



PHILIPPINE GUIDELINES on PERIODIC HEALTH EXAMINATION



Screening for Hearing Disorders



PERIODIC HEALTH EXAMINATION TASK FORCE 2023



As of 29 September 2023



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This clinical practice guideline (CPG) is intended for general practitioners, specialists, and allied health professionals who are primary care providers. Although adherence to this guideline is encouraged by The Department of Health (DOH), the written recommendations should **not** restrict healthcare providers from using their clinical judgment in handling individual cases. Providers should consider the variables unique to disease manifestation, as well as patient characteristics, values, and preferences.

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This CPG is limited by the best available scientific evidence at the time of its formulation. New evidence may emerge after CPG creation, which may affect its validity and applicability in the future.

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Participating Societies, Organizations, Agencies and/or Institutions

Association of Clinical Audiologists of the Philippines (ACAP)
Department of Labor and Employment (DOLE)
Philippine Academy of Family Physicians (PAFP)
Philippine Academy of Neurotology, Otology & Related Sciences (PANORS)
Philippine Association of Speech Language Pathologists (PASP)
Philippine National Ear Institute (PNEI)
Philippine Society for Developmental and Behavioral Pediatrics (PSDBP)
Philippine Society of Otolaryngology-Head and Neck Surgery (PSO-HNS)

List of Abbreviations

ACAP	Association of Clinical Audiologists of the Philippines
ABR	Auditory Brainstem Response
ANSD	Auditory Neuropathy Spectrum Disorder
ASSR	Auditory Steady State Response
AABR	Automated Auditory Brainstem Response
BOA	Behavioral Observation Audiometry
BPPV	Benign Paroxysmal Positional Vertigo
BAER	Brainstem Auditory Evoked Responses
CEA	Cost-Effectiveness Analysis
CMV	Cytomegalovirus
COI	Conflict of Interest
COIRC	COI Review Committee
CP	Consensus Panel
CTFPH	Canadian Task Force on Preventive Health Care
DOH	Department of Health
DOLE	Department of Labor and Employment
DALY	Disability-Adjusted Life Years
EHDI	Early Hearing Detection and Intervention
ERE	Evidence Review Experts
EtD	Evidence to Decision
GDP	Gross Domestic Product
GP	General Practitioner
GRADE	Grading of Recommendations, Assessment, Development, and Evaluation
GDP	Gross Domestic Product
HHIE-S	Hearing Handicap For The Elderly – Screening Version
HL	Hearing Loss
HSAQ	Hearing Self-Assessment Questionnaire
Inner EAR	Inner Effectiveness of Aural Rehabilitation
JCIH	Joint Committee on Infant Hearing
LR	Likelihood Ratio
MA	Meta-Analysis
MD	Mean Difference
NHANES	National Health and Nutrition Examination Survey
NICE	National Institute for Health and Care Excellence
NIH-ICE	National Institutes of Health-Institute of Clinical Epidemiology
NMB	Net Monetary Benefit
NNT	Number Needed to Treat
NR	Not Reported
OAE	Otoacoustic Emissions
OME	Otitis Media with Effusion
OR	Odds Ratio
PBHL	Permanent Bilateral Hearing Loss
PCHI	Permanent Childhood Hearing Impairment
PAFP	Philippine Academy of Family Physicians
PANOR S	Philippine Academy of Neurotology, Otology & Related Sciences
PASP	Philippine Association of Speech Language Pathologists
PGH-EU	Philippine General Hospital – Ear Unit
PHIC	Philippine Health Insurance Corporation

PNEI	Philippine National Ear Institute
PSDBP	Philippine Society for Developmental and Behavioral Pediatrics
PSO-HNS	Philippine Society of Otolaryngology-Head and Neck Surgery
PTA PTT	Pure Tone Audiometry Pure Tone Threshold
RCT	Randomized Controlled Trial
RETSPLs RFMHT ROC	Reference Equivalent Threshold Sound Pressure Levels Revised Five-Minute Hearing Test Receiving Operating Characteristic
ROI RR	Return of Investment Relative Risk
SAI-WHAT	Screening for Auditory Impairment – Which Hearing Assessment Test
SC SMD SR	Steering Committee Standardized Mean Difference Systematic Review
UNHS	Universal Newborn Hearing Screening
USPSTF	US Preventive Services Task Force
WHO WIN WVT	World Health Organization Words in Noise Whispered Voice Test
YLDs	Years Lived with Disability

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Executive Summary

This clinical practice guideline (CPG) is an output from the joint undertaking of the DOH and NIH-ICE. The guideline is intended to be used by general practitioners and specialists in the primary care setting, allied health practitioners, policy makers, employers and administrators, funders of healthcare, other stakeholders in the health industry, and even patients. This CPG is a set of 10 recommendations based on systematic synthesis of evidence to address screening for hearing and vestibular disorders among apparently healthy children (from prenatal to school age) and adults.

The guideline development process followed the widely accepted Grading of Recommendations, Assessment, Development, and Evaluation or the GRADE approach including GRADE Adolopment,¹ a systematic process of adapting evidence summaries and the GRADE Evidence to Decision or EtD² framework. It included the following steps: (1) identification of critical questions and critical outcomes, (2) retrieval of current evidence, (3) assessment and synthesis of the evidence base for these critical questions, (4) formulation of draft recommendations, (5) convening of a multi-sectoral stakeholder panel to discuss values and preferences and assess the strength of the recommendations, and (6) planning for dissemination, implementation, impact evaluation and updating.

The recommendations in this CPG shall hold and will be updated after 3 years or when new evidence arises.

¹

²

Summary of Recommendations

Table 1. Recommendations on screening for hearing disorders

Recommendation	Certainty of Evidence	Strength of Recommendation
Asymptomatic Apparently Healthy Children		
Among asymptomatic apparently healthy school-aged children, we recommend hearing loss screening using smartphone-based screening audiometry.	High	STRONG
Among apparently healthy newborns, we recommend hearing screening using OAE or AABR.	Moderate	STRONG
Among asymptomatic apparently healthy children with known risk factors for congenital and late-onset hearing loss (such as family history of hearing loss, maternal history of cytomegalovirus and syphilis infections, and culture-positive congenital infection, craniofacial anomalies and syndromes associated with hearing loss or progressive or late-onset hearing loss), we recommend hearing screening and periodic monitoring for delayed-onset hearing loss.	Very Low	STRONG
Among asymptomatic apparently healthy school-aged children, we suggest hearing loss screening using tuning fork test.	Low	WEAK
Among asymptomatic apparently healthy school-aged children, we suggest against hearing loss screening using pneumatic otoscopy.	Low	WEAK
Among asymptomatic apparently healthy school-aged children, we suggest against hearing screening using pure tone audiometry.	Very Low	WEAK
Asymptomatic Apparently Healthy Elderly Adults		
Among asymptomatic apparently healthy elderly adults (50 years old and above), we suggest hearing loss screening using portable pure tone audiometer screener or mobile-based audiometric applications.	Very Low	WEAK
Vestibular Disorders		
Among asymptomatic apparently healthy children and adults (<60 years old), we recommend against screening for vestibular disorders using clinical balance testing (Tandem Walking or Romberg's Test).	Very Low	STRONG
Among asymptomatic apparently healthy elderly adults (>60 years old), we recommend against screening for vestibular disorders using	Very Low	STRONG

Recommendation	Certainty of Evidence	Strength of Recommendation
clinical balance testing (Tandem Walking or Romberg's Test).		
Asymptomatic Apparently Healthy Pregnant Women		
Among asymptomatic apparently healthy pregnant women, we recommend against prenatal/antenatal screening for hearing loss using fetal heart rate monitoring.	Very Low	STRONG

References

1. Schunemann H, Wiercioch W, Brozek J, Etxeandia-Ikobaltzeta I, Mustafa R, Manja V. GRADE Evidence to Decision (EtD) frameworks for adoption, adaptation, and de novo development of trustworthy recommendations: GRADE-ADOLOPMENT. *J Clin Epidemiol*. 2017;81:101-10.
2. Schunemann HJ, Mustafa R, Brozek J, Santesso N, Alonso-Coello P, Guyatt G, et al. GRADE Guidelines: 16. GRADE evidence to decision frameworks for tests in clinical practice and public health. *J Clin Epidemiol*. 2016;76:89-98.

1. Introduction

The Philippine Guidelines on Periodic Health Examination (PHEX) was initially published in 2004.¹ It was a comprehensive guide on screening interventions committed to providing early prevention services for apparently healthy Filipinos. It was the first to offer evidence-based recommendations for screening, made possible through the concerted effort of medical and paramedical organizations composed of more than a hundred experts, researchers, and stakeholders.¹ It was inspired by the Canadian and the US Preventive Services Task Forces (USPSTF), but tailored to the Philippine setting.

The process of updating this guideline commenced in 2021 to support the Universal Health Care Act, which aims to provide all Filipinos access to quality and affordable medical services starting with primary care benefits.^{2,3}

This CPG's evidence-based recommendations for prioritized health screening were formulated using the GRADE Evidence-to-Decision (EtD) framework.^{4,5} This framework aims to facilitate the adaptation of recommendations and decisions of experts and stakeholders based on specific contexts, essential health outcomes, benefits, and harms while looking through the equity, applicability, and feasibility lenses.

The evidence used were classified into two: (1) screening for a risk factor, and (2) screening for early disease. Screening for the former determined the effective management of the condition as a risk factor, and screening for the latter focused on the performance of the tests that will be used to detect and subsequently treat that early disease and prevent it from progressing.

Due to potentially mislabeling healthy persons as ill, health screening may pose as a threat to an individual's psychological, social, physical, and even financial well-being. The consensus panel used five criteria, aligned with the EtD framework, to determine if screening for a particular condition can be beneficial and pragmatic: (1) high burden of illness, (2) accurate screening tests, (3) early treatment must be more effective than late treatment, (4) confirmatory tests and early management must be safe and available, and (5) costs of screening must be proportional with the potential benefit.

Hearing loss causes a substantial health impact to both adults; it a significant contributor to the global burden of disease. The World Health Organization (WHO) estimates that nearly 2.5 billion people will have some degree of hearing loss by 2050, of whom at least 700 million will require rehabilitation services. Majority of these people live in low- and middle-income countries, where access to ear and hearing care is often limited.⁶ This emphasizes the importance of hearing screening. Early detection encourages early treatment and helps prevent any long-term damage of untreated hearing problem. The listed consensus statements focuses on apparently healthy, asymptomatic children and adult Filipinos—those who do not have any signs or symptoms of hearing or vestibular disease such as decreased hearing, speech delay, imbalance, dizziness, vertigo and others.

Aside from government regulatory agencies and policy makers, the target users of this guideline include primary care providers, general physicians, specialists, training institutions, payors, patients, the general public, and industry partners.

References

1. Dans A, Morales D. Philippine Guidelines on Periodic Health Examination (PHEX): Effective Screening for Diseases among Apparently Healthy Filipinos. Manila: The Publications Program; 2004.

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3. PhilHealth. Circular No. 2020-0022: Implementing Guidelines for the PhilHealth Konsultasyong Sulit at Tama (PhilHealth Konsulta) Package. In: Corporation PHI, editor. Pasig City: PhilHealth; 2020.
4. Alonso-Coello P, Schünemann H, Moberg J, Brignardello-Petersen R, Davoli M, Treweek S, et al. GRADE Evidence to Decision (EtD) frameworks: a systematic and transparent approach to making well informed healthcare choices. 1: Introduction. *BMJ*. 2016;353:i2016.
5. Schünemann H, Wiercioch W, Brozek J, Etxeandia-Ikobaltzeta I, Mustafa R, Manja V. GRADE Evidence to Decision (EtD) frameworks for adoption, adaptation, and de novo development of trustworthy recommendations: GRADE-ADOLOPMENT. *J Clin Epidemiol*. 2017;81:101-10.
6. World report on hearing. World Health Organization; 2021 [cited 2022 Dec 3]. Available from: <https://www.who.int/teams/noncommunicable-diseases/sensory-functions-disability-and-rehabilitation/highlighting-priorities-for-ear-and-hearing-care>

2. Scope and Purpose

This CPG's recommendations address the need for hearing screening among apparently healthy individuals across different life stages—from fetal to elderly stage. The clinical questions cover different hearing screening tests (e.g., Otoacoustic Emissions [OAE], Automated Auditory Brainstem Response [AABR], Auditory Steady State Response [ASSR], Behavioral Observation Audiometry [BOA], tympanometry, tuning fork test, pneumatic otoscopy, screening audiometry, Pure Tone Audiometry [PTA]), genetic testing, clinical vestibular tests (Tandem Walking and Romberg's Test), and fetal heart rate monitoring. Critical outcomes for the pediatric population included speech delay, hearing loss, psychosocial development, quality of life, and school performance. Critical outcomes for the adult population included hearing loss, work-related injuries and disabilities, risk of fall, and quality of life.

3. CPG Development Methodology

3.1. Organization of the Process

The DOH outlined the guideline development process into four phases: (1) preparatory phase, (2) evidence synthesis, (3) conversion of the evidence to recommendations (EtD step), and (4) implementation and evaluation.¹

In the preparatory phase, the Task Force Steering Committee (SC) set the CPG objectives, scope, target audience, and clinical questions. The committee formed two other working groups, the technical work group (TWG) and the consensus panel (CP).

The TWG, composed of evidence review experts (EREs), was tasked to review existing CPGs, appraise and summarize evidence, and draft initial recommendations. The evidence summaries were then presented to the consensus panel members to finalize the recommendations.

The consensus panel consisted of multisectoral representatives tasked to review the evidence summaries and develop recommendations during the *en banc* meeting. They prioritized critical and important outcomes, discussed necessary considerations revolving around the recommendations, and voted on each recommendation and its strength.

3.2. Creation of the Evidence Summaries

The clinical questions were developed using the PICO (Population, Intervention, Comparator, and Outcome) format. The EREs searched for and appraised practice guidelines related to periodic health screening, including but not limited to those of the Canadian Task Force on Preventive Health Care (CTFPH), US Preventive Services Task Force (USPSTF), National Institute for Health and Care Excellence (NICE), and Philippine medical organizations. When a relevant CPG published within the last 5 years was deemed of good quality using the AGREE II tool, its evidence summaries were adapted and updated with recent evidence.

The appraisal results of existing CPGs and their evidence summaries determined the need for a systematic search in electronic databases (e.g., MEDLINE via PubMed, CENTRAL, Google Scholar) in order to carry out de-novo systematic reviews and meta-analysis for each question. All searches were done from November 2022 to May 2023. Details on the time periods were discussed under the specific questions. Relevant local databases and websites of medical societies were also utilized in the search. Keywords were based on PICO (MeSH and free text) terms set for each question. The EREs also contacted authors of related articles to verify details and identify other research studies for appraisal, if needed.

EREs appraised the directness, methodological validity, results, and applicability of each relevant article included. The EREs generated evidence summaries for each of the four questions. Each evidence summary included evidence on the burden of the problem, diagnostic performance, benefit, harm, and social and economic impact of the screening test/intervention. Evidence that will facilitate the decision (i.e., cost of screening test, cost-effectiveness studies, qualitative studies) were also included in the evidence summaries. The Quality of Evidence was assessed using the GRADE approach.²

Table 2. Basis for Assessing the Quality of the Evidence using GRADE Approach

Certainty of Evidence	Interpretation
High	We are very confident that the true effect lies close to that of the estimate of the effect
Moderate	We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low	Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very Low	We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect
Factors that lower quality of the evidence are: <ul style="list-style-type: none">● Risk of bias● Important inconsistency of results● Some uncertainty about directness● High probability of reporting bias● Sparse data/Imprecision● Publication bias	
Additional factors that may increase quality are: <ul style="list-style-type: none">● All plausible residual confounding, if present, would reduce the observed effect● Evidence of a dose-response gradient● Large effect	

3.3. Composition of the CPG Panel

The SC convened the CP considering possible conflicts of interests of each panel member. To ensure fairness and transparency, the composition was guided by the DOH manual.¹ Content experts and other key stakeholders were invited to join the CP. The key stakeholders included policymakers, patient advocates, allied medical practitioners such as audiologists and speech pathologists, and physicians from different settings (e.g., public primary care settings, private practice, occupational health settings). The allied medical practitioners are members of Philippine Association of Speech Language Pathologists (PASP) and Association of Clinical Audiologists of the Philippines (ACAP). The physicians are members of the different medical societies namely: Philippine Academy of Family Physicians (PAFP), Philippine Society of Otolaryngology-Head and Neck Surgery (PSO-HNS), Philippine Academy of Neurotology, Otology & Related Sciences (PANORS), Philippine National Ear Institute (PNEI) and Philippine Society for Developmental and Behavioral Pediatrics (PSDBP). One panelist represents the Department of Labor and Employment (DOLE).

3.4. Formulation of the Recommendations

Draft recommendations were formulated based on the quality of evidence, trade-offs between benefit and harm, cost-effectiveness, applicability, feasibility, equity, resources and uncertainty due to research gaps. Prior to the series of videoconference meetings, the consensus panel received the draft recommendations together with evidence summaries based on the EtD framework shown in Table 3. These recommendations, together with the evidence summaries, were presented during the *en banc* meeting.

Table 3. Detailed considerations based on the EtD framework³

- | |
|---|
| <ol style="list-style-type: none">1. Is the problem a priority?2. How accurate is the test?3. How substantial are the desirable anticipated effects?4. How substantial are the undesirable anticipated effects?5. What is the certainty of the evidence of test accuracy?6. Is there important uncertainty about or variability in how much people value the main outcomes, including adverse effects and burden of the test and downstream outcomes of clinical management guided by the test results?7. Does the balance between desirable and undesirable effects favor the test or the comparison?8. How large are the resource requirements (costs)?9. What is the certainty of the evidence of resource requirements (costs)?10. Does the cost-effectiveness of the test favor the test or the comparison?11. What would be the impact on health equity?12. Is the test acceptable to key stakeholders?13. Is the test feasible to implement? |
|---|

The strength of each recommendation (i.e., strong or weak) was determined by the panel considering the abovementioned factors. Strong recommendation means that the panel is “confident that the desirable effects of adherence to a recommendation outweigh the undesirable effects”. Weak recommendation means that the “desirable effects of adherence to a recommendation probably outweigh the undesirable effect but is not confident”.⁴

The recommendation for each question and its strength was determined through voting. A consensus decision was reached if 75% of all CP members agreed.² Consensus was reached in the first voting for all key questions except hearing screening for adults, for which additional research evidence was sought from the evidence reviewers. Evidence-based draft recommendations were also revised based on input arrived at by consensus during the *en banc* discussions.

3.5. Managing Conflicts of Interest

Each TF member was required to fill out and sign a declaration of interest form and submit their curriculum vitae. The SC and the Conflict of Interest (COI) Rview Committee (COIRC) screened the nominees for any possible conflict of interest that may bias their decisions. Those with significant potential COI based on the decision of the COIRC were not allowed to vote during the *en banc* meeting but fully participated in the panel discussions.

The SC facilitated the whole CPG formulation process, but their members had no direct participation in assessing and synthesizing the evidence, generating the evidence summaries and evidence-based draft recommendations of the EREs, and voting on final recommendations during the *en banc* consensus panel review. They invited relevant organizations to nominate individuals who can become part of the CP.

3.6. External Review Process

To improve quality and gather feedback on draft recommendations, this CPG was reviewed by independent stakeholders who were not members of the Task Force. Open-ended questions, comments, and suggestions were gathered from the reviewer. The panel then considered the results in formulating the final recommendations.

3.7. Planning for Dissemination and Implementation

All recommendations will be incorporated in a web-based and mobile application accessible to the public. The evidence summaries and the full CPG manuscript will be posted online in the DOH website and in <https://phex.ph>. An abridged manuscript of the CPG will be published in the Acta Medica Philippina. This will also be published in the official websites of the participating organizations. The CPG will undergo quality screening by the DOH Evidence Generation and Management Division for recognition and implementation as a National Practice Guideline by DOH and the Philippine Health Insurance Corporation (PHIC).

References

1. Department of Health, Philippine Health Insurance Corporation. Manual for Clinical Practice Guideline Development. 2018.
2. Balshem H, Helfand M, Schünemann HJ, Oxman AD, Kunz R, Brozek J, Vist GE, Falck-Ytter Y, Meerpohl J, Norris S, Guyatt GH. GRADE guidelines: 3. Rating the quality of evidence. *J Clin Epidemiol*. 2011 Apr;64(4):401-6. doi: 10.1016/j.jclinepi.2010.07.015. Epub 2011 Jan 5. PMID: 21208779.
3. Schünemann H, Wiercioch W, Brozek J, Etxeandia-Ikobaltzeta I, Mustafa R, Manja V. GRADE Evidence to Decision (EtD) frameworks for adoption, adaptation, and de novo development of trustworthy recommendations: GRADE-ADOLOPMENT. *J Clin Epidemiol*. 2017;81:101-10.
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4. Recommendation and Evidence Summaries

4.1. Hearing screening in asymptomatic apparently healthy children

4.1.1. Maternal history of infection, family history of hearing loss, physical examination

RECOMMENDATION

Among asymptomatic apparently healthy children with known risk factors for congenital and late-onset hearing loss (such as family history of hearing loss, maternal history of cytomegalovirus and syphilis infections, and culture-positive congenital infection, craniofacial anomalies and syndromes associated with hearing loss or progressive or late-onset hearing loss), we recommend hearing screening and periodic monitoring for delayed-onset hearing loss.

(*strong recommendation, very low certainty evidence*)

Considerations

The Republic Act No. 9709 or Universal Newborn Hearing Screening Act of 2009 mandates that all Filipino newborns should undergo hearing screening. While the consensus panel recognized that the recommendation above is specific to the high-risk population, this does not disregard the need to do newborn hearing screening for the general, non-high-risk population. Furthermore, the panelists deemed that monitoring for delayed-onset hearing loss, not just baseline hearing screening, is important for the high-risk population. However, delayed-onset hearing loss should be clearly defined to appropriately determine the timing of follow-up or specific age of re-testing after newborn hearing screening.

The evidence base used for this specific guideline development only included studies published in the last five years. The panelists noted that most newborn hearing screening studies were published prior to the year 2000, and were not included in the evidence base. This may have contributed to why the quality of evidence available was very low. Ultimately, the panel decided that there is no need to repeat the evidence review to add more studies.

Early intervention from early detection using a simple, virtually harmless test is cost-effective, and is impactful on individual and socioeconomic levels. Given that risk factors are well-established, the consequences of missing delayed-onset hearing may be detrimental to a child's development.

Overall, despite the very low certainty of evidence, a unanimous strong recommendation for hearing screening and monitoring was made by the panelists due to the benefits, cost-effectiveness, and the strong association between the risk factors and delayed-onset hearing loss—based on odds ratio.

Key Findings

Family history of hearing loss, craniofacial anomalies, and maternal history of infection (e.g., congenital toxoplasmosis, rubella, cytomegalovirus, herpes, syphilis, and other culture-

positive congenital infections) were identified as factors which significantly increased the risk of childhood hearing loss.

Eighteen studies (12 prospective studies and 6 retrospective studies) looked at the relationship between congenital cytomegalovirus and childhood hearing loss. There were two observational studies that examined the association between risk factors for hearing loss and childhood hearing status. Of the two, one observational study had a high risk of bias due to unclear risk of attrition and reporting bias.

Due to the abovementioned findings, the overall certainty of evidence was downgraded to very low.

Introduction

The prevalence of congenital bilateral permanent profound hearing loss in the Philippines is 1.3 per 1000 live births and increases to 22 per 1000 live births for unilateral mild and moderate hearing loss. Even for milder and unilateral forms of hearing impairment, there is significant delay in mental development during infancy, which encompasses development of locomotor, personal-social, hearing and speech skills, hand and eye coordination, and performance tests.¹

The 2019 Position Statement of the Joint Committee on Infant Hearing (JCIH) identified the following risk factors for congenital or delayed-onset childhood hearing loss²:

- Family history of early, progressive, or delayed onset permanent childhood hearing loss
- Neonatal intensive care of more than 5 days
- Hyperbilirubinemia with exchange transfusion regardless of length of stay
- Aminoglycoside administration for more than 5 days
- Asphyxia or hypoxic ischemic encephalopathy
- Extracorporeal membrane oxygenation
- In utero infections, such as herpes, rubella, syphilis, toxoplasmosis, cytomegalovirus (CMV), and Zika virus
- Certain birth conditions or findings:
 - Craniofacial malformations including microtia/atresia, ear dysplasia, oral facial clefting, white forelock, and microphthalmia
 - Congenital microcephaly, congenital or acquired hydrocephalus
 - Temporal bone abnormalities
- At least 400 syndromes with atypical hearing thresholds
- Culture-positive infections associated with sensorineural hearing loss, including confirmed bacterial and viral (especially herpes viruses and varicella) meningitis or encephalitis
- Events associated with hearing loss:
 - Significant head trauma especially basal skull/temporal bone fractures
 - Chemotherapy
- Caregiver concern regarding hearing, speech, language, developmental delay and/or developmental regression

The JCIH endorses early detection and intervention for all infants who are, or who are at risk of being or becoming deaf or hard of hearing, in order to maximize their language and communication competence, literacy development, and psychosocial well-being. Without appropriate language exposure and access, these children fall behind their hearing peers in communication, language, speech, cognition, reading, and social-emotional development, and delays may continue to affect the child's life into adulthood.²

Review Methods

A systematic search was done from database inception until 19 April 2023 using Medline, Cochrane Library, National Institute for Health and Care Excellence (NICE), US Preventive Services Task Force (USPSTF), Canadian Task Force on Preventive Health Care (CTFPH), and Google Scholar with a combined MeSH and free text search using the terms: “newborn and childhood/pediatric hearing screening, maternal history of infection, family history of hearing loss, physical examination/craniofacial anomalies.”

A filter was placed to include only clinical trials, RCTs, systematic reviews, and meta-analysis. Outcomes of interest included hearing loss, speech delay, school performance, quality of life, adverse events, psychosocial and neurodevelopmental disorders. Only studies with the outcome of interest were included.

The references of included studies were also hand searched to identify additional studies that may not have appeared in the database search. No language restrictions were applied. Additional search was done for unpublished studies through communications with authors or known researchers. Full search strategy is presented in the appendix.

Results

Characteristics of Included Studies

Two observational studies examined the association between risk factors for hearing loss and childhood hearing status. Dumanch et al. performed a retrospective data review of 115,039 children born over a 3-year time span and looked at the association between risk factors for hearing loss and early childhood hearing status (normal hearing, congenital hearing loss, or delayed-onset hearing loss).³ Fitzgibbons et al. performed a retrospective data review of 613,027 infants born over a 10-year period and looked at the association between risk factors for hearing loss and permanent childhood hearing loss.⁴

One meta-analysis summarized evidence regarding the strength of the relationship between congenital CMV and childhood hearing loss by looking at 15 studies involving 235,026 children.⁵

Prognostic Outcomes

Family history of hearing loss

Family history of permanent childhood hearing loss demonstrated a significant relationship with congenital hearing loss (OR 10.164, 95% CI 7.430 to 14.736) and delayed-onset hearing loss (OR 8.715, 95% CI 6.380 to 11.903) [3]. It was also found to significantly increase the risk of permanent childhood hearing loss (OR 4.61, 95% CI 3.37 to 6.32).⁴

Physical examination

Craniofacial anomalies, including cleft lip or palate, microtia, atresia, choanal atresia, significantly increased the risk of both congenital hearing loss (OR 56.827, 95% CI 34.335 to 94.053) and delayed-onset hearing loss (OR 50.629, 95% CI 80.045).³ It was also found to significantly increase the risk of permanent childhood hearing loss (OR 2.68, 95% CI 2.03 to 3.53).⁴

Maternal history of infection

Perinatal infections, namely toxoplasmosis, rubella, CMV, herpes, and syphilis, significantly increase the risk of permanent childhood hearing loss (OR 1.119, 95% CI 0.752 to 1.665).⁴

A meta-analysis of 15 studies involving 235,026 children showed that congenital CMV significantly increased the risk of childhood hearing loss (OR 8.45, 95% CI 3.95 to 18.10).⁵ Very low quality evidence from 1 observational study showed that congenital CMV significantly increased the risk of congenital hearing loss (OR 44.179, 95% CI 5.720 to 341.250) and delayed-onset hearing loss (OR 98.0.42, 95% CI 27.524 to 349.236).³

Congenital syphilis significantly increased the risk of delayed-onset hearing loss (OR 389.537, 95% CI 224.308 to 6,424.460), but not congenital hearing loss (OR 0, 95% CI 0). Other culture-positive congenital infections significantly increased the risk of both congenital hearing loss (OR 65.154, 95% CI 22.883 to 185.509) and delayed-onset hearing loss (OR 11.801, 95% CI 1.609 to 86.565). There was no association between hearing loss and congenital herpes, rubella, or toxoplasmosis due to the absence of such cases.³

Table 4. Summary of findings for maternal history of infection, family history of hearing loss, physical examination

Critical Outcomes	Basis (No. and Type of Studies, Total Participants)	Effect Size	95% CI	Interpretation	Certainty of Evidence
Family history of permanent childhood hearing loss and congenital hearing loss	1 observational study (n=115,039)	OR 10.164	7.43-14.73	Significant	Very Low
Family history of permanent childhood hearing loss and delayed-onset hearing loss	1 observational study (n=115,039)	OR 8.715	6.38-11.90	Significant	Very Low
Family history of hearing loss and permanent childhood hearing loss	1 observational study (n=613,027)	OR 4.61	3.37-6.32	Significant	Low
Craniofacial anomalies and congenital hearing loss	1 observational study (n=115,039)	OR 56.827	35.334-94.053	Significant	Very Low
Craniofacial anomalies and delayed-onset hearing loss	1 observational study (n=115,039)	OR 50.629	32.02-80.04	Significant	Very Low
Craniofacial anomalies and permanent childhood hearing loss	1 observational study (n=613,027)	OR 2.68	2.03-3.53	Significant	Low
Congenital CMV and childhood hearing loss	18 observational studies (n=235,026)	OR 8.45	3.95-18.10	Significant	Low
Congenital CMV and congenital hearing loss	1 observational study (n=115,039)	OR 44.179	5.72-341.25	Significant	Very Low
Congenital CMV and delayed-onset hearing loss	1 observational study (n=115,039)	OR 98.042	27.52-349.23	Significant	Very Low
Congenital syphilis and congenital hearing loss	1 observational study (n=115,039)	OR 0	0	Not significant	Very Low
Congenital syphilis and delayed-onset hearing loss	1 observational study (n=115,039)	OR 389.537	24.30-6242.46	Significant	Very Low
Congenital herpes and congenital hearing loss	1 observational study (n=115,039)	OR 0	0	Not significant	Very Low
Congenital herpes and delayed-onset hearing loss	1 observational study (n=115,039)	OR 0	0	Not significant	Very Low

Congenital rubella and congenital hearing loss	1 observational study (n=115,039)	OR 0	0	Not significant	Very Low
Congenital rubella and delayed-onset hearing loss	1 observational study (n=115,039)	OR 0	0	Not significant	Very Low
Congenital toxoplasmosis and congenital hearing loss	1 observational study (n=115,039)	OR 0	0	Not significant	Very Low
Congenital toxoplasmosis and delayed-onset hearing loss	1 observational study (n=115,039)	OR 0	0	Not significant	Very Low
Other culture-positive congenital infection and congenital hearing loss	1 observational study (n=115,039)	OR 65.15	22.88-185.50	Significant	Very Low
Other culture-positive congenital infection and delayed-onset hearing loss	1 observational study (n=115,039)	OR 11.801	1.60-86.56	Significant	Very Low

CI confidence interval; CMV cytomegalovirus; OR odds ratio

Certainty of Evidence

One observational study had a high risk of bias due to unclear risk of attrition and reporting bias. Hence, the overall certainty of evidence was downgraded to very low.

Recommendations from Other Groups

Table 5. Summary of other groups' recommendations for maternal history of infection, family history of hearing loss, physical examination

Group/Agency	Recommendation	Strength of Recommendation/Certainty/Quality of Evidence
Joint Committee on Infant Hearing (2019)	<ul style="list-style-type: none"> • A history of family members being deaf or hard of hearing with onset in childhood, has consistently been shown to be predictive that the diagnosis is secondary to a spectrum of genetic causes, and therefore stands alone as a particularly concerning risk factor. Monitoring continues to be based on both the etiology and the level of family concern, with a diagnostic evaluation recommended by 9 months of age or earlier if parent or caregiver concern is expressed. • In-utero infections (i.e., herpes, rubella, syphilis and toxoplasmosis) pose a risk and require follow-up by 9 months of age. • Congenital CMV is a leading cause of non-genetic unilateral or bilateral early, progressive, and delayed onset sensorineural hearing loss, therefore the recommendation for follow-up audiology assessment is no later than 3 months of age. • For children with craniofacial malformations including microtia/atresia, ear dysplasia, oral facial clefting, white forelock, and microphthalmia; congenital microcephaly, congenital or acquired hydrocephalus; and temporal bone abnormalities, a diagnostic evaluation recommended by 9 months of age or earlier if there are concerns of on-going surveillance of hearing skills and speech milestones. 	Ungraded

Ongoing Studies and Research Gaps

A protocol for a systematic review was submitted by Vos et al. that aims to review the risk factors associated with permanent hearing loss in children, including congenital, early, or late onset. Risk factors associated with progressive hearing loss will be investigated as a secondary aim.⁶

Additional Considerations for Evidence to Decision (EtD) Phase

Cost

Table 6. Estimated cost of hearing screening at the PGH-EU

Procedure	Cost (PHP)
Otoacoustic emission	380.00-600.00
Auditory brainstem response	1,885.00-2,210.00

A study by Santos-Cortez and Chiong determined the cost of establishing a universal newborn hearing screening program using local prevalence data and current costs of screening, diagnostics, and intervention strategies for bilateral permanent hearing loss. The typical cost for OAE (Otoacoustic Emissions) testing in screening centers then was P300, whereas the cost of an ABR (Auditory Brainstem Response) test varied from P800 to P2,000. Based on the calculations they did, the actual cost (without factoring in inflation) for conducting screenings on a large volume of children over a five-year period, when packaged as two OAE tests plus one ABR test, may amount to as little as P86 per child.¹

The impact becomes more obvious if costs are compared per individual at two levels: (1) early detection (e.g., by age 6 months), and (2) early intervention (e.g., by age 1 year). A simple diagnostic cost of PHP 87 can save an individual or family about PHP 3.3 to PHP 4 million if done in the newborn period. On a national level, the difference between estimated cost of testing each baby born in a year (PHP 540,000,000) against the total savings amortized on a yearly basis (PHP 2,453,988,630) is underscored when based on a 60-year timeline. These results show that long-term benefits and savings from UNHS on a national scale significantly outweigh the immediate costs of testing and intervention even in the first year of national implementation.¹

PhilHealth has a Z-package for Children with Hearing Impairment, which covers assessment and habilitation. The corresponding rates per laterality are as follows:⁷

Table 7. PHIC Z-package coverage

Description	Rate (PHP)
Assessment and hearing aid provision, with moderate hearing loss a. Assessment: OAE Screening and ABR b. Hearing aid fitting, hearing aid device, batteries good for five years, ear mold and hearing aid verification c. Ear mold refitting every six months for five years	53,460.00
Assessment and hearing aid provision, with severe to profound hearing loss a. Assessment: OAE Screening and ABR b. Hearing aid fitting, hearing aid device, batteries good for five years, ear mold and hearing aid verification c. Ear mold refitting every four months for five years	67,100.00
Assessment and hearing aid provision, with moderate hearing loss a. Assessment: Age-Appropriate Behavioral Audiometry	45,400.00

b. Hearing aid fitting, hearing aid device, batteries good for five years, ear mold and hearing aid verification c. Ear mold refitting once a year for five years	
Assessment and hearing aid provision, with severe to profound hearing loss a. Assessment: Age-Appropriate Behavioral Audiometry b. Hearing aid fitting, hearing aid device, batteries good for five years, ear mold and hearing aid verification c. Ear mold refitting every six months for five years	54,100.00
Assessment and hearing aid provision, with moderate hearing loss a. Assessment: Diagnostic Pure Tone Audiometry b. Hearing aid fitting, hearing aid device, batteries good for five years, ear mold and hearing aid verification c. Ear mold refitting once a year for three years	43,880.00
Speech therapy assessment and sessions for moderate hearing loss	22,100.00
Speech therapy for severe to profound hearing loss	63,420.00
Replacement of hearing aid for moderate hearing loss, 5 to less than 18 years old	43,670.00
Replacement of hearing aid for severe to profound hearing loss, 5 to less than 18 years old	48,670.00

ABR auditory brainstem response; OAE otoacoustic emissions

Patient's Values and Preference, Equity, Acceptability, and Feasibility

No studies were found discussing patient's values and preferences, acceptability, and feasibility in screening for risk factors for hearing loss.

References

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4. Fitzgibbons EJ, Driscoll C, Myers J, Nicholls K, Beswick R. Predicting hearing loss from 10 years of universal newborn hearing screening results and risk factors. *International Journal of Audiology*. 2021 Feb 16;1–9.
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6. Vos B, Noll D, Pigeon M, Bagatto M, Fitzpatrick EM. Risk factors for hearing loss in children: a systematic literature review and meta-analysis protocol. *Systematic Reviews*. 2019 Jul 17;8(1).
7. PhilHealth Circular No. 2018-0011. [cited 24 March 2023]. Available from: <https://www.philhealth.gov.ph/circulars/2018/circ2018-0011.pdf>

4.1.2. Otoacoustic Emissions, Automated Auditory Brainstem Response, Auditory Steady State Response Tests

RECOMMENDATIONS

Among apparently healthy newborns, we recommend hearing screening using OAE or AABR.
(strong recommendation, moderate certainty evidence)

No recommendation can be made regarding the use of ASSR in hearing screening.

Considerations

This guideline development aims to review current and updated evidence on hearing screening. While it does not aim to challenge the law, formulated recommendations from these guidelines may reaffirm the Newborn Hearing Screening Act or may serve as basis for modification of currently implemented laws.

The consensus panel recognized that hearing screening with OAE and AABR is beneficial in terms of quality of life, speech development, and school performance. On the other hand, the panel noted ASSR has limited value as a hearing screening test. However, ASSR is still considered a useful and more objective diagnostic test providing frequency specific threshold information compared to ABR. The panel decided that there was insufficient data to make a recommendation on ASSR screening. This was done so as not to prejudice general practitioners against using the test whenever deemed necessary.

Key Findings

Five observational studies on the impact of universal newborn hearing screening (UNHS) were included in a systematic review and meta-analysis. Screening tests used in the intervention group were OAE, AABR, or both.

UNHS increased the proportion of infants diagnosed with permanent bilateral hearing loss by nine months of age ($RR=3.28$, 95% CI 1.84, 5.85) and improved the mean age of diagnosis by up to 13 months (95% CI -26.3, -0.01). Infants who received UNHS by eight years also showed increased neurodevelopment (expressive and receptive language), but very low certainty evidence showed no effect on literacy at 19 years.

The pooled sensitivity of OAE is 96.3% (95% CI=81.0, 99.9%) and the pooled specificity is 92.5% (95% CI=92.2, 92.9%). The pooled sensitivity of OAE+ABR is 95.1% (95% CI=86.3, 99.0%) and the pooled specificity is 98.6% (95% CI=98.7, 98.5%). Other studies reported on harms from UNHS such as parental anxiety and stress from waiting times for definitive testing and amplification and false-positive results.

Two of the five included studies had serious risk of bias primarily due to a lack of adjustment of confounders. Publication and small study bias could not be assessed, due to the small number of studies used. Overall certainty of evidence is moderate.

Introduction

Prevalence studies worldwide show that 1 to 1.5 per 1000 babies are born with severe or profound permanent bilateral hearing loss (PBHL). An additional 1 to 2 per 1000 newborns have bilateral mild to moderate hearing loss or unilateral hearing loss of any degree.¹ In the Philippines, 1 in 724 or 0.14% of babies are born with bilateral severe to profound hearing loss.² Both severe and profound PBHL result in major impairments to language and literacy development, functioning in adulthood, and quality of life.^{1,3,4} Republic Act No. 9709, or the Act that establishes the “Universal Newborn Hearing Screening for the Prevention, Early Diagnosis, and Intervention of Hearing Loss” mandates that all newborns should be screened for hearing loss or impairment before discharge in hospitals or within 3 months if born in a non-hospital setting.⁵

There are two main tests used in UNHS: OAE or AABR, also known as brainstem auditory evoked responses (BAER). OAE and AABR are simple non-invasive 30-minute bedside tests. OAE measurements are obtained from the ear canal using a sensitive microphone within a probe assembly for recording cochlear responses to acoustic stimuli. Accordingly, OAEs reflect the status of the peripheral auditory system extending to the cochlear outer hair cells. AABR measurements are obtained from the surface electrodes that record neural activity in the cochlea, auditory nerve, and brainstem in response to acoustic stimuli delivered through an earphone. Thus, AABR measurements reflect the status of the peripheral auditory system, the eighth nerve, and the brainstem auditory pathway.⁶

Review Methods

A systematic search was done from database inception until 11 January 2023 using Medline, Cochrane Library, NICE, USPSTF, CTFPH, and Google Scholar with a combined MeSH and free text search using the terms: “newborn and childhood/pediatric hearing screening, otoacoustic emissions, automated auditory brainstem response, automated auditory steady state response.” A filter was placed to include only clinical trials, RCTs, systematic reviews, and meta-analysis.

Outcomes of interest included hearing loss, speech delay, school performance, quality of life, adverse events, psychosocial and neurodevelopmental outcomes. Only studies with the outcome of interest were included.

The references of included studies were also hand searched to identify additional studies that may not have appeared in the database search. No language restrictions were applied. Additional search was done for unpublished studies through communications with authors or known researchers. Subgrouping by newborn and childhood hearing screening was planned. Full search strategy is presented in the appendix.

Results

Characteristics of Included Studies

Five observational studies discussing the effects of UNHS on 1,025,611 newborns were included.⁷⁻¹¹ Two studies were conducted in the US,^{9,11} and one each in Australia,¹⁰ Netherlands,⁸ and the United Kingdom.⁷

Four of the five studies (1,025,497 newborns) evaluated large population-based government programs and prospectively followed all live-born infants from birth to screening at nine months of age.^{7,8,10,11} An infant who failed UNHS received a definitive hearing assessment from an audiologist as soon as possible after screening. Three of these studies followed up all children

with PBHL to ascertain developmental outcomes including receptive language, expressive language, and literacy at three to eight years.^{7,8,10} The fourth study looked at the developmental follow-up of age- and sex-matched UNHS children with non-UNHS controls at eight years.¹¹ The remaining study recruited 63 children with PBHL and retrospectively reviewed their past medical records to determine if the children received UNHS, audiological assessment, or amplification devices, and the timing of these procedures.⁹ UNHS was done in the first 24-48 hours of birth,⁷ by two weeks,¹⁰ and by 28 days,⁹ while the timing of screening was not described in the other two studies.^{8,11}

The screening tests used in the intervention group were OAEs, AABR, or both. The comparison group (no UNHS) received no screening at any time in one study,⁹ no screening in the first eight months of life followed by distraction screening at eight months or later in two studies,^{7,8} and selective or risk factor screening (i.e., screening in infants admitted to neonatal intensive care units, infants with craniofacial abnormalities, severe jaundice etc.) in two studies.^{10,11}

Primary outcomes were: (1) “any” identification of PBHL, (2) age of detection of PBHL, and (3) neurodevelopment (i.e., receptive language, expressive language, and literacy). The secondary outcome was the age of amplification (i.e., the age that hearing aids were provided to the child). The characteristics of the included studies are summarized in the appendix.

Efficacy Outcomes

The systematic review and meta-analysis show that UNHS increased the proportion of infants diagnosed with PBHL by 9 months of age and improved the mean age of diagnosis by up to 13 months. There were also increases in neurodevelopment (expressive and receptive language) in infants who received UNHS by 8 years, but very low certainty of evidence showed no effect on literacy at 19 years.⁶

The relative risk of identification of PBHL before six months in infants with UNHS compared to infants without UNHS was 2.83 (RR=2.83, 95% CI=0.87, 9.16, two studies, 104 newborns, low certainty of evidence. The mean age of identification of PBHL was 13.2 months earlier in infants with UNHS compared to infants without UNHS (95% CI=-26.31 to -0.01, 197 newborns). The mean age of amplification was 14.2 months earlier (95% CI= -19.26, -9.12, three studies, 368 newborns, very low certainty of evidence).

The standardized mean difference (SMD) at follow-up in receptive language development at 3-8 years between infants with UNHS compared to infants without UNHS was 0.60 z scores (95% CI 0.07, 1.13, one study, 101 children, low certainty of evidence) and the mean difference in developmental quotients was 7.72 (95% CI= -.03, 15.47, three studies, 334 children, low certainty of evidence). The SMD in expressive language development was 0.39 z scores (95% CI=-0.20, 0.97, one study, 87 children, low certainty of evidence) and the mean difference in developmental quotients was 10.10 scores (95% CI=1.47, 18.73, three studies, 334 children, low certainty of evidence).

The mean difference in literacy at follow-up to 5-11 years was 0.58 z scores (95% CI=0.03, 1.13, one study, 41 children, very low certainty evidence). The mean difference in literacy at follow-up to 13-19 years was 0.15 z scores (95% CI=-0.76, 1.05, one study, 60 children, low certainty evidence). The outcomes are summarized in the GRADE Table and Forest Plots in the appendices.

The pooled sensitivity of OAE is 96.3% (95% CI=81.0, 99.9%) and the pooled specificity is 92.5% (95% CI=92.2, 92.9%) based on 2 observational studies.^{12,13} The pooled sensitivity of OAE+ABR is 95.1% (95% CI=86.3, 99.0%) and the pooled specificity is 98.6% (95% CI=98.7, 98.5%) based on 4 observational studies.¹⁴⁻¹⁷ These are summarized in the appendix.

ASSR can provide ear- and frequency-specific threshold information at elevated intensity levels up to 120 dB HL and higher, providing better and more reliable investigation of ears with minimal residual hearing. Furthermore, ASSR thresholds may be used for hearing aid fitting prior to cochlear implantation.¹⁸ Strong correlations have been demonstrated between air conduction ASSR and ABR in infants younger than 6 months of age.¹⁹

A study by Mijares et al. aimed to evaluate the efficiency of an automated hearing screening test based on auditory steady state responses using simultaneous air- and bone-conduction stimuli. The estimated diagnostic efficiency of this screening test was equivalent (100% sensitivity and 97.7% specificity) to the efficiency reported for OAE and AABR.²⁰ The introduction of bone conduction in the screening reduced the false positive rate from 13.3% to 2.2%.

Studies show ASSR is more time consuming than the ABR, there are fewer correlations between ASSR and PTA thresholds on the 500 Hz and the 4000 Hz frequencies, and fewer correlations in children with auditory neuropathy spectrum disorder (ANS).²¹ Furthermore, the maximum presentation level usually does not exceed 110 dB HL to avoid saturation.²²

Safety Outcomes

Reported harms from UNHS included parental anxiety and stress from waiting times for definitive testing and amplification, and false-positive results.²³ The Beck Anxiety Inventory Questionnaire was used to investigate anxiety among mothers whose babies failed the first stage of the Universal Newborn Hearing Program. During the first screening, 74% of the mothers felt mild anxiety. This decreased to 68% before the mothers underwent the second screening. The frequency of these is primarily dependent on the quality assurance measures in a screening program.

There was also concern that maximum output stimuli from AABR and ASSR may cause cochlear damage. This was of greatest concern for ASSR where at least 10 minutes of averaging may be required to reduce the residual EEG noise.²⁴

Electrophysiological testing with sedation or anesthesia may be indicated, provided there are no medical contraindications and if the results of the evaluation will influence the treatment or management of the child. Recent research has shown the potential risk to cognitive function in the young child who undergoes general anesthesia, which is sometimes required for initial and/or repeated ABR measurement for the purpose of diagnosis or monitoring.²⁵ The JCIH 2019 guidelines recognized that medically fragile children may not be candidates for anesthesia.²⁶

Table 8. Summary of findings for OAE, AABR, ASSR for children

Critical Outcomes	Basis (No. and Type of Studies, Total Participants)	Effect Size		Interpretation	Certainty of Evidence
		Relative (95% CI)	Absolute (95% CI)		
In all children born, proportion eventually identified with PBHL	3 observational studies (n=1,021,497)	RR = 1.01 (0.89, 1.14)		Inconclusive	Low
In all children born, proportion identified with PBHL before 9 mo	1 observational study (n=156,733)	RR = 3.28 (1.84, 5.85)		Benefit	Low
In children with PBHL, proportion identified with PBHL before 6 mo	1 observational study (n=173)	RR = 2.83 (0.87, 9.16)		Inconclusive (but trend favors UNHS)	Very low
In children with PBHL, mean age of	2 observational studies (n=197)		MD = 13.16 lower (26.31)	Benefit	Very low

identification of PBHL, in months			lower to 0.01 lower)		
In children with PBHL, mean receptive language at 3-8 y (z-score)	1 observational study (n=101)		MD = 0.61 higher (0.07 higher to 1.13 higher)	Benefit	Very low
In children with PBHL, mean receptive language at 3-8 y (developmental quotient)	3 observational studies (n=334)		MD= 7.61 higher (1.16 lower to 16.38 higher)	Inconclusive (but trend favors UNHS)	Very low
In children with PBHL, mean expressive language at 3-8 y (z score)	1 observational study (n=87)		MD= 0.39 higher (0.2 lower to 0.97 higher)	Inconclusive (but trend favors UNHS)	Very low
In children with PBHL, mean expressive language at 3-8 y (developmental quotient)	3 observational studies (n=334)		MD= 10.01 higher (1.77 higher to 18.25 higher)	Benefit	Very low
In children with PBHL, mean literacy at 5-11 y (z score)	1 observational study (n=41)		MD= 0.58 higher (0.03 higher to 1.13 higher)	Benefit	Very low
In children with PBHL, mean literacy at 13-19 y (z score)	1 observational study (n=60)		MD 0.15 higher (0.76 lower to 1.05 higher)	Inconclusive	Very low

CI confidence interval; MD mean difference; PBHL permanent bilateral hearing loss; RR relative risk; UNHS universal newborn hearing screening

Certainty of Evidence

Overall certainty of evidence is moderate. This was due to risk of bias since all of the studies were observational studies.

Recommendations from Other Groups

Cheng Wen et al. aimed to assess the quality of global guidelines or consensus statements for newborn and childhood hearing screening, and to compare various guidelines between other countries and China.²⁷ They assessed 15 newborn and 6 childhood hearing screening guidelines, respectively. Most newborn guidelines recommend the 1-3-6 guidelines and pre-discharge screening; however, the specific screening times differ. 93.3% of newborn hearing screening guidelines recommend “primary screening-rescreening-diagnosis-intervention” for well-babies while 73.33% of the guidelines recommend “initial screening-diagnosis-intervention” for newborns in neonatal intensive care unit (NICU). 33.33% of the newborn hearing screening guidelines recommended initial screening coverage of >95% while 46.66% did not mention it. For childhood screening guidelines, the screening populations differed across guidelines (age range 0-9 years). Most guidelines recommend pediatric hearing screening for all preschoolers. Only 50% of the guidelines specify screening and rescreening techniques, including pure tone hearing screening, OAE, tympanometry, and others. Using the AGREE II tool, it showed that newborn hearing screening guidelines had superior quality over childhood ones.

Table 9. Summary of other groups' recommendations for OAE, AABR, ASSR for children

Group or Agency	Recommendation	Strength of Recommendation/ Certainty/Quality of Evidence
The Joint Committee on Infant Hearing (2019) ²⁶	Recommends to screen well babies before discharge with OAE/AABR. Rescreening should be done within 1 month, diagnosis within 3 months and intervention within 6 months.	Ungraded
European Standards of Care for Newborn Health (2018) ²⁸	Recommends to screen well babies before discharge with AABR. Rescreening should be done within 1 month, diagnosis within 3 months and intervention within 6 months.	Strong recommendation
The Newborn Hearing Screening Program in Germany (2018) ²⁹	Recommends to screen well babies on the 2nd or 3rd day of life before discharge with OAE/AABR. Rescreening should be done within 1 month, diagnosis within 3 months and intervention within 6 months.	Ungraded
The Health Professions of South Africa (2018) ³⁰	Recommends to screen well babies within 1 month of age with OAE. Rescreening should be done within 1 month after discharge, diagnosis before 3 months of age and intervention before 6 months of age and within 8 months.	Ungraded
International Consensus (ICON) on Audiological Assessment of Hearing Loss in Children (2018) ²³	Recommends to screen well babies before discharge with OAE. Rescreening should be done within 1 month after discharge, diagnosis within 3 months of age and intervention within 6 months.	Graded
Indian Academy of Pediatrics (2017) ³¹	Recommends to screen well babies 72 hours after birth or on the day of discharge with OAE. Rescreening should be done 4 weeks after first screening, or at 6 weeks on the first immunization visit, diagnosis within 3 months of age and intervention within 6 months.	Ungraded
Newborn hearing screening protocol in the Tuscany region (2017) ³²	Recommends to screen well babies 24 hours after birth and before discharge with OAE. Rescreening should be done within 1 month diagnosis within 3 months of age and intervention within 6 months.	Ungraded
Public Health England (2016) ³³	Recommends to screen well babies within 72 hours after birth to 10 days of age with OAE. Rescreening should be done within 4-5 weeks of age, diagnosis within 4 weeks of screen completion and intervention within 4 weeks of screen completion or by 44 weeks gestational age.	Ungraded
New Zealand Ministry of Health (2016) ³⁴	Recommends to screen well babies with OAE/AABR. Rescreening should be done within 1 month, diagnosis within 3 months of age and intervention within 6 months.	Ungraded
IPOG Consensus Recommendations: Hearing loss in the Pediatric Patient (2016) ³⁵	Recommends to screen well babies with OAE/AABR.	Ungraded
Australian National Framework for Neonatal Hearing Screening (2013) ³⁶	Recommends to screen well babies 24-72 hours after birth and before discharge with OAE/AABR. Rescreening should be done within 2 weeks after first screening and within 1 month of age, diagnosis within 3 months of age and intervention within 3 months and no later than 6 months of age.	Ungraded
Canadian Pediatric Society (2011) ³⁷	Recommends to screen well babies with OAE. Rescreening should be done within 1 month, diagnosis within 3 months of age and intervention within 6 months.	Ungraded
Ministry of Health of the People's Republic of China (2010) ³⁸	Recommends to screen well babies 48 hours after birth and before discharge with OAE/AABR. Rescreening should be done within 42 days of age, diagnosis within 3 months of age and intervention within 6 months.	Ungraded
Early Hearing Detection and Intervention: 2010 CODEPH	Recommends to screen well babies with OAE/AABR. Rescreening should be done within 1 month, diagnosis within 3 months of age and intervention within 6 months.	Ungraded

Recommendation (2010) ³⁹		
World Health Organization Newborn and infant hearing screening: current issues and guiding principles in action (2010) ⁴⁰	Recommends to screen well babies with OAE/AABR. Rescreening should be done within 1 month, diagnosis within 3 months of age and intervention within 6 months.	Ungraded
England Audiology and Health (2017) ⁴¹	Recommends hearing in the 4-7 years of age group. Screening technology not indicated.	Ungraded
World Health Organization Childhood hearing loss strategies for prevention and care (2016) ⁴²	Recommends hearing screening in the preschool- and school-aged children. Screening technology not indicated.	Ungraded
Hall JW Effective and Efficient Preschool Hearing Screening: Essential for Successful Hearing Detection and Intervention (EDHI) (2016) ⁴³	Recommends that all pre-school children from the age of 6 months to 5 years should be screened. Screening technology includes distortion-product otoacoustic emissions, acoustic reflex for broadband noise signal, otoscopy, and pure tone hearing screening at 20 dB HL.	Ungraded
National Health and Family Planning Commission of the People's Republic of China (2013) ⁴⁴	Recommends screening in the 0-6 years age group. Screening technology includes ear appearance examination, auditory behavioral observation, portable auditory assessment instrument and OAE. Referral for diagnosis: positive results on any of the auditory behavioral observation method screening tools or any of the audiological assessment instrument screening tools or failure of OAE screening.	Ungraded
Skarzynski H et al. Screening for hearing problems in pre-school and school-age children: European Consensus Statement (2012) ⁴⁵	Recommends screening in all children aged 4-7 years.	Ungraded
American Academy of Audiology (2011) ⁴⁶	Recommends the following populations to be screened: pre-school, kindergarten, and grades 1,3,5,7/9. Screening technology includes pure tone screening, tympanometry, acoustic reflex and reflectometry, screening with Speech Stimuli Materials and OAEs.	Ungraded

Ongoing Studies and Research Gaps

The following research needs are recommended by JCIH²⁶:

- Continued and accelerated research into optimizing screening, diagnostics, and amplification intervention protocols, emphasizing timelines and accuracy based on rigorous evidence regarding efficacy.
- Exploration of preschool hearing screening programs to determine the ability to identify late-onset or missed hearing loss.
- Increased longitudinal research on the efficacy and quality of early intervention strategies to assure optimal outcomes (developmental and quality of life) for children who are deaf or hard of hearing and their families.
- Increased inquiry and study of the cost and utility/benefit of early hearing detection and intervention (EHDI) program systems.

There is also a need to evaluate the effectiveness of the universal newborn hearing screening program in the Philippines as well as make a nationwide prevalence study of hearing loss

among the different subgroups of the pediatric population, risk factors, and social determinants.

Additional Considerations for Evidence to Decision (EtD) Phase

Cost

For the cost-analysis evidence of UNHS, a 2013 study in the Philippines was conducted to investigate both short- and long-term costs for hearing centers and for families of the hearing-impaired children.⁴⁷ Based on the calculations they did, the actual cost (without factoring in inflation) for conducting screenings on a large volume of children over a five-year period, when packaged as two OAE tests plus one ABR test, may amount to as little as P86 per child.⁴⁷

The impact becomes more obvious if the costs are compared per individual at two levels: (1) early detection (e.g., 6 months) and (2) early intervention (e.g., by age 1 year). A simple diagnostic cost of PHP 87 can save an individual or family about PHP 3.3 to PHP 4 million if done in the newborn period. On a national level, the difference between estimated cost of testing each baby born in a year (PHP 540,000,000) against the total savings amortized on a yearly basis (PHP 2,453,988,630) is underscored when based on a 60-year timeline. These results show that long-term benefits and savings from UNHS on a national scale significantly outweigh the immediate costs of testing and intervention even in the first year of national implementation.⁴⁷

Table 10. Resource table for hearing screening and confirmatory tests

Parameter		Screening intervention		Confirmatory tests	
		OAE	AABR	ASSR	ABR ± ASSR ⁺
Unit cost (PHP)*	Charity	380	1885	2040	1885-3925
	Pay	600	2210	2400	2210-4610

AABR automated auditory brainstem response; ASSR auditory steady state response; OAE otoacoustic emissions

⁺Combination refers to complete audiology evaluation

*Range based on Charity and Pay rates at the Philippine General Hospital Ear Unit (as of 1 March 2023)

Patient's Values and Preference, Equity, Acceptability, and Feasibility

The factors to consider in the approach to newborn hearing screening, especially in the context of low- to middle-income countries, include the following: (1) human resources (the availability of audiologists and whether non-professional personnel are available to conduct screening), (2) equipment (availability of equipment for screening and/or diagnostic assessment), (3) data management (availability of an effective and efficient data management and tracking system), and (4) costs (clinical assessment and management costs for newborns and infants with hearing screening).³⁰

For the acceptability of screening tests on infants and children, the main components identified are parental knowledge and understanding of the screening process and the testing procedure, potential consequences of a confirmed diagnosis, and consent.⁴⁸

There are no published studies that directly assess the feasibility of universal newborn screening in the Philippines. Feasibility of UNHS in the country can be assessed indirectly through the cost-analysis 2013 study.⁴⁷

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4.1.3. Behavioral Observation Audiometry, Genetic Testing, and Tympanometry

RECOMMENDATION

No recommendations can be made regarding the use of BOA, genetic testing, and tympanometry in hearing screening.

Considerations

The consensus panel decided there was insufficient data to make a recommendation on hearing screening using BOA, genetic testing, and tympanometry. There were issues on small study population, feasibility concerns, and screening test accuracy.

The population of the study found on BOA, aside from being limited with only 50 participants, involved high risk infants and not the general population. The study also involved infants 3- to 12-months old. The current practice is to use BOA until 6 months of age only.

On feasibility, there is a lack of trained audiologists to conduct BOA nationwide; thus, limiting it as a screening tool. If done by untrained individuals, overdiagnosis may occur.

Finally, the accuracy of BOA as a screening test may be low because it requires subjective assessment by the audiologist and the clinician.

Key Findings

There were no direct studies on the effects of screening for hearing loss in asymptomatic apparently healthy children using the three tests: BOA, tympanometry, and genetic testing.

One cross-sectional study screened 50 infants with risk factors for hearing impairment using BOA and yielded a sensitivity of 94.2% and specificity of 67.7%.

One randomized controlled trial (RCT) found no benefit in screening for otitis media with effusion (as a surrogate outcome for hearing loss) using tympanometry and its subsequent treatment with tympanostomy tube insertion in preschool children.

Two cohort studies looked into the effect of hearing aid use on auditory and language development. Results showed that acquisition and development of language skills increased with more consistent hearing aid use.

No studies were found on genetic testing. Additionally, no studies discussed the following outcomes: school performance, quality of life, psychosocial disorder, and neurodevelopmental disorders.

Introduction

Based on patient and audiology profiles of the Philippine National Ear Institute (PNEI) in 2007, the most common diagnoses were chronic otitis media (26.6%), followed by hearing loss of unknown etiology (13.0%), and tinnitus (9.3%). However, pediatric representation in the population was limited—comprising only 13.1%, with ages ranging from 5 to 18 years old.¹

According to the National Health and Nutrition Examination Survey (NHANES) covering the years 2001-2010, hearing loss directly affects 23% of Americans aged 12 years or older. Prevalence was higher among Hispanic and non-Hispanic Whites than among non-Hispanic Blacks; it was also higher among men than women.² In terms of risk factors, a national survey in 2020 showed that the following were associated with greater risk of moderate hearing loss in the better ear: (1) presence of a middle ear condition, and (2) socioeconomic status.³

Impact of Hearing Loss in Children

The effect of hearing loss on children is dependent on age at onset and severity. Early detection and intervention affect prognosis. Delaying hearing tests unfavorably affects growing children in terms of delayed language acquisition, speech development, literacy, and social skills. It also negatively impacts skills in financial independence and overall quality of life.^{4,5} Thus, cost-effective screening and early intervention for hearing loss is important in resource-limited countries like the Philippines.

Use of Tympanometry, BOA, and Genetic Testing

Tympanometry provides useful quantitative information about the presence of fluid in the middle ear, mobility of the middle ear system, and ear canal volume especially in the evaluation of otitis media with effusion (OME) in infants and young children. Tympanometry is not reliable in infants younger than seven months because of the highly compliant ear canals of infants.⁶

BOA is a test performed in neonates and infants under approximately six months developmental age or other non-cooperating children, children with disabilities, with a diagnosis of autism, or when behaviors or involuntary reflexes in response to audiology stimuli are evaluated.

Genetic testing is commonly conducted as part of the diagnostic work up of patients with autism, Down syndrome, developmental delay, congenital defects, and CMV infections. Genetic testing is also done on individuals with hearing loss of unclear underlying reason.^{7,8}

Review Methods

A systematic search was done from database inception until 10 February 2023 using NICE, USPSTF, Canadian Task Force on Preventive Health Care, MEDLINE, Cochrane, HERDIN, and clinicaltrials.gov databases using the combined MeSH and keyword terms: "hearing, hearing loss, screening, asymptomatic children, language delay, school performance, quality of life, psychosocial disorder, neurodevelopmental disorders, tympanometry, behavioral observation audiometry, genetics." A filter was placed to include only human studies and full texts. Only studies with the outcome of interest were included.

References of included studies were also hand searched to identify additional studies that may not have appeared in the database search. No language restrictions were applied. Additional search was done for unpublished studies through communications with authors or known researchers. The full search strategy and the PRISMA are presented in the appendix.

Results

There were no direct studies found on the effects of screening for hearing loss in asymptomatic apparently healthy children using the three tests: BOA, tympanometry, and genetic testing. The search yielded studies wherein the population on which the above procedures were used

were: (1) patients not previously well, (2) have comorbidities such as diabetes mellitus and chemotherapy-induced hearing loss, or (3) those with congenital abnormalities.

Characteristics of Included Studies

Evidence for the review is based on four studies: 1 RCT for tympanometry, 1 cross-sectional study for BOA, and 2 cohort studies for hearing aid use.

OME is a common disease in childhood, is often asymptomatic, but can cause significant hearing impairment. In the community setting using pneumatic otoscopy as the gold standard, tympanometry had a sensitivity of 65-95% and specificity of 65-80%.^{9,10} In the school setting, tympanometry was found to be 64.71% sensitive and 73.58% specific, with a positive predictive value of 44% and negative predictive value of 13.33%.¹¹ Based on the American Academy of Audiology childhood hearing screening guidelines in 2012, the sensitivity is 91-92% and specificity is 91-97%.¹²

1 RCT studied the efficacy of preschool screening for OME in children using 3-monthly tympanometry. The study determined its association with language delay using automatic oto-admittance middle ear analyzers (Grason-Stadler 27) and the subsequent treatment with tympanostomy tube insertion. 1,439 Dutch children were screened in their homes by tympanometry every three months on nine consecutive occasions between their second and fourth birthdays. A total of 20,466 ears screened and 43 of the 84 eligible children completed the trial.¹³ No evidence was found on the outcomes of school performance, quality of life, psychosocial disorder, and neurodevelopmental disorders.

1 cross-sectional study that included 50 infants, 3-12 months of age, with at least one risk factor for hearing impairment (e.g., family history of childhood hearing impairment; congenital perinatal infection such as CMV, rubella, herpes, toxoplasmosis, syphilis; birth weight <1,500 grams; hyperbilirubinemia requiring exchange transfusion; history of bacterial meningitis especially *Haemophilus influenzae*; history of birth asphyxia with APGAR scores of 0-4 at 1 minute or 0-6 at 5 minutes; hospitalization in neonatal intensive care unit greater than 48 hours) were subjected to BOA testing, transient-evoked OAE, AABR, ABR and ASSR. The sensitivity and specificity of the various tests was calculated, with ABR test as the gold standard.¹⁴

For the 2 cohort studies used, the first study had a cohort composed of 35 bilaterally hearing impaired children in Brazil diagnosed using tympanometry. It studied the association of systematic hearing aid use with auditory or language development.¹⁵ The second study was composed of 306 children with bilateral hearing loss aged 1 to 9 years old in the United States. It studied the association of hearing aid use and parent-reported ratings of their child's language skills.¹⁶

Efficacy Outcomes: Tympanometry

Verbal Expression

Bilateral long-lasting OME for at least 3 to 6 months caused significant impairment of expressive language skills. Treatment with insertion of ventilating tubes did not improve verbal expression significantly (p value=0.60).¹³

Verbal Comprehension

Bilateral long-lasting OME for at least 3 to 6 months did not cause significant impairment of verbal comprehension skills. Treatment with insertion of ventilating tubes did not improve verbal expression significantly (p value=0.74).¹³

Table 11. Summary of findings for tympanometry

Critical Outcomes	Basis	Effect Size	95% CI	Interpretation	Certainty of Evidence
Verbal expression	1 RCT (43 children)	MD = 0.11 p value 0.60	Not computed	No difference	Low
Verbal comprehension	1 RCT (43 children)	MD 0.06 p value 0.74	Not computed	No difference	Low
Adverse events	1 RCT (43 children)			No reported adverse events	

CI confidence interval; MD mean difference; RCT randomized controlled trial

Efficacy Outcomes: Behavioral Observation Audiometry

Hearing Impairment

In infants with risk factors for hearing loss, BOA was found to be 94.20% sensitive and 67.7% specific.¹⁴

Table 12. Summary of findings for behavioral observation audiometry

	Basis	Estimate	95% CI	Certainty of Evidence
Sensitivity	1 cross-sectional study (50 children)	94.2%	Not computed	Low
Specificity	1 cross-sectional study (50 children)	67.7%	Not computed	Low
Adverse events	1 cross-sectional study (50 children)	No reported adverse events		

CI confidence interval

Efficacy Outcomes: Auditory/Language Development and Hearing Aid Use

Consistent and systematic use of hearing aids showed a strong relationship with auditory and language skills.¹⁵ Children with a higher amount of hearing aid use had higher parent ratings for language skills.¹⁶

Table 13. Summary of findings for efficacy of hearing use on auditory/language development

Outcomes	Basis	Estimate	95% CI	Interpretation	Certainty of Evidence
Auditory and language skills*	1 cohort study (35 children)	MD 22.0 (p=0.01)	Not computed	Favors treatment	Low
Parent-reported rating of language skills**	1 cohort study (306 children)	OR 0.19 (p=0.03)	Not computed	Favors treatment	Low

CI confidence interval; MD mean difference; OR odds ratio

*Measured by Infant-Toddler Meaningful Auditory Integration Scale questionnaire

**Measured by LittleEARS Auditory questionnaire, mean hearing aid use of 10.8 hours per day

Safety Outcomes

No adverse events were reported for behavioral observation audiometry and repeated tympanometry.

Certainty of Evidence

Overall certainty of evidence is low due to risk of bias and indirectness.

Recommendations from Other Groups

Table 14. Summary of other groups' recommendations for tympanometry, BOA, genetic testing for children

Group	Recommendation	Strength of recommendation and certainty of evidence
World Health Organization. CHILDHOOD HEARING LOSS Strategies for prevention and care (2016) ¹⁷	Implement school-based hearing screening with the aim of identifying, referring, and managing common ear diseases and hearing loss.	Not applicable
National Center for Hearing Assessment and Management, Utah State University (2019) ¹⁸	All families of children who are confirmed as deaf or hard of hearing should be offered a genetics evaluation and counseling.	Not applicable
American Academy of Audiology childhood hearing screening guidelines (2012) ¹²	Tympanometry should be used as a second-stage screening method following failure of pure tone or otoacoustic emissions screening. Rescreen with tympanometry after a defined period: after failing the immediate pure tone rescreening and in 8-10 weeks for children failing pure tone or OAE screening and tympanometry.	Not applicable
Task force Guideline of Brazilian Society of Otology – hearing loss in children (2023) ⁷	Genetic testing should be considered in children with hearing loss of unknown cause.	Not applicable

Ongoing Studies and Research Gaps

No ongoing studies on effects of screening for hearing loss in asymptomatic apparently healthy children using BOA, tympanometry, and genetic testing were found as of February 2023.

Additional Considerations for Evidence to Decision (EtD) Phase

Cost

No cost-effectiveness studies were found on the use of BOA, tympanometry, and genetic testing to screen for hearing loss among asymptomatic apparently healthy children. Table 15 lists the cost of tympanometry and genetic testing.

Table 15. Cost table of tympanometry and genetic testing

Procedure	Cost
Tympanometry*	PHP 500
Karyotyping for Down's Syndrome**	PHP 5,500
Genetic Testing for Alport's Syndrome	USD 350 with additional PHP 5,500 processing and courier fee

*Price from UST Hospital Hearing and Dizziness Center

**Price from University of the Philippines Manila-National Institutes of Health

Patient's Values and Preference, Equity, Acceptability, and Feasibility

No studies were found directly focusing on patient values and preference, equity, acceptability, and feasibility. However, Kingsbury et al. identified the following barriers to equity in pediatric hearing health care: socioeconomic status, poverty, caregiver education levels, rurality and distance to diagnostic centers, private or public insurance coverage for hearing health care services, access to qualified professionals, and cultural and linguistic differences.¹⁹

Other Considerations: Physician Preference

General practitioners may prefer to use tympanometry since it requires less training than pneumatic otoscopy and is easier to use and interpret. However, perceived high cost seems to inhibit their intent to use it.²⁰

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4.1.4. Pure Tone Audiometry

RECOMMENDATION

Among asymptomatic apparently healthy school-aged children, we suggest against hearing screening using pure tone audiometry.
(weak recommendation, very low certainty evidence)

Considerations

Pure tone audiometry (PTA) is considered the gold standard for diagnosing hearing loss. The consensus panel noted that there are no existing guidelines on when to do hearing screening after the newborn period. Screening children before school entry may contribute to detecting educationally significant hearing loss, which affects the academic performance of the child.

To perform conventional PTA, a trained audiologist or audiometrist and a standard device are necessary. As of 2020, there are approximately 120 audiologists in the Philippines, with less than 10% practicing outside Metro Manila. This may affect the feasibility of conducting nationwide testing for all school-aged children. While audiologists are lacking, there is an adequate number of hearing testing centers with audiometrists who can perform the test but cannot interpret data.

The panel recognized the potential benefits of screening in the school-aged population. The feasibility of screening can also be increased with some guideline modifications and health systems improvement. However, the issues of training costs, machine availability, and logistics issues prevented the panel from providing a strong recommendation on screening using PTA.

Key Findings

One systematic review that included 8 studies on the accuracy of pure tone screening in preschool- and school-aged children was found; however, a wide range of accuracy values was noted. Sensitivity for PTA ranged from 0.50 to 1.0. Specificity ranged from 0.50 to 0.99. Positive and negative likelihood ratios had ranges of 2.18-81 and 0.00-0.91, respectively. Overall certainty of evidence is very low.

There is an urgent need for global standardization, which will facilitate more accurate studies of hearing loss prevalence, and determination of screening test sensitivity and specificity.

Introduction

A 2020 national survey shows 25.5% mild hearing impairment and 7.1% moderate hearing impairment in children less than 10 years old. Factors associated with greater risk of moderate hearing loss in the better ear were presence of a middle ear condition (adjusted odds ratio = 2.39, 95% CI = 1.49-3.85) and socioeconomic status (household income; adjusted odds ratio = 1.64, 95% CI = 1.23-2.19).¹ Disabling hearing loss, defined by the World Health Organization (WHO) as hearing loss greater than 40 dB in the better hearing ear, impairs skills in interpersonal communication, psychosocial wellbeing, scholastic and professional career opportunities, financial independence, and overall quality of life.²

Worldwide, screening protocols for children of school age differ in terms of screening tests included and thresholds used. The most common protocols included a mix of pure tone screening (0.5, 1, 2, and 4 kHz), otoscopy, and tympanometry.³

Review Methods

A systematic search was done from database inception until 03 April 2023 using MEDLINE, Cochrane, HERDIN, Google Scholar, clinicaltrials.gov, and local and international medical societies for Otorhinolaryngology using the combined MeSH and keyword terms: “hearing loss, children, audiometry, treatment.” A filter was placed to include only clinical trials, RCTs, and meta-analyses. Further search methods to update the studies included in the systematic reviews were done. Only studies with the outcome of interest were included. The references of included studies were also hand searched to identify additional studies that may not have appeared in the database search. No language restrictions were applied.

Results

Characteristics of Included Studies

Main evidence was obtained from 1 systematic review that included 8 studies investigating the accuracy of pure tone screening in preschool- and school-aged children.⁴ It included 13,428 participants from the age of 3 years. PTA was done using various models (pure tone audiometer, portable audiometer) and manufacturer (Welch Allyn, MicoAudiometrics). Frequencies for screening are within 0.5, 1.0, 2.0, and 4.0 kHz. Parameters for hearing loss range from average HL >20dB in better ear to pure tone threshold (PTT) >30dB for either ear at any test frequency.

Supplemental evidence from a scoping review for school entry hearing screening protocols for low- and middle-income countries was also obtained.⁵ This review included 19 studies, 5 of which investigated diagnostic accuracy in a total of 1,875 participants aged 5-12 years.

Accuracy Outcomes

Sensitivity of PTA ranged from 0.50 to 1.0 with an outlier value of 0.12. This outlier from 2011 was associated with methodological issues. In this 2011 study, participants were unable to complete gold standard testing with an audiologist in a soundproof booth. This was needed to calculate pure tone threshold test sensitivity and specificity.⁴

Specificity ranged from 0.50 to 0.99. Positive and negative likelihood ratios ranged widely at 2.18-81 and 0.00-0.91, respectively. Sensitivity, specificity, and likelihood values were reported but not pooled due to wide variability of the study characteristics, particularly in age, screening technology, and screening parameters.

Scoping review study also showed a wide range of sensitivity (0.50-1.00) and specificity (0.49-1.0) across four different screening methods.⁵

Table 16. Various pure tone audiometry screening vs. diagnostic audiological assessment

Basis (No. and Type of Studies, Total Participants)		Sn	Sp	Certainty of Evidence
8 cohort studies (n=13,428)	Overall result	0.50-1.0	0.5-0.99	Very low
	AudioScope (combined otoscopic examination and automated pure tone audiometry) (3 studies)	0.85-0.97	0.5-0.97	
	Manual audiometers (7 studies)	0.5-1.0	0.54-0.99	

Sn sensitivity; Sp specificity

Efficacy Outcomes

There were no direct studies on the beneficial effects of screening for hearing loss in children using different modalities. Instead, studies on the effectiveness of common interventions and relevant outcomes were used.

2 meta-analyses were done in children, aged 6-15 years old with profound unilateral hearing loss, which examined the mean scores of Quality of Life outcomes.⁶ In a fixed effect meta-analysis that included 2 cohort studies and a total of 73 participants, no effect of treatment could be shown -0.20 (0.65 to -0.26).^{7,8} In a random-effect meta-analysis that included 6 before and after studies and a total of 61 participants, a strong positive effect of hearing treatment on quality of life was shown 1.32 (0.35 to 2.29).⁹⁻¹⁴

Speech discrimination showed a gain of 27.1% to 78% among children with hearing aids in quiet conditions. However, 0% to 2% gain is seen among hearing aid wearers when subjected to noise conditions.¹⁵ A single retrospective longitudinal study showed stark differences in median test score for speech recognition (Lafon test) between those with hearing aids (92% [96-100]) and without hearing aids (16% [0 - 58]).¹⁶ Delay in developmental outcomes is directly associated with the median time between the time of detection of hearing loss in screening and the introduction of first amplification device. Severe developmental delay (more than 1 year of delay in chronological age as compared to actual age) is seen in patients who were fitted at 30 months from the time of detection.¹⁷

Table 17. Benefits and harm of hearing loss interventions

Outcomes	No. of Studies	Estimates (95% CI) [Range]	Interpretation	Certainty of Evidence
Quality of life	2 (n=73)	SMD: -0.20 (0.65 to -0.26)	Inconclusive	Low
	6 (n=61)	SMD: 1.32 (0.35 to 2.29)	Benefit	Low
Speech discrimination	4 (n=52)	Speech gain range: Quiet Condition: + [27.1% to 78%] Noise Presented: + [0% to 2%]	Benefit	Low
	1 (n=25)	Median Lafon test score at 55dB: w/ HA: 92% [96-100] w/o HA: 16% [0 - 58]	Benefit	Low
Delay in developmental outcome	1 (n=40)	Developmental delay: Median time to 1st amplification device Mild: 15 months Moderate: 15 months Severe: 30 months	Inconclusive	Very Low
Presence of ear canal debris	1 (n=64)	RR 4.0 (1.7-9.3)	Harm	Very Low
Bacterial growth in swab culture	1 (n=64)	RR: 5.0 (1.6-15.6)	Harm	Very Low

CI confidence interval; HA hearing aids; RR relative risk; SMD standardized mean difference

Safety Outcomes

No systematic reviews and meta-analyses directly addressed the safety profile of audiometry tests used as hearing screening. Evidence for safety outcomes in this review will be for hearing loss interventions.

An observational study involving unilateral hearing aid users examined the ear canal debris and microbial analysis of swab culture taken from the hearing aid side and compared them with the contralateral ear without hearing aid. Results showed an RR of 4.0 (1.7-9.3) for presence of ear canal debris and RR of 5.0 (1.6-15.6) for bacterial growth in swab culture.¹⁸

Certainty of Evidence

Overall certainty of evidence is very low. Most of the studies did not report methods for blinding, independent administration of the screening or reference standard, nor was there adequate participant representation. Across the studies, there was no standardized method of screening and/or protocol. Wide ranges of confidence intervals for the positive and negative likelihood ratios were also noted.

Recommendations from Other Groups

Table 18. Summary of other groups' recommendations for PTA for children

Group or Agency	Recommendation	Strength of Recommendation/ Certainty/Quality of Evidence
American Academy of Audiology Childhood Hearing Screening Guidelines (2011) ¹⁹	The American Academy of Audiology endorses detection of hearing loss in early childhood and school-aged populations using evidence-based hearing screening methods. The charge of the Subcommittee on Childhood Hearing Screening was to develop evidence-based recommendations for hearing screening for children from age 6 months until high school.	
Bright Futures/American Academy of Pediatrics (2017) ²⁰	Suggests a hearing risk assessment at all health maintenance visits and periodic hearing screening for all children between 4 and 21 years of age.	Grade 2C (Weak Recommendation)

Ongoing Studies and Research Gaps

In current literature, no established or proposed standardization of hearing screening protocols for children of school age exist. There is an urgent need for global standardization, which will facilitate more accurate studies of hearing loss prevalence, and determination of screening test sensitivity and specificity.²¹

Additional Considerations for Evidence to Decision (EtD) Phase

Cost

A cost-effectiveness study of a hearing screening program for primary school children in Iran showed an averted disability-adjusted life years (DALY) at 7 years for each child.²² This means that hearing screening programs prevent an equivalent 7 years of life lived with disability.

Table 19. Cost table of hearing screening and confirmatory test

Parameter	Screening intervention	Confirmatory test
	Pure tone audiometry	Complete audiology evaluation
Unit cost of screening intervention (PHP)	Public: Free Private: 700-1000 ^a	1500-3000 ^b

^aRange is based on testing centers^bRange is based on private consultation and procedural fees

Patient's Values and Preference, Equity, Acceptability, and Feasibility

A review on equity evaluation discussed the social determinants of hearing which influence hearing disease diagnosis, management, and rehabilitation. These social determinants can be broken into the following domains: (1) healthcare access and quality, (2) education access and quality, (3) social and community context, (4) economic stability, and (5) neighborhood and built environment.²³

For the acceptability of screening tests on infants and children, the main components identified are: (1) parental knowledge and understanding of the screening process and the testing procedure, (2) potential consequences of a confirmed diagnosis, and (3) consent.²⁴ Maternal anxiety was the most explored emotional impact of childhood hearing screening.

A 2020 study demonstrated that identifying hearing loss and ear disease in 3-year-old children in the preschool setting is feasible in an area of high socioeconomic deprivation.²⁵

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4.1.5. Tuning Fork Tests, Pneumatic Otoscopy, Phone-based Screening Audiometry

RECOMMENDATIONS

Among asymptomatic apparently healthy school-aged children, we recommend hearing loss screening using smartphone-based screening audiometry.
(strong recommendation, high certainty evidence)

Among asymptomatic apparently healthy school-aged children, we suggest hearing loss screening using tuning fork test.
(weak recommendation, low certainty evidence)

Among asymptomatic apparently healthy school-aged children, we suggest against hearing loss screening using pneumatic otoscopy.
(weak recommendation, low certainty evidence)

Considerations

The consensus panel formulated the strong recommendation on phone-based screening audiometers based on high quality of evidence. With the universal availability of mobile phones, the panel recognized that phone-based hearing tests may assist in large-scale hearing screening. However, the panel noted that protocol standardization for application, equipment, and testing environment must be done. Phone-based applications may also need regular updating and calibration to produce reliable results.

The panel voted for a weak recommendation on screening using a tuning fork test due to low quality of evidence. The panel recognized tuning fork tests have low resource requirements. From 2004-2007, training workshops in screening school-aged children using 512 Hz tuning fork were held for school nurses. However, there is no evidence if this is being practiced currently.

The panel voted against the use of pneumatic otoscopy because of low certainty evidence. Other issues considered were: (1) training requirements, (2) cost, and (3) limited availability of pneumatic otoscopes in primary health care settings.

Key Findings

A systematic review on the Rinne test using 256 Hz fork resulted in 76.7% to 82% and 66.0% to 98.9% on sensitivity (Sn) and specificity (Sp), respectively. The 512 Hz fork resulted in 64.0% to 87% and 55.0% to 85.0% on Sn and Sp, respectively.

One study on pneumatic otoscopy showed Sn and Sp of 0.80 and 0.92, respectively. Meta-analysis on screening audiometry results were pooled which showed Sn: 0.85 (0.69-1.00) and 0.96 (0.89-1.00).

More updated studies are needed to determine the reliability of tuning fork tests, screening audiometry, and pneumatic otoscopy in screening for hearing loss among children.

Introduction

Hearing loss refers to a compromised ability to hear sounds at normal thresholds. In children, an average pure tone threshold higher than 15 dB HL at 500, 1000, 2000, and 4000 Hz is considered outside the normal reference range.¹

Based on the results of a 2020 cross-sectional national survey done in the Philippines, the prevalence of moderate or worse hearing loss was 7.5% in children less than 18 years old. The prevalence of hearing loss was high compared to rates reported by high-income countries. Higher proportions of severe to profound hearing loss were also documented. Hence, the Philippine population has both high prevalence and more severe cases of hearing loss.²

Hearing loss (HL) is a common childhood disability. An estimated 1.1/1000 to 1.7/1000 newborns have permanent bilateral severe to profound HL; 1/1000 to 2/1000 newborns have mild to moderate bilateral or unilateral HL. By 19 years old, 15-18% may develop delayed onset HL or HL secondary to trauma, medication effects, and infection. HL in children often occurs before language and speech development, adversely affecting academic proficiency and quality of life. Thus, early identification and treatment of HL is vital in the prevention of speech-language delay and its consequences.³ Hearing loss negatively affects classroom learning abilities, language development, academic performance and social development. Early detection using appropriate audiological and speech therapy interventions may decrease these future risks.⁴

Children at risk for hearing loss need to be closely monitored to ensure the identification of hearing loss as early as possible and to avoid delays in treatment. It has been suggested that the prevalence of permanent hearing loss increases during childhood. Hearing loss may also occur after childhood in 25-50% of children who have risk factors.¹

Review Methods

Search strategies were done for available clinical practice guidelines (CPGs) on hearing loss screening among children from the following organizations: USPSTF, WHO, NICE, and CTFPH. Conduction of systematic searches using the two electronic databases, PubMed and Cochrane library, was also done using the terms: "hearing loss in children, hearing screening in children, tuning fork tests, Weber, Rinne, screening audiometry, pneumatic otoscopy." A detailed search strategy may be found in the appendix.

The following inclusion criteria was used for screening of studies: (1) pediatric population (0-18 years old), (2) asymptomatic, healthy children, and adolescents, (3) tuning fork tests, screening audiometry and pneumatic otoscopy as intervention, and (4) CPGs, Systematic Reviews / Meta-analysis, or RCTs.

Results

Characteristics of Included Studies

Tuning fork test

A systematic review investigated the diagnostic accuracy of tuning fork test which included 17 studies with a total of 3,158 participants in determining conductive hearing loss.⁵ Participants included both adult and pediatric population. Among the studies in the systematic review, four solely included pediatric patients.⁶⁻⁹ Weber and Rinne Tuning Fork Tests were done using

256- and 512-Hz forks as index tests. Sensitivity and specificity were analyzed by comparing against the diagnostic pure tone audiometry as the reference standard.

Pneumatic otoscopy

No direct studies were found in the pediatric population. A prospective cohort study of 37 adult patients investigated the diagnostic accuracy of video-pneumatic otoscopy in determining conductive hearing loss. The outcome parameter was the movement of the umbo, which was tested against the temporal computed bone tomography. The study used pure tone audiometry as the reference standard.¹⁰

Screening audiometry

A meta-analysis synthesized the current evidence on diagnostic accuracy of smartphone-based applications as screening audiometry tools in hearing loss assessment. Conventional PTA was used as the reference test. 5 out of 25 studies focused on accuracy determination in the pediatric population (n=1721).¹¹

Diagnostic Performance of Screening Tests

Table 20. Diagnostic accuracy of tuning fork test, pneumatic otoscopy, and screening audiometry

Index Test (No. of Studies, Total Participants)		Sensitivity (95% CI)	Specificity (95% CI)	Certainty of Evidence
Rinne ⁵	256 Hz (2, n=745)	0.76 – 0.82	0.66 – 0.98	Low
	512 Hz (2, n=745)	0.64 – 0.87	0.55 – 0.85	Low
Weber ⁵	256 Hz (1,n=687)	0.18	0.97	Low
	512 Hz (1,n=125)	0.65	0.75	Low
Pneumatic Otoscopy (1, n=37) ¹⁰		0.80	0.92	Low
Screening Audiometry (5, n=1721) ¹¹		0.85 (0.69 – 1.00)	0.96 (0.89 – 1.00)	High

CI confidence interval; Hz Hertz

Table 21. Smartphone-based applications used in the pooled studies of pediatric population from meta-analysis

Study	Application	Operating system	Equipment	Calibration	Soundproof booth
Corona et al.	hearTest	Android	Headphone	NR	Yes
Durgut et al.	HearingTest™ (version 1.1.3)	Android	Headphone	NR	No
Mahomed-Asmail et al.	hearScreen	Android	Headphone	RETSPLs	No
Swanepoel et al.	hearScreen™	Android	Headphone	RETSPLs	No
Yimtae et al.	PASS Speech Audiometry	Android	Headphone	NR	No

NR not reported; RETSPLs reference equivalent threshold sound pressure levels

Efficacy Outcomes

There were no direct studies found on the beneficial effects of screening for hearing loss in children using tuning fork test, pneumatic otoscopy, and audiometry screening.

Safety Outcomes

No direct evidence was found on the harm associated with screening for hearing loss in children using tuning fork tests, screening audiometry, and pneumatic otoscopy.

Certainty of Evidence

In the systematic review of the diagnostic accuracy of tuning fork tests, authors assessed the risk of bias in the included studies using the Quadas-2 tool. All 4 studies involving pediatric

patients were documented to have high risk of bias due to patient selection, and low risk of bias in relation to the index test and the reference standard. For flow and timing, the studies of Behn and Capperhad had low risk of bias. On the other hand, the studies of Haapaniemi and Wilson had an unclear risk of bias.

Recommendations from Other Groups

2 clinical practice guidelines and 1 updated task force guideline on screening for hearing loss in the pediatric age group were found. However, these three guidelines gave no guidance on the benefits or harms of screening asymptomatic healthy children for hearing loss using tuning fork tests, screening audiometry and pneumatic otoscopy.

Ongoing Studies and Research Gaps

More updated studies are needed to determine the reliability of tuning fork tests, screening audiometry, and pneumatic otoscopy in screening for hearing loss among children.

Additional Considerations for Evidence to Decision (EtD) Phase

Cost

A cost-effectiveness study on a hearing screening program for primary school children in Iran showed an averted disability-adjusted life years (DALY) at 7 years for each child.¹² This indicates hearing screening programs prevent an equivalent 7 years of life lived with disability.

Table 22. Cost table of hearing screening and confirmatory test

Parameter	Screening intervention			Confirmatory test	
	Rinne and Weber	Pneumatic otoscopy	App-based screening audiometry	Pure tone audiometry	Complete audiology evaluation
Unit cost of screening intervention (PHP)	Public (OPD fee): 200 Private (consult fee): 500-1000	Public (OPD fee): 200 Private (consult fee): 500-1000	0-200	Public: Free Private: 700-1000 ^a	1500-3000 ^b

OPD outpatient department

^aRange is based on testing centers

^bRange is based on private ENT consultation and procedural fees

Patient's Values and Preference, Equity, Acceptability, and Feasibility

No local study was found on the values, preference, equity, acceptability, and feasibility of hearing loss screening in children using tuning fork tests, screening audiometry, and pneumatic otoscopy.

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4.2. Hearing Screening in Asymptomatic Apparently Healthy Adults

RECOMMENDATIONS

Among asymptomatic apparently healthy elderly adults (50 years old and above), we suggest hearing loss screening using portable pure tone audiometer screener or mobile-based audiometric applications.*
(weak recommendation, very low certainty evidence)

No recommendation can be made on screening asymptomatic apparently healthy adults less than 50 years old due to insufficient evidence.

Remarks:

*This recommendation applies to the general population; however, for specific at-risk populations, screening recommendations as provided for by existing guidelines will apply.

Considerations

The consensus panel formulated this weak recommendation due to issues involving cost-effectiveness, feasibility, and the population in the evidence base. Additionally, studies had very low certainty evidence due to issues of unclear patient selection, unclear methods of calculating accuracy, and indirectness.

For this evidence review, the primary outcome was hearing aid use. In terms of cost-effectiveness, hearing aids are costly and not subsidized by the Filipino government. Many Filipino patients experience financial difficulties with device procurement. Aside from hearing aid use, other treatments for hearing loss include sign language, counseling on behavioral modifications (such as changes in body position when communicating, avoiding conversations in noisy environments), and occupational therapy. Proper counseling can also prevent further deterioration of hearing in affected individuals.

Issues on feasibility include the lack of trained professionals to perform proper audiology, and the uncommon use of tone-emitting otoscopes in the Philippines. However, screening audiometers are already being used for hearing screening in some industries. Some phone- or tablet-based audiometric applications for screening audiology are free, intuitive, and can be used by primary health care physicians.

With the evidence available being limited to the population 50 years old and above, the panel decided that there is insufficient evidence to screen healthy asymptomatic adults below 50 years old, but existing laws and guidelines will apply for specific high-risk populations.

Characterizing the population in this review further, the panel recognized that the population should not only be limited to “industrial workers.” This is because all types of workers are exposed to occupational noise. It was alluded that the limited evidence found on high risk population may be due to the use of “industrial workers” in the search, which may have excluded studies on other noise-exposed workers.

Finally, the panel recognized that baseline hearing screening is lacking especially in high-risk industries and should be advocated. The promotion of hearing health awareness and hearing conservation programs should also be prioritized. Currently, there are safety and health laws mandating companies to have hearing conservation programs and provide employee compensation for any hearing loss caused by or aggravated by the workplace.

Key Findings

One RCT that investigated the effectiveness of hearing screening in the long-term outcomes of old veterans was used for direct evidence in this review.

Hearing screening using the combination of tone-emitting otoscopy (AudioScope) and Hearing Handicap for the Elderly-Screening Version (HHIE-S) questionnaire resulted in significant benefit in terms of hearing aid use among screened patients compared to those unscreened. When used as a sole screening test, the AudioScope also provided benefit from increased hearing aid use among patients who were screened. However, no significant increase in hearing aid use was seen in the HHIE-S group. In terms of quality of life, no statistically significant difference was seen in the trial. Data on clinical outcomes for screening other subpopulations such as industrial workers were not found.

The overall certainty of evidence was very low quality due to risk of bias issues from blinding and attrition, indirectness concern from the population involved rather than the general adult population, and issue on imprecision from wide confidence intervals in one screening test.

Introduction

In the Philippines, moderate to severe hearing loss has an alarming estimated prevalence of 15%. Of these, 14.7% are adults between 18 and 65 years old and 49.1% are adults older than 65 years old. Increased age, presence of an outer or middle ear condition, and higher income are associated with increased risk of moderate hearing loss in the Filipino population.¹ The WHO report on hearing loss, on the other hand, highlights three specific factors leading to hearing loss: otitis media, exposure to loud noise, and age-related hearing loss.² The Global Burden of Disease study reports that the global number of years lived with disability (YLDs) attributable to hearing loss was 43.5 million in 2019, with age-related hearing loss being the third largest source of global YLDs and the leading source for adults more than 70 years of age.³

Hearing loss can be addressed through the use of hearing technologies, use of sensory substitution, and/or rehabilitative therapy. Hearing aids are currently the mainstay of intervention. However, a key to effective management of hearing loss is its early identification, which subsequently allows expedited intervention and improved quality of life. A variety of hearing assessment questionnaires and technologies (e.g., PTA, screening audiometry, and tone-emitting otoscopes) enable the screening of ear diseases and hearing loss.

Economically, the WHO estimates that unaddressed hearing loss causes an overall global cost of USD 980 billion annually, including health sector costs, educational support, loss of productivity, and societal costs. Of this global cost, 54% is attributed to low- and middle-income countries.³

The impact of hearing loss is broad. Hearing is a human intrinsic capacity and the most relied upon sense for communication. Hearing loss adversely affects day-to-day functioning and, therefore, many aspects of life. It can cause employment difficulties, social isolation and loneliness, higher rates of depression, and lower quality of life.³

Review Methods

A search was done for available clinical practice guidelines (CPGs) on hearing loss screening among adults from the following organizations: USPSTF, WHO, and NICE. Systematic searches were also conducted using the two electronic databases, PubMed and Cochrane, using the terms: “*hearing loss, screening, pure tone audiometry, screening audiometry, industrial workers.*” A filter was placed to include only meta-analyses (MAs), systematic reviews (SRs), randomized controlled trials (RCTs), and cost-effectiveness analyses (CEAs). The detailed search strategy may be found in the appendix.

We used the following inclusion criteria for screening of studies: (1) adult population working in industrial areas or with regular exposure to noise, (2) pure tone audiometry or screening audiometry as intervention, (3) CPGs, SRs/MAs, or RCTs, and (4) studies published within the last 5 to 10 years.

Results

Characteristics of Included Studies

3 guidelines on hearing loss screening among adult populations were found. The guidelines were appraised using the AGREE-II tool by two independent reviewers. Only 1 guideline with available evidence summary (USPSTF 2021) was deemed to be of high quality, garnering >70% in the Rigor of Development domain and 70% overall score upon appraisal; hence, was adapted in this review.⁴ This guideline included key questions on the benefit and harms of screening for hearing loss in asymptomatic adults aged 50 years or older. In particular, 1 screening RCT (Screening for Auditory Impairment – Which Hearing Assessment Test trial or SAI-WHAT trial) with fair quality rating was used as the basis for the clinical question on health benefit from hearing loss screening.^{5,6} The SAI-WHAT trial (n=2,314) was a 4-armed RCT which recruited older veterans (mean age 60.7 years, 94.4% male) to determine whether routine hearing loss screening would lead to improved health outcomes after 1 year from screening.⁶ Intervention groups were as follows: (a) no screening, (b) tone-emitting otoscope screening only (using a Welch Allyn AudioScope; to test hearing a 40-dB tone at 2,000 Hz in either ear), (c) questionnaire only (using the HHIE-S questionnaire), and (d) dual screening with otoscope and questionnaire. The primary outcome was the percentage of hearing aid use one year after screening. In terms of safety outcomes, the guideline did not find any trials that evaluated potential harms linked with hearing loss screening.

Efficacy Outcomes

Hearing loss rates

Based on the SAI-WHAT trial with a total of 2,314 enrolled and randomized patients, positive screening tests were 18.6% in the AudioScope group, 59.2% in the HHIE-S group, and 63.6% in the combined group. The control group did not have any patient testing positive for hearing loss due to no screening conducted.

Hearing aid use

In the SAI-WHAT trial, the highest rate of 1-year hearing aid use was seen among patients who underwent combination screening with AudioScope and HHIE-S questionnaire at 7.4%. In contrast, single screening tests were seen to have lower 1-year hearing aid use rates at 6.3% for the otoscope group, and 4.1% for the questionnaire group. Lowest percentage was seen in the control group (no screening) with a 3.3% rate.

Individual comparison of the dual screening group with the control group revealed a computed RR of 0.44 (95% CI 0.27 to 0.71, NNT 24.4) indicating clear benefit of dual screening over no screening. Similarly AudioScope screening alone was also shown to provide clear benefit with computed RR of 0.52 (95% CI 0.31 to 0.85, NNT 33.3) compared to control. However, analysis of the questionnaire screening using HHIE-S resulted in an RR of 0.79 (95% CI 0.45 to 1.39, NNT 125) which indicated unclear benefit.

It should be noted that the trial was conducted in a high-prevalence setting where the cost of hearing aids is not a deterrent factor towards treatment.

Quality of life

The SAI-WHAT trial stated that no statistically significant difference was seen at 1 year in terms of clinical outcome measures using the Inner Effectiveness of Aural Rehabilitation (Inner EAR) scale. The percentages of patients with minimum clinically important improvement were 36% to 40% in the screened groups compared to 36% in the control group.⁶ However, further analysis of these data could not be done due to the unavailable supplementary material of the SAI-WHAT trial.

Work-related injuries/Disabilities

No eligible studies were found on the evaluation of work-related injuries or disabilities associated with hearing loss screening.

Subgroups

Only outcomes for the elderly population were available. No outcomes were available for other subgroups.

Safety Outcomes

No eligible studies were found on the evaluation of safety associated with hearing loss screening.

Table 23. Summary of findings for hearing screening for adults

Critical Outcomes	Basis	Effect Size	95% CI	Interpretation	Certainty of Evidence
Hearing Aid Use	1 RCT (n = 1392)	RR 0.44 (dual screening)	0.27 to 0.71	Benefit	Very Low
		RR 0.52 (AudioScope)	0.31 to 0.85	Benefit	
		RR 0.79 (HHIE-S questionnaire)	0.45 to 1.39	No benefit	

CI confidence interval; HHIE-S Hearing Handicap Inventory for the Elderly-Screening Version; RCT randomized controlled trial;
RR relative risk

Diagnostic Accuracy of Screening Tests

Table 24. Summary of accuracy for included screening tests*

Test	Hearing loss severity (PTA db range)	No. of studies (No. of participants)	% (95% CI)		LR (95% CI)			
			Sensitivity	Specificity	Positive	Negative		
Single question	Mild (>20 to 25)	10 (12,637)	Pooled: 66 (58-73)	Pooled: 76 (68-83)	Pooled: 2.7 (2.2-3.4)	Pooled: 0.45 (0.38-0.53)		
	Moderate (>35 to 40)	6 (8,774)	Pooled: 80 (68-88)	Pooled: 74 (59-85)	Pooled: 3.1 (2.0-4.7)	Pooled: 0.27 (0.18-0.41)		
HHIE-S score <8b	Mild (>25)	4 (7,194)	58 (53-61)	85 (83-87)	3.9 (3.8-3.9)	0.49 (0.49-0.50)		
			58 (45-70)	76 (69-84)	2.4 (1.7-3.5)	0.55 (NR)		
			44 (NR)	85 (NR)	2.9 (1.6-4.9)	0.7 (0.6-0.8)		
			34 (31-37)	95 (94-96)	5.8 (6.6-7.0)	0.69 (0.69-0.70)		
	Moderate (>40)	5 (2,820)	Pooled: 68 (52-81)	Pooled: 78 (67-86)	Pooled: 3.21 (2.4-4.2)	Pooled: 0.41 (0.28-0.59)		
HSAQ score ≥15	Mild (>25)	1 (112)	100 (89-100)	75 (64-84)	4 (2.7-5.9)	0		
RFMHT score ≥15	Mild (>25)	1 (74)	80 (NR)	55 (NR)	1.8 (NR)	0.36 (NR)		
WVT	Mild (>25 to 30)	5 (669)	Pooled: 94 (31-100)	Pooled: 87 (82-90)	Pooled: 7.1 (5.1-9.7)	Pooled: 0.06 (0.00-1.94)		
	Moderate (>40)	3 (296)	46 (36-56)	78 (68-86)	2.08 (NR)	0.69 (NR)		
			30 ^a (8-65)	100 ^a (92-100)	NR	0.69 ^a		
			100 (95-100)	84 (70-81)	6.0 (4.7-7.7)	0.0 (NR)		
Watch tick	Mild (>25)	1 (107)	44 (35-53)	100 (NR)	NR	0.56 (NR)		
	Moderate (>40)	1 (107)	60 (50-69)	99 (92-100)	60.0 (NR)	0.40 (NR)		
Finger rub	Mild (>25)	1 (107)	27 (20-36)	98 (85-100)	13.5 (NR)	0.74 (NR)		
	Moderate (>40)	1 (107)	35 (26-46)	97 (90-99)	11.67 (NR)	0.67 (NR)		
Digits in noise	Mild (>20 to 25)	3 (4,110)	79 (77-81)	76 (74-78)	3.3 (3.3-3.3)	0.28 (0.27-0.28)		
			80 (66-92)	83 (69-92)	4.7 (3.5-6.3)	0.25 (0.20-0.30)		
			81 (79-84)	65 (60-70)	2.3 (2.3-2.4)	0.29 (0.28-0.29)		
WIN	Mild (>25)	1 (1,049)	97 (96-98)	46 (39-52)	1.8 (1.8-1.8)	0.06 (0.05-0.06)		
Handheld screening audiometry	Mild (>25 to 30)	2 (215)	71 (63-80)	91 (84-97)	7.5 (3.7-15.4)	0.32 (NR)		
			93 (NR)	70 (NR)	3.1 (NR)	0.10 (NR)		
	Moderate (>40)	4 (411)	100 (91-100)	42 (32-57)	1.72 (NR)	0		
			96 (90-100)	80 (74-87)	4.9 (3.5-6.9)	0.05 (NR)		
			98 (NR)	24 (NR)	1.29 (NR)	0.08 (NR)		
Pure tone portable audiometer screener	Moderate (>40)	1 (405)	94 (85-98)	72 (64-79)	3.4 (3.2-3.6)	0.08 (0.04-0.15)		
			50-59y: 94 (NR)	50-59y: 93 (NR)	50-59y: 13.4 (NR)	50-59y: 0.06 (NR)		
			60-69y: 90 (NR)	60-69y: 94 (NR)	60-69y: 15.6 (NR)	60-69y: 0.11 (NR)		
			70-79y: 90 (NR)	70-79y: 92 (NR)	70-79y: 10.6 (NR)	70-79y: 0.11 (NR)		
			80-89y: 90 (NR)	80-89y: 90 (NR)	80-89y: 9.2 (NR)	80-89y: 0.11 (NR)		
uHear app			90-96y: 88 (NR)	90-96y: 93 (NR)	90-96y: 11.8 (NR)	90-96y: 0.13 (NR)		
			2 (78)	68 (45-86)	87 (76-94)	NR		

	Moderate (>40)		100 (66-100)	89 (77-96)		
Ear Trumpet app	Moderate (>40 dB)	1 (33)	88 (64-97)	96 (86-99)	21.4 (7.9-58.3)	0.13 (0.05-0.35)
	Mild (>20 dB)	1 (35)	Quiet examination room: 96.3 (NR)	Quiet examination room: 83.1 (NR)	NR	NR
			Clinic waiting area: 100 (NR)	Clinic waiting area: 72 (NR)		
ShoeBOX app	Moderate (>40 dB)	1 (33)	100 (81-100)	96 (86-99)	24.5 (9.2-65.3)	0
Audiogram mobile app	Mild (>20 dB)	1 (37)	Quiet examination room: 85.3 (NR)	Quiet examination room: 95.1 (NR)	NR	NR
			Clinic waiting area: 87.6 (NR)	Clinic waiting area: 92.3 (NR)		
Hearing test with Audiogram app	Mild (>20 dB)	1 (35)	Quiet examination room: 87.8 (NR)	Quiet examination room: 69.4 (NR)	NR	NR
			Clinic waiting area: 89 (NR)	Clinic waiting area: 68.2 (NR)		

HHIE-S Hearing Handicap Inventory for the Elderly-Screening Version; HSAQ Hearing Self-Assessment Questionnaire; LR likelihood ratio; NR not reported; PTA pure tone average; RFMHT Revised Five-Minute Hearing Test; WIN words in noise; WVT whispered voice test

*Adapted from the 2021 US Preventive Task Force Services on Screening for Hearing Loss in Older Adults⁴

^aEstimates here are based on a positive screening test definition of 2 or more consecutive hearing grades starting from the moderate-severe threshold zone ranging from 0.5 to 2.0 kHz. Using a scoring method that defined a positive screening test result based on PTA of 40 dB or greater at 0.5, 1.0, or 2.0 kHz, sensitivity was high in both cohorts (100%), but specificity was relatively low (38% and 36%).

The USPSTF in 2021 looked into clinical tests as screening tools for hearing loss among adults, and evaluated their diagnostic accuracy in identifying mild to moderate hearing loss. These clinical tests were broadly categorized to a single question, a questionnaire, a handheld audiometric device, or a mobile-based audiometric application.

The pooled sensitivity and specificity for single question screening in identifying mild hearing loss were 66% (95% CI, 58% to 73%) and 76% (95% CI, 68% to 73%), respectively. For moderate hearing loss, pooled analysis showed 80% sensitivity (95% CI, 68% to 88%) and 74% specificity (95% CI, 59% to 85%).

HHIE-S was used to look into the diagnostic accuracy of a questionnaire as a hearing screening test in detecting mild hearing loss. The pooled sensitivity ranged from 34-58%, and the specificity from 76-95%. For moderate hearing loss, HHIE-S had a pooled sensitivity of 68% (95% CI, 52%-81%) and specificity of 78% (95% CI, 67-86%).

For the whispered voice test (WVT), the pooled sensitivity and specificity for detecting mild hearing loss were 94% (95% CI, 31%-100%) and 87% (95% CI, 82%-90%), respectively. Screening audiometers, on the other hand, had the following pooled accuracies: 64-93% sensitivity and 70-91% specificity for detecting mild hearing loss, and higher sensitivity of 94-100% but variable specificity of 24-80% for detecting moderate hearing loss.

One study on portable pure tone audiometer screener showed sensitivity of 88-94% and specificity of 90-94% on screening for moderate hearing loss. Mobile-based audiometric applications were also included in the guideline, with sensitivity and specificity ranging from

85-100% and 69-95% for mild hearing loss, respectively. Sensitivity and specificity values were 68-100% and 87-96% for moderate hearing loss, respectively.

Certainty of Evidence

The overall certainty of evidence was of very low quality due to: (1) issues on serious risk of bias from high lost-to-follow-up rates and blinding issues, (2) indirectness issue from inclusion of elderly population only rather than of general adult population above 18 years old, and (3) issues on imprecision from wide confidence intervals. The GRADE evidence profile may be seen in the appendix.

Recommendations from Other Groups

Two other international guidelines (WHO 2021, NICE 2018) have recommendations regarding hearing screening among the general population.^{7,8} The World Health Organization, via the 2021 WHO Hearing Loss Report, recommended hearing screening followed by provision of hearing aids should be done in: (1) adults in high-risk occupations, and (2) older adults aged 50-60 years old and above.⁷ In this report, high-risk populations for hearing loss was characterized by: (1) exposure to noise above 80 decibels for >40hrs per week, (2) exposure to ototoxic chemicals at work, and (3) receiving ototoxic medicines. Hearing screening among these populations have been found to be cost effective if followed by provision of hearing aids. However, duration and frequency of hearing screening were not tackled in the report. NICE UK, on the other hand, did not provide a hearing screening recommendation. Instead, it recommended hearing assessment among: (1) symptomatic adults, and (2) those who are suspected to have hearing difficulties.⁸

Table 25. Summary of other groups' recommendations for hearing screening for adults

Group or Agency	Population	Recommendation	Strength of Recommendation/ Certainty of Evidence
Screening for Hearing Loss in Older Adults US Preventive Services Task Force Recommendation Statement ⁴	Adults 50 years and older	Among asymptomatic adults 50 years or older, the US Preventive Services Task Force (USPSTF) concludes that the current evidence is insufficient to assess the balance of benefits and harms of screening for hearing loss in older adults. More research is needed.	Not applicable
Hearing loss in adults: assessment and management ⁸	Adults aged 18 years old and above	Hearing assessment is recommended in adults who present for the first time with hearing difficulties or with sudden onset or rapid worsening of hearing loss in one or both ears or in whom a hearing difficulty is suspected.	Not applicable
World Health Organization Hearing Loss Report and WHO Hearing Screening Considerations of Implementation Report ⁷	High risk occupations and older adults age 60 years old and above	Recommend screening followed by provision of hearing aids should be offered to older adults and for adults with high risk occupations for timely identification and management of hearing loss.	Not applicable

Ongoing Studies and Research Gaps

No ongoing RCTs are available to determine the effect of hearing screening on clinical outcomes, particularly among industrial workers.

Additional Considerations for Evidence to Decision (EtD) Phase

Cost

Economic models in other countries have demonstrated the cost-effectiveness of hearing loss screening among adults.^{7,9}

The cost-effectiveness of telephone-based hearing screening versus no screening among 10,000 adults aged 50 years was estimated by the WHO in middle- and high-income settings using an economic model.⁷ The model assumes that all adults identified with hearing impairment will be referred to receive hearing aid. Initial uptake and likely continued use of the hearing aid over the remaining lifetime were accounted for. Table 26 shows the summary of costs per disability-adjusted life years (DALY) averted, net monetary benefit (NMB), and return on investment (ROI) values. Based on this model, adult screening programs can be cost-effective in both middle- and high-income settings if with: (1) good referral rate to intervention after screening, (2) accurate screening, and (3) low cost of screening (e.g., telephone- or internet-based). However, it is not cost-saving from a societal perspective in a middle-income setting. This is due to the relatively high cost of hearing aids compared to the gross domestic product (GDP) per capita in the middle-income setting.

Table 26. Cost-effectiveness of adult universal screening programs for 10,000 adults aged 50 years in middle- and high-income settings

	High-income setting (Netherlands)*	Middle-income setting (China)*
Total cost	720,894.14	9,043,864.84
Total intervention cost	485,577.02	5,946,162.94
Total costs averted	835,399.36	2,516,202.87
Cost per DALY _a averted Health Perspective Only	18,026.73	12,196.83
Potential lifetime education & productivity costs per DALY averted	-366,907.66	-2,516,202.87
Combined perspective	-8,178.09	7,035.53
Lifetime value of DALY averted	788,604.60	8,877,785.02
NMB: potential Return on Investment	1.62	1.49
ROI: All costs	1.16	0.28
DALYs gained	14.00	487.52
GDP per capita	56,328.90	18,210.09

DALY disability-adjusted life years; GDP gross domestic product; NMB net monetary benefit; ROI return on investment

*Costs are estimated in 2019 international dollars

The cost-effectiveness of adult hearing screening among ages 55 years and above was also demonstrated by an economic model in the United Kingdom. The model compared adult hearing screening with subsequent service provision (full package of care, with assessment, hearing aid fitting, hearing aid device/s, follow-up and repair) versus referral to hearing care by a general practitioner (GP). While the total cost of services increased significantly from £ 21 million to £ 38 million, 30,000 quality-adjusted life years is gained per 100,000 adults with the hearing screening program. This shows that hearing screening has a justifiable cost per

quality-adjusted life year ratio, and favorable incremental cost-effectiveness ratio. Despite greater costs, it offers greater gains compared to GP referral.⁹

The cost of screening for hearing loss varies according to the test. Table 27 shows the estimated cost of screening and subsequent management for hearing loss in the Philippines.

Table 27. Estimated cost of screening and subsequent management for hearing loss

Parameter	Cost (PHP)
Pure tone and speech audiometry	195-590*
Unit cost of hearing aid	35,000-280,000**

*Costing from the Philippine General Hospital Ear Unit depends on patient classification (service versus private)

**Unit cost of hearing aid depends on the type, feature, and performance level

Patient's Values and Preference, Equity, Acceptability, and Feasibility

At present, the screening for hearing loss and its subsequent management (e.g., hearing aid fitting, device, and repair) among adults remain out-of-pocket and are not covered by PhilHealth. However, those with hearing impairment, ranging from mild to profound hearing loss, qualify as persons with disability and are therefore entitled to at least 20% discount and VAT exemption for assistive devices (i.e., hearing aid).

There are no studies on the health system impact of screening hearing loss among adults. However, the WHO identifies the following considerations for its implementation: (1) development of diagnostic audiology services in parallel with screening programs, (2) availability of hearing technology and rehabilitation services, (3) development of professional accountability, risk management, quality assurance, and program evaluation, (4) site selection based on local context, ease of access for older people, availability of human resources, and ability to ensure control, and (5) training, supervision, and ongoing support of human resources for hearing screening program.⁹

There are no studies on patient values and preferences with regard to screening of hearing loss as well as use of hearing aid among Filipino adults.

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4.3. Tandem Walking and Romberg's Test as Vestibular Testing in Asymptomatic Apparently Healthy Adult and Children

RECOMMENDATIONS

Among asymptomatic apparently healthy children and adults (<60 years old), we recommend against screening for vestibular disorders using clinical balance testing (Tandem Walking or Romberg's Test).

(strong recommendation, very low certainty evidence)

Among asymptomatic apparently healthy elderly adults (>60 years old), we recommend against screening for vestibular disorders using clinical balance testing (Tandem Walking or Romberg's Test).

(strong recommendation, very low certainty evidence)

Considerations

The consensus panel voted against adult and pediatric screening for vestibular disorders since these conditions usually present with drastic symptoms, which lead to physician consultation. Screening for vestibular disorders may not be a practical utilization of patient and physician resources because these conditions are rarely occult. Furthermore, the evidence base for the <60 year old population had issues involving indirectness, poor study design, nonuniformity of reference standards, and lack of clarity in showing improvement in health outcomes. Similar issues were encountered in the evidence pertaining to the >60 year old population.

On the nature of the tests, they do not differentiate between central and peripheral causes of vestibular disease. Unnecessary referrals and overdiagnosis may also occur due to the tests' wide confidence intervals and variable specificity.

The panel recognized that for the geriatric population, there may be a lack of awareness of symptoms of vestibular disorders (e.g., occasional falls). Screening for this group may be considered in the future provided: (1) more studies are done, and (2) a more reproducible screening test becomes available.

Key Findings

No direct or indirect evidence that favors screening or non-screening of asymptomatic individuals for vestibular disorders was found. For cost-effectiveness, it is unclear if the benefits of early screening would translate to cost savings or if screening would lead to higher costs from unnecessary confirmatory tests or referrals to subspecialists. Looking at health outcomes, there was no evidence directly associating screening for vestibular disorders among asymptomatic patients with improved or worsened health-related outcomes (e.g., mortality or disability).

For diagnostic accuracy, there were 9 case-control studies that compared the diagnostic sensitivity and specificity of either Tandem walking or Romberg's test among patients with vestibular disorders. Based on 4 studies, the overall pooled sensitivity (0.17) of tandem walking with eyes open was low, but specificity was high (0.97). Modifying the tandem walking test with eyes closed improved the overall pooled sensitivity (0.69) but lowered the specificity (0.51) compared to performing the test with eyes open. Subgroup analysis for the diagnostic accuracy of tandem walking with eyes closed among the elderly population showed a

significant improvement in the test's sensitivity (0.68) and specificity (0.62). For the Romberg's test, using a cut-off of 20-30 seconds, the overall pooled sensitivity was low (0.16) but the specificity was high (0.99). All diagnostic studies included in this review had a uniformly high risk of bias due to having a case-control design, unblinded assessors, not having prespecified diagnostic thresholds, or non-assessment of control patients with the reference standard.

We found 2 updated clinical practice guidelines on benign paroxysmal positional vertigo and Meniere's disease, but both gave no guidance on the benefits or harms of screening asymptomatic healthy individuals for vestibular disorders.

In this review, the panel opted not to recommend screening for vestibular disorders among asymptomatic apparently healthy children and adults (younger than 60 years of age), and elderly patients (older than 60 years of age) using clinical balance testing (Tandem walking and Romberg's test). This was due to the lack of direct evidence for associating screening or non-screening of vestibular disorders with the improvement of health-related outcomes, and the high risk of bias from the diagnostic studies included in this review.

Introduction

Vertigo and dizziness are frequent symptoms in the community, with an estimated lifetime prevalence of 17–30%.¹ In a German study, the 1-year prevalence of vertigo was 1.6%, and the 1-year incidence was 0.6%.² A systematic review looked at the etiology of vertigo in the primary care setting. Benign paroxysmal positional vertigo (BPPV), vestibular neuritis, and Meniere's disease were listed as the most common causes of vertigo.³ Among vestibular disorders, BPPV is the most common vestibular disorder across ages.⁴ Overall, the prevalence of BPPV ranges from 10.7 to 140 per 100,000 population.^{5,6} Women are affected more than men with a female:male ratio of 2.2 to 1.5:1.⁴

Vertigo is defined as an illusory sensation of motion of either the self or the surroundings in the absence of true motion.⁵ In most instances, "true" vertigo is nearly always a manifestation of vestibular dysfunction, with symptoms being classically distinguished as either central or peripheral. Vestibular diseases almost always present with symptoms of dizziness or vertigo. Most clinical algorithms begin with a patient complaining of dizziness or vertigo since the clinical history and manner of presentation matter most in identifying the etiology of the underlying vestibular disorder.^{7,8} Vestibular disorders impair the quality of life and can be very debilitating. The dizziness handicap inventory is a widely accepted tool used to evaluate the self-perceived handicap imposed by vestibular disorders.⁹ A recent large retrospective cohort study noted that adult participants who failed the modified Romberg's test had an elevated mortality risk from all causes (adjusted hazard ratio 1.44; 95% CI 1.23-1.69) compared to those without balance problems.¹⁰ Subgroup analysis also showed that the risk for mortality was only significant for those older than 50 years of age.

Review Methods

A systematic search was done until 30 December 2022, for randomized and non-randomized studies on healthy children and adults using Medline, Cochrane, and Google Scholar using combined MeSH and free text search using the terms: "vestibular, Tandem, Romberg." Studies that compared the Romberg test or Tandem walking test with reference standard were included in this review. Outcomes of interest included sensitivity and specificity of diagnosing vestibular disorders. No limits were placed on age. For systematic reviews and clinical practice guidelines, only studies within the past 5 years were included. Subgroup analysis based on

age was done. For all diagnostic studies, the risk of bias was assessed using the QUADAS-2 tool.

Results

Characteristics of Included Studies

9 case-control studies that compared the diagnostic sensitivity and specificity of either Tandem walking or Romberg's test among patients with vestibular disorders were found. 6 studies included Tandem walking as their index test, while 6 included Romberg's test. There were no randomized controlled studies or cross-sectional studies that tested asymptomatic individuals using clinical balance testing to diagnose vestibular disorders. The characteristics of included studies are summarized in the appendix.

Diagnostic Performance of Screening Tests

Tandem walking (eyes open)

4 studies (n=984) that screened for vestibular disorders using tandem walking with eyes opened were found. 2 studies used a cut-off of 5 steps, 1 used 20 steps, while the last study did not specify its cut-off. The pooled sensitivity of tandem walking with eyes open was low at 0.17 (95% CI, 0.05 to 0.44). Although the pooled specificity was high at 0.97, there was a wide range of confidence intervals (95% CI, 0.45 to 0.99).

Tandem walking (eyes closed)

3 studies modified the tandem walking test by having the participants close their eyes (n=605). Using a cut-off of 5 steps, the modified test showed a higher pooled sensitivity at 0.69 (95% CI, 0.62 to 0.75) compared to performing the test with eyes open. The pooled specificity is moderate at 0.51 (95% CI, 0.24 to 0.78). In 1 study, raising the cut-off steps increased the test's sensitivity but lowered its overall specificity.

1 study performed a subgroup analysis of the test according to age. Among those under 50 years, the test had a sensitivity of 0.70 and a specificity of 0.75 using a cut-off of 7 steps. While among those older than 50 years of age, the test showed a sensitivity of 0.68 and a specificity of 0.62 using a cut-off of 4 steps. In another study, among subjects older than 60, the ROC value for tandem walking with eyes closed was high (ROC=0.83) with a test sensitivity of 0.75, and specificity of 0.78, but the cut-off value was not described.

Romberg's test/Clinical test of sensory interaction

4 studies screened for vestibular disorders using the Romberg's test (n=943). The overall pooled sensitivity of the Romberg's test was low 0.16 (95% CI, 0.04 to 0.45), using a cut-off of 20-30 seconds, while the overall pooled specificity was high at 0.99 but with a wide range of confidence interval (95% CI, 0.16 to 1.0). Studies with subgroup analysis showed that among adults less than 60 years of age, a modified Romberg's test had a sensitivity range of 0.55-0.67 and a specificity of 0.70-83, using a cut-off of 30 seconds. Among the elderly 60-79 years of age, a modified Romberg's test had a sensitivity of 0.72-0.83 and specificity of 0.58-62 using a lower cut-off of 8 seconds. In the extreme age of >80 years, using a cut-off value of only 3 seconds resulted in a sensitivity of 0.67 and specificity of 0.71.

Table 28. Summary of findings for vestibular testing for children and adults

Pooled analysis	Basis	Pooled estimate	95% CI	Certainty of Evidence
Tandem walking (eyes open)				
Sensitivity	4 studies (n=465)	0.17	0.05 to 0.44	Very low
Specificity	4 studies (n=519)	0.97	0.45 to 0.99	Very low
Tandem walking (eyes closed)				
Sensitivity	3 studies (n=208)	0.69	0.62 to 0.75	Very low

Specificity	3 studies (n=397)	0.51	0.24 to 0.78	Very low
Romberg's test				
Sensitivity	4 studies (n=442)	0.16	0.04 to 0.45	Very low
Specificity	4 studies (n=501)	0.99	0.16 to 1.0	Very low

CI confidence interval

Benefits and Harms of Screening Tests

This review did not find any direct or indirect evidence from RCTs or controlled cohort studies that early screening of healthy individuals for vestibular disorders with clinical balance testing was associated with improved health outcome. Based on the diagnostic tests pooled in this review, tandem walking with eyes closed offered the best pooled sensitivity at 0.69 (95%CI, 0.62 to 0.75) and pooled specificity at 0.51 (95% CI, 0.24-0.78) in identifying patients with vestibular disorders using a cut-off of 5 steps.

For the Romberg's test, the test had low sensitivity and wide range of specificity. However, modifying the Romberg's test (eyes closed on foam) and lowering the cut-off point for older participants improved the sensitivity and specificity of the test.

Overall, the diagnostic tests included in this review uniformly had low certainty of evidence due to a high risk of bias from unblinded assessors, not having prespecified diagnostic thresholds, and non-assessment of control patients with the reference standard. Also, studies used different diagnostic thresholds contributing to inconsistency.

Safety Outcomes

Looking at harm, aside from the inherent risk of falling associated with the clinical balance testing (Romberg's test and Tandem walking test), no direct evidence was found on the harm associated with screening for individuals with vestibular disorders.

Recommendations from Other Groups

We found 2 updated clinical practice guidelines on benign paroxysmal positional vertigo and Meniere's disease.^{5,11} Both gave no guidance on the benefits or harms of screening asymptomatic healthy individuals for vestibular disorders.

Ongoing Studies and Research Gaps

More studies are needed to determine the health and cost impact of screening or non-screening of asymptomatic individuals for vestibular disorders.

Additional Considerations for Evidence to Decision (EtD) Phase

Cost

The costs to the health care system and the indirect costs of BPPV are significant. One SR noted that GPs in the community setting frequently encounter patients with dizziness and vertigo.¹² However, diagnosing the etiology of vertigo and dizziness is challenging and difficult. Except for BPPV, verifying the underlying cause of vertigo requires sophisticated care and complex tests (e.g., CT scan or MRI imaging).^{12,13} In a recent study from the United States, dizziness and vertigo were among the most frequently referred neurological symptoms to subspecialty centers and services. In a US national study, 3.9 million emergency care visits due to dizziness in 2011 resulted in USD 3.9 billion total costs (i.e., on average USD 1,004 per patient and visit).¹⁴ Many patients may also undergo potentially unnecessary diagnostic

testing or therapeutic interventions to diagnose vertigo, with costs estimates reaching USD 2000.¹⁵

Patient's Values and Preference, Equity, Acceptability, and Feasibility

No study examined the cost-effectiveness of screening for asymptomatic patients using clinical balance testing to diagnose vestibular disorders. Nevertheless, screening for vestibular disorders requires only a detailed clinical history and physical examination. GPs can readily do clinical maneuvers such as Romberg's test and Tandem Walking examination.⁷

No local study was found on the acceptability of doing either the Tandem walking test or Romberg's test as a screening tool. A US study in a science museum collected normative data among healthy subjects using both tests. Overall, the participants evaluated in the experiment had a good and positive experience.¹⁶

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4.4. Fetal Heart Rate Monitoring for Prenatal/Antenatal Hearing Screening

RECOMMENDATION

Among asymptomatic apparently healthy pregnant women, we recommend against prenatal/antenatal screening for hearing loss using fetal heart rate monitoring.
(strong recommendation, very low certainty evidence)

Considerations

The consensus panel considered screening cost-effectiveness, benefits, and harms in the formulation of this recommendation. Screening at a very early stage may entail additional cost on top of newborn hearing screening without additional benefit. This is due to absence of evidence-based intervention available for the antenatal stage. The potential harm of early detection causing parental anxiety may also be investigated in future studies.

Members of the panel recognized that the evidence is not against screening per se. The accuracy of fetal heart rate monitoring is higher compared to newborn hearing screening tests based on presented evidence so this may have potential. In the future, advances in technology may provide early intervention for the antenatal stage.

Key Findings

There were 2 observational studies that investigated the use of prenatal/antenatal ultrasound as a form of hearing screening.

Studies showed significant fetal acceleration response starting from the 26th week of gestation with an increasing response rate from the 28th to 37th weeks of gestation. 1 study had a positive rate of 100% on the 28th and 34th-37th week and normal hearing after standard screening test at birth. Studies concerning routine fetal and umbilical Doppler ultrasound examination in low-risk populations did not result in increased antenatal, obstetric, and neonatal interventions.

The observational studies included were designed as exploratory research rather than diagnostic accuracy studies. Variation in the population profile was also noted, with one study focusing on high-risk populations for its diagnostic accuracy assessment. Overall certainty of the evidence was downgraded to very low due to indirectness.

Introduction

In 2009, Republic Act No. 9709 was enacted mandating all newborns be screened for hearing loss or impairment before discharge in hospitals or within three months if born in a non-hospital setting. This legislative mandate was initiated based on the 2004 PNEI study where 1 per 724 babies are found to be born with bilateral severe to profound hearing loss.¹ Moreover, people with disabling hearing loss live in low- or middle-income countries.² This is locally supported by the findings of the 2020 national survey showing factors associated with a greater risk of moderate hearing loss in the better ear were the presence of a middle ear condition (adjusted odds ratio 2.39, 95% CI 1.49-3.85) and socioeconomic status (household income; adjusted odds ratio 1.64, 95% CI 1.23-2.19).³ Disabling hearing loss, defined by the WHO as hearing loss greater than 40 dB in the better hearing ear, impairs skills in interpersonal communication,

psychosocial well-being, scholastic and professional career opportunities, financial independence, and overall quality of life.⁴

Structural parts of the ears develop in the first 20 weeks of gestation while the neurosensory part of the auditory system develops primarily after 20 weeks of gestational age. The period from 25 weeks of gestation to 5 to 6 months of age is most critical to the development of the neurosensory part of the auditory system.⁵ Available literature has also shown that the human fetus is able to hear and respond to stimuli with fetal movements.⁶⁻⁸ However, there are very few studies aimed at the application of fetal heart rate response to screen fetal hearing status.

Review Methods

A systematic search was done from database inception until 18 November 2022 through MEDLINE, Cochrane, HERDIN, Google Scholar, clinicaltrials.gov, and local and international medical societies for Otorhinolaryngology using the combined MeSH and keywords: "hearing screening, fetal heart rate." A filter was placed to include only clinical trials, randomized controlled trials, and meta-analyses. Only studies with the outcome of interest were included. The references of included studies were also hand searched to identify additional studies that may not have appeared in the database search. No language restrictions were applied. No limits were placed on the age of gestation.

Results

Characteristics of Included Studies

Evidence for this review was obtained from 2 non-randomized observational studies (1 prospective cohort, 1 cross-section) that investigated the fetal heart rate response to acoustic stimulation to assess fetal hearing development based on the age of gestations.^{9,10} Both studies' initial objective was to prove the relation of fetal heart rate to hearing development in different weeks of gestation. Only 1 of the 2 studies investigated the accuracy of the test based on a standard (audiometry test after birth) in a low-risk, healthy population.

The first study investigated both fetal hearing development and the accuracy of the test.⁹ It included 12 healthy participants for fetal hearing development and 31 high-risk participants for the accuracy study. The fetal hearing development arm of the study compared the fetal heart rate responses to stimulation in relation to the age of gestation every second week between the 22nd to 34th week. The accuracy arm assessed the responses of the high-risk pregnancy group at 34 weeks of gestation compared to their tone-audiometry test at three years of age.

In the second study, 39 participants from low-risk pregnancies assessed fetal heart rate response to acoustic stimulation.¹⁰ Participants were divided into 9 groups according to their age of gestation every 2 weeks between the 20th to 37th week. The accuracy of the test was determined by neonatal hearing screening using automated auditory brainstem response in low-risk, healthy populations.

Accuracy Outcomes

There were no significant changes in fetal heart rate acceleration during the 20th to 24th week of gestation. There was a characteristic trend of increasing positivity rate for each successive week. Both studies showed significant fetal acceleration response starting from 26 weeks age of gestation ($p<0.05$).^{9,10} One study showed an increasing significant acceleration rate from 28 to 37 weeks age of gestation ($p<0.001$).¹⁰

In the study involving low-risk, healthy pregnant women, results showed 100% positive rate at the 28th and 34th-37th week and normal hearing after automated auditory brainstem response at birth.¹⁰

The other study featured a high-risk population. It assessed participants using the confirmatory audiometric play assessment at age three. Results showed a sensitivity of 89.29, specificity of 100, NNP=0.107 at p<0.1, and sensitivity of 75, specificity of 100, NNP=0.25 at p<0.05 at 34th week.⁹

Efficacy Outcomes

There were no direct studies found on the beneficial effects of screening for hearing loss using fetal heart rate monitoring. This review investigated studies on the effectiveness of UNHS and its relevant outcomes. In addition, evidence of harm in using Doppler ultrasound in pregnant women is only found in literature that examined the effects of the ultrasound procedure for fetal monitoring and not hearing loss screening.

Speech and Language Outcomes

In children with permanent childhood hearing impairment (PCHI), UNHS and early identification results in positive effects on developmental progress on language outcomes as compared to children that did not undergo UNHS.¹¹ Among these outcomes are receptive language, expressive language, speech ability, and reading ability.

Table 29. Impact of early identification of permanent childhood hearing impairment on speech and language outcomes*

Outcomes	No. of Studies	Cohen's d/ key findings	Level of Certainty
Receptive Language	3	1.04	Poor
		0.30	Good
		No significant variation among groups. ^a	Fair
Expressive Language	3	1.03	Good
		0.21	Good
		No significant variation among groups ^a	Fair
Speech Ability	2	.10 (NS)	Good
		No significant variation among groups ^a	Fair
Reading ability	2	0.28	Good
		No significant variation among groups ^a	Fair
Number of sentences	1	0.24	Good
Number of categories of high frequency morphological markers	1	0.30	Good
Number of categories of low frequency morphological markers	1	.03 (NS)	Good
Number of sentences with multiple clauses	1	No significant variation among groups ^b	Good
Phonological simplifications	1	No significant variation among groups ^b	Good
Narrative structure	1	Significant superiority in <9 months group ^b	Good
Narrative content	1	Significant superiority in <9 months group ^b	Good

NS not significant

*Outcome results from the studies were not pooled in the systematic review.

^aPotential contributors to this negative effect are: (1) the inclusion of children with only mild PCHI, a relatively low ascertainment rate from the cohort of eligible participants, and (2) very small numbers (11 cases) of children whose PCHI was identified before 6 months.

^bOrdinal outcomes are measured between groups screening at <9 months of age and >9months of age.

Safety Outcomes

No study directly addressed the safety profile of Doppler ultrasound in fetal heart rate monitoring. Evidence for safety outcomes in this review was based on a study that assessed the effects on obstetric practice and pregnancy outcome of routine fetal and umbilical Doppler ultrasound in unselected and low-risk pregnancies.¹²

Routine fetal and umbilical Doppler ultrasound examination in low-risk populations did not result in increased antenatal, obstetric, and neonatal interventions. There were no group differences noted for the study's primary outcomes of perinatal death (RR 0.80, 95% CI 0.35 to 1.83) and neonatal morbidity (RR 0.99, 95% CI 0.06 to 15.75).¹²

There was no available evidence on long-term outcomes such as childhood neurodevelopment. There was also no data that assessed maternal outcomes, specifically maternal satisfaction.¹²

Certainty of Evidence

The baseline certainty of evidence was low due to the level of the two observational studies.

Available literature pointed to significant differences in the accuracy arm of the studies (34th week) and the study question (20th-24th week). The observational studies were designed as exploratory research rather than a diagnostic accuracy study. Variation in the population profile was also noted in the studies, with one study focusing on high-risk population for its diagnostic accuracy assessment.

Overall certainty of evidence was downgraded to very low due to indirectness.

Table 30. Summary of findings for antenatal hearing screening*

Basis (No. and Type of Studies, Total Participants)	Sensitivity	Specificity	Interpretation	Certainty of Evidence
1 cross-sectional study (n=31)	0.89	0.99	Equivalent	Very low

*Compares prenatal doppler ultrasound at 34 weeks AOG vs. play audiometry at 3 years old

Recommendations from Other Groups

There were no available statements and recommendations from groups and governing bodies in relation to the assessment of fetal heart rate and screening of hearing impairment in prenatal/antenatal population.

Ongoing Studies and Research Gaps

The observational studies were designed as exploratory research rather than a diagnostic accuracy study. Further studies focusing on improving the protocols for the measurement or diagnostic accuracy of Doppler ultrasound from the 28th week of gestation may be done to establish more reliable evidence.

Additional Considerations for Evidence to Decision (EtD) Phase

Cost

Several systematic reviews looked at the cost-effectiveness of interventions and programs that dealt with fetal ultrasound for different outcome measures.¹³⁻¹⁵ However, there were no studies that focused on cost-effectiveness of screening for hearing loss as an outcome.

A Filipino study looked into the cost analysis of UNHS. It was conducted to investigate both short-term and long-term costs for hearing centers and for families of the hearing-impaired children.¹⁶

Compared to the scenario with no intervention, a lifetime savings at the individual level is about PHP 3.3 to PHP 4 million. On a 60-year timeline, the estimated cost of testing each baby born in a year is PHP 540,000,000; the total savings amortized on a yearly basis is estimated at PHP 2,453,988,630. Projected calculations showed that if screening a large volume of babies over a five-year period, if packaged at two OAE tests plus one ABR test, the cost is only approximately PHP 86 per child. These results show that long-term benefits and savings from UNHS on a national scale significantly outweigh the immediate costs of testing and intervention even in the first year of national implementation.¹⁷

Table 31. Resource table for hearing screening and confirmatory tests

Parameter	Screening intervention			Confirmatory Tests
	Fetal heart rate monitoring by Doppler ultrasound	Otoacoustic emissions	Auditory brain response	Complete audiology evaluation
Unit cost of screening intervention (PHP)	Public: Free Private: 500-1000 ^a	300 ^b	800 to 2,000 ^b	1500-3000 ^c

^aRange is based on private OBGYN consultation fees

^bRange is based on testing centers

^cRange is based on private ENT consultation and procedural fees

Patient's Values and Preference, Equity, Acceptability, and Feasibility

A review on evaluating equity through the social determinants of hearing health discussed the factors that influence the hearing disease diagnosis, management, and rehabilitation. These social determinants can be broken into the following domains: healthcare access and quality, education access and quality, social and community context, economic stability, and neighborhood and built environment.¹⁷

For the acceptability of screening tests on infants and children, the main acceptability components identified were parental knowledge and understanding of the screening process and the testing procedure, potential consequences of a confirmed diagnosis, and consent.¹⁸

The establishment of an infant hearing screening program in a regional referral hospital in Southwestern Uganda showed positive feasibility study results in a third-world and resource-limited setting.¹⁹ However, there were no studies that directly assessed the feasibility of universal newborn screening in the Philippines. Feasibility of UNHS in the country can be assessed indirectly through 1 cost-analysis study found.¹⁶ Additionally, barriers in practicability still affect the feasibility of the program in a primary care setting.²⁰

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5. Research Implications/Gaps

Most of the available evidence gathered had very low to low certainty of evidence. This suggests paucity of high quality studies such as RCTs on diagnostic accuracy tests, either as direct or indirect evidence. Furthermore, data is lacking in terms of cost-effectiveness, equity, values, applicability, and feasibility across all clinical questions identified in this CPG.

There is a lack of direct evidence available across all tests. Specifically for vestibular testing, no direct or indirect evidence was found that favors screening or non-screening among asymptomatic individuals for vestibular disorders. Because of this, diagnostic performance of tests was established using indirect evidence.

At present, a nationwide prevalence study of hearing loss among the different subgroups of the pediatric population, risk factors, and social determinants are lacking. There is also a need to evaluate the effectiveness of the universal newborn hearing screening program in the Philippines. Longitudinal research on the efficacy and quality of early detection and intervention strategies to assure optimal outcomes (developmental and quality of life) for newborns diagnosed with hearing loss is suggested.

There is currently no standard timing of follow-up or specific age of retesting suggested after newborn hearing screening. The evidence gathered identified some risk factors associated with delayed-onset hearing loss. Although the panelists agreed that periodic hearing monitoring is necessary for high-risk populations, no high-quality evidence is available to recommend proper timing of re-screening.

The following research needs for the children are recommended by the JCIH: (1) continued and accelerated research into optimizing screening, diagnostic and amplification intervention protocols, emphasizing timelines and accuracy based on rigorous evidence regarding efficacy; (2) exploration of preschool hearing screening programs to determine the ability to identify late-onset or missed hearing loss; (3) increased longitudinal research on the efficacy and quality of early intervention strategies to assure optimal outcomes (developmental and quality of life) for children who are deaf or hard of hearing and their families; and (4) increased inquiry and study of the cost and utility/benefit of early hearing detection and intervention (EHDI) program systems.

More updated studies are needed to determine the reliability of different hearing tests in screening for hearing loss among children. This may be the reason why even worldwide, screening protocols for children of school age differ in terms of timing, screening tests included, and thresholds used. There are currently no established or proposed standardization of hearing screening protocols for the school age population. Global standardization may help facilitate more accurate studies on hearing loss prevalence and determination of screening test sensitivity and specificity. Furthermore, a cost-effectiveness study of hearing screening programs for primary school children is available abroad but not in the local setting.

Evidence on the effect of screening on critical outcomes for the adult high risk population (i.e., work-related injuries and disabilities, safety and quality of life) is also lacking. Similar to that of children's, cost-effectiveness of screening in adults have been demonstrated abroad but not locally.

The epidemiology of balance symptoms and disorders in the local setting is not yet known. In the US, dizziness and vertigo were among the most frequently referred neurological symptoms to subspecialty centers and services and constitutes a significant proportion of emergency care visits. Having this information locally may assist in planning interventions, avoiding overdiagnosis and unnecessarily referrals and improving disease outcomes. Regarding

diagnostic accuracy of clinical balance testing, all diagnostic studies included in the review had a uniformly high risk of bias due to having a case-control design, unblinded assessors, not having prespecified diagnostic thresholds, or non-assessment of control patients with the reference standard. Future studies may consider addressing these limitations.

Using fetal heart rate monitoring to detect prenatal hearing loss is feasible and may diagnose prenatal deafness before newborn hearing screening. However, its current value is questionable in the absence of timely management available. In the future, more advanced technology may be able to provide in utero interventions for prenatal hearing loss and improve health outcomes for the unborn child.

Many research questions emerged from collating the evidence for this CPG and can be explored further. Filling in these gaps can provide a clearer picture of the impact of screening programs using previously mentioned tests and may influence the recommendations for updating this guideline.

6. Dissemination and Implementation

Dissemination

A full copy of this document will be sent to the Department of Health for transmittal and publication. The Disease Prevention and Control Bureau will transmit copies of this CPG to the Philippine Health Insurance Corporation (PHIC) and health maintenance organizations (HMOs) and non-governmental organizations (NGOs) involved in a periodic health examination. The recommendations and the evidence summaries will also be posted in the different societies involved in the consensus panel, such as PASP, ACAP, PAFP, PSO-HNS, PANORS, PNEI and PSDBP.

The DOH plans to develop a simplified version of this CPG and make it available in a format ready for reproduction and dissemination to the patients in different healthcare settings. It will also be available for interested parties who visit the DOH website. Different medical societies may also include the guidelines in their own websites.

Implementation

The SC will develop a program of monitoring and set different criteria to determine the best practices of relevant stakeholders in terms of diagnosis and management of hearing disorders. Monitoring the use of this CPG may also be a subject of research by interested parties.

As one of the PHEX guidelines, its recommendations will be incorporated into an online application that can be accessed by PCPs and patients. For any individual person, after provision of basic demographic data, the application will enumerate the screening tests that should be done. The use of the app can serve as documentation of the uptake of the CPG.

7. Applicability Issues

The PHEX Task Force accentuates some caveats of this CPG using equity and applicability lenses. Social and cultural factors, institutional environment, resources, and healthcare provider- and patient-related factors should be considered. This CPG does not necessarily supersede the consumers' (i.e., health professionals, hospital administrators, employers, payors, patients) values, settings, and circumstances.

Although this CPG intends to influence the direction of health policies for the general population, it should not be the sole basis for recreating or abolishing practices that aim to improve the health conditions of many Filipinos, particularly those part of the workforce.

8. Outcome of External Review

Insights from three external reviewers were given consideration in writing the final manuscript and recommendations.

The first recommendation was to consider hearing screening per age group in formulating key questions. This was based on the premise that some types of hearing tests are age-dependent. The initial key questions were formulated this way and evolved to what they are now after being heavily discussed and agreed upon by the steering committee, central committee, and technical working group. The removal of age stratification was done to prevent bias in establishing which screening test should be performed for each age group.

A second recommendation to include earlier studies (from 1990 to present) on newborn hearing screening was suggested. This was proposed to help minimize uncertainty in making recommendations. However, published work from this aforementioned period were included when the evidence reviewers chose well-made guidelines or reviews as references. The volume and permutation of prior studies and their appraisal can be best seen in evidence-based summaries, reviews, and guidelines. Moreover, evidence from previous studies generally focus on diagnostic accuracy or epidemiological studies, rather than serving as effectiveness studies.

It was also recommended that price ranges of diagnostic tests from both private and government sectors for better comparison be included. Inclusion of private rates was not deemed feasible; they are particularly varied across centers because they are income- or rebates-driven.

The last recommendation was to clearly define “delayed-onset hearing loss” to appropriately determine the timing of follow-up or specific age of re-testing after newborn hearing screening. Delayed-onset hearing loss in newborn is not within the purview of this clinical practice guideline; it is not within the existing guidelines and evidence. Additionally, the incidence of delayed-onset hearing loss should justify the additional second routine screening after newborn hearing screening. However, this CPG advises monitoring for the high risk newborn.

The following recommendations may be considered for the next update and evidence review: (1) consider learning outcomes as a function of hearing in school-aged children; and (2) consider the search terms “noise exposure” and “occupational risk” in the evidence review of high-risk asymptomatic adults.

9. Updating of the Guidelines

The recommendations herein shall hold until such time that new evidence on screening, diagnosing or managing various risk factors and diseases emerges and contingencies dictate updating this Philippine Guidelines on Periodic Health Examination. This guideline will be updated after three (3) years.

10. Appendices

PERIODIC HEALTH EXAMINATION TASK FORCE ON HEARING DISORDER 2023

Steering Committee Members:	Ryner Jose D. Carrillo, MD, MSc (Chair) Abigail S. Salcedo, MD (Co-chair) Lina Rose A. Alcances, MD, MOH, FPSOHNS Jose Leonard R. Pascual V, MD, FPNA
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SUMMARY OF COI DECLARATIONS

Name	Affiliation	Summary of Declared Conflicts of Interest	Management
Ma. Teresita S. Cucueco	DOLE	No COI	
Abigael C. Andal-Saniano	PAFP	No COI	
Cindy C. Llego	PSDBP	Non-Financial COI: PHEX 2 CP for Congenital & - Development Disorders	To declare COI during CP meeting
Joanna Sebastian M. De Ramos	PANORS	Non-Financial COI: Member of PANORS	To declare COI during CP meeting
Jan Alexeis C. Lacuata	AHMC	Non-Financial COI: Otolaryngologist, Head and Neck surgeon at Lablife Medical & Diagnostics Center	To declare COI during CP meeting
Kimberly Mae C. Ong	PSOHNS	Non-Financial COI: Author of papers on hearing screening; Part of NHSRC and PNEI under UPM; Member of PSOHNS	To declare COI during CP meeting
Larissa Christia F. Adique	PASP	Non-Financial COI: Speech Therapist and Audiologist working as part-time faculty for DLSU	To declare COI during CP meeting
Talitha Karisse L. Yarza	ACAP	Non-Financial COI: Training Team Lead of Hearing for Life Project; Audiologist	To declare COI during CP meeting
Jaymilyn V. Catangay-Ombao	PASP	Financial COI: Consultant Clinical Audiologist at a hearing clinic that provides newborn hearing screening services	Cannot vote on key question no. 1
Rosario R. Ricalde	PSOHNS, PNEI	Financial COI: Owns Intellectual Property Rights of a Hearing screening machine	Reassigned from Steering Committee to Consensus Panelist; Cannot vote on key question no. 1
Elmer M. Dela Cruz	PSOHNS, ACAP	Financial COI: Manila Doctors Hospital - stockholder	Cannot vote on all the questions but may share his opinion with the group.
Hubert DC. Ramos	ACAP	Financial COI: Hearing and Aural Rehab (HeAR) center - shareholder	Cannot vote on all the questions but may share his opinion with the group.
Maria Rina T. Reyes-Quintos	PSOHNS, PNEI	Financial COI: The Medical City – stockholder; Hearing & Dizziness Unit - Director	Cannot vote on all the questions but may share her opinion with the group.

Maternal History of Infection, Family History of Hearing Loss, Physical Examination

Appendix 1. Characteristics of Included Studies

Table 1. Study characteristics

Title/Author	Study design	Country	Number of patients	Population	Intervention Group(s)	Control	Outcomes
Dumanch 2017	Retrospective data review	US, one state (Iowa), cohort recruitment, follow up for outcome data collection until the child reaches 3 y	115,039	Infants	UNHS		Hearing status (normal hearing, congenital hearing loss, delayed-onset hearing loss)
Fitzgibbons 2020	Retrospective data review	Australia, one state (Queensland), cohort recruitment	613,027	Infants	UNHS		Hearing status (permanent childhood hearing loss, normal hearing or transient conductive hearing loss)
Liu 2021	Meta-analysis	Sweden, Canada, USA, India, Iran, UK, Brazil	235,026	Children			Childhood hearing loss

Appendix 2. GRADE Evidence Profile

Author(s): Charlotte Averill Tan, MD

Question: Risk factors of childhood hearing loss

Bibliography:

- Dumanich KA, Holte L, O'Hollearn T, Walker E, Clark J, Oleson J. High Risk Factors Associated With Early Childhood Hearing Loss: A 3-Year Review. *American Journal of Audiology*. 2017 Jun 13;26(2):129–42.
- Fitzgibbons EJ, Driscoll C, Myers J, Nicholls K, Beswick R. Predicting hearing loss from 10 years of universal newborn hearing screening results and risk factors. *International Journal of Audiology*. 2021 Feb 16;1–9.

Nº of studies	Study design	Certainty assessment					Nº of patients		Effect		Certainty	Importance
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Hearing loss	Normal hearing	Relative (95% CI)	Absolute (95% CI)		
Family history of hearing loss and congenital hearing loss												
1	Observational studies	serious ^a	not serious	not serious	serious ^b	none	41	175	RR 10.164 (7.430 to 14.736)		⊕○○ VERY LOW	CRITICAL
Family history of hearing loss and delayed-onset hearing loss												
1	Observational studies	serious ^a	not serious	not serious	serious ^b	none	48	246	RR 8.715 (6.380 to 11.903)		⊕○○ VERY LOW	CRITICAL
Family history of hearing loss and permanent childhood hearing loss												
1	Observational studies	serious ^a	not serious	not serious	not serious	none	220	5965	RR 4.61 (3.37 to 6.32)		⊕⊕○ LOW	CRITICAL
Perinatal infection and permanent childhood hearing loss												
1	Observational studies	serious ^a	not serious	not serious	not serious	none	40	532	RR 1.19 (0.752 to 1.665)		⊕⊕○ LOW	CRITICAL
Congenital CMV and congenital hearing loss												
1	Observational studies	serious ^a	not serious	not serious	serious ^b	none	1	216	RR 44.179 (5.720 to 341.250)		⊕○○ VERY LOW	CRITICAL
Congenital CMV and delayed-onset hearing loss												
1	Observational studies	serious ^a	not serious	not serious	serious ^b	none	3	292	RR 98.042 (27.524 to 349.236)		⊕○○ VERY LOW	CRITICAL
Congenital syphilis and congenital hearing loss												
1	Observational studies	serious ^a	not serious	not serious	not serious	none	0	217	RR 0 (0)		⊕○○ VERY LOW	CRITICAL
Congenital syphilis and delayed-onset hearing loss												
1	Observational studies	serious ^a	not serious	not serious	serious ^b	none	1	294	RR 389.537 (24.308 to 6242.46)		⊕○○ VERY LOW	CRITICAL
Congenital herpes and congenital hearing loss												
1	Observational studies	serious ^a	not serious	not serious	not serious	none	0	217	RR 0 (0)		⊕○○ VERY LOW	CRITICAL

Congenital herpes and delayed-onset hearing loss												
1	Observational studies	serious ^a	not serious	not serious	not serious	none	0	295	RR 0 (0)		⊕○○○ VERY LOW	CRITICAL
Congenital rubella and congenital hearing loss												
1	Observational studies	serious ^a	not serious	not serious	not serious	none	0	217	RR 0 (0)		⊕○○○ VERY LOW	CRITICAL
Congenital rubella and delayed-onset hearing loss												
1	Observational studies	serious ^a	not serious	not serious	not serious	none	0	295	RR 0 (0)		⊕○○○ VERY LOW	CRITICAL
Congenital toxoplasmosis and congenital hearing loss												
1	Observational studies	serious ^a	not serious	not serious	not serious	none	0	217	RR 0 (0)		⊕○○○ VERY LOW	CRITICAL
Congenital toxoplasmosis and delayed-onset hearing loss												
1	Observational studies	serious ^a	not serious	not serious	not serious	none	0	295	RR 0 (0)		⊕○○○ VERY LOW	CRITICAL
Other culture-positive congenital infection and congenital hearing loss												
1	Observational studies	serious ^a	not serious	not serious	serious ^b	none	4	213	RR 65.154 (22.883 to 185.509)		⊕○○○ VERY LOW	CRITICAL
Other culture-positive congenital infection and delayed-onset hearing loss												
1	Observational studies	serious ^a	not serious	not serious	serious ^b	none	1	294	RR 11.801 (11.609 to 86.565)		⊕○○○ VERY LOW	CRITICAL
Craniofacial anomalies and congenital hearing loss												
1	Observational studies	serious ^a	not serious	not serious	serious ^b	none	18	199	RR 56.827 (35.334 to 94.053)		⊕○○○ VERY LOW	CRITICAL
Craniofacial anomalies and delayed-onset hearing loss												
1	Observational studies	serious ^a	not serious	not serious	serious ^b	none	22	273	RR 50.629 (32.023 to 80.045)		⊕○○○ VERY LOW	CRITICAL
Craniofacial anomalies and permanent childhood hearing loss												
1	Observational studies	serious ^a	not serious	not serious	not serious	none	314	952	RR 2.68 (2.03 to 3.53)		⊕⊕○○ LOW	CRITICAL

Explanations

- a. Issues on attrition and reporting bias, wide confidence interval
- b. Wide confidence interval

OAE, AABR, ASSR for Children

Appendix 1. Characteristics of Included Studies

Table 1. Study characteristics

Title/Author	Study design	Country	Number of patients	Population	Intervention Group(s)	Control	Outcomes
Kennedy 1990	Non-randomized study of intervention (NRSI) concurrent controls prospective data collection	UK, eight districts, 1993-1996 cohort recruitment, follow up for outcome data collection until the child reaches 14y	156733 children recruited into the initial cohort in eight districts (68714 intervention, 88019 control). Follow-up data collection from 100 children with PBHL (41 intervention, 59 control)	Newborn	UNHS with OAE followed by BAER if OAE failed	Usual care including distraction test at 8m	PBHL identified <9m, receptive language 8y, expressive language 8y, literacy 8y, literacy 14y
Korver 2010	NRSI concurrent controls retrospective data collection	Netherlands, nationwide, 2003-2005 cohort recruitment, follow up for outcome data collection until the child reaches 5 y	570386 children recruited into the initial cohort (335 560 intervention, 234 826 control). Follow-up data collection from 150 children with PBHL (80 intervention, 70 control)	Newborn	OAE twice followed by BAER if OAE failed	Usual care including distraction test at 8m	Receptive language 8y, expressive language 8y, mean age at amplification
Sininger 2009	NRSI concurrent controls prospective data collection	US, one state (California), 1996-2004 cohort recruitment, follow-up for outcome data collection until the child reaches 4 y	Children recruited into the initial cohort not stated. Follow-up data collection from 64 children with PBHL (47 intervention, 17 control)	Newborn	OAE or BAER once – for all infants	Usual care including distraction test at 8m	Mean age of identification of PBHL
Wake 2016	NRSI concurrent controls prospective data collection	Australia, two states (NSW intervention and Victoria control), 2003-2005 cohort recruitment, follow up for outcome data collection until the child reaches 8 y	298 378 children in two states (NSW – intervention (n=173 523) and Victoria – control (n= 124 855)). Follow-up data collection from 94 children with PBHL (42 intervention, 52 control)	Newborn	BAER if fail twice are referred for diagnostic audiology – for all infants		
Yoshinaga 2000	NRSI concurrent controls prospective data collection	US, one state (Colorado), 1998-2002 cohort recruitment, follow up for outcome data collection until the child reaches 3 y	Children recruited into the initial cohort not stated. Follow-up data collection from 50 children with PBHL (25 intervention, 25 control)	Newborn	OAE or BAER once – for all infants	OAE or BAER once – only for infants with risk factors (including NICU admission)	Receptive language 8y, expressive language 8y, PBHL identified <6m

Appendix 2. Sensitivity and Specificity of Hearing Screening Tests

Table 2. Hearing screening test accuracy (OAE) - Sensitivity

Study	Sensitivity (%)	95% Confidence Interval	TP/(TP+FN)	TN/(TN+FP)
Ng	100.0	29.2 - 100.0	3/3	1027/1061
De Capua	95.8	78.9 - 99.9	23/24	18163/19675
Pooled Sensitivity	96.3	81.0 - 99.9		

Heterogeneity chi-squared = 0.24 (d.f = 1) p = 0.624

Inconsistency (I-squared) = 0.0%

Table 3. Hearing screening test accuracy (OAE) - Specificity

Study	Specificity (%)	95% Confidence Interval	TP/(TP+FN)	TN/(TN+FP)
Ng	96.8	95.6 - 97.8	3/3	1027/1061
De Capua	92.3	91.9 - 92.7	23/24	18163/19675
Pooled Specificity	92.5	92.2 - 92.9		

Heterogeneity chi-squared = 36.31 (d.f = 1) p = 0.000

Inconsistency (I-squared) = 97.2%

Table 4. Hearing screening test accuracy (OAE+ABR) - Sensitivity

Study	Sensitivity (%)	95% Confidence Interval	TP/(TP+FN)	TN/(TN+FP)
Wessex	91.7	73.0 - 99.0	22/24	20885/21255
O Connor	92.3	64.0 - 99.8	12/13	11213/11726
Calevo	100.0	83.2 - 100.0	20/20	32217/32238
Almenar Latorre	100.0	39.8 - 100.0	4/4	1521/1528
Pooled Sensitivity	95.1	86.3 - 99.0		

Heterogeneity chi-squared = 3.10 (d.f = 3) p = 0.376

Inconsistency (I-squared) = 3.4%

Table 5. Hearing screening test accuracy (OAE+ABR) - Specificity

Study	Specificity (%)	95% Confidence Interval	TP/(TP+FN)	TN/(TN+FP)
Wessex	98.3	98.1 - 98.4	22/24	20885/21255
O Connor	95.6	95.2 - 96.0	12/13	11213/11726
Calevo	99.9	99.9 - 100.0	20/20	32217/32238
Almenar Latorre	99.5	99.1 - 99.8	4/4	1521/1528
Pooled Specificity	98.6	98.7 - 98.5		

Heterogeneity chi-squared = 1248.9 (d.f = 3) p = 0.000

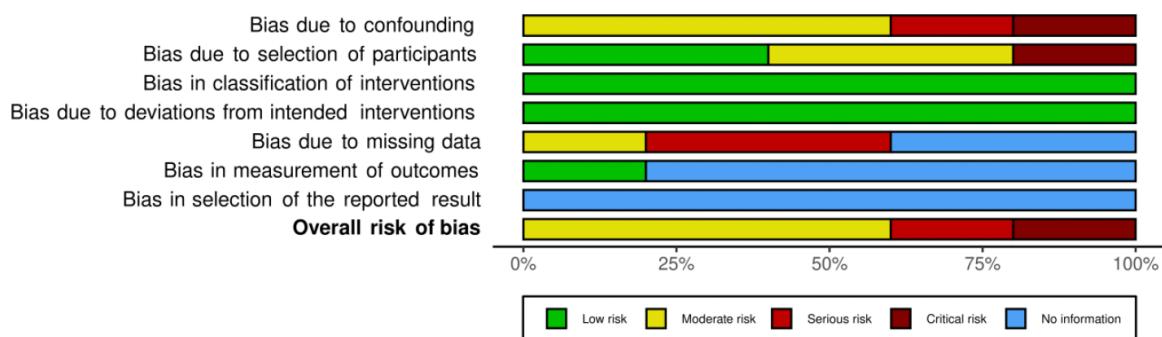
Inconsistency (I-squared) = 99.8%

Appendix 3. Risk of Bias in the Included Studies

Study	Risk of bias domains							
	D1	D2	D3	D4	D5	D6	D7	Overall
Kennedy 1999	(-)	(+)	(+)	(+)	(-)	(+)	(?)	(-)
Korver 2010	(-)	(+)	(+)	(+)	(X)	(?)	(?)	(-)
Sininger 2009	!	!	(+)	(+)	(?)	(?)	(?)	!
Wake 2016	(-)	(-)	(+)	(+)	(X)	(?)	(?)	(-)
Yoshinaga 2000	(X)	(-)	(+)	(+)	(?)	(?)	(?)	(X)

Domains:
 D1: Bias due to confounding.
 D2: Bias due to selection of participants.
 D3: Bias in classification of interventions.
 D4: Bias due to deviations from intended interventions.
 D5: Bias due to missing data.
 D6: Bias in measurement of outcomes.
 D7: Bias in selection of the reported result.

Judgement
█ Critical
█ Serious
█ Moderate
█ Low
█ No information



Appendix 4. GRADE Evidence Profile

No of studies	Study design	Certainty assessment					No of patients		Effect		Certainty	Importance
		Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	UNHS	No screening or selective screening	Relative (95% CI)	Absolute (95% CI)		
In all children born, proportion eventually identified with PBHL												
3	Observational studies	Very serious ^a	Not serious	Not serious	Not serious	None	556/574 797 (0.1%)	433/446 700 (0.1%)	RR 1.01 (0.89, 1.14)	0 fewer per 1,000 (from 0 fewer to 0 more)		LOW CRITICAL
In all children born, proportion identified with PBHL before 9 mo												
1	Observational studies	Serious ^b	Not serious	Not serious	Serious ^c	None	41/68 714 (0.1%)	16/88 019 (0.0%)	RR 3.28 (1.84 to 5.85)	1 more per 1,000 (from 1 more to 3 more)		LOW CRITICAL
In children with PBHL, proportion identified with PBHL before 6 mo												
1	Observational studies	Very serious ^{bd}	Serious ^d	Not serious	Serious ^c	None	44/100 (44.0%)	13/73 (17.8%)	RR 2.83 (0.87 to 9.16)	805 more per 1,000 (from 57 fewer to 1000 more)		VERY LOW CRITICAL
In children with PBHL, mean age of identification of PBHL in months												
2	Observational studies	Very serious ^d	Serious ^d	Not serious	Serious ^c	None	115	82	-	MD = 13.16 lower (26.31 lower to 0.01 lower)		VERY LOW CRITICAL
In children with PBHL, mean receptive language at 3-8 years (z score)												
1	Observational studies	Very serious ^a	Not serious	Not serious	Serious ^c	None	52	49	-	MD = 0.61 higher (0.07 higher to 1.13 higher)		VERY LOW CRITICAL
In children with PBHL, mean receptive language at 3-8 years (developmental quotient)												
3	Observational studies	Very serious ^a	Serious ^d	Not serious	Very serious ^{cd}	None	174	160	-	MD = 7.61 higher (1.16 lower to 16.38 higher)		VERY LOW CRITICAL
In children with PBHL, mean expressive language at 3-8 years (z score)												
1	Observational studies	Very serious ^a	Not serious	Not serious	Very serious ^{cd}	None	46	41	-	MD = 0.39 higher (0.02 lower to 0.97 higher)		VERY LOW CRITICAL
In children with PBHL, mean expressive language at 3-8 years (developmental quotient)												
3	Observational studies	Very serious ^a	Serious ^d	Not serious	Serious ^c	None	21	20	-	MD = 10.01 higher (1.77 higher to 18.25 higher)		VERY LOW CRITICAL
In children with PBHL, mean literacy at 5-11 years (z score)												
1	Observational studies	Very serious ^a	Not serious	Not serious	Very serious ^{cd}	None	21	20	-	MD = 0.58 higher (0.03 higher to 1.13 higher)		VERY LOW CRITICAL
In children with PBHL, mean literacy at 13-19 years (z score)												
1	Observational studies	Very serious ^a	Not serious	Not serious	Very ^f	None	31	29	-	MD = 0.15 higher (0.76 lower to 1.05 higher)		VERY LOW CRITICAL

Explanations

- a. Risk of bias very serious due to confounding, selection, and missing data bias
- b. Risk of bias serious due to selection and missing data bias
- c. Small sample size (less than 300 participants in dichotomous outcomes or less than 400 in continuous outcomes)
- d. Risk of bias very serious due to due to confounding and selection bias
- e. Severe unexplained heterogeneity ($I^2 \geq 60\%$)
- f. Wide confidence interval crossing the line of no effect

Appendix 4. Forest Plots

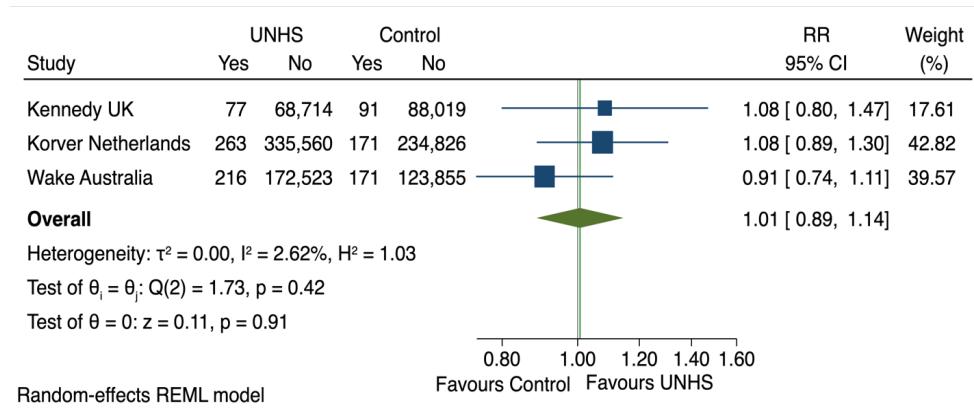


Figure 1. In all children born, proportion of children who were eventually diagnosed with permanent bilateral hearing loss (PBHL)

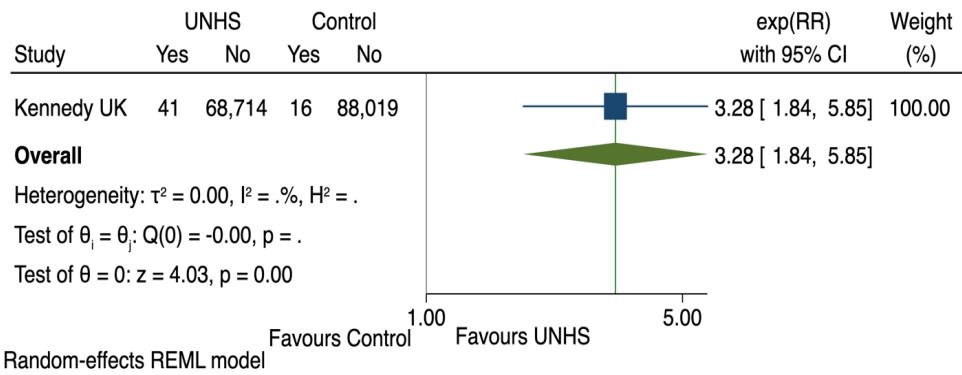


Figure 2. In all children born, proportion identified with PBHL before 9 months

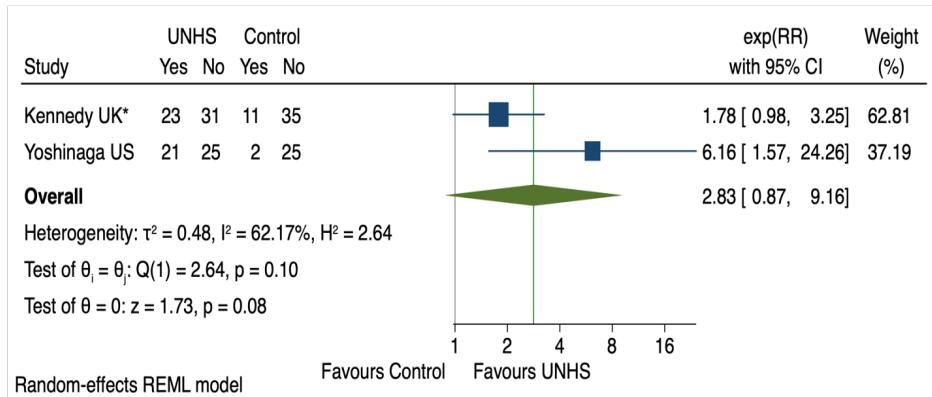


Figure 3. In children with PBHL, proportion identified with PBHL before 6 months

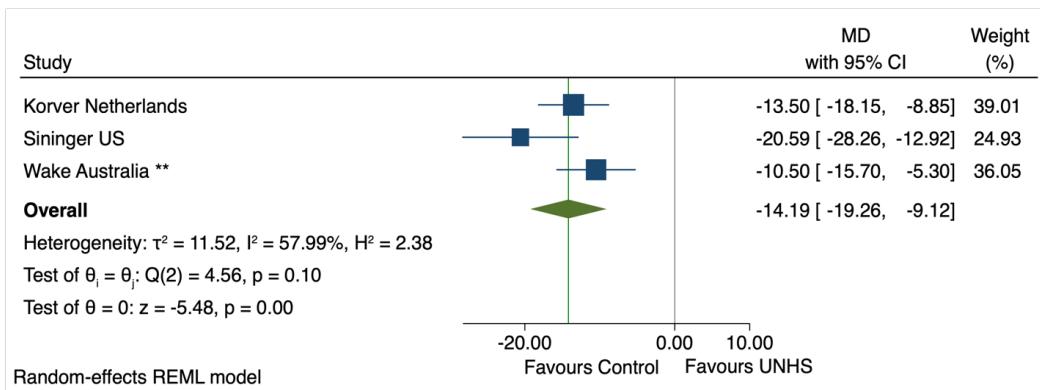


Figure 4. In children with PBHL, mean age of identification of PBHL in months

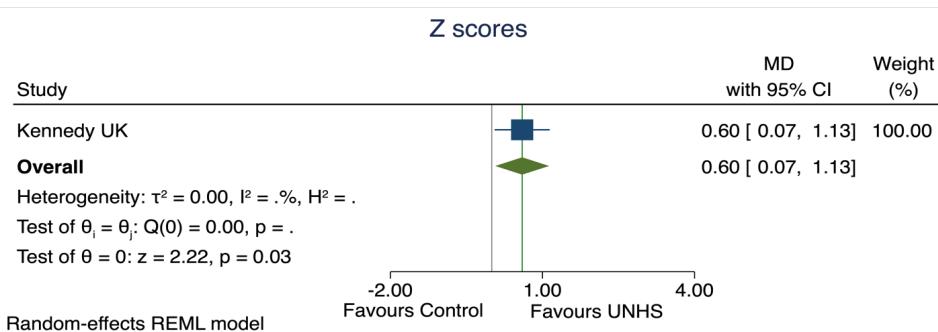


Figure 5. In children with PBHL, mean receptive language at 3-8 years (z score)

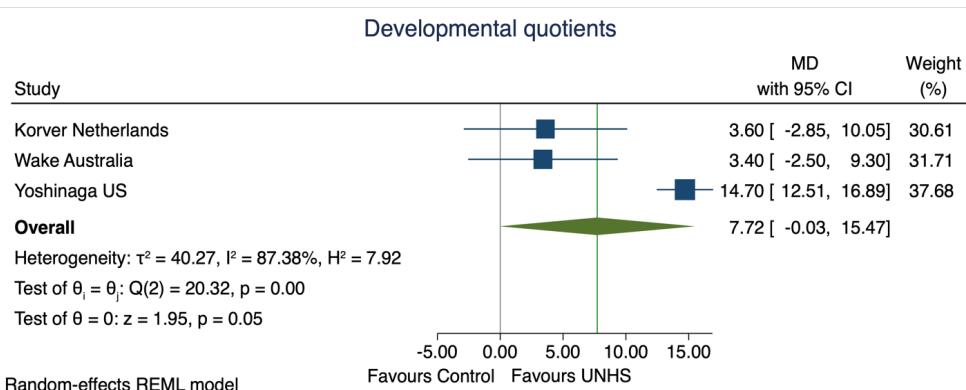


Figure 6. In children with PBHL, mean receptive language at 3-8 years (developmental quotient)

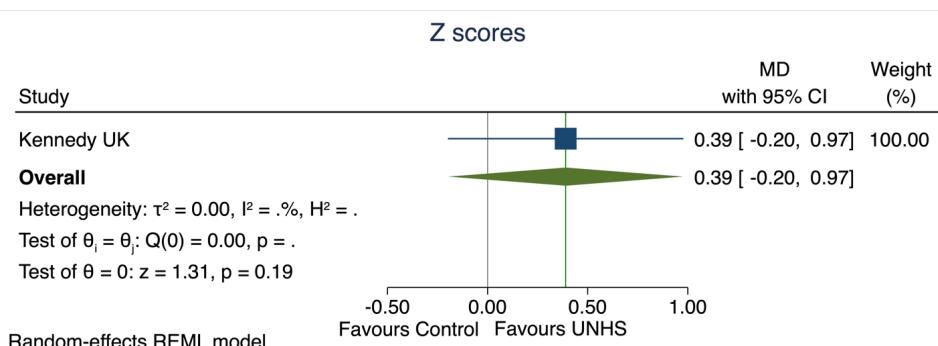


Figure 7. In children with PBHL, mean expressive language at 3-8 years (z score)

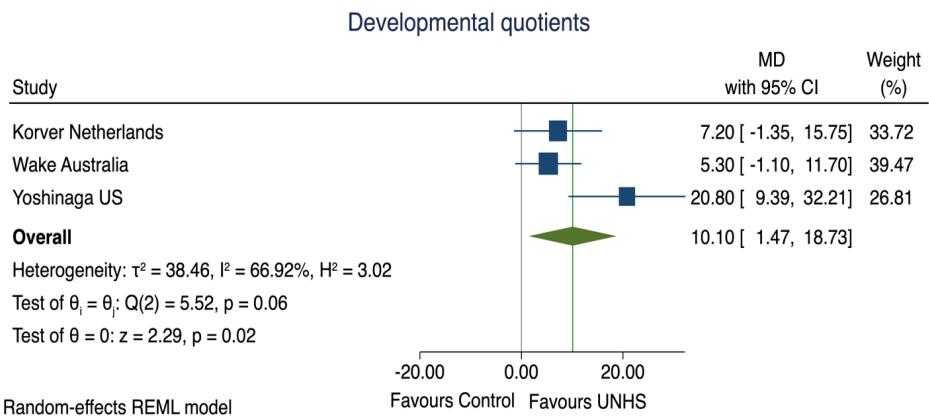


Figure 8. In children with PBHL, mean expressive language at 3-8 years (developmental quotient)

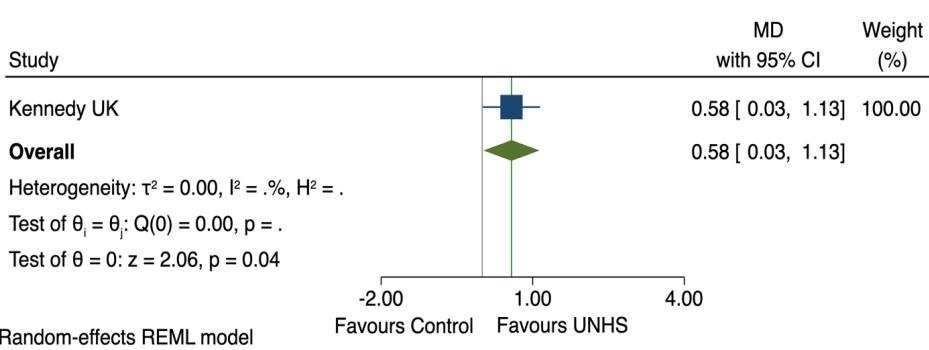


Figure 9. In children with PBHL, mean literacy at 5-11 years (z score)

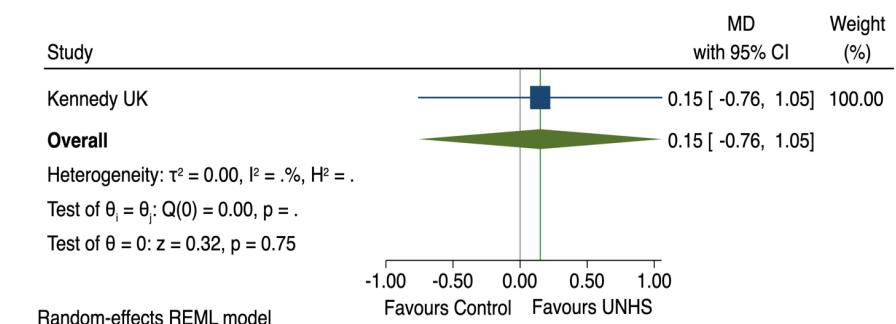


Figure 10. In children with PBHL, mean literacy at 13-19 years (z score)

Tympanometry, BOA, Genetic Testing for Children

Appendix 1. Characteristics of Included Studies

Title/Author	Study design	Country	Number of patients	Population	Intervention Group(s)	Control	Outcomes
Screening for otitis media with effusion in preschool children. Zielhuis GA, Rach GH, van den Broek P. 1989	Screening followed by randomized controlled trial for treatment	Netherlands	1,439 children were screened 43 out 84 eligible children completed the trial	Children born between 01 September 1982 and 31 August 1983 Nijmegen, Netherlands	Tympanostomy tube insertion	No procedure	Verbal expression Verbal comprehension
The role of current audiological tests in the early diagnosis of hearing impairment in infant. Kuki S, et al. 2013	Cross-sectional	India	50 infants (100 ears)	Children 3-12 months of age, with risk factors for hearing impairment	Screening using behavioral observation testing/ audiometry Gold standard: auditory brainstem-evoked response		Hearing impairment
Determinants of Communication Skills Development in Children with Hearing Impairment. Novaes BC et al 2012	Cohort	Brazil	35 children	Children with bilateral hearing impairment diagnosed using tympanometry	Hearing aid use		Language development
Speech Recognition and Parent-Ratings from Auditory	Cohort	United States	306 children	Children 1 to 9 years old with bilateral hearing impairment	Hearing aid use		Parent rating of language skills

Development Questionnaires in Children Who Are Hard of Hearing. McCreery RW et al 2015							
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Appendix 2. GRADE Evidence Profile

Question: Should screening for hearing loss using tympanometry be done in asymptomatic apparently healthy children?

Certainty assessment							No of patients		Effect		Certaint y	Importanc e
No of studie s	Study design	Risk of bias	Inconsistenc y	Indirectnes s	Imprecisio n	Other consideratio ns	tympanometr y	non e	Relativ e (95% CI)	Absolut e (95% CI)		
Verbal expression (follow-up: mean 2 years; assessed with: language development test)												
1	randomis ed trials	not seriou s	not serious	serious ^a	serious ^b	none			-	0 (0 to 0)	⊕⊕○○ Low	CRITICAL
Verbal comprehension (follow-up: mean 2 years; assessed with: language development test)												
1	randomis ed trials	not seriou s	not serious	serious ^a	serious ^b	none			-	0 (0 to 0)	⊕⊕○○ Low	CRITICAL

a. Screening done to detect OME as surrogate outcome for hearing loss.

b. Small number completing the trial (translating to small sample size).

Question: Should screening for hearing loss using behavioral observation audiometry be done in asymptomatic apparently healthy children?

Certainty assessment							No of patients		Effect		Certainty	Importance
No of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Behavioral observation audiometry	none	Relative (95% CI)	Absolute (95% CI)		
Sensitivity												
1	non-randomised	not serious	not serious	not serious	not serious	none			-	0 (0 to 0)	⊕⊕ ○○ Low	CRITICAL
Specificity												
1	non-randomised	not serious	not serious	not serious	not serious	none			-	0 (0 to 0)	⊕⊕ ○○ Low	CRITICAL

PTA for Children

Appendix 1. GRADE Evidence Profile

Question: Hearing aid compared to no hearing aids for hearing loss in children

Nº of studies	Study design	Risk of bias	Certainty assessment				Nº of patients		Effect		Certainty	Importance
			Inconsistency	Indirectness	Imprecision	Other considerations	hearing aid	no hearing aids	Relative (95% CI)	Absolute (95% CI)		
Quality of Life												
2	observational studies	not serious	not serious	serious ^a	not serious	none			not estimable		⊕○○○	Very low
Quality of Life												
6	observational studies	not serious	not serious	serious ^a	not serious	none			not estimable		⊕○○○	Very low
Speech Discrimination												
4	observational studies	not serious	serious ^b	not serious	not serious	none			not estimable		⊕○○○	Very low
Speech Discrimination												
1	observational studies	not serious	not serious	not serious	not serious	none			not estimable		⊕⊕○○	Low
Developmental Delay												
1	observational studies	not serious	not serious	not serious	not serious	none			not estimable		⊕⊕○○	Low
Lack of Ear Canal Debris												
1	observational studies	not serious	not serious	not serious	not serious	none	17/32 (53.1 %)	27/32 (84.4 %)	not estimable		⊕⊕○○	Low
Lack of Bacterial Growth												
1	observational studies	not serious	not serious	not serious	not serious	none	17/32 (53.1 %)	29/32 (90.6 %)	not estimable		⊕⊕○○	Low

CI: confidence interval

Explanations

- a. Majority of the interventions were aimed for profound hearing loss.
- b. Heterogeneity in the specific conditions and device measures.

Question: Should pure tone audiometry be used to screen for hearing loss in apparently healthy children?

Sensitivity	0.50 to 1.00	Prevalence	7.1
Specificity	0.50 to 0.99		

Outcome	No of studies (No of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested	Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias		
True positives (patients with hearing loss)	8 studies 13428 patients	cross-sectional (cohort type accuracy study)	serious ^a	not serious	serious ^b	serious ^c	none	36 to 71	 Very low
False negatives (patients incorrectly classified as not having hearing loss)								0 to 35	
True negatives (patients without hearing loss)	8 studies 13428 patients	cross-sectional (cohort type accuracy study)	serious ^a	not serious	serious ^b	serious ^c	none	465 to 920	 Very low
False positives (patients incorrectly classified as having hearing loss)								9 to 464	

Explanations

- a. Most of the studies did not report methods for blinding, independent administration of the screening or reference standard or had adequate participant representation.
- b. No standardized method of screening and/or protocol is used across the studies.
- c. Wide range of confidence interval for the Positive and Negative Likelihood ratios.

Appendix 2. Forest Plots

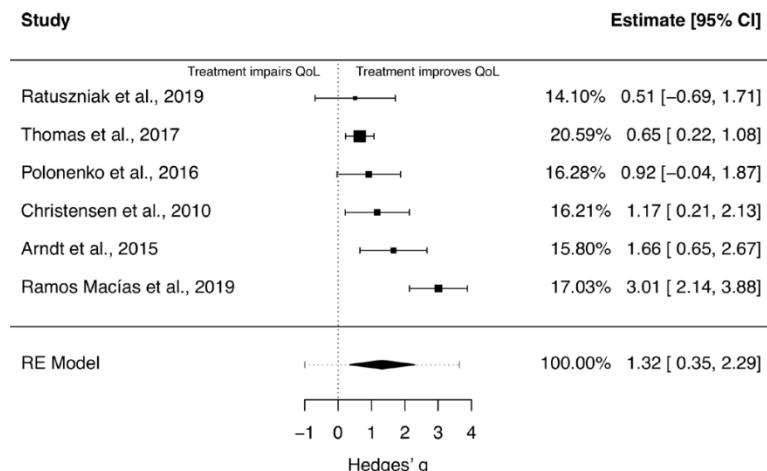


Figure 1. Forest plot of random-effects meta-analysis of before and after comparison studies. QoL, quality of life. RE, random-effects.

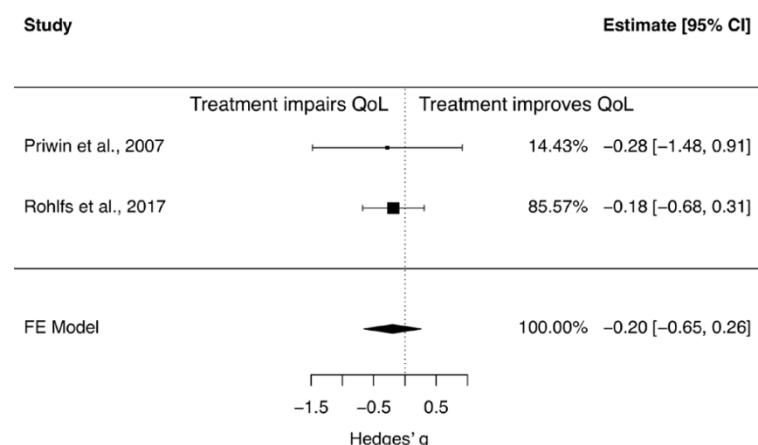


Figure 2. Forest plot of fixed-effect meta-analysis of before and after comparison studies. QoL, quality of life. RE, random-effects.

TFT, Pneumatic Otoscopy, Screening Audiometry for Children

Appendix 1. Characteristics of Included Studies

No.	Clinical Trial ID/Title	Study Design	Population	Intervention/Comparator	Intervention Group(s)
1	Kelly et al, 2018 Diagnostic Accuracy of Tuning Fork Tests For Hearing Loss: A Systematic Review	Systematic Review	n=3,158 17 studies included = combined adult and pediatric population 4=pediatric (Behn, Haapaniemi, Wilson,Capper) 6=adult 2=pediatric and adult 5=not specified	Standard Audiometry	Tuning Fork Tests
2	Behn et al, 2007 (part of systematic review by Kelly) Accuracy of Weber and Rinne Tuning Fork Tests in Evaluation of Children with Otitis Media with Effusion		Children with OME N=58	Standard Audiometry	Weber and Rinne Tuning Fork Tests
3	Haapaniemi et al, 1996 (part of systematic review by Kelly) C-1 tuning Fork Tests in school-aged Children		School-aged children N=687	Standard Audiometry	C-1 Tuning Fork Test
4	Wilson et al, 1975 (part of systematic review by Kelly) Accuracy of the Bing and Rinne Tuning Fork Tests		Pediatric N=50	Standard Audiometry	Bing and Rinne Tuning Fork Tests
5	Capper et al, 1987 (part of systematic review by Kelly) Tuning Fork Tests in Children (An evaluation of their usefulness)		Pediatric N=125		Tuning Fork Tests
6	Aasham et al, 2004 Cost-effectiveness of Audiometric Screening of first-year preparatory pupils in Dhofar region, Oman	Cross-sectional analytical	First year preparatory pupils from selected schools	No screening	Audiometric screening
7	Canadian Task Force on Preventive Health Care, 1989	CPG	Preschool children and adolescents	NA	NA
8	American Academy of Audiology Clinical Practice Guidelines: Childhood Hearing Screening	CPG	Early childhood and school-based population	NA	NA

	2011				
9	Task Force Guideline of Brazilian Society of Otology-Hearing loss in children-Part I Evaluation	Task Force Guideline	Children and Adolescents 0-18 years old	NA	NA

Appendix 2. Cost-effectiveness Studies

Author	Year	Country	Population	Intervention	Control	Cost-effective? (Y/N)
Aasham et al.	2004	Oman	First year preparatory pupils in selected schools A total of 1894 children were tested over 3 school years (37% of the study population)	Micro-audiometer screening for hearing loss	No screening	NO. None of the study participants were found to have sensorineural hearing loss. Only 14 children (0.74%) with suspected hearing impairment were referred to a specialist. The physicians and nurses spent 8-10 minutes per ear examination per child, with a less than 1% yield. The screening expenditure was 5 USD per student. Based on the screening results, the authors concluded that expanding the audiometric screening of school children to first-year preparatory pupils was not cost-effective.

Appendix 3. Recommendations from Other Groups

Guideline	Population	Recommendations
Canadian Task Force on Preventive Health Care (CMAJ, 1998)	Preschool children and adolescents	There is Insufficient evidence to recommend the inclusion or exclusion of screening for hearing impairment among preschool children
American Academy of Audiology Clinical Practice Guidelines: Childhood Hearing Screening (2011)	Early childhood and school-based population	<p>The American Academy of Audiology endorses detection of hearing loss in early childhood and school-aged populations using evidence-based hearing screening methods</p> <p>Screen populations age 3 (chronologically and developmentally) and older using pure tone screening..</p> <p>Otoacoustic Emissions (OAE) should be used only for preschool and school age children for whom pure tone screening is not developmentally appropriate (ability levels <3 years)</p> <p>Tympanometry should be used as a second-stage screening method following failure of pure tone or otoacoustic emissions screening.</p> <p>No recommendations were given as to the use of tuning fork tests, screening audiometry and pneumatic otoscopy for hearing loss detection in this population.</p>
Task force Guideline of Brazilian Society of Otology - hearing loss in children - Part I - Evaluation (2022)	0-18 years	Regardless of Universal Newborn screening outcomes, all infants and children should be routinely monitored for hearing, cognitive, and oral language development, as well as for achievement of educational milestones (Strong recommendation - High- quality evidence).

Appendix 4. GRADE Evidence Profile

Question: Should Rinne Test (256Hz) be used to screen hearing loss in healthy school children?

Sensitivity	0.76 to 0.82		Prevalences	0%	
Specificity	0.66 to 0.98				

Outcome	Nº of studies (Nº of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested	Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias		
True positives (patients with hearing loss)	2 studies 0 patients	cohort & case-control type studies	serious ^a	not serious	not serious	serious ^b	none	0 to 0	 Low
								0 to 0	
False negatives (patients incorrectly classified as not having hearing loss)	2 studies 0 patients	cohort & case-control type studies	serious ^a	not serious	not serious	serious ^b	none	660 to 980	 Low
								20 to 340	

Explanations

- a. Inadequate reporting of patient selection process.
- b. Non reporting of confidence intervals.

Question: Should Rinne Test (512Hz) be used to screen hearing loss in healthy school children?

Sensitivity	0.64 to 0.87	Prevalences 0%	
Specificity	0.55 to 0.85		

Outcome	No of studies (№ of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested	Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias		
True positives (patients with hearing loss)	2 studies 745 patients	cohort & case-control type studies	serious ^a	not serious	not serious	serious ^b	none	0 to 0	 Low
False negatives (patients incorrectly classified as not having hearing loss)								0 to 0	
True negatives (patients without hearing loss)	2 studies 745 patients	cohort & case-control type studies	serious ^a	not serious	not serious	serious ^b	none	550 to 850	 Low
False positives (patients incorrectly classified as having hearing loss)								150 to 450	

Explanations

- a. Inadequate reporting of patient selection process.
- b. Non reporting of confidence intervals.

Question: Should Webber Test (256Hz) be used to screen hearing loss in healthy school children?

Sensitivity	0.18	
Specificity	0.97	

Prevalences	0%	
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Outcome	Nº of studies (Nº of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested	Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias		
True positives (patients with hearing loss)	1 studies 687 patients	cohort & case-control type studies	serious ^a	not serious	not serious	serious ^b	none	0 (0 to 0)	 Low
								0 (0 to 0)	
False negatives (patients incorrectly classified as not having hearing loss)	1 studies 687 patients	cohort & case-control type studies	serious ^a	not serious	not serious	serious ^b	none	970 (0 to 0)	 Low
								30 (1000 to 1000)	
True negatives (patients without hearing loss)									
False positives (patients incorrectly classified as having hearing loss)									

Explanations

- a. Inadequate reporting of patient selection process.
- b. Non reporting of confidence intervals.

Question: Should Webber Test (512Hz) be used to screen hearing loss in healthy school children?

Sensitivity	0.65	
Specificity	0.75	

Prevalences	0%	
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Outcome	Nº of studies (Nº of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested	Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias		
True positives (patients with hearing loss)	1 studies 125 patients	cohort & case-control type studies	serious ^a	not serious	not serious	serious ^b	none	0 (0 to 0)	 Low
								0 (0 to 0)	
False negatives (patients incorrectly classified as not having hearing loss)	1 studies 125 patients	cohort & case-control type studies	serious ^a	not serious	not serious	serious ^b	none	970 (0 to 0)	 Low
								30 (1000 to 1000)	
True negatives (patients without hearing loss)									
False positives (patients incorrectly classified as having hearing loss)									

Explanations

- a. Inadequate reporting of patient selection process.
- b. Non reporting of confidence intervals.

Question: Should Pneumatic Otoscopy be used to screen hearing loss in healthy school children?

Sensitivity	0.80 (95% CI: -- to --)	Prevalences 0%	
Specificity	0.92 (95% CI: -- to --)		

Outcome	Nº of studies (Nº of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested	Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias		
True positives (patients with hearing loss)	1 studies 37 patients	cohort & case-control type studies	not serious	serious ^a	not serious	serious ^b	none	0 (0 to 0)	 Low
								0 (0 to 0)	
False negatives (patients incorrectly classified as not having hearing loss)	1 studies 37 patients	cohort & case-control type studies	not serious	serious ^a	not serious	serious ^b	none	920 (0 to 0)	 Low
								80 (1000 to 1000)	
True negatives (patients without hearing loss)	1 studies 37 patients	cohort & case-control type studies	not serious	serious ^a	not serious	serious ^b	none	920 (0 to 0)	 Low
								80 (1000 to 1000)	

Explanations

- a. Population did not focus on the pediatric age.
- b. Non-reporting of confidence interval.

Question: Should screening audiometry be used to screen for hearing loss in healthy children?

Sensitivity	0.85 (95% CI: 0.69 to 1.00)	Prevalences 0%	
Specificity	0.96 (95% CI: 0.89 to 1.00)		

Outcome	No of studies (No of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested	Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias		
True positives (patients with hearing loss)	5 studies 1721 patients	cohort & case-control type studies	not serious	not serious	not serious	not serious	none	0 (0 to 0)	 High
False negatives (patients incorrectly classified as not having hearing loss)								0 (0 to 0)	
True negatives (patients without hearing loss)	5 studies 1721 patients	cohort & case-control type studies	not serious	not serious	not serious	not serious	none	960 (890 to 1000)	 High
False positives (patients incorrectly classified as having hearing loss)								40 (0 to 110)	

Hearing Screening for Adults

Appendix 1. Characteristics of Included Studies

Table 1. Study characteristics

Title/Author	Study design	Location	Number of patient(s)	Population	Intervention Group(s)	Control	Outcomes
USPSTF 2021	CPG	United States of America	NA	general population	NA	NA	Improved health outcomes Accuracy of screening test Efficacy of interventions Harms of screening
Yueh 2010 (SAI-WHAT Trial) (basis of USPSTF 2021 CPG)	RCT	United States of America	n = 2314	Outpatients (veterans) seeking general medical care, aged >50 years and were eligible to receive audiology services	-Otoscope only - Questionnaire only -Dual screening	No screening	Percentage of Positive Screens Audiology Visit frequency One-year hearing aid use Effect on Quality of Life

Appendix 2: Quality Assessment of Studies

Table 2. Quality assessment of retrieved CPGs using AGREE-II tool

	WHO 2021	USPSTF 2021	NICE 2018
Domain 1. Scope and Purpose (3 items)	77.8	91.7	83.3
Reviewer 1	17	19	19
Reviewer 2	17	20	17
Domain 2. Stakeholder Involvement (3 items)	66.7	100.0	72.2
Reviewer 1	15	21	11
Reviewer 2	15	21	21
Domain 3: Rigour of Development (8 items)	43.8	93.8	21.9
Reviewer 1	32	50	11
Reviewer 2	26	56	26
Domain 4. Clarity of Presentation (3 items)	77.8	100.0	72.2
Reviewer 1	13	21	13
Reviewer 2	21	21	19
Domain 5. Applicability (4 items)	68.8	83.3	50.0
Reviewer 1	20	26	28
Reviewer 2	21	22	4
Domain 6. Editorial Independence (2 items)	66.7	100.0	58.3
Reviewer 1	10	14	4
Reviewer 2	10	14	14
OVERALL GUIDELINE ASSESSMENT	66.7	100.0	41.7
Reviewer 1	5	7	2
Reviewer 2	5	7	5

Table 3. Quality assessment of RCT in USPSTF 2021, adapted from Chou 2011

Appendix Table 4. Quality Ratings for Trials of Screening and Treatment													
Study, Year (Reference)	Randomization	Allocation Concealed	Groups Similar at Baseline	Eligibility Criteria Specified	Blinding			Intention-to-Treat Analysis	Reporting of Attrition and Contamination	Differential or Overall High Loss to Follow-up or Incomplete Follow-up	Funding Source	External Validity	Quality Rating
Screening													
Yueh et al, 2010 (17)	Described as randomized, method not reported	Yes	Yes	Yes	Not applicable	Not applicable	Cannot tell	Yes	Yes	High overall loss to follow-up	Veterans Health Administration	Mean age, 61 y (SD, 9) 94% male 75% white Mean hearing loss: NR	Fair

Appendix 3. GRADE Evidence Profile

Hearing loss screening compared to no screening in apparently healthy adult population											
Certainty assessment							Summary of findings				
Participants (studies) Follow-up	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence	Study event rates (%)		Relative effect (95% CI)	Anticipated absolute effects	
							With no screening	With hearing loss screening		Risk with no screening	Risk difference with hearing loss screening
Hearing Aid Use											
2314 (1 RCT)	serious ^a	not serious	serious ^b	serious ^c	none	⊕○○○ Very low	Dual screening group revealed a computed RR of 0.44 (95% CI, 0.27 to 0.71) indicating clear benefit of dual screening over no screening. AudioScope screening alone was also shown to provide clear benefit with computed RR of 0.52 (95% CI, 0.31 to 0.85) compared to control. However, analysis of the questionnaire screening using HHIE-S resulted in an RR of 0.79 (95% CI, 0.45 to 1.39) which indicated no benefit.				

CI: confidence interval

Explanations

- a. Fair quality rating (from Chou 2011) due to high loss to follow-up and unclear blinding status of outcome assessors
- b. Only older veteran patients (>50yrs old) were included in the study compared to the clinical question which intends to include the adult general population above 18yrs old.
- c. The CI of one screening test (questionnaire) straddled the line of no benefit

Vestibular Testing for Children and Adults

Appendix 1. Characteristics of Included Studies

No.	Clinical Trial ID/Title	Study design	Population	Intervention/Comparator	Outcomes
1	Cohen 2012 Tests of walking balance for screening vestibular disorders	Case-Control	Case: n=66 N=21 – BPPV N=27 – unilateral vestibular impairment N=18 – postoperative acoustic neuroma patients Control: n=127 adults without histories of neurologic, orthopedic, visual, or otologic disorders Inclusions: Ambulatory without assistive device, no joint replacement or orthopedic limitations, and no pain while walking.	Index test: Tandem walk, 10 steps – eyes open (EO) and eyes closed (EC). Reference standard: unspecified	Sensitivity and Specificity
2	Cohen 2014 Utility of Stepping, Walking and Head Impulses for Screening Patients for Vestibular Impairments	Case-Control	Case: n=60 Vestibular impairments Control: n=60 Healthy adults The asymptomatic controls, including 33 females and 27 males, were screened with a health history and Dix-Hallpike maneuvers, and were given bi-thermal caloric tests, on which they all had normal range responses, i.e., unilateral weakness of < 20%.	Index test: Tandem walking, 10 steps - eyes open (EO) and eyes closed (EC). Reference standard: unspecified	Sensitivity and Specificity
3	Cohen 2014 Standing balance tests for screening people with vestibular impairments	Case-Control	Case: n=90 n=18 acoustic neuroma n=21 BPPV n=51 peripheral unilateral weakness Case patients were diagnosed by board-certified physicians, mostly otolaryngologists and neurologists. BPPV patients were diagnosed based on a positive response to the	Index test: Romberg's test, 30 seconds – eyes open (EO) and eyes close (EC) Reference standard: unspecified	Sensitivity and Specificity

			Dix-Hallpike maneuver and any other clinical and laboratory tests used by the physician. UW patients all had at least a 20% weakness on bithermal caloric testing. Control: n=156 Healthy adults who have negative head impulse tests, observation of gait, and Dix-Hallpike maneuvers. All subjects were independently ambulatory, had no joint replacements or history of neurologic disease, and had functional vision with their corrective lenses.		
4	Cohen 2017 Tandem walking as a quick screening test for vestibular disorders	Case-Control	Case: n=90 N=33 peripheral unilateral weakness N=28 BPPV N=8 unilateral weakness and BPPV N=7 Meniere's disease N=14 others Adult patient who had a variety of vestibular impairments. No significant musculoskeletal impairments or other neurologic disorders. Control: n=292 Adult healthy control subjects with no otologic, neurologic or significant musculoskeletal impairments	Index test: Tandem Walking, 10 steps – eyes close (EC) Reference standard: unspecified	Sensitivity and Specificity
5	Cohen 2019 Screening for vestibular disorders using the modified Clinical Test of Sensory Interaction and Balance and Tandem Walking with eyes closed	Case-Control	Case: n=90 n=33 unilateral vestibular weakness n=28 BPPV n=8 dual diagnosis n=7 Meniere's disease n=14 Others Control: n=292 Healthy adults free from known neurologic and significant musculoskeletal impairments. Able to walk unassisted.	Index test: Romberg's test, 30 seconds – eyes closed (EC). Tandem walking, 10 steps – eyes closed (EC). Reference standard: unspecified	Sensitivity and Specificity

6	Gökler 2018 Evaluation of Benign Paroxysmal Positional Vertigo in American Football Players	Case-Control	Case: n=16 BPPV athletes who are positive with BPPV. Control:n=96 Adult healthy athletes and non-athletes	Index test: Romberg's test, unspecified Tandem walking, unspecified Reference standard: Dix-hall pike	Sensitivity and Specificity
7	Longridge 2010 Clinical Romberg Testing Does Not Detect Vestibular Disease	Case-Control	Case: n=52 vestibular patients. Vestibular patients sequentially enrolled. Patients in the study were initial referrals to our clinic and therefore had not yet been fully evaluated by a specialist or undergone standard neuro-otologic investigations such as caloric testing, posturography, etc. Control: n=44 patients seen for other otologic conditions other than a vestibular problem. None of them had any history of dizziness or vestibular disease.	Index test: Modified Romberg's test, tandem modification, 20 seconds – eyes open (EO) and eyes closed (EC) Tandem walking, 5 steps – eyes open (EO) and eyes closed (EC). Reference standard: unspecified	Sensitivity and Specificity
8	Salah 2020 Clinical Balance Testing to Screen for Patients With Vestibular Disorders: A Retrospective Case-control Study	Case-Control	Case: n=331 Subjects from hospital who have chronic complaints of dizziness and/or disequilibrium of at least 3 months due to a proven underlying vestibular disorder, e.g., unilateral vestibular hypofunction, bilateral vestibular hypofunction, vestibular schwannoma, central vestibular disorder, neurotrauma, and post cochlear implantation. Control: n= 318 Healthy adults Exclusion criteria used for the control group were: 1) actual complaints or a history of vertigo or dizziness; 2) neurologic, otologic, orthopedic, or other medical conditions impeding balance (e.g., diabetes mellitus, orthostatic hypotension); 3) nursing home residents; 4) dependence on the assistance	Index test: Modified Romberg's test , tandem modification, 30 seconds – eyes open (EO) and eyes closed (EC). Tandem walking, 20 steps – eyes open (EO). Reference standard: unspecified	Sensitivity and Specificity

			of another person or the assistance of a support device (e.g., cane, crutch, walker); 5) a fall within the last 6 months		
9	Zamysłowska-szmytko 2015 Bedside Examination for Vestibular Screening in Occupational Medicine	Case- Control	Case: n=43 vestibular group of 43 caloric-positive subjects Control: n=43 VNG-normal group of 43 patients All patients were referred to Audiology and Phoniary Clinic by audiologists because of subchronic or chronic vertigo, dizziness, unbalance.	Index test: Romberg's test, unspecified – eyes open (EO) and eyes close (EC) Reference standard: unspecified	Sensitivity and Specificity

Appendix 2. Risk of Bias

	Risk of Bias				Applicability Concerns		
	Patient Selection	Index Test	Reference Standard	Flow and Timing	Patient Selection	Index Test	Reference Standard
Cohen2012	-	-	?	-	?	+	+
Cohen2014_Feb	-	?	-	-	-	+	+
Cohen2014_July	-	?	?	-	-	+	+
Cohen2017	-	?	?	-	-	+	+
Cohen2019	-	?	?	-	-	+	+
Gokler2018	-	?	+	+	+	+	+
Longridge2010	-	?	-	-	-	+	+
salah2020	-	?	?	-	-	+	+
Zamyslowska2015	-	?	?	+	-	+	+

- High
 ? Unclear
 + Low

Appendix 3. Summary of Findings

Pooled analysis	Basis	Pooled estimate	95% Confidence Interval	Certainty of Evidence
Tandem Walking (eyes open)				
Sensitivity	4 studies (n=465)	0.17	0.05 to 0.44	Very low
Specificity	4 studies (n=519)	0.97	0.45 to 0.99	Very low
Tandem Walking (eyes closed)				
Sensitivity	3 studies (n=208)	0.69	0.62 to 0.75	Very low
Specificity	3 studies (n=397)	0.51	0.24 to 0.78	Very low
Romberg's Test				
Sensitivity	4 studies (n=442)	0.16	0.04 to 0.45	Very low
Specificity	4 studies (n=501)	0.99	0.16 to 1.0	Very low

Appendix 4. Grade Evidence Profile

Question: Should Should Tandem Walking (Eyes Open) be used to screen for Vestibular disorders in asymptomatic healthy children and adults?

Sensitivity	0.17 (95% CI: 0.05 to 0.44)	Prevalences	1.6%
Specificity	0.97 (95% CI: 0.45 to 0.99)		

Outcome	Nº of studies (Nº of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested	Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias		
True positives (patients with Vestibular disorders)	4 studies 465 patients	case-control type accuracy study	very serious ^a	serious ^b	serious ^c	serious ^d	none	3 (1 to 7)	000 Very low
False negatives (patients incorrectly classified as not having Vestibular disorders)								13 (9 to 15)	
True negatives (patients without Vestibular disorders)	4 studies 519 patients	case-control type accuracy study	very serious ^a	serious ^b	serious ^c	serious ^d	none	954 (443 to 974)	000 Very low
False positives (patients incorrectly classified as having Vestibular disorders)								30 (10 to 541)	

Explanations

a. Case-Control Design, Controls were not evaluated for vestibular disorders using the reference standard, some studies did not prespecify their diagnostic threshold.

b. data is not from RCT

c. one study cut off 20 sec; 3 studies cut off 5 seconds.

d. wide sensitivity and specificity range

Question: Should Tandem Walking (Eyes Close) be used to screen for Vestibular disorders in asymptomatic healthy children and adults?

Sensitivity	0.69 (95% CI: 0.62 to 0.75)	Prevalences	1.6%
Specificity	0.51 (95% CI: 0.24 to 0.78)		

Outcome	№ of studies (№ of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested	Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias		
True positives (patients with Vestibular disorders)	3 studies 208 patients	case-control type accuracy study	very serious ^a	serious ^b	not serious	not serious	none	11 (10 to 12)	Very low
False negatives (patients incorrectly classified as not having Vestibular disorders)								5 (4 to 6)	
True negatives (patients without Vestibular disorders)	3 studies 397 patients	case-control type accuracy study	very serious ^a	serious ^b	not serious	very serious ^c	none	502 (236 to 768)	Very low
False positives (patients incorrectly classified as having Vestibular disorders)								482 (216 to 748)	

Explanations

a. case-control study design, the reference standard was not applied to control patients, the diagnostic thresholds were not prespecified

b. data is not from RCT

c. wide range for specificity

Question: Should Romberg's Test be used to screen for Vestibular disorders in asymptomatic healthy children and adults?

Sensitivity	0.16 (95% CI: 0.04 to 0.45)	Prevalences	1.6%
Specificity	0.99 (95% CI: 0.16 to 1.00)		

Outcome	№ of studies (№ of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested	Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias		
True positives (patients with Vestibular disorders)	4 studies 442 patients	case-control type accuracy study	very serious ^a	serious ^b	serious ^c	serious ^d	none	3 (1 to 7)	Very low
False negatives (patients incorrectly classified as not having Vestibular disorders)								13 (9 to 15)	
True negatives (patients without Vestibular disorders)	4 studies 501 patients	case-control type accuracy study	very serious ^a	serious ^b	serious ^c	serious ^e	none	974 (157 to 984)	Very low
False positives (patients incorrectly classified as having Vestibular disorders)								10 (0 to 827)	

Explanations

a. case-control design, reference standard was not applied to the control group, unclear blinding

b. not an RCT study

c. different thresholds used 20-30 seconds. some studies did not specify

d. wide range of sensitivity

e. wide range of specificity

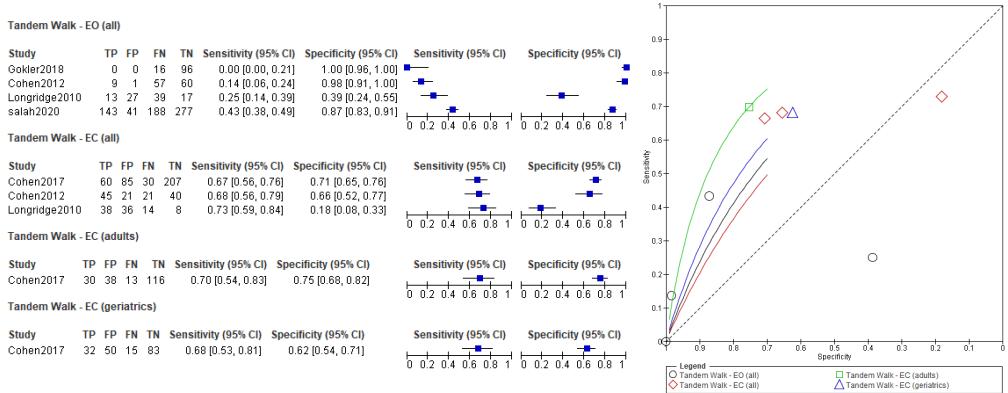


Figure 1. Diagnostic Performance of Tandem Walking with eyes open and eyes closed.

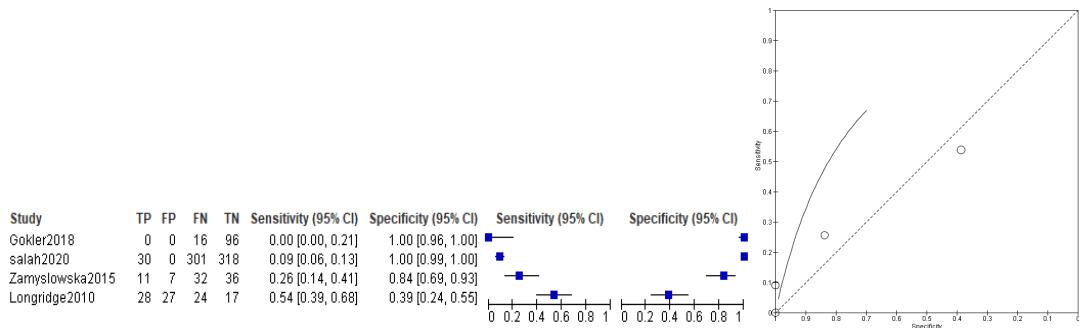


Figure 2. Diagnostic Performance of Romberg's Test with eyes open and eyes closed.

Table 1. Diagnostic Performance of Tandem Walking with eyes open and eyes closed using different cut-off steps (Cohen 2012)

Eyes open	Sensitivity	Specificity	Eyes Closed	Sensitivity	Specificity
			2 steps	0.23	0.92
3 steps	0.05	1.00	3 steps	0.45	0.82
5 steps	0.14	0.99	5 steps	0.68	0.66
7 steps	0.27	0.92	7 steps	0.83	0.41
8 steps	0.36	0.89	8 steps	0.86	0.38

Table 2. Diagnostic Performance of Modified Romberg's test – eyes closed on foam (Cohen 2014, Cohen 2019)

	Sensitivity (range)	Specificity (range)	Cut-point
21-59 yrs (n=401)	0.55 – 0.67	0.70 – 0.83	30 sec
60-79 (n=283)	0.72 – 0.83	0.58 – 0.62	8 sec
>80 yrs (n=36)	0.67	0.71	3 sec

Antenatal Hearing Screening

Appendix 1. Summary of Study Characteristics

Study ID/Author/Year	Setting	Index Test	Index Test Specimen	Population	Sample Size	Reference standard	Reference Standard Specimen
Fetal heart rate response to acoustic stimulation in relation to fetal development and hearing impairment Johansson, B., Wedenberg, E. and Westin, B. /1992	Non-randomized observational study	Fetal Heart Rate Acceleration	34 weeks AOG Fetus	High risk pregnant participants	31	Audiometric tests, play-audiometry	Index test specimen in their 3 years of age
Use of sound-elicited fetal heart rate accelerations to assess fetal hearing in the second and third trimester Hibiya-Motegi, Nakayama, Matsuoka, Takeda,	Non-randomized observational study	Fetal Heart Rate Acceleration	28 and 34-37 weeks AOG Fetus	Low risk pregnant participants	39	automated auditory brainstem response	Index test specimen at their birth

Appendix 2. GRADE Evidence Profile

Question: Should fetal heart monitoring be used to screen for prenatal/antenatal hearing in healthy pregnant women 21-24 weeks AOG?

Sensitivity	0.89	Prevalence	10%
Specificity	0.99		

Outcome	No of studies (Nº of patients)	Study design	Factors that may decrease certainty of evidence					Effect per 1,000 patients tested	Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias		
True positives (patients with [target condition])	1 studies 31 patients	cross-sectional (cohort type accuracy study)	not serious	serious ^{ab}	not serious	not serious	none	5 (0 to 0)	⊕○○ Very Low
								5 (10 to 10)	
False negatives (patients incorrectly classified as not having [target condition])								495 (0 to 0)	-
								495 (990 to 990)	
True negatives (patients without [target condition])	0 studies patients								
False positives (patients incorrectly classified as having [target condition])									

Explanations

a. Diagnostic-accuracy assessment arm of the study focuses on the high-risk population.

b. Diagnostic-accuracy assessment arm of the study focuses on the 37 weeks AOG.

SEARCH STRATEGY

Maternal History of Infection, Family History of Hearing Loss, Physical Examination

SEARCH STRATEGY and yield (April 19, 2023, 2023, 6:00 PM) per database

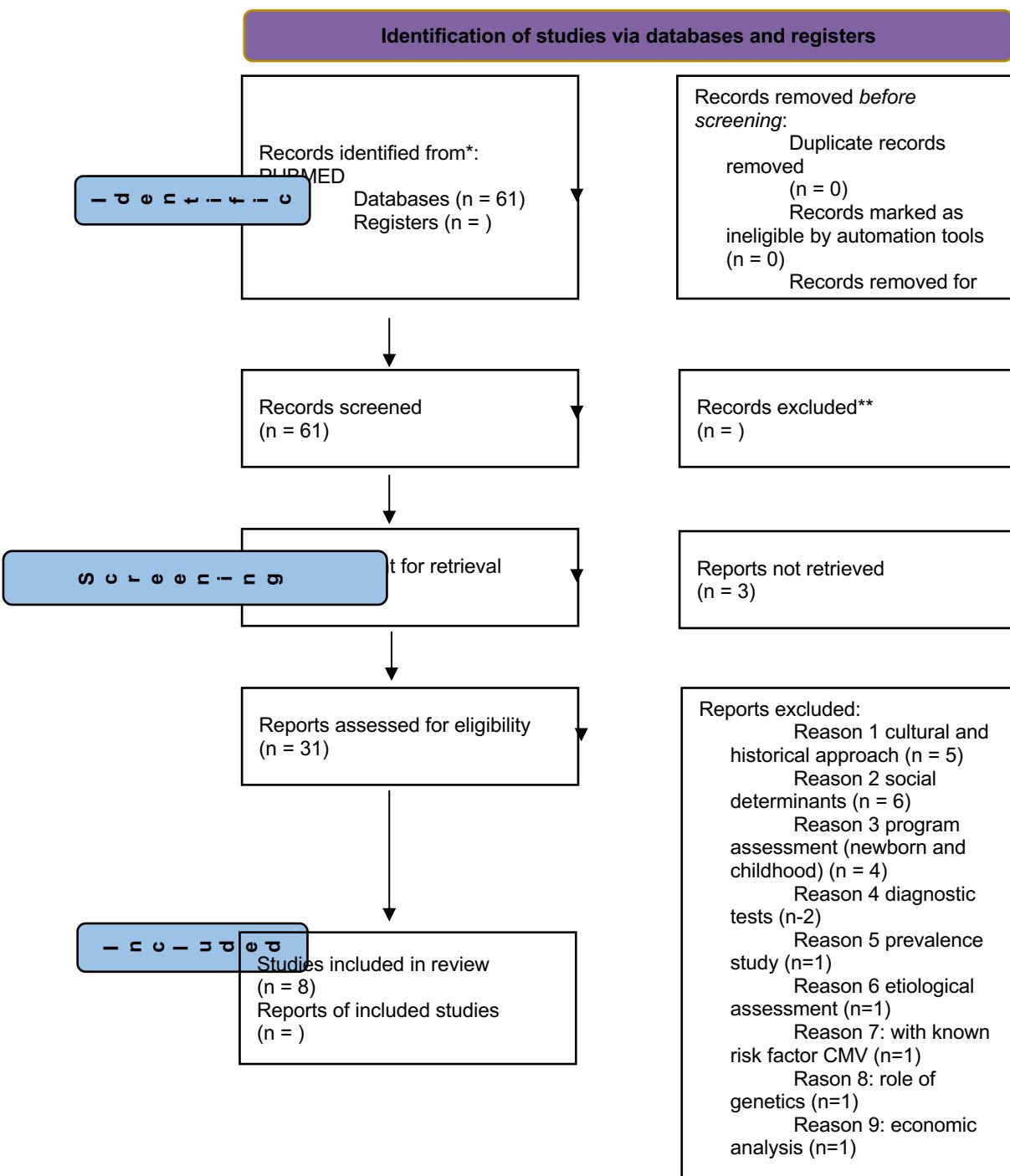
DATABASE	SEARCH STRATEGY / SEARCH TERMS	DATE AND TIME OF SEARCH	RESULTS	
			Yield	Eligible
Medline	("childhood"[All Fields] OR "childhoods"[All Fields]) AND ("hearing loss"[MeSH Terms] OR ("hearing"[All Fields] AND "loss"[All Fields]) OR "hearing loss"[All Fields]) AND ("risk factors"[MeSH Terms] OR ("risk"[All Fields] AND "factors"[All Fields]) OR "risk factors"[All Fields]))	April 19, 2023 6:00 PM	343	2
	("childhood"[All Fields] OR "childhoods"[All Fields]) AND ("hearing loss"[MeSH Terms] OR ("hearing"[All Fields] AND "loss"[All Fields]) OR "hearing loss"[All Fields]) AND (("medical history taking"[MeSH Terms] OR ("medical"[All Fields] AND "history"[All Fields] AND "taking"[All Fields]) OR "medical history taking"[All Fields] OR ("family"[All Fields] AND "history"[All Fields]) OR "family history of"[All Fields]) AND ("hearing loss"[MeSH Terms] OR ("hearing"[All Fields] AND "loss"[All Fields]) OR "hearing loss"[All Fields]))	April 19, 2023	124	0
	("childhood"[All Fields] OR "childhoods"[All Fields]) AND ("hearing loss"[MeSH Terms] OR ("hearing"[All Fields] AND "loss"[All Fields]) OR "hearing loss"[All Fields]) AND (("maternally"[All Fields] OR "maternities"[All Fields] OR "maternity"[All Fields] OR "mothers"[MeSH Terms] OR "mothers"[All Fields] OR "maternal"[All Fields]) AND ("infect"[All Fields] OR "infectability"[All Fields] OR "infectable"[All Fields] OR "infectant"[All Fields] OR "infectants"[All Fields] OR "infected"[All Fields] OR "infecteds"[All Fields] OR "infectibility"[All Fields] OR "infectible"[All Fields] OR "infecting"[All Fields] OR "infection s"[All Fields] OR "infections"[MeSH Terms] OR "infections"[All Fields] OR "infection"[All Fields] OR "infective"[All Fields] OR "infectiveness"[All Fields] OR "infectives"[All Fields] OR "infectivities"[All Fields] OR "infects"[All Fields] OR "pathogenicity"[MeSH Subheading] OR "pathogenicity"[All Fields] OR "infectivity"[All Fields]))	6:00 PM	46	1
	("childhood"[All Fields] OR "childhoods"[All Fields]) AND ("hearing loss"[MeSH Terms] OR ("hearing"[All Fields] AND "loss"[All Fields]) OR "hearing loss"[All Fields]) AND ("physical examination"[MeSH Terms] OR ("physical"[All Fields] AND "examination"[All Fields]) OR "physical examination"[All Fields]))	April 19, 2023	143	0
National Institute for Health and Care Excellence	Hearing screening	March 24, 2023 6:00 PM	0	0
US Preventive Services Task Force	Hearing screening, neonate Hearing screening, pediatric	March 24, 2023 6:00 PM	3	0
Canadian Task Force on Preventive Health Care	Hearing screening, neonate Hearing screening, Pediatric	March 24, 2023 6:00 PM	0	0
Cochrane Library	Hearing screening, Neonate Hearing screening, Pediatric	March 24, 2023 6:00 PM	3 2	0
Google Scholar	Pediatric hearing screening guidelines	March 24, 2023 6:00 PM	38	0

Otoacoustic Emissions, Automated Auditory Brainstem Response, Auditory Steady State Response Tests

SEARCH STRATEGY and yield (January 2023) per database

DATABASE	SEARCH STRATEGY / SEARCH TERMS	DATE AND TIME OF SEARCH	RESULTS	
			Yield	Eligible
Medline	Search: (((hearing screening[Title/Abstract] AND (y_5[Filter])) OR (otoacoustic emissions AND (y_5[Filter]))) OR (automated auditory brainstem response AND (y_5[Filter]))) OR (auditory steady state response AND (y_5[Filter])) AND ((y_5[Filter])) AND (review[Filter] OR systematicreview[Filter]))) AND (((newborn AND (y_5[Filter])) OR (childhood AND (y_5[Filter]))) OR (0-18 years old[Title/Abstract] AND (y_5[Filter])) AND (y_5[Filter]))) Filters: in the last 5 years Sort by: Most Recent	January 2, 2023	61	
National Institute for Health and Care Excellence	Hearing screening	January 2, 2023	0	0
US Preventive Services Task Force	Hearing screening, neonate Hearing screening, pediatric	January 2, 2023	3	0
Canadian Task Force on Preventive Health Care	Hearing screening, neonate Hearing screening. pediatric	January 2, 2023	0	0
Cochrane library	Hearing screening. Neonate Hearing screening. pediatric	January 2, 2023	3 2	0 0
Google Scholar	Pediatric hearing screening guidelines	January 11, 2023	38	

PRISMA Flow Diagram



Behavioral Observation Audiometry, Genetic Testing, and Tympanometry

Search strategy and yield as of 10 February 2023

Guideline search

United States Preventive Services Task Force

#	Query	Yield
1	Hearing (no filter)	131

Canadian Task Force on Preventive Health Care

#	Query	Yield
1	Hearing (all guidelines)	10

National Institute for Health and Care Excellence

#	Query	Yield
1	Hearing	182
2	Hearing AND Screening	39

American Academy of Audiology

#	Query	Yield
1	All guidelines under Infant and Young Child Identification and Assessment and Pediatric Diagnostics	5
1	All guidelines under Pediatric Diagnostics	7

Philippine Society of Otolaryngology-Head and Neck Surgery

#	Query	Yield
1	All clinical practice guidelines	2

Database search

Cochrane

#	Query	Yield
1	Hearing loss	84

PUBMED

#	Query	Yield
1	((("guideline"[Publication Type] OR "practice guideline"[Publication Type] OR "recommendation*[Title] OR "standard*[Title] OR "standard*[Title] OR "guideline*[Title]) AND ("hearing tests"[MeSH Terms] OR ("hearing"[All Fields] AND "tests"[All Fields]) OR "hearing tests"[All Fields] OR ("hearing"[All Fields] AND "test"[All Fields]) OR "hearing test"[All Fields]) AND ("hearing"[MeSH Terms] OR "hearing"[All Fields] OR "hearings"[All Fields])) AND ((y_10[Filter] AND (fft[Filter]) AND (humans[Filter]) AND (english[Filter]) AND (allinfant[Filter] OR infant[Filter] OR preschoolchild[Filter] OR child[Filter] OR adolescent[Filter])))	62

HERDINPLUS

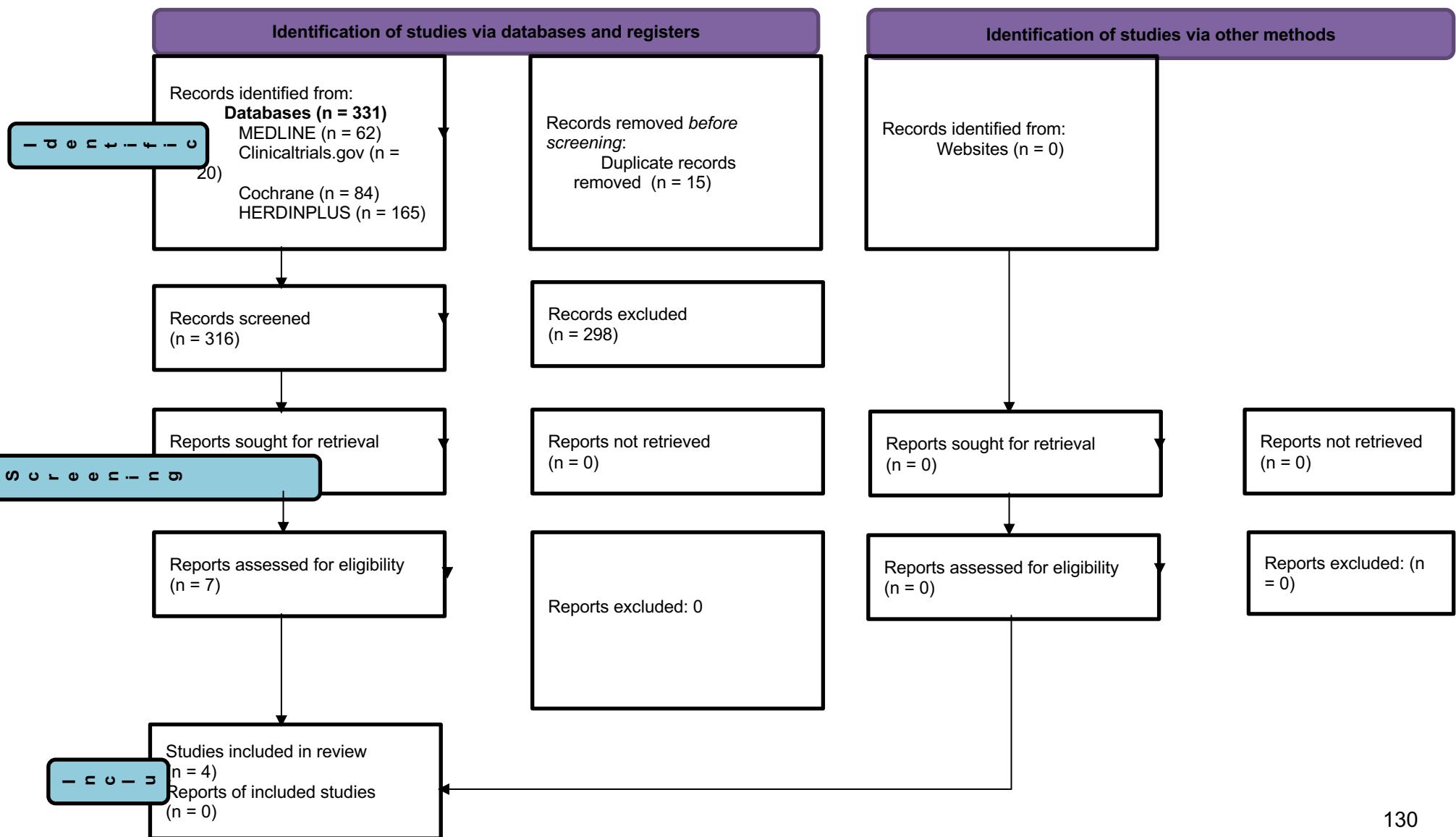
#	Query	Yield
1	Hearing	165

Clinicaltrials.gov

#	Query	Yield
1	Condition or disease: hearing loss Other Terms: screening, available, completed, child	20

PRISMA Flow Diagram

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71



Pure Tone Audiometry

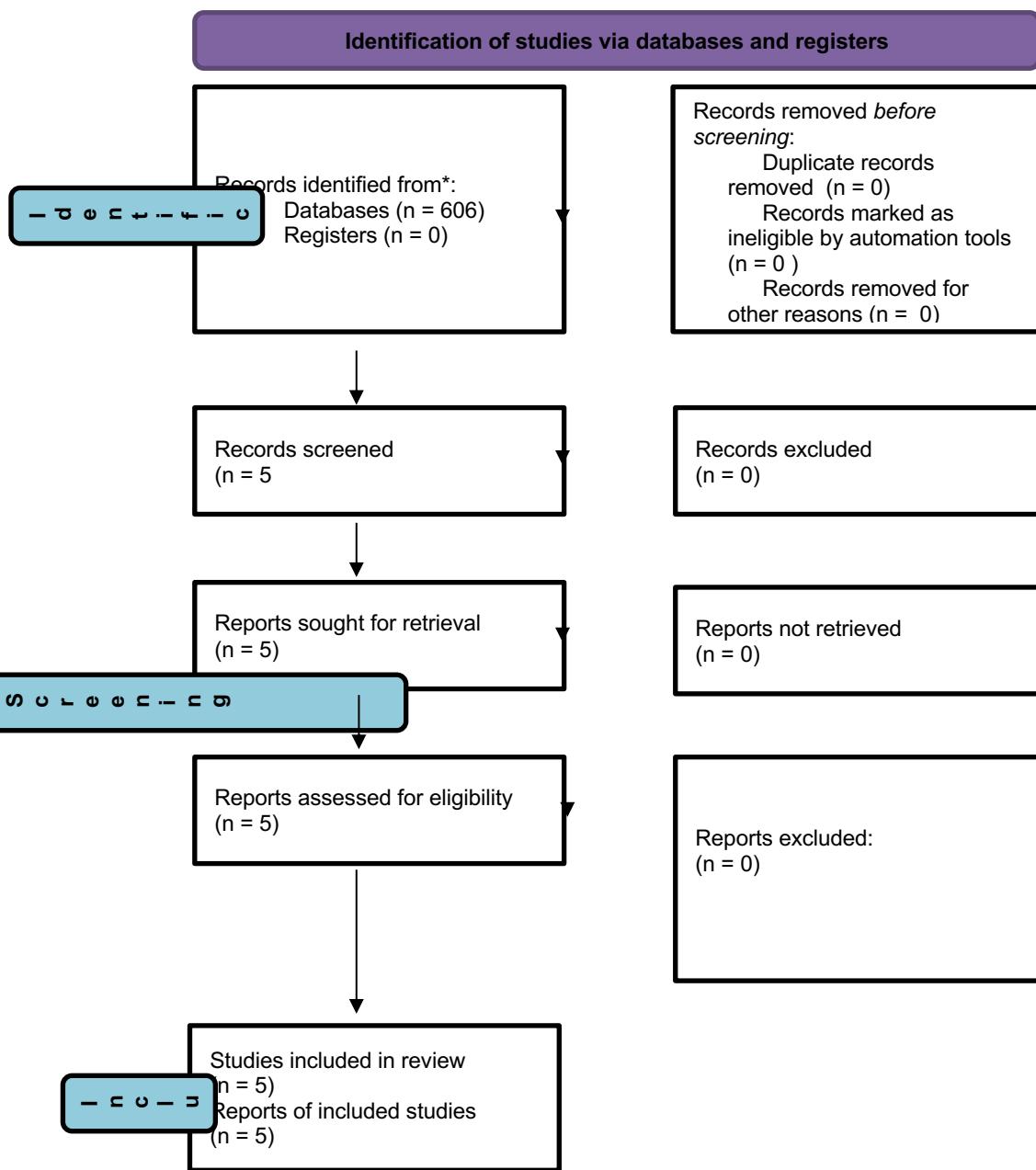
Search strategy and yield as of 10 March 2023

DATABASE	#	SEARCH STRATEGY / SEARCH TERMS	DATE OF SEARCH	RESULTS	
				Yield	Eligible
USPSTF	1	Hearing	01 March 2023	128	0
Canadian Task Force on Preventive Health	1	all published guidelines	01 March 2023	22	
	2	All archived guidelines		1	
	3	#1 and #2		23	0
National Institute for Health and Care Excellence	1	Hearing	01 March 2023	185	
	2	Hearing AND Screening		38	0
American Academy of Audiology	1	All guidelines under Infant and Young Child Identification and Assessment and Pediatric Diagnostics	01 March 2023	4	0
Philippine Society of Otolaryngology-Head and Neck Surgery	1	All CPGs	01 March 2023	2	0
Cochrane	1	all topics under " Ear, nose & throat" category	01 March 2023	202	
	2	all topics under " Ear, nose & throat" + "ear" category		85	0
PUBMED	1	(PUBMED: Search using (guideline [Publication Type] OR practice guideline [Publication Type] or recommendation*[Title] OR standard* [Title] OR standard* [Title] OR guideline* [Title]) AND hearing test) AND (hearing)	09 March 2023	2	
	2	Hearing AND screening		47,002	
	3	#2 AND children		16,841	
	4	#3 AND accuracy		394	
	5	#4 AND review		54	
	6	#1 + #5		56	2
	7	#3 AND audiometry Filters: Year 2014 - 2023		890	

	8	#7 AND accuracy Filters: Year 2014 - 2023		43	0
	9	Hearing Loss AND children AND treatment		15,538	
	10	#9 AND systematic		874	
	11	#9 AND meta analysis		148	1
HERDIN	1	Hearing AND screening	10 March 2023	65	0
Clinicaltrials.gov		Condition or Disease: Hearing Loss Other Terms: screening Age Group: Child (birth – 17)	10 March 2023	14	0

PRISMA Flow Diagram

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71



Tuning Fork Tests, Pneumatic Otoscopy, Phone-based screening Audiometry

Table 3. Pubmed Search Strategy

DATABASE	SEARCH STRATEGY / SEARCH TERMS	DATE AND TIME OF SEARCH	RESULTS	
			Yield	Eligible
Medline	Hearing screening (("hearing"[MeSH Terms] OR "hearing"[All Fields] OR "hearings"[All Fields]) AND ("diagnosis"[MeSH Subheading] OR "diagnosis"[All Fields] OR "screening"[All Fields] OR "mass screening"[MeSH Terms] OR ("mass"[All Fields] AND "screening"[All Fields]) OR "mass screening"[All Fields] OR "early detection of cancer"[MeSH Terms] OR ("early"[All Fields] AND "detection"[All Fields] AND "cancer"[All Fields]) OR "early detection of cancer"[All Fields] OR "screen"[All Fields] OR "screenings"[All Fields] OR "screened"[All Fields] OR "screens"[All Fields])) AND ((meta-analysis[Filter] OR randomizedcontrolledtrial[Filter] OR review[Filter] OR systematicreview[Filter]) AND (fft[Filter])))	4/14/2023 1203 am	4091	0
	Tuning Fork Tests (("tuned"[All Fields] OR "tunes"[All Fields] OR "tuning"[All Fields] OR "tunings"[All Fields]) AND "fork"[All Fields] AND ("test s"[All Fields] OR "tested"[All Fields] OR "testing"[All Fields] OR "testings"[All Fields] OR "tests"[All Fields])) AND ((meta-analysis[Filter] OR randomizedcontrolledtrial[Filter] OR review[Filter] OR systematicreview[Filter]) AND (fft[Filter])))	4/14/2023 1236 am	26	
	Weber Tuning Fork Test (("weber"[All Fields] OR "webers"[All Fields]) AND ("tuned"[All Fields] OR "tunes"[All Fields] OR "tuning"[All Fields] OR "tunings"[All Fields]) AND "fork"[All Fields] AND ("research design"[MeSH Terms] OR ("research"[All Fields] AND "design"[All Fields]) OR "research design"[All Fields] OR "test"[All Fields])) AND ((meta-analysis[Filter] OR randomizedcontrolledtrial[Filter] OR review[Filter] OR systematic review[Filter]) AND (fft[Filter])))	4/14/2023 1235 am	4	
	Rinne Tuning Fork Test (("rinne"[All Fields] OR "rinne s"[All Fields]) AND ("tuned"[All Fields] OR "tunes"[All Fields] OR "tuning"[All Fields] OR "tunings"[All Fields]) AND "fork"[All Fields] AND ("research design"[MeSH Terms] OR ("research"[All Fields] AND "design"[All Fields]) OR "research design"[All Fields] OR "test"[All Fields])) AND ((meta-analysis[Filter] OR randomizedcontrolledtrial[Filter] OR review[Filter] OR systematicreview[Filter]) AND (fft[Filter])))	4/14/2023 1230 am	4	

	("hearing"[MeSH Terms] OR "hearing"[All Fields] OR "hearings"[All Fields]) AND ("diagnosis"[MeSH Subheading] OR "diagnosis"[All Fields] OR "screening"[All Fields] OR "mass screening"[MeSH Terms] OR ("mass"[All Fields] AND "screening"[All Fields]) OR "mass screening"[All Fields] OR "early detection of cancer"[MeSH Terms] OR ("early"[All Fields] AND "detection"[All Fields] AND "cancer"[All Fields]) OR "early detection of cancer"[All Fields] OR "screen"[All Fields] OR "screenings"[All Fields] OR "screened"[All Fields] OR "screens"[All Fields]) AND (("meta analysis"[Publication Type] OR "randomized controlled trial"[Publication Type] OR "review"[Publication Type] OR "systematic review"[Filter]) AND "loatrfull text"[Filter]) AND (("tuned"[All Fields] OR "tunes"[All Fields] OR "tuning"[All Fields] OR "tunings"[All Fields]) AND "fork"[All Fields] AND ("test s"[All Fields] OR "tested"[All Fields] OR "testing"[All Fields] OR "testings"[All Fields] OR "tests"[All Fields]) AND (("meta analysis"[Publication Type] OR "randomized controlled trial"[Publication Type] OR "review"[Publication Type] OR "systematic review"[Filter]) AND "loatrfull text"[Filter]))) AND ((meta-analysis[Filter] OR randomizedcontrolledtrial[Filter] OR review[Filter] OR systematicreview[Filter]) AND (fft[Filter]))	04/14/2023 11		
	Hearing loss in children (("hearing loss"[MeSH Terms] OR ("hearing"[All Fields] AND "loss"[All Fields]) OR "hearing loss"[All Fields]) AND ("child"[MeSH Terms] OR "child"[All Fields] OR "children"[All Fields] OR "child s"[All Fields] OR "children s"[All Fields] OR "childrens"[All Fields] OR "childs"[All Fields])) AND ((meta-analysis[Filter] OR randomizedcontrolledtrial[Filter] OR review[Filter] OR systematicreview[Filter]) AND (fft[Filter]))	04/14/2023 416 pm 2700		
	Pneumatic otoscopy (("pneumatic"[All Fields] OR "pneumatically"[All Fields] OR "pneumatics"[All Fields]) AND ("otoscopies"[All Fields] OR "otoscopy"[MeSH Terms] OR "otoscopy"[All Fields])) AND ((meta-analysis[Filter] OR randomizedcontrolledtrial[Filter] OR review[Filter] OR systematicreview[Filter]) AND (fft[Filter]))	04/14/2023 423 pm 34		
	("pneumatic"[All Fields] OR "pneumatically"[All Fields] OR "pneumatics"[All Fields]) AND ("otoscopies"[All Fields] OR "otoscopy"[MeSH Terms] OR "otoscopy"[All Fields])	04/14/2023 440 pm 281		

	("pneumatic"[All Fields] OR "pneumatically"[All Fields] OR "pneumatics"[All Fields]) AND ("otoscopies"[All Fields] OR "otoscopy"[MeSH Terms] OR "otoscopy"[All Fields]) AND (("diagnosis"[MeSH Subheading] OR "diagnosis"[All Fields] OR "screening"[All Fields] OR "mass screening"[MeSH Terms] OR ("mass"[All Fields] AND "screening"[All Fields]) OR "mass screening"[All Fields] OR "early detection of cancer"[MeSH Terms] OR ("early"[All Fields] AND "detection"[All Fields] AND "cancer"[All Fields]) OR "early detection of cancer"[All Fields] OR "screen"[All Fields] OR "screenings"[All Fields] OR "screened"[All Fields] OR "screens"[All Fields]) AND ("hearing loss"[MeSH Terms] OR ("hearing"[All Fields] AND "loss"[All Fields]) OR "hearing loss"[All Fields])) AND ("child"[MeSH Terms] OR "child"[All Fields] OR "children"[All Fields] OR "child s"[All Fields] OR "children s"[All Fields] OR "childrens"[All Fields] OR "childs"[All Fields])	04/14/2023 445 pm	37	
	screening audiometry ("diagnosis"[MeSH Subheading] OR "diagnosis"[All Fields] OR "screening"[All Fields] OR "mass screening"[MeSH Terms] OR ("mass"[All Fields] AND "screening"[All Fields]) OR "mass screening"[All Fields] OR "early " detection of cancer"[MeSH Terms] OR ("early"[All Fields] AND "detection"[All Fields] AND "cancer"[All Fields]) OR "early detection of cancer"[All Fields] OR "screen"[All Fields] OR "screenings"[All Fields] OR "screened"[All Fields] OR "screens"[All Fields]) AND ("audiometry"[MeSH Terms] OR "audiometry"[All Fields] OR audiometries"[All Fields])	04/14/2023 455 pm	15, 471	
	("diagnosis"[MeSH Subheading] OR "diagnosis"[All Fields] OR "screening"[All Fields] OR "mass screening"[MeSH Terms] OR ("mass"[All Fields] AND "screening"[All Fields]) OR "mass screening"[All Fields] OR "early detection of cancer"[MeSH Terms] OR ("early"[All Fields] AND "detection"[All Fields] AND "cancer"[All Fields]) OR "early detection of cancer"[All Fields] OR "screen"[All Fields] OR "screenings"[All Fields] OR "screened"[All Fields] OR "screens"[All Fields]) AND ("audiometry"[MeSH Terms] OR "audiometry"[All Fields] OR "audiometries"[All Fields]) AND ("hearing loss"[MeSH Terms] OR ("hearing"[All Fields] AND "loss"[All Fields]) OR "hearing loss"[All Fields]) AND ("child"[MeSH Terms] OR "child"[All Fields] OR "children"[All Fields] OR "child s"[All Fields] OR "children s"[All Fields] OR "childrens"[All Fields] OR "childs"[All Fields])	04/14/2023 510 pm	3,367	
	("practice guideline"[Publication Type] OR "practice guidelines as topic"[MeSH Terms] OR "clinical practice guidelines"[All Fields]) AND (("hearing loss"[MeSH Terms] OR ("hearing"[All Fields] AND "loss"[All Fields]) OR "hearing loss"[All Fields]) AND ("diagnosis"[MeSH Subheading] OR "diagnosis"[All Fields] OR "screening"[All Fields] OR "mass screening"[MeSH Terms] OR ("mass"[All Fields] AND "screening"[All Fields]) OR "mass screening"[All Fields] OR "early detection of cancer"[MeSH Terms] OR ("early"[All Fields] AND "detection"[All Fields] AND "cancer"[All Fields]) OR "early detection of cancer"[All Fields] OR "screen"[All Fields] OR "screenings"[All Fields] OR "screened"[All Fields] OR "screens"[All Fields])) AND ("child"[MeSH Terms] OR "child"[All Fields] OR "children"[All Fields] OR "child s"[All Fields] OR "children s"[All Fields] OR "childrens"[All Fields] OR "childs"[All Fields]) AND ("adolescence"[All Fields] OR "adolescence"[All Fields] OR "adolescent"[MeSH Terms] OR "adolescent"[All Fields] OR "adolescence"[All Fields] OR "adolescents"[All Fields] OR "adolescent s"[All Fields])	04/14/2023 530 pm	18	

Table 2. Search strategy on other databases and existing guideline databases

DATABASE	SEARCH STRATEGY / SEARCH TERMS	RESULTS	DATE AND TIME OF SEARCH
Cochrane Library	#1 Screening for Hearing Loss #2 Hearing Impairment #3 Hearing Loss in Children #4 Tuning Fork Tests #5 Screening audiometry #6 Pneumatic otoscopy #7 children AND hearing loss OR hearing impairment #4 and #3 #6 and #3 #5 and #3	12 2526 30 20 98 46 53 4 (hit:1) 4 23	04/10/2023 513 pm
USPSTF	"hearing loss" Filters: Adolescent and Child Status: All Type of Preventive Service: Screening	51	04/10/2023 705 pm
NICE	"hearing" Filters: Type: Guidance Status: Published	1	04/10/2023 730 pm
CTFPH	"hearing"	1	04/10/2023 740 pm
WHO	free text search "hearing loss screening" "hearing loss screening in children" "hearing screening"	0 0 6	04/10/2023 805 pm

Hearing Screening in Asymptomatic Apparently Healthy Adults

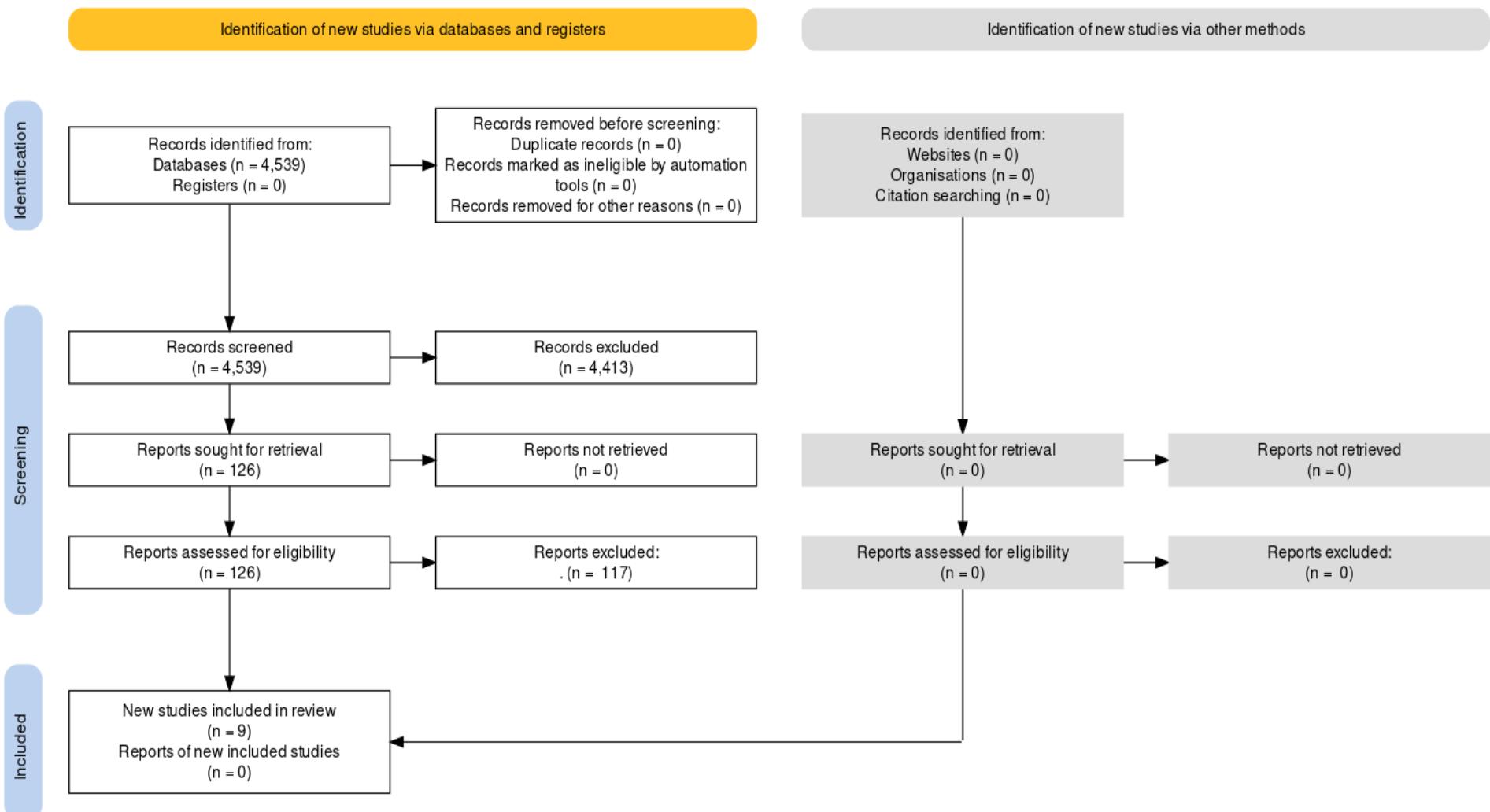
Search Strategy (date of last search Nov. 17, 2022)

DATABASE	SEARCH STRATEGY / SEARCH TERMS	DATE OF SEARCH	RESULTS	
			Yield	Eligible
Medline	((pure tone audiometry) OR (screening audiometry)) AND (hearing loss screening)) AND (industrial workers)	Nov. 17, 2022 17:00 GMT+8	175 (7 abstracts retrieved)	0
CENTRAL	1 Screening for Hearing Loss #2 Hearing Impairment #3 Pure Tone Audiometry #4 Audiometric Test #5 Industrial workers #6 #1 OR #2 #7 #3 OR #4 #8 #5 AND #6 #9 #7 AND #8	Nov. 17, 2022	2	0
USPSTF	"hearing loss" Filters: Status: All Type of Preventive Service: Screening	Nov. 17, 2022	92	1
NICE	"hearing" Filters: Type: Guidance Status: Published	Nov. 17, 2022	1	1
WHO	free text search "hearing loss screening"	Nov. 17, 2022	2	1
CTFPHC	"hearing"	Nov. 17, 2022	1	1

Tandem Walking and Romberg's Test as Vestibular Testing in Asymptomatic Apparently Healthy Adult and Children

Information Source	Search Strategy (as of 30 December 2022)	Yield	Eligible
Clinical Practice Guidelines and Systematic Review			
MEDLINE (PubMed) Clinical practice guidelines and Systematic reviews on Vestibular disorders limit: 5 years	("vestibular"[All Fields] AND (((("meta-analysis"[Title] OR "systematic review"[Title] OR "systematic literature review"[Title] OR "systematic scoping review"[Title] OR "systematic narrative review"[Title] OR "systematic qualitative review"[Title] OR "systematic evidence review"[Title] OR "systematic quantitative review"[Title] OR "systematic meta review"[Title] OR "systematic critical review"[Title] OR "systematic mixed studies review"[Title] OR "systematic mapping review"[Title] OR "systematic cochrane review"[Title] OR "systematic search and review"[Title] OR "systematic integrative review"[Title]) NOT ("comment"[Publication Type])) NOT ("protocol"[Title] OR "protocols"[Title])) NOT "MEDLINE"[Filter] OR ("cochrane database syst rev"[Journal] AND "review"[Publication Type]) OR "systematic review"[Publication Type])) AND (2018:2022[pdat])	332	0
Cochrane Library	ID #1 Search vestibular Hits 2817 #2 romberg 281 #3 Tandem 4812 #4 #1 AND (#2 OR #3) 70	70	0
By population: vestibular disorders			
MEDLINE (PubMed) Asymptomatic healthy individuals with vestibular disorders	("vestibular"[All Fields] OR "Vestibular System"[MeSH Terms]) AND ("asymptomatic"[All Fields] OR "asymptomatically"[All Fields] OR "asymptomatics"[All Fields])	413	0
By intervention: clinical balance tests			
MEDLINE (PubMed) Screening tests for vestibular disorders and balance	((("screen**"[Title/Abstract] OR "mass screening"[MeSH Terms] OR "assess**"[Title/Abstract] OR "prevent**"[Title/Abstract]) AND (((("healthies"[All Fields] OR "healthy"[All Fields]) AND ("vestibular"[All Fields] OR ("balance"[All Fields] OR "balanced"[All Fields] OR "balances"[All Fields] OR "balancing"[All Fields])))))) AND (systematicreview[Filter]))	312	0
MEDLINE (PubMed) Tandem Walking	("tandem"[All Fields] OR "tandems"[All Fields]) AND "walk**"[All Fields]	1152	6
MEDLINE (PubMed) Romberg's Test	"romberg"[All Fields] OR "romberg s"[All Fields]	2260	6

PRISMA Flow Diagram



Fetal Heart Rate Monitoring for Prenatal/Antenatal Hearing Screening

Search strategy and yield as of 20 November 2022

USPSTF

#	Query	Yield
1	Hearing	127

Canadian Task Force on Preventive Health

#	Query	Yield
1	all published guidelines	22
2	All archived guidelines	1
3	#1 and #2	23

National Institute for Health and Care Excellence

#	Query	Yield
1	Hearing	185
2	Hearing AND Screening	38

American Academy of Audiology

#	Query	Yield
1	All guidelines under Infant and Young Child Identification and Assessment and Pediatric Diagnostics	4

Philippine Society of Otolaryngology-Head and Neck Surgery

#	Query	Yield
1	All CPGS	2

Cochrane

#	Query	Yield
1	all topics under " Ear, nose & throat" category	202
2	all topics under " Ear, nose & throat" + "ear" category	85

PUBMED

#	Query	Yield

1	(PUBMED: Search using (guideline [Publication Type] OR practice guideline [Publication Type] or recommendation*[Title] OR standard* [Title] OR standard* [Title] OR guideline* [Title]) AND hearing test) AND (hearing)	2
2	fetus OR fetal OR prenatal OR antenatal	636,262
3	Hearing Screening	46, 323
4	#2 AND #3	1,282
5	#4 AND heart rate	14
6	#1 + #5	16

HERDIN

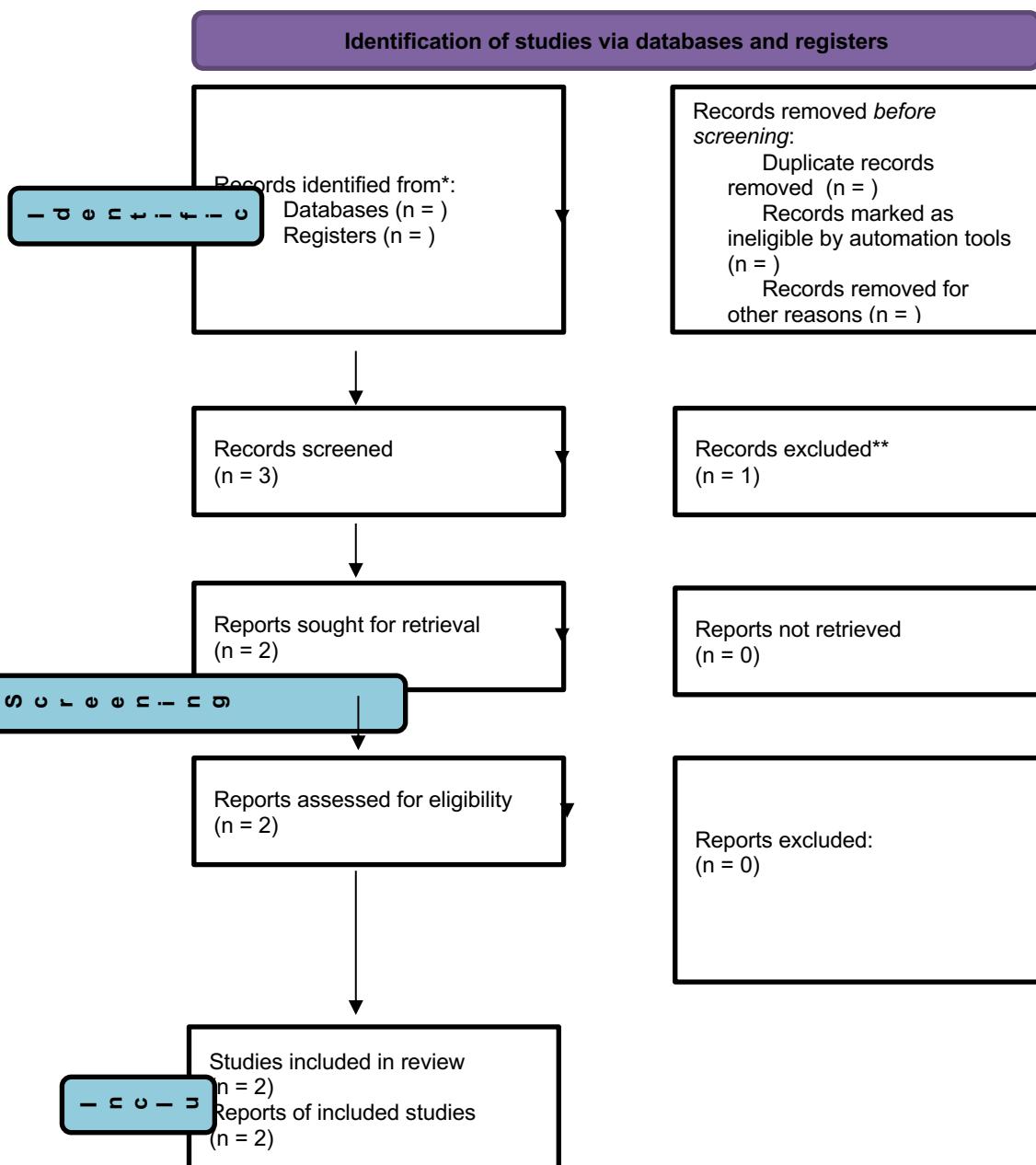
#	Query	Yield
1	screen OR hearing OR fetus OR fetal OR heart rate	4510
2	hearing	270
3	Hearing AND screening	65
4	#1 AND #2	34

Clinicaltrials.gov

#	Query	Yield
1	Other Terms: Hearing OR heart rate	113
2	Condition or Disease: Hearing Disorders Other Terms: heart rate	5
3	Condition or Disease: Hearing Loss Other Terms: heart rate	4

PRISMA Flow Diagram

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71





AGREE Reporting Checklist 2016

AGREE
REPORTING CHECKLIST

This checklist is intended to guide the reporting of clinical practice guidelines.

CHECKLIST ITEM AND DESCRIPTION	REPORTING CRITERIA	Page #
DOMAIN 1: SCOPE AND PURPOSE		
1. OBJECTIVES <i>Report the overall objective(s) of the guideline. The expected health benefits from the guideline are to be specific to the clinical problem or health topic.</i>	<input checked="" type="checkbox"/> Health intent(s) (i.e., prevention, screening, diagnosis, treatment, etc.) <input checked="" type="checkbox"/> Expected benefit(s) or outcome(s) <input checked="" type="checkbox"/> Target(s) (e.g., patient population, society)	13
2. QUESTIONS <i>Report the health question(s) covered by the guideline, particularly for the key recommendations.</i>	<input checked="" type="checkbox"/> Target population <input checked="" type="checkbox"/> Intervention(s) or exposure(s) <input checked="" type="checkbox"/> Comparisons (if appropriate) <input type="checkbox"/> Outcome(s) <input type="checkbox"/> Health care setting or context	17
3. POPULATION <i>Describe the population (i.e., patients, public, etc.) to whom the guideline is meant to apply.</i>	<input checked="" type="checkbox"/> Target population, sex and age <input checked="" type="checkbox"/> Clinical condition (if relevant) <input type="checkbox"/> Severity/stage of disease (if relevant) <input type="checkbox"/> Comorbidities (if relevant) <input type="checkbox"/> Excluded populations (if relevant)	15
DOMAIN 2: STAKEHOLDER INVOLVEMENT		
4. GROUP MEMBERSHIP <i>Report all individuals who were involved in the development process. This may include members of the steering group, the research team involved in selecting and reviewing/rating the evidence and individuals involved in formulating the final recommendations.</i>	<input checked="" type="checkbox"/> Name of participant <input checked="" type="checkbox"/> Discipline/content expertise (e.g., neurosurgeon, methodologist) <input checked="" type="checkbox"/> Institution (e.g., St. Peter's hospital) <input type="checkbox"/> Geographical location (e.g., Seattle, WA) <input checked="" type="checkbox"/> A description of the member's role in the guideline development group	4, 17
5. TARGET POPULATION PREFERENCES AND VIEWS <i>Report how the views and preferences of the target population were sought/considered and what the resulting outcomes were.</i>	<input checked="" type="checkbox"/> Statement of type of strategy used to capture patients'/publics' views and preferences (e.g., participation in the guideline development group, literature review of values and preferences) <input checked="" type="checkbox"/> Methods by which preferences and views were sought (e.g., evidence from literature, surveys, focus groups) <input type="checkbox"/> Outcomes/information gathered on patient/public information <input checked="" type="checkbox"/> How the information gathered was used to inform the guideline development process and/or formation of the recommendations	15
6. TARGET USERS <i>Report the target (or intended) users of the guideline.</i>	<input checked="" type="checkbox"/> The intended guideline audience (e.g. specialists, family physicians, patients, clinical or institutional leaders/administrators) <input checked="" type="checkbox"/> How the guideline may be used by its target audience (e.g., to inform clinical decisions,	13

	to inform policy, to inform standards of care)	
DOMAIN 3: RIGOUR OF DEVELOPMENT		
7. SEARCH METHODS <i>Report details of the strategy used to search for evidence.</i>	<input checked="" type="checkbox"/> Named electronic database(s) or evidence source(s) where the search was performed (e.g., MEDLINE, EMBASE, PsychINFO, CINAHL) <input checked="" type="checkbox"/> Time periods searched (e.g., January 1, 2004 to March 31, 2008) <input checked="" type="checkbox"/> Search terms used (e.g., text words, indexing terms, subheadings) <input checked="" type="checkbox"/> Full search strategy included (e.g., possibly located in appendix)	16
8. EVIDENCE SELECTION CRITERIA <i>Report the criteria used to select (i.e., include and exclude) the evidence. Provide rationale, where appropriate.</i>	<input checked="" type="checkbox"/> Target population (patient, public, etc.) characteristics <input checked="" type="checkbox"/> Study design <input checked="" type="checkbox"/> Comparisons (if relevant) <input checked="" type="checkbox"/> Outcomes <input checked="" type="checkbox"/> Language (if relevant) <input checked="" type="checkbox"/> Context (if relevant)	17
9. STRENGTHS & LIMITATIONS OF THE EVIDENCE <i>Describe the strengths and limitations of the evidence. Consider from the perspective of the individual studies and the body of evidence aggregated across all the studies. Tools exist that can facilitate the reporting of this concept.</i>	<input checked="" type="checkbox"/> Study design(s) included in body of evidence <input checked="" type="checkbox"/> Study methodology limitations (sampling, blinding, allocation concealment, analytical methods) <input checked="" type="checkbox"/> Appropriateness/relevance of primary and secondary outcomes considered <input checked="" type="checkbox"/> Consistency of results across studies <input checked="" type="checkbox"/> Direction of results across studies <input checked="" type="checkbox"/> Magnitude of benefit versus magnitude of harm <input checked="" type="checkbox"/> Applicability to practice context	11-12
10. FORMULATION OF RECOMMENDATIONS <i>Describe the methods used to formulate the recommendations and how final decisions were reached. Specify any areas of disagreement and the methods used to resolve them.</i>	<input checked="" type="checkbox"/> Recommendation development process (e.g., steps used in modified Delphi technique, voting procedures that were considered) <input checked="" type="checkbox"/> Outcomes of the recommendation development process (e.g., extent to which consensus was reached using modified Delphi technique, outcome of voting procedures) <input checked="" type="checkbox"/> How the process influenced the recommendations (e.g., results of Delphi technique influence final recommendation, alignment with recommendations and the final vote)	17
11. CONSIDERATION OF BENEFITS AND HARMS <i>Report the health benefits, side effects, and risks that were considered when formulating the recommendations.</i>	<input checked="" type="checkbox"/> Supporting data and report of benefits <input checked="" type="checkbox"/> Supporting data and report of harms/side effects/risks <input type="checkbox"/> Reporting of the balance/trade-off between benefits and harms/side effects/risks <input type="checkbox"/> Recommendations reflect considerations of both benefits and harms/side effects/risks	20-75

12. LINK BETWEEN RECOMMENDATIONS AND EVIDENCE <i>Describe the explicit link between the recommendations and the evidence on which they are based.</i>	<input checked="" type="checkbox"/> How the guideline development group linked and used the evidence to inform recommendations <input checked="" type="checkbox"/> Link between each recommendation and key evidence (text description and/or reference list) <input checked="" type="checkbox"/> Link between recommendations and evidence summaries and/or evidence tables in the results section of the guideline	18
13. EXTERNAL REVIEW <i>Report the methodology used to conduct the external review.</i>	<input checked="" type="checkbox"/> Purpose and intent of the external review (e.g., to improve quality, gather feedback on draft recommendations, assess applicability and feasibility, disseminate evidence) <input checked="" type="checkbox"/> Methods taken to undertake the external review (e.g., rating scale, open-ended questions) <input checked="" type="checkbox"/> Description of the external reviewers (e.g., number, type of reviewers, affiliations) <input checked="" type="checkbox"/> Outcomes/information gathered from the external review (e.g., summary of key findings) <input checked="" type="checkbox"/> How the information gathered was used to inform the guideline development process and/or formation of the recommendations (e.g., guideline panel considered results of review in forming final recommendations)	18, 78
14. UPDATING PROCEDURE <i>Describe the procedure for updating the guideline.</i>	<input checked="" type="checkbox"/> A statement that the guideline will be updated <input checked="" type="checkbox"/> Explicit time interval or explicit criteria to guide decisions about when an update will occur <input checked="" type="checkbox"/> Methodology for the updating procedure	19, 78
DOMAIN 4: CLARITY OF PRESENTATION		
15. SPECIFIC AND UNAMBIGUOUS RECOMMENDATIONS <i>Describe which options are appropriate in which situations and in which population groups, as informed by the body of evidence.</i>	<input checked="" type="checkbox"/> A statement of the recommended action <input checked="" type="checkbox"/> Intent or purpose of the recommended action (e.g., to improve quality of life, to decrease side effects) <input checked="" type="checkbox"/> Relevant population (e.g., patients, public) <input checked="" type="checkbox"/> Caveats or qualifying statements, if relevant (e.g., patients or conditions for whom the recommendations would not apply) <input checked="" type="checkbox"/> If there is uncertainty about the best care option(s), the uncertainty should be stated in the guideline	11-12
16. MANAGEMENT OPTIONS <i>Describe the different options for managing the condition or health issue.</i>	<input checked="" type="checkbox"/> Description of management options <input checked="" type="checkbox"/> Population or clinical situation most appropriate to each option	20-75
17. IDENTIFIABLE KEY RECOMMENDATIONS <i>Present the key recommendations so that they are easy to identify.</i>	<input checked="" type="checkbox"/> Recommendations in a summarized box, typed in bold, underlined, or presented as flow charts or algorithms <input checked="" type="checkbox"/> Specific recommendations grouped together in one section	11-12, 20-175
DOMAIN 5: APPLICABILITY		

18. FACILITATORS AND BARRIERS TO APPLICATION <i>Describe the facilitators and barriers to the guideline's application.</i>	<input checked="" type="checkbox"/> Types of facilitators and barriers that were considered <input checked="" type="checkbox"/> Methods by which information regarding the facilitators and barriers to implementing recommendations were sought (e.g., feedback from key stakeholders, pilot testing of guidelines before widespread implementation) <input checked="" type="checkbox"/> Information/description of the types of facilitators and barriers that emerged from the inquiry (e.g., practitioners have the skills to deliver the recommended care, sufficient equipment is not available to ensure all eligible members of the population receive mammography) <input checked="" type="checkbox"/> How the information influenced the guideline development process and/or formation of the recommendations	79
19. IMPLEMENTATION ADVICE/TOOLS <i>Provide advice and/or tools on how the recommendations can be applied in practice.</i>	<input checked="" type="checkbox"/> Additional materials to support the implementation of the guideline in practice. For example: <ul style="list-style-type: none"> ○ Guideline summary documents ○ Links to check lists, algorithms ○ Links to how-to manuals ○ Solutions linked to barrier analysis (see Item 18) ○ Tools to capitalize on guideline facilitators (see Item 18) ○ Outcome of pilot test and lessons learned 	10, 19, 79
20. RESOURCE IMPLICATIONS <i>Describe any potential resource implications of applying the recommendations.</i>	<input checked="" type="checkbox"/> Types of cost information that were considered (e.g., economic evaluations, drug acquisition costs) <input checked="" type="checkbox"/> Methods by which the cost information was sought (e.g., a health economist was part of the guideline development panel, use of health technology assessments for specific drugs, etc.) <input checked="" type="checkbox"/> Information/description of the cost information that emerged from the inquiry (e.g., specific drug acquisition costs per treatment course) <input checked="" type="checkbox"/> How the information gathered was used to inform the guideline development process and/or formation of the recommendations	79
21. MONITORING/ AUDITING CRITERIA <i>Provide monitoring and/or auditing criteria to measure the application of guideline recommendations.</i>	<input checked="" type="checkbox"/> Criteria to assess guideline implementation or adherence to recommendations <input checked="" type="checkbox"/> Criteria for assessing impact of implementing the recommendations <input type="checkbox"/> Advice on the frequency and interval of measurement <input type="checkbox"/> Operational definitions of how the criteria should be measured	10, 80
DOMAIN 6: EDITORIAL INDEPENDENCE		
22. FUNDING BODY <i>Report the funding body's influence on the</i>	<input checked="" type="checkbox"/> The name of the funding body or source of funding (or explicit statement of no funding)	10

<i>content of the guideline.</i>	<input checked="" type="checkbox"/> A statement that the funding body did not influence the content of the guideline	
23. COMPETING INTERESTS <i>Provide an explicit statement that all group members have declared whether they have any competing interests.</i>	<input checked="" type="checkbox"/> Types of competing interests considered <input checked="" type="checkbox"/> Methods by which potential competing interests were sought <input checked="" type="checkbox"/> A description of the competing interests <input checked="" type="checkbox"/> How the competing interests influenced the guideline process and development of recommendations	10

From:

Brouwers MC, Kerkvliet K, Spithoff K, on behalf of the AGREE Next Steps Consortium. The AGREE Reporting Checklist: a tool to improve reporting of clinical practice guidelines. *BMJ* 2016;352:i1152. doi: 10.1136/bmj.i1152.