, >30 dB, and >35 dB) were 17%, 19%, 2%, and 1%, respectively. While in the questionnaire-based evaluation, the prevalence was 6% (95% CI: 3%–9%). In addition, based on population characteristics, the prevalence of hearing impairment for school or community-based children was 6% (95% CI: 5%–7%) while the prevalence for children with comorbidities was 23% (95% CI: 15%–31%). Chronic suppurative otitis media, impacted cerumen, advanced stage of human immunodeficiency virus, tuberculosis infection, and age of the children were associated with hearing impairment in sub-Saharan Africa.

Conclusion: Hearing impairment in children and adolescents in sub-Saharan Africa was high, and associated with preventable and treatable risk factors.

Keywords

Hearing impairment, children, sub-Saharan Africa, systematic reviews, meta-analysis

Date received: 26 August 2019; accepted: 13 March 2020

Background

Hearing impairment is a significant cause of disability worldwide, and more than two-thirds of the population with hearing impairment live in developing countries. Worldwide, 466-million people are living with disabling hearing loss and 34 million are children. If the current trend continues, it is...
estimated that by 2050, over 900-million people will have hearing impairment. According to the World Health Organization (WHO), 60% of childhood hearing impairment is preventable. Evidence has shown that 31% of hearing impairment cases can be attributed to prenatal and postnatal infections, 17% to birth-related causes, 4% to ototoxic medicines, and 8% to other causes such as substance abuse.

The burden of hearing impairment is more in developing countries, specifically sub-Saharan Africa (SSA), where the majority of the children with significant hearing problems is living. The sense of hearing is fundamental to facilitating communication and fostering social interaction. In children, disabling hearing impairment impedes speech and language development and affects children’s educational and vocational attainment. Furthermore, it causes difficulty in obtaining, performing, and keeping a job, not to mention the stigma, feelings of isolation, loneliness, and depression, coupled with the experience of violence, poverty, and poor health, that create a huge social and economic burden on society worldwide. Without suitable interventions, hearing impairment is a barrier to both education and social integration. These consequences can be reduced by early detection with appropriate audiological and speech interventions.

The integration of childhood hearing screening services in schools with existing public health initiatives by international organizations such as the WHO and United Nations Children’s Fund (UNICEF), combined with sustainable capacity development and training of local health professionals, should reduce the burden of childhood hearing impairment in developing countries, and make a positive contribution to the United Nations Sustainable Development Goals (SDGs). While hearing aid use to reduce the burden of hearing impairment in high-income countries, there is little evidence of their use in developing countries. However, identifying the leading causes of hearing impairment and implementing preventive action could reduce the hearing-related problem in developing countries.

Hearing impairment in children is defined as when the hearing loss measure (decibels hearing level) is greater than 30 decibels hearing level (dB HL) in the better hearing ear. However, various studies use the normality criteria which range from 20 to 40 dB. Despite the ratification of existing laws and policies on disability by many countries, and some progress made in terms of legislative and policy reform, the realities for children with disabilities have not yet changed mainly because of poverty and lack of human resources. Due to that, the number of children with hearing disabilities and those living with disabilities are grossly underestimated.

In SSA, several pockets and fragmented primary studies were undertaken among children and adolescents to assess the prevalence of hearing impairment and its associated factors. Nevertheless, there are great variations and inconsistencies in the available findings. This demonstrating the demand for a comprehensive analysis of the magnitude of hearing impairment to inform policymakers, program planners, service providers, advocators as well as concerned stakeholders to place more emphasis on childhood hearing impairment in developing countries. Hence, the aim of this systematic review and meta-analysis was to determine the pooled prevalence of childhood hearing impairment and its associated factors in SSA.

Methods

Study protocol development

The identification and screening of studies, as well as the eligibility assessment of full texts, were conducted as per Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement (see Additional file 1 in the Supplemental material). The review protocol has been registered at the international prospective register of systematic reviews (PROSPERO) (ID: CRD42018104920), and the registration number of this review is available at https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42018104920.

Data source and search strategies

A literature search was carried out through main electronic databases and indexing platforms. PubMed, Medline (Ovid®), CINAHL (EBSCOhost), African Journals Online, and other relevant sources such as Google Scholar and WHO websites were used to search studies. The studies’ search was performed using the search strings that have emerged from keywords, such as (a) population (child, child preschool, children, childhood, pre-adolescent, adolescent) AND (b) outcome (hearing impaired persons OR hearing impaired OR hearing disabled persons OR deaf persons OR deaf Person OR person, deaf OR persons, deaf OR hard of hearing persons OR hearing disorder OR hearing loss) AND (c) study design (cross-sectional, prevalence, epidemiology, observational) AND (d) location (sub-Saharan Africa, or South of Sahara Africa). Finally, all studies, which were in line with the review title, were retrieved and screened for inclusion in the systematic review (see Additional file 2 in the Supplemental material).

Inclusion and exclusion criteria

All observational studies (cross-sectional, case–control, and cohort) and survey reports were included in the systematic review and meta-analysis. However, case reports, case series, commentaries, and editorials were excluded from the systematic review. All studies with the primary objective to determine the prevalence of hearing impairments and its associated factors among children in SSA were considered. We had included a community or facility-based studies. All studies that have reported the prevalence of hearing impairments, but not its associated factors, were also included. We had excluded...
studies that only investigated hearing impairments with a qualitative approach. However, we included studies that had both quantitative and qualitative study findings, by only considering the quantitative findings. Both published and unpublished studies from 2000 to 2018 which were written in the English language and fulfilled all other criteria were included in the systematic review.

Screening and eligibility of studies

Along with the application of appropriate limits, online records from each database or directory were exported to EndNote citation manager. The studies were then merged into one folder to identify and remove duplicates using endnote. Thereafter, two authors (A.D. and T.F.G.) independently screened the studies based on preset inclusion criteria. Through title screening, the studies that clearly mentioned hearing impairment were selected for abstract screening. Consequently, studies that fulfilled the eligibility criteria based on their titles and abstracts were retrieved for full-text screening. The full-text screenings were carried out by two independent authors (A.D. and T.F.G.). In each case, third and fifth authors (A.S. and T.A.) were consulted to resolve disagreements. The study’s selection process flow diagram was adapted from the PRISMA guidelines. The detail of the selection process is illustrated using the flow chart (Figure 1).

Critical appraisal of studies

Studies were critically evaluated to ascertain the validity of their findings. Studies’ methodological robustness and validity were appraised using the Joanna Briggs Institute (JBI) critical appraisal checklist for observational studies. The JBI critical appraisal checklist for studies reporting prevalence data contain nine important questions (Q1–Q9) and for cohort (Q1–Q11), primarily addresses the methodological aspect of each study. Scores of the two authors (A.D. and T.F.G.) in consultation with the third and fifth authors (A.S. and T.A.) (in case of disagreement between the two authors’ appraisal results) were used for the final decision. Studies with the number of positive responses (yes) greater than half of the number of checklists (i.e. a score of five and above) were included in the systematic review and meta-analysis. Particular attention was given to clear statements of the objective of the studies, sampling techniques, precision of measurement of outcomes of interest and exposure variables, as well as documentation of sources of bias or confounding (see Additional file 3 in the Supplemental material).

Data extraction

The data extraction template was constructed by (AD, AS, and TFG) using Microsoft Excel (2013). The two authors (A.D. and T.A.) extracted and stored data systematically using a data extraction form. In addition, studies’ description was recorded using tables labeled design, aim, sample size, key finding (prevalence of hearing impairments), and secondary outcome (associated factors) (Table 1). Numerical data (frequency) were extracted and recorded in the Microsoft Excel sheet (see Additional file 4 in the Supplemental material).

Data synthesis and statistical analysis

The extracted data were imported from Microsoft Excel to Stata version 14 and Comprehensive Meta-Analysis (CMA) software for analysis, for the pooled estimation of outcome measures (prevalence of hearing impairment). Subgroup analyses were also conducted to minimize the degree of heterogeneity. The data analysis was carried out by the two authors (A.D. and A.S.). The presence of statistical heterogeneity was checked by using the Cochran Q test. The levels of heterogeneity among the studies were quantified using the I² statistics, and substantial heterogeneity was assumed if the I² value was $\geq 60\%$. In the case of high heterogeneity, the subgroup analysis was performed using the random effect model. The presence of publication bias was checked by using a funnel plot.

Results

Search results

A literature search in main electronic databases including PubMed, Medline, CINAHL, and Google Scholar retrieved a
| Author, year, & country          | Study design     | Primary interest                                                                 | Target population                        | Sample size (n) | Diagnostic method                                                                 | Normality criterion                                                                 | Key findings and risk factors                                                                 |
|---------------------------------|------------------|----------------------------------------------------------------------------------|------------------------------------------|----------------|---------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
| Basañez et al., 2015            | Cross-sectional  | To examine the prevalence and etiology of hearing loss                           | Children 5–14 years                      | 639            | Hearing thresholds at 500, 1000, 2000, and 4000 Hz                              | >30 dB HL                                                                          | Hearing impairment = 3.1%                                                                         |
| Hrapcak et al., 2016            | Cross-sectional  | To assess the prevalence and types of hearing loss                               | Children 4–14 years                      | 380            | Electronic medical record review, and otoscopy, tympanometry, TEOAE audiometry   | >20 dB HL                                                                          | Hearing impairment = 24%, conductive = 82%, and sensorineural = 14%                             |
| Alabi et al., 2008              | Prospective      | To determine the prevalence of sensorineural hearing loss                         | Children 4–15 years                      | 370            | PTA at frequencies of 500, 1000, 2000, 4000, and 8000 Hz                        | >25 dB HL                                                                          | Hearing impairment = 33.0% SNHL = 3.8% CHL = 27.5% SNHL = 0% CHL = 25%                            |
| Christopher et al., 2013        | Cross-sectional  | To determine the prevalence, types, and severity of hearing impairment in HIV    | Children 6 months–5 years                | 2668           | OAE screen frequency (500, 1000, 2000, and 4000Hz)                             | >25 dB HL                                                                          | Hearing impairment = 5%                                                                           |
| Clark, 2008                     | Cross-sectional  | To present results on the prevalence of hearing impairment and otology           | Children 3–18 years                      | 281            | Otoscopic, tympanometry, and PTA of HL at 1, 2 and 4 kHz                         | >25 dB HL                                                                          | Unilateral hearing impairment = 24.5% Bilateral hearing impairment = 12.5%                       |
| Devendra et al., 2013           | Case–control     | To estimate the prevalence of hearing impairment                                 | Children 2–9 years                       | 263            | WHO protocol                                                                    | None                                                                                | Hearing impairment = 12% among cases versus controls = 2%                                      |
| Edmond et al., 2010             | Prospective      | To assess disabling sequelae of meningitis                                       | Children >4 years                        | 213            | WHO protocol                                                                    | >25 dB HL                                                                          | Hearing impairment = 51.8% among cases and 30.3% among controls                                 |
| Geda et al., 2016               | Cross-sectional  | To assess the magnitude and types of hearing impairment                          | Children <15 years                       | 21,572         | UNICEF's disability screening tool                                               | None                                                                                | Hearing impairment = 1.94%                                                                        |
| Hunt et al., 2017               | Cross-sectional  | To determine the prevalence of chronic supportive otitis media and mild hearing impairment | Children 4–6 years                      | 281            | PTA                                                                             | >25 dB HL                                                                          | Hearing impairment = 2.2%, mild 48.6%, mild-to-moderate 17.1%, moderate-to-severe 14.3%, severe-to-profound 20.0% |
| Ilechukwu et al., 2016          | Cross-sectional  | To determine the prevalence of ear-related problems                              | Children <17 years                       | 248            | Otoscopy confirmed by the otolaryngologist                                      | None                                                                                | Hearing impairment = 7.3%                                                                         |
| Olusanya, 2000                  | To assess the prevalence and pattern of hearing impairment                       | School children                         | 359            | Parental interviews, autoscopy PTA                                               | >20 dB HL                                                                          | Hearing impairment = 13.9% Otitis media with effusion and impacted cerumen significant association with hearing impairment |
| Nakku et al., 2017              | Cross-sectional  | To determine the types of hearing impairment                                      | Children 6–12 years                      | 227            | PTA                                                                             | None                                                                                | Overall hearing impairment = 9.3%, conductive = 15.9%, SNHL = 6.2% Age = 11–12 years, previous ear infection, and the use of TB drugs |
| Mahomed-Asmail, 2016            | Cross-sectional  | To identify the prevalence and characteristics of hearing impairment             | Children Grades 1–3                      | 1070           | Otoscopy, tympanometry, and PTA of HL at 1, 2 and 4 kHz                         | >25 dB HL                                                                          | Hearing impairment = 2.2%, mild 48.6%, mild-to-moderate 17.1%, moderate-to-severe 14.3%, severe-to-profound 20.0% |
| Author, year, & country | Study design | Primary interest | Target population | Sample size (n) | Diagnostic method | Normality criterion | Key findings and risk factors |
|-------------------------|--------------|------------------|-------------------|----------------|-----------------|---------------------|-----------------------------|
| Seddon et al., 2013<sup>5</sup> | Cross-sectional | To determine the frequency and extent of hearing impairment in children | Children <15 years | 94 | Otoscopy, tympanometry, PTA, and DPOAEs at 1, 2, 4, and 8 kHz | >25 dB HL | Hearing loss = 24%, Tuberculosis |
| Tataryn et al., 2017<sup>5</sup> Malawi | Cross-sectional | To estimate the prevalence of hearing impairment | Children <18 years | 720 | DPOAE PTA | >35 dB HL | Hearing impairment = 27%, and 73% of them had a bilateral hearing impairment |
| Westerberg et al., 2005<sup>5</sup> Zimbabwe | Cross-sectional | To determine the prevalence of significant hearing impairment | Primary school children | 5528 | Microumometric, thresholds at 1, 2, and 4 kHz in a quiet classroom | 40 dB HL | A conductive hearing loss of 1.4%, sensorineural hearing impairment = 56/1.0%, and significant hearing impairment = 2.4% |
| Yousof Hussein et al., 2018<sup>5</sup> | Cross-sectional | To determine and describe hearing impairment | Preschool children 3–6 years | 725 | Otoscopy, tympanometry, and PTA at 1, 2, and 4 kHz | >25 dB HL | Hearing impairment = 18.7%, conductive = 65.2%, SNHL = 28.2%, and mixed losses = 6.5% |
| Olusanya, 2003<sup>36</sup> Nigeria | Case-control | To determine whether impacted cerumen had been removed were at greater risk of hearing impairment | Children 4–10 years | 113 cases | PTA at frequencies of 0.5, enlisted for 1, 2, and 4 kHz | None | 23% case hearing loss |
| Borenstein et al., 2015<sup>51</sup> Zimbabwe | Cross-sectional | To determine the prevalence, cause, and severity of hearing impairment | Children 5–17 years | 113 controls | Otoscopic and PTA | >20 dB HL | Hearing impairment = 4.4%, Otos media and a history of impacted cerumen |
| Omondi et al., 2007<sup>54</sup> Kenya | Cross-sectional | Parental awareness of childhood hearing impairment and the pattern of access to and utilisation of ambulatory care services | Primary school children | 1411 | PTA | >26 dB HL | Hearing impairment = 32.3%, Recent CD4 count <330 cell/µL |
| Oluwatson et al., 2011<sup>35</sup> Nigeria | Cross-sectional | To carry out otoscopic and audiologic examinations | Preschool children | 101 | PTA | >25 dB HL | Hearing impairment = 2.13% Impacted cerume (21.8) |
| Westerberg et al., 2008<sup>50</sup> Uganda | Cross-sectional | To determine the prevalence and causes of disabling hearing loss | All ages | 6041 | WHO protocol | None | Hearing impairment = 1.02% in children Cerumen impaction, chronic suppurrative otitis media, and meningitis resulted in disabling hearing loss in 41% of children |
| Louw et al., 2018<sup>33</sup> South Africa | Cross-sectional | Prevalence of hearing loss at primary health care clinics | Children 3–14 years | 126 | PTA | 25 dB HL | Hearing impairment = 4.8% younger age-associated factors |
| North-Matthiassen, 2007<sup>57</sup> South Africa | Retrospective audit | The hearing profile among school learners | Children 6–12 years | 1101 | PTA | 25 dB HL | Hearing impairment = 7.9% |
| Couper, 2002<sup>25</sup> South Africa | Cross-sectional | To determine the prevalence of disability in children | Children <10 years | 2036 | WHO protocol | None | Hearing impairment = 1% |
| Maczuga et al., 2014<sup>48</sup> Cameron | Nested case-control | To assess prevalence of visual, hearing, and musculoskeletal impairment | Children 4–17 years | 3567 | OAE and PTA | 35 dB HL | Hearing impairment = 3.6% |

Note. TEOAE: transitory evoked otoacoustic emissions; OAE: otoacoustic emissions; WHO: World Health Organization; UNICEF: United Nations Children’s Fund; PTA: pure tone audiometry; SNHL: sensor neural hearing loss; CHL: conductive hearing loss; HIV: human immunodeficiency virus; DPOAE: distortion product otoacoustic emissions; ABR: auditory brainstem response.
total of 1,594 studies. Of these, 540 studies were found to be duplicates through EndNote and manual tracing. The remaining studies were screened using their titles and abstracts, and 962 of them did not fulfill the inclusion criteria and were thus removed from the systematic review process. The full texts of 92 studies were thoroughly assessed to ensure the presence of at least the primary outcome measures in a sufficient and non-ambiguous way. In this regard, 61 studies did not meet the inclusion criteria and were thus removed. Eventually, 26 studies addressing the outcome of interest were included (Figure 1).

**Study characteristics**

From the studies included in the analysis, Twenty-one studies were cross sectional5,24,25,27–30,42–55 while three studies were case–control,56–58 and the remaining studies were prospective cohort.23,26 All the included studies were conducted between 2000 and 2018 with the sample size ranging from 94 to 21,572. All included studies were written in English. General characteristics and descriptions of the studies are recorded (Table 1).

**The pooled prevalence of hearing impairment**

In studies with a sample of 57,572 children, the pooled prevalence of hearing impairment was 10% (95% confidence interval (CI): 9%–11%) (Figure 2). The prevalence of hearing impairment varied with normality criteria and the most commonly used normality criterion was 25 and 30 dB, but this also ranged between 20 and 40 dB. Based on this variability, we did subgroup analysis for normality criterion and study population characteristics. In three studies that used a threshold of >20 dB HL, the pooled prevalence of hearing impairment was 17% (95% CI: 11%–24%). In thirty studies that used a threshold of >25 dB HL, the pooled prevalence of hearing impairment was 19% (95% CI: 15%–23%). In a couple of studies that used a threshold of >30 dB HL, the pooled prevalence of hearing impairment was 2% (95% CI: 2%–3%). In another two studies that used a threshold of >35 dB HL, the pooled prevalence was 1% (95% CI: 1%–1%). On the other hand, in six studies that used questioners based on self-report or parental interview methods to assess childhood hearing impairment, the pooled prevalence was 6% (95% CI: 3%–9%) (Figure 3).

The magnitude of hearing impairment also varied with the characteristics of the study population. This review included articles with heterogeneous groups of study subjects; many of the studies done from school or community-based children, and others were based on specific groups of children like children living with HIV (human immunodeficiency virus), a survivor of meningitis, sickle cell anemia,
and tuberculosis. We did subgroup analysis based on population characteristics included in the study. The pooled prevalence of hearing impairment for school or community-based children was 6% (95% CI: 5%–7%). In addition, the pooled prevalence of hearing impairment for children with comorbidities was 23% (95% CI: 15%–31%); Figure 4).

The studies analyzed different populations, age groups, diagnosis criteria, and methods, revealing heterogeneity in the findings. There was variation in the diagnostic methods and normality criteria across the selected studies. In nine studies, auditory threshold and otoscopy were used for screening procedure. In 14 studies, automated pure tone audiometry was applied. In addition, several studies used TEOAE (transitory evoked otoacoustic emission) audiometric diagnosis and WHO or UNICEF questions based parental interview to assess hearing impairment. Regarding normality criteria, there were differences even among those that utilized the same technique ranging from 20 to 40 dB. Due to these differences, there were variations in the prevalence values encountered, especially because some studies analyzed prevalence through different criteria and/or assessed a wider age group. Similarly, the study of associated factors was not homogeneous. Eighteen studies did not include an analysis of associated factors besides the prevalence of hearing impairment. Due to the low number of studies that evaluated associated factors, the causes established by the studies were indicated as associated factors.

**Risk factors of hearing impairment**

*Chronic suppurative otitis media and impacted cerumen.* In three studies, hearing impairment was significantly associated with chronic suppurative otitis media (CSOM) or ear infection. Although the strength of the association varies (ranging from 2 to 7 times), those children who had a story...
of recurrent ear infection were more likely to have than their counterparts. Likewise, in some studies, children who had impacted cerumen were 6 times more likely to have hearing impairment than those who were not having impacted cerumen.

**HIV and tuberculosis infection.** In two studies, children and adolescents who were at a severe immunodeficiency stage, that is, WHO stages 3 and 4 or their CD4 count less than 350 cells/µL, were 2 times more likely to have hearing impairment than their counterparts. Furthermore, hearing impairment was associated with childhood exposure to anti-TB medication. An additional only one study reported that malnourished children were 2 times more likely to have hearing impairment than well-nourished children.

**Age, gender, and ethnicity.** In three studies, hearing impairment was associated with an age fewer than 12 years, and children of this age range were more prone to hearing impairment than older adolescents. In one study, age or gender did not have an association with hearing impairment. Regarding ethnicity, one study reported that Caucasian children were 3 times more likely to have hearing impairment than African children who reside in Africa.

**Discussion**

This systematic review and meta-analysis aimed to identify the prevalence of hearing impairment and its associated factors and made recommendations to prevent hearing impairment. The presence of hearing impairment in children as a health problem has been widely reported. The challenge is more significant in developing countries because routine screening for hearing impairment and early intervention is unfortunately not carried out. This systematic review summarized up-to-date empirical evidence and indicates key areas of action regarding hearing impairment in SSA. This is an important step forward to ensure child health program planners and policymakers related to disabilities in SSA make informed decisions regarding where the corrective
measures should be instituted and maximized. We found out that the pooled prevalence hearing impairment was 10% (CI): 9%–11%, and CSOM, impacted cerumen, advanced stage of HIV, TB infection, and age of the children were associated with hearing impairment in SSA.

Generating a coherent set of estimation become challenging due to clinical heterogeneity including variations in the identification methods for hearing impairment, normality criteria, and population groups, which result in variability in the prevalence of hearing impairment. Due to this, the subgroup analysis finding has shown that hearing impairment was 17% for using a threshold of >20 dB HL, 19% for >25 dB HL, 2% for >30 dB HL, and 1% for >35 dB HL, while the prevalence of hearing impairment using questionnaire-based self-report or parental interview method was 6% (95% CI: 3%–9%). Furthermore, this review included articles with heterogeneous groups of study subjects; many of the studies conducted from school-based or community children, and others were based on a specific group of children like living with HIV, and survivors of meningitis, sickle cell anemia, and tuberculosis. We did a subgroup analysis based on population characteristics. The prevalence of hearing impairment for school or community-based children was 6% (95% CI: 5%–7%) and 23% (95% CI: 15%–31%) for children with above comorbidities.

Regardless of this, hearing impairment estimation is relatively comparable with the systematic review of hearing impairment in Africa. However, this finding was higher than a systematic review reported from Germany and worldwide children. In fact, this might be due to children in SSA are living in poverty, malnutrition, and living with a high prevalence of infections that predispose for hearing impairment. Furthermore, the higher prevalence of hearing impairment may reflect a systematic bias of school-based surveys due to the exclusion of school non-attenders. In addition, this might be due to the lower thresholds used for defining hearing impairment in the included studies (20–30 dB). However, the prevalence of hearing impairment varies from 1.94% to 32.3%. While some studies utilized the threshold screening and otoscopy method, others used the diagnostic assessment and the use of WHO or UNICEF parental interview methods for screening purpose. Thus, hearing impairment measurement variation may also result in difference in the magnitude of the hearing impairment.

Moreover, there was variability in the study of risk factors associated with hearing impairment. It must be highlighted that the age ranges with age groups were not the same. Some studies mixed toddlers and preschoolers with school-aged individuals and adolescents. Unfortunately, many of the studies did not clearly present the causes of hearing impairment. However, we found the most common causes of hearing impairment like CSOM, the leading cause of preventable childhood hearing loss in developing countries. This might be a result of low socioeconomic status, overcrowding, malnutrition, and exposure to wood smoke. In addition, hearing impairment in children and adolescents in developing countries may have been caused by higher rates of childhood infections such as tuberculosis, measles, HIV, and meningitis, which impacted cerumen, and from the use of ototoxic drugs. Also, factors of hearing impairment were often not well assessed, limiting the utility for improving service delivery. Therefore, better data are demanded on the prevalence of hearing impairment and its associated factors in SSA.

The present review had certain limitations. First, the search was only limited to articles published in the English language. Second, despite the incorporation of studies from different parts of the region, the representativeness of the population is not as strong because the studies were observational in nature and had high heterogeneity. Finally, this review was not powered to formally assess potential associations of hearing impairment, and analysis was limited by the low number of articles observed. This review also has strengths like the selection and inclusion of both published and unpublished literature which has the potential to minimize publication bias. Moreover, our search strategy was extensive using multiple reputable databases and search engines. In addition, it fills the data gap and urges the concerned body to initiate the screening and intervention programs to reduce the burden of childhood hearing impairment.

Conclusion

There is a high prevalence of hearing impairment in children and adolescents in SSA, and also, many of the risk factors are preventable and treatable. Further, a well-designed epidemiological study in a more representative population using standardized definitions of hearing impairment and objective methods for case ascertainment seems warranted. This is because very few studies are available to investigate the associated factors of hearing impairment. Furthermore, the available studies used different cutoff making the comparison more difficult. Therefore, we recommend that the diagnosis modality should be standardized for studies in SSA and other developing countries. In addition, regular community and school-based screening activities for early detection and necessary intervention programs should be designed by concerned stakeholders on childhood hearing impairment.

Acknowledgements

We would like to thank the School of Nursing and Midwifery, College of Health and Medical sciences, Haramaya University for their non-financial support.

Author contributions

A.D. conceived and designed the review. A.D. carried out activities from inception to the draft of the manuscript and is the guarantor of the review. A.D., A.S., T.A., and T.F.G. developed search strings, selection, and analysis. All authors provided intellectual contribution for interpretation and rigorously reviewed the manuscript. All authors read and approved the final version of the manuscript.
Declaration of conflicting interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding
The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iDs
Assefa Desalew https://orcid.org/0000-0001-6065-0708
Tilahun Ali https://orcid.org/0000-0003-0523-8336

Supplemental material
Supplemental material for this article is available online.

References
1. World Health Organization (WHO). 3 March 2016: world hearing day: childhood hearing loss: act now, here’s how! Vol. 8. Geneva: WHO, 2016, pp. 151–153, http://www.who.int/pbd/deafness/world-hearing-day/2016
2. Khairi Md Daud M, Noor RM, Rahman NA, et al. The effect of mild hearing loss on academic performance in primary school children. Int J Pediatr Otorhinolaryngol 2010; 74(1): 67–70.
3. Tian H, Lu C, Yang J, et al. WHO global estimates on prevalence of hearing loss. Global Biogeochem Cycles 2015; 29(6): 775–792.
4. Olusanya BO. Addressing the global neglect of childhood hearing impairment in developing countries. PLoS Med 2007; 4(4): e74.
5. Ilechukwu GC, Ilechukwu CGA, Ezeanolue BC, et al. Ear-related problems among children attending the paediatric and otorhinolaryngology out-patients clinics of the University of Nigeria Teaching Hospital, Enugu. Afr Health Sci 2016; 16(2): 363–366.
6. World Health Organization (WHO). Deafness and hearing loss. Geneva: WHO, 2018, http://www.who.int/en/news-room/fact-sheets/detail/deafness-and-hearing-loss
7. World Health Organization (WHO). Addressing the rising prevalence of hearing loss. Geneva: WHO, 2018, p. 40, https://apps.who.int/iris/handle/10665/260336
8. Kaspar A, Kei J, Driscoll C, et al. Overview of a public health approach to pediatric hearing impairment in the Pacific Islands. Int J Pediatr Otorhinolaryngol 2016; 86: 43–52.
9. Mulwafu W, Kuper H and Ensink RJH. Prevalence and causes of hearing impairment in Africa. Trop Med Int Health 2016; 21(2): 158–165.
10. Adedeji TO, Tobih JE, Sogebi OA, et al. Management challenges of congenital & early onset childhood hearing loss in a sub-Saharan African country. Int J Pediatr Otorhinolaryngol 2015; 79(10): 1625–1629.
11. Rogha M and Mokhtari E. Study of the knowledge of pediatricians and senior residents relating to the importance of hearing impairment and deafness screening among newborns. Iran J Otorhinolaryngol 2014; 26(75): 57–64.
12. World Health Organization (WHO). Childhood hearing strategies for prevention and care. Geneva: WHO, 2016, p. 30, http://www.who.int/about/licensing
13. Olatoke F, Ologe FE and Nwawolo CCSM. The prevalence of hearing loss among schoolchildren with chronic supplicative otitis media in Nigeria, and its effect on academic. Ear Nose Throat J 2008; 87(12): E19.
14. UNICEF. The state of the world’s children, Executive summary 2013: children with disabilities [Internet]. New York: United for Children, 2013, pp. 1–26, available from. http://www.unicef.org/publications/files/SOWC2013
15. UNICEF. A post—2015 world fit for children—issue brief: strengthening resilience through disaster risk. New York: UNICEF, 2015, pp. 2–3, http://www.unicef.org/post2015
16. Stevens G, Flaxman S, Brunskill E, et al. Global and regional hearing impairment prevalence: an analysis of 42 studies in 29 countries. Eur J Public Health 2013; 23(1): 146–152.
17. World Health Organization (WHO). Primary ear and hearing care training resource: advanced level. Geneva: Chronic Disease Prevention and Management, WHO Library Cataloguing-in-Publication Data, WHO, 2006, https://www.who.int/pbd/deafness/activities/hearing_care/advanced.pdf?ua=1
18. Osei AO, Larnyo PA, Azaglo A, et al. Screening for hearing loss among school going children. Int J Pediatr Otorhinolaryngol 2011; 11: 7–12.
19. The Lancet. Taking childhood hearing loss seriously. Lancet 2007; 369(9569): 1234.
20. Stevens G, Flaxman S, Brunskill E, et al. Global and regional hearing impairment prevalence: an analysis of 42 studies in 29 countries. Eur J Public Health. 2013;23(1):146–152. doi:10.1093/eurpub/ckr176
21. World Health Organization (WHO) Millions of people in the world have hearing loss that can be treated or prevented. Geneva: WHO, 2013, p. 20, http://www.who.int/pbd/deafness/news/Millionslivewithhearingloss.pdf?ua=1
22. World Health Organization (WHO) Global school health initiatives: achieving health and education outcomes (Report of a meeting, Bangkok, Thailand, 23–25 November 2015). Geneva: WHO, 2017, www.who.int/healthpromotion/publications
23. Alabi S, Ernest K, Eletta P, et al. Otological findings among Nigerian children with sickle cell anaemia. Int J Pediatr Otorhinolaryngol 2008; 72(S): 659–663.
24. Clark JL. Hearing loss in Mozambique: current data from Inhambane Province. Int J Audiol 2008; 47(Suppl. 1): S49–S56.
25. Tataryn M, Polack S, Chokotho L, et al. Childhood disability in Malawi: a population based assessment using the key informant method. BMC Pediatr 2017; 17(1): 1–12.
26. Edmond K, Dieye Y, Griffiths UK, et al. Prospective cohort study of disabling sequelae and quality of life in children with bacterial meningitis in urban Senegal. Pediatr Infect Dis J 2010; 29(11): 1023–1029.
27. Hunt L, Mulwafu W, Knott V, et al. Prevalence of paediatric chronic suppurative otitis media and hearing impairment in rural Malawi: a cross-sectional tele-otoscopy survey. Trop Med Int Heal 2017; 22(Suppl. 1): 106–107.
28. Mahomed-Asmail F, Swanepoel de W and Eikelboom RH. Hearing loss in urban South African school children (grade 1 to 3). Int J Pediatr Otorhinolaryngol 2016; 84: 27–31.
29. Hrapcak S, Kuper H, Bartlett P, et al. Hearing loss in HIV-infected children in Lilongwe, Malawi. PLoS ONE 2016; 11(8): e0161421.
30. Matsekete J, Chidziva C, Matinhira N, et al. Hearing impairment and deafness among HIV infected children and adolescents in Harare, Zimbabwe. Cent Afr J Med 2015; 61(9–12): 56–61.

31. World Health Organization (WHO). Prevention of blindness and deafness—grades of hearing impairment. Geneva: WHO, 2013, p. 4000, http://www.who.int/pbd/deafness/hearing_impairment_grades

32. Olusanya BO and Newton VE. Global burden of childhood hearing impairment and disease control priorities for developing countries. Lancet 2007; 369(9569): 1314–1317.

33. Jamison DT, Breman JG, Measham AR, et al. Disease control priorities in developing countries. 2nd ed. Washington, DC: The World Bank for Reckonstruction and Development / The World Bank, 2006, pp. 1293–1307.

34. McPherson B and Swart SM. Childhood hearing loss in sub-Saharan Africa: a review and recommendations. Int J Pediatr Otorhinolaryngol 1997; 40(1): 1–18.

35. The African Child Policy Forum (ACPF). Educating children with disabilities in Africa. Addis Ababa, Ethiopia: ACPF, 2011.

36. World Health Organization (WHO). Multi-country assessment of national capacity to provide hearing care. Geneva: WHO, 2013, pp. 1–49, http://www.who.int/pbd/deafness

37. UNICEF & UNESCO. Children with disabilities (Paper commissioned for Fixing the Broken Promise of Education for All: Findings from the Global Initiative on Out-of-School Children [UIS/UNICEF, 2014]. Findings from the Global Initiative on Out-of-School Children [UIS/UNICEF, 2015]), Montreal, QC, Canada: UNESCO Institute for Statistics (UIS), 2014, pp. 1–12.

38. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009; 6(7): e1000097.

39. EndNote™ Online. EndNote online—quick reference guide. Philadelphia, PA, 2015, https://endnote.com/wp-content/uploads/m/pdf/en-online-qrc.pdf

40. Moola S, Munn Z, Tufanaru C, et al. Checklist for observational studies (UBI Reviewer’s Manual). Joanna Briggs Institute, 2017, https://joannahiggs.org/sites/default/files/2019-05/JBI_Critical_Appraisal-Checklist_for_Case_Series2017_0.pdf

41. Borenstein M, Hedges L, Higgins J, et al. Comprehensive Meta Analysis (CMA). Version 2.00, 2004 https://www.meta-analysis.com › downloads › Meta-Analysis-Manual.

42. Yousuf Hussein S, Swane pooel W, Mahomed-Asmail F, et al. Hearing loss in preschool children from a low income South African community. Int J Pediatr Otorhinolaryngol 2018; 115: 145–148.

43. Olusanya BO, Okolo AA and Ijaduola GT. The hearing profile of Nigerian school children. Int J Pediatr Otorhinolaryngol 2000; 55(3): 173–179.

44. Christopher N, Edward T, Sabrina BK, et al. The prevalence of hearing impairment in the 6 months - 5 years HIV/AIDS-positive patients attending paediatric infectious disease clinic at Mulago Hospital. Int J Pediatr Otorhinolaryngol 2013; 77(2): 262–265.

45. Seddon JA, Thee S, Jacobs K, et al. Hearing loss in children treated for multidrug-resistant tuberculosis. J Infect 2013; 66(4): 320–329.

46. Basanez I, Nakku D, Stangl S, et al. Prevalence of hearing loss among primary school children in Mbarara, Uganda. Int J Pediatr Otorhinolaryngol 2015; 79(12): 2359–2363.

47. Geda B, Berhane Y, Assefa N, et al. In rural Eastern Ethiopia hearing loss is the most frequent disability during childhood: a community based survey. PLoS ONE 2016; 11(5): e0152791.

48. Nakku D, Nyaiteera V, Llowet E, et al. HIV status and hearing loss among children between 6 and 12 years of age at a large urban health facility in south western Uganda. Int J Pediatr Otorhinolaryngol 2017; 101: 172–177.

49. Westerberg BD, Skowronski DM, Stewart IF, et al. Prevalence of hearing loss in primary school children in Zimbabwe. Int J Pediatr Otorhinolaryngol 2005; 69(4): 517–525.

50. Westerberg BD, Lee PK and Lukwago L. Cross-sectional survey of hearing impairment and ear disease in uganda. J Otolaryngol Head Neck Surg 2008; 37: 753–758.

51. North-Matthiasen C and Singh SA. The hearing profile among learners in schools in the Western Cape, South Africa. Int J Pediatr Otorhinolaryngol 2007; 71(1): 113–118.

52. Couper J. Prevalence of childhood disability in rural KwaZulu-Natal. S Afr Med J 2002; 92(7): 549–552.

53. Louw C, Swanepoel DW, Eikelboom RH, et al. Prevalence of hearing loss at primary health care clinics in South Africa. Afr Health Sci 2018; 18(2): 313–320.

54. Omondi D, Ogol C, Otieno S, et al. Parental awareness of hearing impairment in their school-going children and healthcare seeking behaviour in Kisumu district, Kenya. Int J Pediatr Otorhinolaryngol 2007; 71(3): 415–423.

55. Oluwatosisin S, Oluyomi S, Abayomi O, et al. Pre-school hearing screening: profile of children from Ogbomoso, Nigeria. Int J Pediatr Otorhinolaryngol 2013; 77(12): 1987–1991.

56. Olusanya BO. Hearing impairment in children with impacted cerumen. Ann Trop Paediatr 2003; 23(2): 121–128.

57. Devendra A, Makawa A, Kazembe PN, et al. HIV and childhood disability: a case-controlled study at a paediatric antiretroviral therapy centre in Lilongwe, Malawi. PLoS ONE 2013; 8(12): e84024.

58. Macaggarl I, Polack S, Kuper H, et al. The north west Cameron disability study country report. London School of Hygiene and Tropical Medicine (LSHTM), 2014, p. I, http://disabilitycentre.lshtm.ac.uk

59. Rao RSP, Subramanya MA, Nair NS, et al. Hearing impairment and ear diseases among children of school entry age in rural South India. Int J Pediatr Otorhinolaryngol 2002; 64(2): 105–110.

60. Lohler J, Walther LE, Hansen F, et al. The prevalence of hearing loss and use of hearing aids among adults in Germany: a systematic review. Eur Arch Otorhinolaryngol 2019; 276(4): 945–956.

61. Wang J, Sung V, Carew P, et al. Prevalence of childhood hearing loss and secular trends: a systematic review and meta-analysis. Acad Pediatr 2019; 19(5): 504–514.

62. Melaku A and Lulseged S. Chronic suppurative otitis media in a children’s hospital in Addis Ababa, Ethiopia. Ethiop Med J 1999; 37(4): 237–246.