National Institute for Health and Care Excellence

Final

Stroke rehabilitation in adults (update)

[D] Evidence reviews for the optimal tool for hearing assessment

NICE guideline NG236

Evidence reviews underpinning recommendations 1.9.1 to 1.9.4 and research recommendations in the NICE guideline

October 2023

Final

These evidence reviews were developed by NICE

Disclaimer

The recommendations in this guideline represent the view of NICE, arrived at after careful consideration of the evidence available. When exercising their judgement, professionals are expected to take this guideline fully into account, alongside the individual needs, preferences and values of their patients or service users. The recommendations in this guideline are not mandatory and the guideline does not override the responsibility of healthcare professionals to make decisions appropriate to the circumstances of the individual patient, in consultation with the patient and/or their carer or guardian.

Local commissioners and/or providers have a responsibility to enable the guideline to be applied when individual health professionals and their patients or service users wish to use it. They should do so in the context of local and national priorities for funding and developing services, and in light of their duties to have due regard to the need to eliminate unlawful discrimination, to advance equality of opportunity and to reduce health inequalities. Nothing in this guideline should be interpreted in a way that would be inconsistent with compliance with those duties.

NICE guidelines cover health and care in England. Decisions on how they apply in other UK countries are made by ministers in the Welsh Government, Scottish Government, and Northern Ireland Executive. All NICE guidance is subject to regular review and may be updated or withdrawn.

Copyright

ISBN: 978-1-4731-5450-6

Contents

1 Optimal tool for hearing assessment

1.1 Review question

In people after stroke, what is the optimal tool for assessment of hearing?

1.1.1 Introduction

A stroke can affect hearing at several levels from simple perception of sounds to the processing of these. In addition, people who have a stroke may already have a hearing deficit since both problems occur more frequently with increasing age. It is therefore unsurprising that a degree of hearing loss is common after a stroke. This is important both for its effect on quality of life in its own right and because it can hinder communication and cause difficulties in participating in rehabilitation.

There is no widely agreed process for assessment of hearing impairment during stroke rehabilitation. The purpose of this review was to evaluate the evidence for the clinical and cost effectiveness of tools which would contribute to an objective assessment of hearing loss after a stroke.

1.1.2 Summary of the protocol

Table 1: PICO characteristics of review question

Population	Inclusion: • Adults (age ≥16 years) who have had a first or recurrent stroke (including people after a subarachnoid haemorrhage) Exclusion: • Children (age <16 years) • People who had a transient ischaemic attack • People with other conditions that cause hearing problems
Target condition	Hearing loss after stroke

Index tests (comparators)	• Tools for assessment of hearing after a stroke:
	  ○ Handheld hearing screener
	  – Cut off:
	  • Problem detected
	  • Problem not detected
	  ○ Hearing specific questionnaires
	  – Hearing Handicap inventory Screening Version (HHIE)
	  • Cut off:
	  ○ ≤16
	  ○ >16
	  – The Amsterdam Inventory Auditory for Disability (AIAD)
	  • Cut off:
	  ○ <64
	  ○ 64-84 (no problem)
	  ○ Bedside clinical tests (any test will be accepted, including those within a comprehensive neurological examination)
	  – Cut off:

	• Problem detected • Problem not detected ○ Combinations of the above For the test-and-treat portion of the review, studies comparing any of the above interventions to each other were considered. The following key confounders were considered for these studies: • Presence of communication difficulties • Cognitive impairment at baseline • Age
Reference standards	• Audiometry [assessment by an audiologist]
Statistical measures and Outcomes	Clinical effectiveness (test and treat) outcomes: At time period • <1 year • ≥1 year • Person/participant generic health-related quality of life (continuous outcomes will be prioritised) • Carer generic health-related quality of life (continuous outcomes will be prioritised) • Activities of daily living (continuous outcomes will be prioritised) • Participation in leisure activities/social groups scores (continuous outcomes will be prioritised) • Psychological distress (continuous outcomes will be prioritised) ○ Depression ○ Anxiety ○ Distress • Stroke-related scales of cognition (continuous outcomes will be prioritised) (including non-spatial attention and working memory, spatial attention, memory and executive function scores) • Speech perception (continuous outcomes will be prioritised) • Functional communication (continuous outcomes will be prioritised) • Stroke-specific Patient-Reported Outcome Measures (continuous outcomes will be prioritised) • Withdrawal due to adverse events (dichotomous outcome) If not mentioned above, other validated scores will be considered and discussed with the committee to deliberate on their inclusion. Diagnostic accuracy outcomes: • Sensitivity • Specificity • Raw data to calculate 2x2 tables to calculate sensitivity and specificity • Area under the curve • Likelihood ratios • Positive predictive values • Negative predictive values • Intra-test and inter-test reliability

Study design	Clinical effectiveness (test and treat)
	• Systematic reviews of RCTs
	• Parallel RCTs
	• Non-randomised studies (if insufficient evidence from parallel RCTs)
	  ○ Prospective cohort study
	  ○ Retrospective cohort study
	Published NMAs and IPDs will be considered for inclusion.
	Diagnostic test accuracy:
	Cross sectional studies and cohort studies will be included.

For full details see the review protocol in Appendix A.

1.1.3 Methods and process

This evidence review was developed using the methods and process described in Developing NICE guidelines: the manual. Methods specific to this review question are described in the review protocol in Appendix A and the methods document.

Declarations of interest were recorded according to NICE's conflicts of interest policy.

1.1.4 Diagnostic evidence

1.1.4.1 Included studies

One cross-sectional study assessing the diagnostic accuracy of various index tests was included in the review;[2] this is summarised in Table 2. This study investigated the following index tests:

- Handheld hearing screener
- Handicap Hearing Inventory in the Elderly
- Amsterdam Inventory Auditory of Disability
- Combined handheld hearing screener and Amsterdam Inventory Auditory of Disability

Evidence from this study is summarised in the clinical evidence summary below in Table 3 and references in 1.1.14 References . The assessment of the evidence quality was conducted with emphasis on test sensitivity and specificity as this was identified by the committee as the primary measure in guiding decision-making. The committee set clinical decision thresholds as sensitivity/specificity 0.9 and 0.75 above which a test would be recommended and 0.6 and 0.5 below which a test is of no clinical use.

No relevant diagnostic test accuracy studies of index test bedside clinical tests in people under investigation for hearing problems after stroke were identified.

See also the study selection flow chart in Appendix C, sensitivity and specificity forest plots in Appendix E, and study evidence tables in Appendix D.

1.1.4.2 Excluded studies

See the excluded studies list in Appendix I.

1.1.5 Summary of studies included in the diagnostic evidence

Table 2: Summary of studies included in the evidence review

Study	Population	Target condition	Index test	Reference standard	Comments
Koohi 2019[2]	People after stroke (including ischaemic and haemorrhagic stroke) Side of stroke: Right = 22 Left = 18 Both = 2 Days since stroke (mean [SD]): 171.9 (76.4) days	Central and peripheral hearing loss	1) Handheld hearing screener using the ASHA protocol 2) Handicap Hearing Inventory in the Elderly (HHIE) 3) Amsterdam Inventory Auditory of Disability (AIAD) 4) Combination of handheld hearing screener and Amsterdam Inventory Auditory of Disability	Audiometry (including a range of audiometric techniques to measure pure-tone average, otoacoustic emissions, acoustic reflex thresholds and brainstem responses)	Setting: Outpatient follow up, United Kingdom Funding: This study was funded by the British Medical Association Helen Lawson grant. Note: The study reported data that could be used to calculate sensitivity and specificity and reported these calculated parameters. Where possible a 2x2 table was constructed and sensitivity and specificity were calculated. This was not possible for index test 4. For index test 1, the study reports sensitivity and specificity for the use of the test in people with peripheral hearing loss only. To maintain consistent with the protocol, this review calculates sensitivity and specificity for all types of hearing loss.

See Appendix D for full evidence tables.

1.1.6 Summary of the diagnostic evidence

Table 3: Clinical evidence summary: diagnostic test accuracy for handheld hearing screener

Studies	N	Risk of bias	Inconsistency	Indirectness	Imprecision	Effect size (95%CI)	Quality
Handheld hearing screener to detect hearing loss (all types) in people after stroke							
1 prospective cohort study	42	Not serious	Not serious	Serious[1]	Serious[2]	Sensitivity=0.69 (0.52-0.84)	LOW
		Not serious	Not serious	Serious[1]	Very serious[2]	Specificity=1.00 (0.54-1.00)	VERY LOW

[1] *Indirectness was assessed using the QUADAS-2 checklist. The evidence was downgraded by 1 increment due to population indirectness (people with communication and cognitive difficulties were excluded from the study).*

[2] *Confidence interval crossed the decision threshold corresponding to 'high sensitivity/specificity' (90%) and/or 'low sensitivity/specificity' (75%).*

Table 4: Clinical evidence summary: diagnostic test accuracy for the Handicap Hearing Inventory in the Elderly questionnaire

Studies	N	Risk of bias	Inconsistency	Indirectness	Imprecision	Effect size (95%CI)	Quality
Handicap Hearing Inventory in the Elderly questionnaire to detect hearing loss (all types) in people after stroke							
1 prospective cohort study	42	Not serious	Not serious	Serious[1]	Not serious	Sensitivity=0.44 (0.28-0.62)	MODERATE
		Not serious	Not serious	Serious[1]	Very serious[2]	Specificity=1.00 (0.54-1.00)	VERY LOW

[1] *Indirectness was assessed using the QUADAS-2 checklist. The evidence was downgraded by 1 increment due to population indirectness (people with communication and cognitive difficulties were excluded from the study).*

[2] *Confidence interval crossed the decision threshold corresponding to 'high sensitivity/specificity' (90%) and/or 'low sensitivity/specificity' (75%).*

Table 5: Clinical evidence summary: diagnostic test accuracy for the Amsterdam Inventory Auditory of Disability questionnaire

Studies	N	Risk of bias	Inconsistency	Indirectness	Imprecision	Effect size (95%CI)	Quality
Amsterdam Inventory Auditory of Disability questionnaire to detect hearing loss (all types) in people after stroke							
1 prospective cohort study	42	Not serious	Not serious	Serious[1]	Not serious	Sensitivity=0.33 (0.19-0.51)	MODERATE
		Not serious	Not serious	Serious[1]	Very serious[2]	Specificity=1.00 (0.54-1.00)	VERY LOW

[1] *Indirectness was assessed using the QUADAS-2 checklist. The evidence was downgraded by 1 increment due to population indirectness (people with communication and cognitive difficulties were excluded from the study).*

[2] *Confidence interval crossed the decision threshold corresponding to 'high sensitivity/specificity' (90%) and/or 'low sensitivity/specificity' (75%).*

Table 6: Clinical evidence summary: diagnostic test accuracy for the combination of the handheld hearing screener and the Amsterdam Inventory Auditory of Disability questionnaire

Studies	N	Risk of bias	Inconsistency	Indirectness	Imprecision	Effect size (95%CI)	Quality
Combination of the handheld hearing screener and the Amsterdam Inventory Auditory of Disability questionnaire to detect hearing loss (all types) in people after stroke							
1 prospective cohort study	42	Not serious	Not serious	Serious[1]	Not serious	Sensitivity=0.5000 (0.1570-0.8430)[3]	MODERATE
		Not serious	Not serious	Serious[1]	Very serious[2]	Specificity=0.8889 (0.5175-0.9972)[3]	VERY LOW

[1] Indirectness was assessed using the QUADAS-2 checklist. The evidence was downgraded by 1 increment due to population indirectness (people with communication and cognitive difficulties were excluded from the study).

[2] Confidence interval crossed the decision threshold corresponding to 'high sensitivity/specificity' (90%) and/or 'low sensitivity/specificity' (75%).

[3] Values taken directly from the study and so are not reported in a forest plot. Please see the evidence table in Appendix D for further information.

1.1.7 Economic evidence

1.1.7.1 Included studies

No health economic studies were included.

1.1.7.2 Excluded studies

No relevant health economic studies were excluded due to assessment of limited applicability or methodological limitations.

See also the health economic study selection flow chart in Appendix F.

1.1.8 Summary of included economic evidence

There are no included health economic studies in this review.

1.1.9 Economic model

This area was not prioritised for new cost-effectiveness analysis.

1.1.10 Unit costs

The Koohi 2019[2] study included in the clinical review considered hearing assessment using two different questionnaires, a handheld hearing screener and a combination of a questionnaire and the handheld screener.

Resource use associated with use of a handheld screener will relate to the staff time doing the assessment and the cost of the device. The clinical study stated that doing an assessment using the handheld screener took 5 minutes (including a discussion about instructions for the test). The handheld hearing screener used in this study was ROTO by Otovation. However, this is not currently listed in the NHS supply chain catalogue and could not be identified on other websites. Other hearing screeners from the same manufacturer were found in the catalogue and costs ranged from £2,034 to £2,754[5] but these were not specified as handheld screeners and so costs may be higher. An Interacoustic single handed use paediatric screening audiometer was listed at £804. Other ongoing costs would include maintenance costs and batteries.

The cost per use is expected to be low considering that the screener would be used for a number of patients. Example costs per use based on the costs above and assumptions about lifetime and usage are shown in Table 4 below.

Table 4: Example hearing screener costs per use

	Example 1	Example 2
Device cost[(a)]	£804	£2034
Years of use[(b)]	3	3
Uses per year[(c)]	436	436
Average cost per use	£0.61	£1.56

(a) Example audiometer costs available in NHS supply chain catalogue:[5] Example 1 Otovation amplitude wireless audiometer T3 ; Example 2 Interacoustic single handed use paediatric screening audiometer.
(b) Assumption
(c) Average stroke cases per year per stroke unit from SSNAP 2019/2020

The clinical study included in this review also assessed two validated questionnaires. The authors noted that the questionnaires took under 10 minutes to complete. The questionnaires are defined as self-reported and so may be completed by the person who has had a stroke. However, in some cases people may to require assistance to do this from staff and there will

be staff time required to review the questionnaire. The amount of staff time required is not stated in the clinical study. There do not appear to be charges for using the assessment questionnaires identified in the clinical review. There will be some costs associated with printing questionnaires.

If hearing problems are identified from screening, then people will be referred to either audiology or an ENT for an audiology assessment. This would include people who were both accurately diagnosed (which is dependent on the sensitivity of the screening tools) and misdiagnosed as having a hearing problem (which is dependent on the specificity of the screening tools).

Relevant example unit costs are provided in Table 5 below to aid consideration of cost effectiveness.

Table 5: Unit costs of health care professionals who may be involved in providing hearing assessments

Resource	Cost per working hour (hospital-based only)[(a)]	Example cost to administer hearing assessment (5 minutes)	Source
Band 6 PT/OT	£52	£4.34	PSSRU 2020[1]
Band 7 PT/OT	£62	£5.17	
(Audiology) Outpatient Audiometry or Hearing Assessment, 19 years and over	£68.64 per appointment		NHS reference costs 2019/2020[4]
(ENT) Outpatient Audiometry or Hearing Assessment, 19 years and over	£137.46 per appointment		

(a) Note: Costs per working hour include salary, salary oncosts, overheads (management and other non-care staff costs including administration and estates staff), capital overheads and qualification costs.

1.1.11 Evidence statements

Clinical evidence statements

Economic

No relevant economic evaluations were identified.

1.1.12 The committee's discussion and interpretation of the evidence

1.1.12.1. The outcomes that matter most

This review included outcomes for a test and treat review and a diagnostic accuracy review. The test and treat review outcomes were person/participant generic health-related quality of life, carer generic health-related quality of life, activities of daily living, participation in leisure activities/social groups scores, psychological distress (depression, anxiety and distress), stroke-related scales of cognition, speech perception, functional communication, stroke-specific Patient-Reported Outcome Measures and withdrawal due to adverse events. For the diagnostic accuracy review sensitivity was considered the most important measure by the committee because determining the presence of hearing problems without any tests is difficult and having a test that can correctly identify a problem would be of significant benefit. The consequences of missing a hearing problem can be that people can have a reduced quality of life and that they do not engage with their rehabilitation effectively. These problems

can be exacerbated for people with communication difficulties, where this can be a significant barrier to engaging with speech and language therapy.

There was no evidence for the test and treat review. For the diagnostic accuracy review, evidence was identified for sensitivity, specificity and positive and negative predictive values.

1.1.12.2 The quality of the evidence

One study was identified for inclusion in this review. The committee acknowledged the limited number of studies and the limited number of participants in the study (42 people). The evidence included the index tests of a handheld hearing screening device; questionnaires including the Handicap Hearing Inventory in the Elderly, Amsterdam Inventory Auditory of Disability; and a combination of the handheld hearing screener and Amsterdam Inventory Auditory of Disability.

The risk of bias for the outcomes was graded as having no major problems. However, the quality of the outcomes were downgraded for population indirectness, as people with communication and cognitive difficulties were excluded from the studies. Due to the significant impact that hearing problems could have on people with these difficulties, the outcomes were deemed to be limited in this capacity. Due to the small sample size, there were often wide confidence intervals in the outcomes leading to imprecision being identified. Therefore, the quality of the evidence ranged from moderate to very low, with outcomes for sensitivity being of moderate quality (due to the sensitivity and confidence intervals all being below that agreed in the decision threshold) and for specificity being of very low quality (due to the confidence intervals crossing both decision thresholds).

1.1.12.3 Benefits and harms

The committee compared the different index tests to each other. When comparing their effectiveness for people with all types of hearing loss, none of the tests had sufficient sensitivity to meet the decision threshold, while all had sufficient specificity to achieve this. In order, the sensitivity was best for the handheld hearing screener (at 0.69) while it was worse for the combination of the handheld hearing screener and Amsterdam Inventory Auditory of Disability questionnaire (0.50), Handicap Hearing Inventory in the Elderly (0.44) and Amsterdam Inventory Auditory of Disability (0.33) questionnaires respectively. The specificity was 1 for the individual tests, while the combination of the handheld hearing screener and Amsterdam Inventory Auditory of Disability questionnaire was lower (0.8889). This was due to the rule to determine if people had a hearing problem with the combination looking at a subscale of the Amsterdam Inventory Auditory of Disability questionnaire rather than the entire questionnaire.

The study also reported the sensitivity and specificity for the handheld hearing screener if considering only peripheral hearing loss, as the handheld hearing screener was designed to investigate the presence of peripheral hearing loss rather than central or mixed hearing loss. In this scenario, the sensitivity was higher achieving the decision threshold (92.59, 95% confidence interval: 75.71-99.09). While the committee was interested in all types of hearing loss, they acknowledged this result when making their decision.

Testing by all of these methods was unlikely to cause harms to the person. The economic considerations and resource use is considered in section 1.1.12.4 Cost effectiveness and resource use. The usual clinical practice would require a person to be referred to an audiologist if a hearing problem is suspected. Hearing problems may not be apparent using routine assessment techniques and so having additional methods for identifying problems is important. Weighing up the limited evidence available, the committee recommended that all people should have their hearing assessed and that a questionnaire could be considered to help identify people with hearing problems as while there was limited sensitivity, the benefits were likely greater than not using any tools. The committee highlighted that anyone using the

tool should be aware of the limitations of the questionnaires and should take into account the views of the person and their family about their hearing. If they have any suspicion about hearing problems, whether from subjective concerns or from screening using hearing questionnaire, these should then be further investigated by audiology services.

Due to the limited evidence available the committee made research recommendations to gather more information with a larger number of participants to investigate the effectiveness of different tools to assess hearing in people after stroke and to gain information about the prevalence of hearing problems, as evidence for this was very limited and could help to provide a better understanding of how likely hearing problems are after a stroke.

1.1.12.4 Cost effectiveness and resource use

No economic evidence was identified for this review. Therefore, the hearing assessment tools included in the only clinical study for this review were evaluated in terms of costs and resource use. The clinical study assessed the diagnostic accuracy of two validated questionnaires (The Amsterdam Inventory Auditory for Disability (AIAD) and the Hearing Handicap Inventory for Elderly (HHIE) questionnaires) for the determination of peripheral hearing loss and/or central auditory processing disorder (CAPD), and a handheld hearing screener (ROTO by Otovation) for the determination of peripheral audiometric hearing loss. The study also compared the diagnostic accuracy of the handheld screener in combination with either questionnaire.

The committee agreed the questionnaires would incur lower resource use compared to the handheld screener, as the authors noted that the questionnaires took under 10 minutes to complete and there does not appear to be charges for using either questionnaire, however there will be some costs associated with printing the questionnaires. The questionnaires are defined as self-reported, which will reduce staff time as it can completed by the person who has had a stroke. However, in some cases people may to require assistance to do this from staff, and there will be staff time required to review the questionnaire. The amount of staff time required is not stated in the clinical study.

Resource use associated with use of a handheld screener will relate to the staff time doing the assessment and the cost of the device. The clinical study stated that doing an assessment using the handheld screener took 5 minutes (including a discussion about instructions for the test), which suggests that using a combination of the screener and either of the questionnaires would therefore take around 15 minutes to complete. The cost of the ROTO handheld screener is not currently listed in the NHS supply chain catalogue and could not be identified on other websites. Other hearing screeners from the same manufacturer were found in the catalogue ranged from £2,034 to £2,754 but these were not specified as handheld screeners and have more sophisticated features such as data management and wireless printing and are also described as being designed to be used by hearing specialists. A single-handed screening audiometer was listed on the NHS supply chain catalogue at £804, however this was designed for paediatric use. Other ongoing costs include maintenance costs and batteries. Given this information, simple cost-calculations were presented to the committee to inform the discussion. Using two of the hearing screeners listed in the catalogue (one handheld and one wireless) and data from 2019/2020 SSNAP data on the number of stroke cases per year, the calculations suggest that the average cost per use is expected to be low (£0.61 for the £804 screener and £.156 for the £2,034 screener), assuming that both devices would last for 3 years.

The committee stated that in terms of the assessment pathway in current practice, after people are given the hearing assessment, those who are identified as having hearing problems are typically referred on to either audiology or an ENT for an audiology assessment. This would include people who were both accurately diagnosed (which is dependent on the sensitivity of the screening tools) and misdiagnosed as having a hearing problem (which is dependent on the specificity of the screening tools). The results of the

clinical study found that the handheld screener and the questionnaires all had 100% specificity in detecting mild or greater hearing loss in stroke patients. The handheld screener had the highest sensitivity in detecting mild or greater hearing loss in stroke patients, however, the combined intervention was both less sensitive and less specific than the handheld screener alone. The co-optee audiologist for this review stated that the hearing questionnaires assessed in the clinical study are widely used in current practice but are not used in isolation, while hearing screeners are not routinely used in audiology as there can be few different factors which impact their reliability (for example, test environments, user error and variability in the results obtained) which need to be considered when selecting the best option and typically they are not as sensitive as manual audiometry. The committee were unsure if the hearing assessment tools being considered would sufficiently assess post-stroke hearing problems, as the audiologist noted that hearing loss following stroke may cause damage of the inner ear (cochlear) but can also cause disruption or damage along the whole hearing pathway including the auditory nerve, which causes more auditory processing type hearing difficulties. Hearing screeners such as the ROTO would not detect this as they are a measure of cochlear function only, therefore hearing screeners alone may not show the entirety of hearing dysfunction caused by stroke and it can be possible to have normal hearing thresholds with abnormal auditory nerve function. However, the clinical study did recommend the use of questionnaires (AIAD and HHIE) as an assessment of the central auditory dysfunction which can be experienced by stroke patient, which may be an issue that needs to be considered as part of the hearing screening program.

The committee highlighted that post-stroke hearing problems are not always currently being routinely assessed, with some estimating that the assessments occur approximately 10% of the time, despite existing recommendations. The committee felt that this was due uncertainty surrounding which assessment tool to use and the staff responsible for providing a hearing assessment. It was noted that new recommendations about the optimal tool to use may have the indirect effect of increasing the number of people being assessed and identified as having hearing problems (and therefore increasing the number referred to audiology or ENT). However, the committee view was that inadequate provision hearing assessments and subsequent lack of treatment for hearing problems can impact quality of life and an individuals' ability to fully engage in rehabilitation. Despite the lack of published economic evidence available, the committee consensus was that improved identification of hearing problems could increase QALYs.

Given the lack of economic evidence and limited clinical evidence, an 'offer' recommendation was made for the assessment of hearing to all people within the first 6 weeks following stroke, and 'consider' recommendations were made for the use of the two hearing questionnaires, as this is anticipated to encourage rehabilitation teams to provide assessments and to improve current practice which currently lacks clarity on how hearing assessments should be provided.

1.1.12.5 Other factors the committee took into account

The committee acknowledged and cross refer to other relevant NICE guidance including NG98 Hearing loss in adults: assessment and management.

The lay representatives on the committee highlighted the importance of early consideration of hearing problems. In their experience when this has not been considered quickly in the past this has led to worsening of symptoms and the worsening of cognitive impairment. Earlier referral for audiology could improve the person's ability to engage with rehabilitation and reduce the chance of adverse events such as cognitive impairment.

1.1.13 Recommendations supported by this evidence review

This evidence review supports recommendations 1.9.1 to 1.9.4 and the research recommendations on handheld hearing screeners and prevalence of hearing problems in Appendix J.

1.1.14 References

1. Beecham J, Curtis L. Unit costs of health and social care 2020. Canterbury. Personal Social Services Research Unit University of Kent, 2020. Available from: https://www.pssru.ac.uk/project-pages/unit-costs/

2. Koohi N, Vickers DA, Utoomprurkporn N, Werring DJ, Bamiou DE. A Hearing Screening Protocol for Stroke Patients: An Exploratory Study. Frontiers in neurology [electronic resource]. 2019; 10:842

3. National Institute for Health and Care Excellence. Developing NICE guidelines: the manual [updated January 2022]. London. National Institute for Health and Care Excellence, 2014. Available from: https://www.nice.org.uk/process/pmg20

4. NHS England and NHS Improvement. 2019/20 National Cost Collection Data Publication. 2022. Available from: https://www.england.nhs.uk/publication/2019-20-national-cost-collection-data-publication Last accessed: 01/02/2023.

5. NHS Supply Chain. NHS Supply Chain Catalogue. 2022. Available from: https://my.supplychain.nhs.uk/catalogue Last accessed: 01/02/2023.

Appendices

Appendix A – Review protocols

Review protocol for the optimal tool for the assessment of hearing in people after stroke

ID	Field	Content
0.	PROSPERO registration number	CRD42021275564
1.	Review title	In people after stroke, what is the optimal tool for assessment of hearing?
2.	Review question	2.3 In people after stroke, what is the optimal tool for assessment of hearing?
3.	Objective	To determine the optimal tool for assessment of hearing in people after a stroke. This evidence review will have two stages: (1) Identify the clinical effectiveness of diagnosis with the test (test plus treatment) (2) If evidence on clinical effectiveness is limited, the diagnostic accuracy of each method will instead be determined
4.	Searches	The following databases (from inception) will be searched: • Cochrane Central Register of Controlled Trials (CENTRAL) • Cochrane Database of Systematic Reviews (CDSR) • Embase • MEDLINE • Epistemonikas Searches will be restricted by: • English language studies • Human studies Other searches: • Inclusion lists of systematic reviews The searches may be re-run 6 weeks before the final committee meeting and further studies retrieved for inclusion if relevant.

		The full search strategies will be published in the final review. Medline search strategy to be quality assured using the PRESS evidence-based checklist (see methods chapter for full details).
5.	Condition or domain being studied	Adults and young people (16 or older) after a stroke
6.	Population	Inclusion: • Adults (age ≥16 years) who have had a first or recurrent stroke (including people after a subarachnoid haemorrhage) Exclusion: • Children (age <16 years) • People who had a transient ischaemic attack • People with other conditions that cause hearing problems
7.	Intervention/Test	• Tools for assessment of hearing after a stroke: o Handheld hearing screener – Cut off: • Problem detected • Problem not detected o Hearing specific questionnaires – Hearing Handicap inventory Screening Version (HHIE) • Cut off: o ≤16 o >16 – The Amsterdam Inventory Auditory for Disability (AIAD) • Cut off: o <64 o 64-84 (no problem) o Bedside clinical tests (any test will be accepted, including those within a comprehensive neurological examination) – Cut off: • Problem detected • Problem not detected o Combinations of the above Where studies include a mixture of the above categories studies will be included if at least 80% satisfy the criteria for one category. If <10% of participants are in a different category (for example: 9% have a Handheld hearing screener assessment, 91% have a Hearing Handicap inventory Screening

		Version assessment this study will be included in the majority category without downgrading for indirectness. If 10-20% are in a different category, this study will be included in the majority category and downgraded for intervention indirectness. Intervention (test-and treat) If people are diagnosed with stroke-related hearing loss, treatment will most likely include hearing aids and/or assistive listening devices.
8.	Comparator/Reference standard/Confounding factors	<u>Effectiveness (test-and-treat)</u> • Compare to each other <u>Diagnostic accuracy</u> • Gold standard (audiometry [assessment by an audiologist]) Confounding factors: Presence of communication difficulties Cognitive impairment at baseline Age

9.	Types of study to be included	Clinical effectiveness (test and treat)
		• Systematic reviews of RCTs
		• Parallel RCTs
		• Non-randomised studies (if insufficient evidence from parallel RCTs)
		  ○ Prospective cohort study
		  ○ Retrospective cohort study
		
		Published NMAs and IPDs will be considered for inclusion.
		
		Diagnostic test accuracy:
		
		Cross sectional studies and cohort studies will be included.

10.	Other exclusion criteria	• Non-English language studies. • Non comparative cohort studies • Before and after studies • Conference abstracts will be excluded as it is expected there will be sufficient full text published studies available.
11.	Context	People with hearing problems after a stroke. This may include people in an acute (<7 days), subacute (7 days – 6 months) or chronic (>6 months) time horizon.
12.	Primary outcomes (critical outcomes)	All outcomes are considered equally important for decision making and therefore have all been rated as critical:

		Clinical effectiveness (test and treat) outcomes:
		At time period
		• <1 year
		• ≥1 year
		
		• Person/participant generic health-related quality of life (continuous outcomes will be prioritised)
		  ○ EQ-5D
		  ○ SF-6D
		  ○ SF-36
		  ○ SF-12
		  ○ Other utility measures (AQOL, HUI, 15D, QWB)
		• Carer generic health-related quality of life (continuous outcomes will be prioritised)
		  ○ EQ-5D
		  ○ SF-6D
		  ○ SF-36
		  ○ SF-12
		  ○ Other utility measures (AQOL, HUI, 15D, QWB)
		• Activities of daily living (continuous outcomes will be prioritised)
		  ○ Barthel Index
		  ○ National Institutes of Health Stroke Scale
		  ○ Orpington Prognostic Scale
		  ○ Canadian Occupational Performance Measure
		  ○ Extended activities of daily living
		• Participation in leisure activities/social groups scores (continuous outcomes will be prioritised)
		  ○ Mayo-Portland Adaptability Inventory 4 (MPAI-4) part C (participation)
		  ○ Frenchay Activities Index
		• Psychological distress (continuous outcomes will be prioritised)
		  ○ Depression
		  – PHQ-9
		  – Hospital Anxiety and Depression scale - depression subscale
		  – Beck Depression Inventory
		  – Hamilton Depression Scale
		  – Centre of Epidemiologic Studies Depression
		  – GHQ-28
		  – Geriatric Depression Scale
		  ○ Anxiety
		  – GAD-7
		  – Hospital Anxiety and Depression scale - anxiety subscale

		– The Geriatric Anxiety Inventory – GHQ-28 – Beck Anxiety Inventory o Distress – The Distress Management System for Stroke (DMSS) • Stroke-related scales of cognition (continuous outcomes will be prioritised) (including non-spatial attention and working memory, spatial attention, memory and executive function scores) • Speech perception (continuous outcomes will be prioritised) o The Bamford-Kowal-Bench sentence test • Functional communication (continuous outcomes will be prioritised) o Aachen Aphasia Test, spoken communication domain score o If dysarthria is the presenting complaint: Therapy Outcome Measures dysarthria activity scale o Amsterdam-Nijmegen Everyday Language Test (ANELT) o Therapy Outcome Measures (TOMs) aphasia activity scale • Stroke-specific Patient-Reported Outcome Measures (continuous outcomes will be prioritised) o Stroke-Specific Quality of Life (SS-QOL) o Stroke Impact Scale (SIS) o Stroke-specific Sickness Impact Profile (SA-SIP30) o Satisfaction with International Classification of Functioning, Disability and Health – Stroke (SATIS-Stroke) o Neuro-QOL? o PROMIS-10? • Withdrawal due to adverse events (dichotomous outcome) If not mentioned above, other validated scores will be considered and discussed with the committee to deliberate on their inclusion. Diagnostic accuracy outcomes: • Sensitivity • Specificity • Raw data to calculate 2x2 tables to calculate sensitivity and specificity • Area under the curve • Likelihood ratios • Positive predictive values

		• Negative predictive values • Intra-test and inter-test reliability
14.	Data extraction (selection and coding)	All references identified by the searches and from other sources will be uploaded into EPPI reviewer and de-duplicated. 10% of the abstracts will be reviewed by two reviewers, with any disagreements resolved by discussion or, if necessary, a third independent reviewer. The full text of potentially eligible studies will be retrieved and will be assessed in line with the criteria outlined above. A standardised form will be used to extract data from studies (see Developing NICE guidelines: the manual section 6.4). 10% of all evidence reviews are quality assured by a senior research fellow. This includes checking: • papers were included /excluded appropriately • a sample of the data extractions • correct methods are used to synthesise data • a sample of the risk of bias assessments Disagreements between the review authors over the risk of bias in particular studies will be resolved by discussion, with involvement of a third review author where necessary. Study investigators may be contacted for missing data where time and resources allow.
15.	Risk of bias (quality) assessment	Risk of bias will be assessed using the appropriate checklist as described in Developing NICE guidelines: the manual. • Systematic reviews: Risk of Bias in Systematic Reviews (ROBIS) • Randomised Controlled Trial: Cochrane RoB (2.0) • Non randomised study, including cohort studies: Cochrane ROBINS-I • Case control study: CASP case control checklist • Diagnostic test accuracy studies: QUADAS-2
16.	Strategy for data synthesis	• Pairwise meta-analyses will be performed using Cochrane Review Manager (RevMan5). Fixed-effects (Mantel-Haenszel) techniques will be used to calculate risk ratios for the binary outcomes where possible. Continuous outcomes will be analysed using an inverse variance method for pooling weighted mean differences.

		Where continuous data is reported with the same outcomes on different numerical scales, outcomes will be meta-analysed using a standardised mean difference so long as the data is only populated by final values or change scores. If there are a mixture of final values and change scores, outcomes will be assessed separately (either as standardised mean differences of final values and change scores as two forest plots, or meta-analysis of outcomes reported on the same scale range). Heterogeneity between the studies in effect measures will be assessed using the I^2 statistic and visually inspected. An I^2 value greater than 50% will be considered indicative of substantial heterogeneity. Sensitivity analyses will be conducted based on pre-specified subgroups using stratified meta-analysis to explore the heterogeneity in effect estimates. If this does not explain the heterogeneity, the results will be presented pooled using random-effects. • GRADEpro will be used to assess the quality of evidence for each outcome, taking into account individual study quality and the meta-analysis results. The 4 main quality elements (risk of bias, indirectness, inconsistency and imprecision) will be appraised for each outcome. Publication bias is tested for when there are more than 5 studies for an outcome. The risk of bias across all available evidence was evaluated for each outcome using an adaptation of the 'Grading of Recommendations Assessment, Development and Evaluation (GRADE) toolbox' developed by the international GRADE working group http://www.gradeworkinggroup.org/ • Where meta-analysis is not possible, data will be presented and quality assessed individually per outcome. • WinBUGS will be used for network meta-analysis, if possible given the data identified.
17.	Analysis of sub-groups	Subgroups that will be investigated if heterogeneity is present: Time after stroke when performing test • Hyperacute <72 hours • Acute 72 hours – 7 days • Subacute 7 days – 6 months • Chronic >6 months Presence of communication difficulties • Communication difficulties present • Communication difficulties not present • Mixed

<table>
<tr><td></td><td></td><td colspan="3">Inpatient or outpatient setting
• Inpatient
• Outpatient
• Mixed

People who are bi/multilingual (capable of speaking and understanding at least two different languages)
• People who are bi/multilingual
• People who are not bi/multilingual

Left/right handedness and laterality of cerebral hemisphere of stroke
• People who are left handed with left sided stroke
• People who are right handed with left sided stroke
• People who are ambidextrous with left sided stroke
• People who are left handed with right sided stroke
• People who are right handed with right sided stroke
• People who are ambidextrous with right sided stroke
• People with bilateral stroke</td></tr>
<tr><td rowspan="8">18.</td><td rowspan="8">Type and method of review</td><td>☒</td><td colspan="2">Intervention</td></tr>
<tr><td>☒</td><td colspan="2">Diagnostic</td></tr>
<tr><td>☐</td><td colspan="2">Prognostic</td></tr>
<tr><td>☐</td><td colspan="2">Qualitative</td></tr>
<tr><td>☐</td><td colspan="2">Epidemiologic</td></tr>
<tr><td>☐</td><td colspan="2">Service Delivery</td></tr>
<tr><td>☐</td><td colspan="2">Other (please specify)</td></tr>
<tr><td></td><td></td><td colspan="2"></td></tr>
<tr><td>19.</td><td>Language</td><td colspan="3">English</td></tr>
<tr><td>20.</td><td>Country</td><td colspan="3">England</td></tr>
<tr><td>21.</td><td>Anticipated or actual start date</td><td colspan="3">24/02/2021</td></tr>
<tr><td>22.</td><td>Anticipated completion date</td><td colspan="3">14/12/2022</td></tr>
<tr><td rowspan="3">23.</td><td rowspan="3">Stage of review at time of this submission</td><td>Review stage</td><td>Started</td><td>Completed</td></tr>
<tr><td>Preliminary searches</td><td>☐</td><td>☐</td></tr>
<tr><td>Piloting of the study selection process</td><td>☐</td><td>☐</td></tr>
</table>

		Formal screening of search results against eligibility criteria	☐	☐
		Data extraction	☐	☐
		Risk of bias (quality) assessment	☐	☐
		Data analysis	☐	☐
24.	Named contact	5a. Named contact National Guideline Centre 5b Named contact e-mail StrokeRehabUpdate@nice.nhs.uk 5e Organisational affiliation of the review National Institute for Health and Care Excellence (NICE) and National Guideline Centre		
25.	Review team members	From the National Guideline Centre: Bernard Higgins (Guideline lead) George Wood (Senior systematic reviewer) Madelaine Zucker (Systematic reviewer) Kate Lovibond (Health economics lead) Claire Sloan (Health economist) Joseph Runicles (Information specialist) Nancy Pursey (Senior project manager)		
26.	Funding sources/sponsor	This systematic review is being completed by the National Guideline Centre which receives funding from NICE.		
27.	Conflicts of interest	All guideline committee members and anyone who has direct input into NICE guidelines (including the evidence review team and expert witnesses) must declare any potential conflicts of interest in line with NICE's code of practice for declaring and dealing with conflicts of interest. Any relevant interests, or changes to interests, will also be declared publicly at the start of each guideline committee meeting. Before each meeting, any potential conflicts of interest will be considered by the guideline committee Chair and a senior member of the development team. Any decisions to exclude a person from all or part of a meeting will be documented. Any changes to a member's declaration of interests will be recorded in the minutes of the meeting. Declarations of interests will be published with the final guideline.		

28.	Collaborators	Development of this systematic review will be overseen by an advisory committee who will use the review to inform the development of evidence-based recommendations in line with section 3 of Developing NICE guidelines: the manual. Members of the guideline committee are available on the NICE website: https://www.nice.org.uk/guidance/indevelopment/gid-ng10175	
29.	Other registration details	N/A	
30.	Reference/URL for published protocol	N/A	
31.	Dissemination plans	NICE may use a range of different methods to raise awareness of the guideline. These include standard approaches such as: • notifying registered stakeholders of publication • publicising the guideline through NICE's newsletter and alerts • issuing a press release or briefing as appropriate, posting news articles on the NICE website, using social media channels, and publicising the guideline within NICE.	
32.	Keywords	Adults; Assessment tools; Diagnostic; Hearing; Intervention; Rehabilitation; Stroke	
33.	Details of existing review of same topic by same authors	N/A	
34.	Current review status	☐	Ongoing
		☐	Completed but not published
		☒	Completed and published
		☐	Completed, published and being updated
		☐	Discontinued
35..	Additional information	N/A	
36.	Details of final publication	www.nice.org.uk	

Review protocol for health economic literature review

Review question	All questions – health economic evidence
Objectives	To identify health economic studies relevant to any of the review questions.
Search criteria	• Populations, interventions and comparators must be as specified in the clinical review protocol above. • Studies must be of a relevant health economic study design (cost–utility analysis, cost-effectiveness analysis, cost–benefit analysis, cost–consequences analysis, comparative cost analysis). • Studies must not be a letter, editorial or commentary, or a review of health economic evaluations. (Recent reviews will be ordered although not reviewed. The bibliographies will be checked for relevant studies, which will then be ordered.) • Unpublished reports will not be considered unless submitted as part of a call for evidence. • Studies must be in English.
Search strategy	A health economic study search will be undertaken using population-specific terms and a health economic study filter – see appendix B below. Databases searched: • Centre for Reviews and Dissemination NHS Economic Evaluations Database (NHS EED) – all years (closed to new records April 2015) • Centre for Reviews and Dissemination Health Technology Assessment database – all years (closed to new records March 2018) • International HTA database (INAHTA) – all years • Medline and Embase – from 2014 (due to NHS EED closure)
Review strategy	Studies not meeting any of the search criteria above will be excluded. Studies published before 2006 (including those included in the previous guideline), abstract-only studies and studies from non-OECD countries or the USA will also be excluded. Each remaining study will be assessed for applicability and methodological limitations using the NICE economic evaluation checklist which can be found in appendix H of Developing NICE guidelines: the manual (2014).[3] Studies published in 2006 or later that were included in the previous guideline will be reassessed for inclusion and may be included or selectively excluded based on their relevance to the questions covered in this update and whether more applicable evidence is also identified. **Inclusion and exclusion criteria** • If a study is rated as both 'Directly applicable' and with 'Minor limitations' then it will be included in the guideline. A health economic evidence table will be completed, and it will be included in the health economic evidence profile. • If a study is rated as either 'Not applicable' or with 'Very serious limitations' then it will usually be excluded from the guideline. If it is excluded, then a health economic evidence table will not be completed and it will not be included in the health economic evidence profile. • If a study is rated as 'Partially applicable', with 'Potentially serious limitations' or both then there is discretion over whether it should be included. **Where there is discretion** The health economist will make a decision based on the relative applicability and quality of the available evidence for that question, in discussion with the guideline committee if required. The ultimate aim is to include health economic studies that are helpful for decision-making in the context of the guideline and the current NHS setting. If several studies are considered of sufficiently high applicability and

	methodological quality that they could all be included, then the health economist, in discussion with the committee if required, may decide to include only the most applicable studies and to selectively exclude the remaining studies. All studies excluded on the basis of applicability or methodological limitations will be listed with explanation in the excluded health economic studies appendix below. The health economist will be guided by the following hierarchies. *Setting:* • UK NHS (most applicable). • OECD countries with predominantly public health insurance systems (for example, France, Germany, Sweden). • OECD countries with predominantly private health insurance systems (for example, Switzerland). • Studies set in non-OECD countries or in the USA will be excluded before being assessed for applicability and methodological limitations. *Health economic study type:* • Cost–utility analysis (most applicable). • Other type of full economic evaluation (cost–benefit analysis, cost-effectiveness analysis, cost–consequences analysis). • Comparative cost analysis. • Non-comparative cost analyses including cost-of-illness studies will be excluded before being assessed for applicability and methodological limitations. *Year of analysis:* • The more recent the study, the more applicable it will be. • Studies published in 2006 or later (including any such studies included in the previous guideline) but that depend on unit costs and resource data entirely or predominantly from before 2006 will be rated as 'Not applicable'. • Studies published before 2006 (including any such studies included in the previous guideline) will be excluded before being assessed for applicability and methodological limitations. *Quality and relevance of effectiveness data used in the health economic analysis:* • The more closely the clinical effectiveness data used in the health economic analysis match with the outcomes of the studies included in the clinical review the more useful the analysis will be for decision-making in the guideline.

Appendix B – Literature search strategies

B.1 Clinical search literature search strategy

Searches were constructed using a PICO framework where population (P) terms were combined with Intervention (I) and in some cases Comparison (C) terms. Outcomes (O) are rarely used in search strategies as these concepts may not be indexed or described in the title or abstract and are therefore difficult to retrieve. Search filters were applied to the search where appropriate.

Table 6: Database parameters, filters and limits applied

Database	Dates searched	Search filter used
Medline (OVID)	1946 – 08 January 2023	Exclusions (animal studies, letters, comments, editorials, case studies/reports) English language
Embase (OVID)	1974 – 08 January 2023	Exclusions (animal studies, letters, comments, editorials, case studies/reports, conference abstracts) English language
The Cochrane Library (Wiley)	Cochrane Reviews to 2023 Issue 1 of 12 CENTRAL to 2023 Issue 1 of 12	Exclusions (clinical trials, conference abstracts)
Epistemonikos (The Epistemonikos Foundation)	Inception – 08 January 2023	Exclusions (Cochrane reviews) English language

Medline (Ovid) search terms

1.	exp Stroke/
2.	Stroke Rehabilitation/
3.	exp Cerebral Hemorrhage/
4.	(stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident").ti,ab.
5.	((cerebro* or brain or brainstem or cerebral*) adj3 (infarct* or accident*)).ti,ab.
6.	"brain attack*".ti,ab.
7.	or/1-6
8.	letter/
9.	editorial/
10.	news/
11.	exp historical article/
12.	Anecdotes as Topic/
13.	comment/
14.	case report/
15.	(letter or comment*).ti.

16.	or/8-15
17.	randomized controlled trial/ or random*.ti,ab.
18.	16 not 17
19.	animals/ not humans/
20.	exp Animals, Laboratory/
21.	exp Animal Experimentation/
22.	exp Models, Animal/
23.	exp Rodentia/
24.	(rat or rats or mouse or mice or rodent*).ti.
25.	or/18-24
26.	7 not 25
27.	limit 26 to English language
28.	Diagnostic Techniques, Otological/
29.	exp hearing tests/
30.	(audiometr* or audiogram*).ti,ab.
31.	((hear or hears or hearing or listen* or audio* or auditory or acoustic* or psychoacoustic* or otolog* or tinnitus or hyperacusis) adj3 (tools or tool or assess* or screen* or question* or test* or measur* or diagnos* or inventory or evaluat* or examin*)).ti,ab.
32.	("Amsterdam Inventory Auditory for Disability" or "Amsterdam Inventory of Auditory Disability" or AIAD or "Amsterdam Inventory for Auditory Disability and Handicap" or AIADH or "Hearing Handicap Inventory for Elderly" or HHIE or "Welch Allyn Audioscope").ti,ab.
33.	(tuning fork adj3 (test* or assess*)).ti,ab.
34.	((Bing or Weber or Rinne or Schwabach) adj5 test*).ti,ab.
35.	or/28-34
36.	27 and 35

Embase (Ovid) search terms

1.	exp Cerebrovascular accident/
2.	exp Brain infarction/
3.	Stroke Rehabilitation/
4.	(stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident").ti,ab.
5.	((cerebro* or brain or brainstem or cerebral*) adj3 (infarct* or accident*)).ti,ab.
6.	"brain attack*".ti,ab.
7.	Intracerebral hemorrhage/
8.	or/1-7
9.	letter.pt. or letter/
10.	note.pt.
11.	editorial.pt.
12.	case report/ or case study/
13.	(letter or comment*).ti.
14.	(conference abstract or conference paper).pt.
15.	or/9-14
16.	randomized controlled trial/ or random*.ti,ab.
17.	15 not 16
18.	animal/ not human/

19.	nonhuman/
20.	exp Animal Experiment/
21.	exp Experimental Animal/
22.	animal model/
23.	exp Rodent/
24.	(rat or rats or mouse or mice or rodent*).ti.
25.	or/17-24
26.	8 not 25
27.	limit 26 to English language
28.	Auditory System Examination/
29.	exp hearing test/
30.	(audiometr* or audiogram*).ti,ab.
31.	((hear or hears or hearing or listen* or audio* or auditory or acoustic* or psychoacoustic* or otolog* or tinnitus or hyperacusis) adj3 (tools or tool or assess* or screen* or question* or test* or measur* or diagnos* or inventory or evaluat* or examin*)).ti,ab.
32.	("Amsterdam Inventory Auditory for Disability" or "Amsterdam Inventory of Auditory Disability" or AIAD or "Amsterdam Inventory for Auditory Disability and Handicap" or AIADH or "Hearing Handicap Inventory for Elderly" or HHIE or "Welch Allyn Audioscope").ti,ab.
33.	(tuning fork adj3 (test* or assess*)).ti,ab.
34.	((Bing or Weber or Rinne or Schwabach) adj5 test*).ti,ab.
35.	or/28-34
36.	27 and 35

Cochrane Library (Wiley) search terms

#1.	MeSH descriptor: [Stroke] explode all trees
#2.	MeSH descriptor: [Stroke Rehabilitation] explode all trees
#3.	MeSH descriptor: [Cerebral Hemorrhage] explode all trees
#4.	(stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident"):ti,ab
#5.	((cerebro* or brain or brainstem or cerebral*) near/3 (infarct* or accident*)):ti,ab
#6.	brain attack*:ti,ab
#7.	(or #1-#6)
#8.	conference:pt or (clinicaltrials or trialsearch):so
#9.	#7 not #8
#10.	MeSH descriptor: [Diagnostic Techniques, Otological] this term only
#11.	MeSH descriptor: [Hearing Tests] explode all trees
#12.	(audiometr* or audiogram*):ti,ab
#13.	((hear or hears or hearing or listen* or audio* or auditory or acoustic* or psychoacoustic* or otolog* or tinnitus or hyperacusis) near/3 (tools or tool or assess* or screen* or question* or test* or measur* or diagnos* or inventory or evaluat* or examin*)):ti,ab
#14.	("Amsterdam Inventory Auditory for Disability" or "Amsterdam Inventory of Auditory Disability" or AIAD or "Amsterdam Inventory for Auditory Disability and Handicap" or AIADH or "Hearing Handicap Inventory for Elderly" or HHIE or "Welch Allyn Audioscope"):ti,ab
#15.	(tuning fork near/3 (test* or assess*)):ti,ab
#16.	((Bing or Weber or Rinne or Schwabach) near/5 test*):ti,ab
#17.	(or #10-#16)

#18.	#9 and #17

Epistemonikos search terms

1.	(title:(tools OR tool OR assess* OR screen* OR question* OR test* OR measur* OR diagnos* OR inventory OR evaluat* OR examin*) OR abstract:(tools OR tool OR assess* OR screen* OR question* OR test* OR measur* OR diagnos* OR inventory OR evaluat* OR examin*)) AND (title:(hear OR hears OR hearing OR listen* OR audio* OR auditory OR acoustic* OR psychoacoustic* OR otolog* OR tinnitus OR hyperacusis) OR abstract:(hear OR hears OR hearing OR listen* OR audio* OR auditory OR acoustic* OR psychoacoustic* OR otolog* OR tinnitus OR hyperacusis)) AND (title:(stroke OR strokes OR cva OR poststroke* OR apoplexy) OR abstract:(stroke OR strokes OR cva OR poststroke* OR apoplexy))

B.2 Health Economics literature search strategy

Health economic evidence was identified by conducting searches using terms for a broad Stroke Rehabilitation population. The following databases were searched: NHS Economic Evaluation Database (NHS EED - this ceased to be updated after 31st March 2015), Health Technology Assessment database (HTA - this ceased to be updated from 31st March 2018) and The International Network of Agencies for Health Technology Assessment (INAHTA). Searches for recent evidence were run on Medline and Embase from 2014 onwards for health economics, and all years for quality-of-life studies. Additional searches were run in CINAHL and PsycInfo looking for health economic evidence.

Table 2: Database parameters, filters and limits applied

Database	Dates searched	Search filters and limits applied
Medline (OVID)	Health Economics 1 January 2014 – 08 January 2023	Health economics studies Quality of life studies Exclusions (animal studies, letters, comments, editorials, case studies/reports,) English language
	Quality of Life 1946 – 08 January 2023	
Embase (OVID)	Health Economics 1 January 2014 – 08 January 2023	Health economics studies Quality of life studies Exclusions (animal studies, letters, comments, editorials, case studies/reports, conference abstracts) English language
	Quality of Life 1974 – 08 January 2023	
NHS Economic Evaluation Database (NHS EED) (Centre for Research and Dissemination - CRD)	Inception –31st March 2015	
Health Technology Assessment Database (HTA) (Centre for Research and Dissemination – CRD)	Inception – 31st March 2018	

Database	Dates searched	Search filters and limits applied
The International Network of Agencies for Health Technology Assessment (INAHTA)	Inception - 08 January 2023	English language
PsycINFO (OVID)	1 January 2014 – 08 January 2023	Health economics studies Exclusions (animal studies, letters, case reports) Human English language
Current Nursing and Allied Health Literature - CINAHL (EBSCO)	1 January 2014 – 08 January 2023	Health economics studies Exclusions (Medline records, animal studies, letters, editorials, comments, theses) Human English language

Medline (Ovid) search terms

1.	exp Stroke/
2.	exp Cerebral Hemorrhage/
3.	(stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident").ti,ab.
4.	((cerebro* or brain or brainstem or cerebral*) adj3 (infarct* or accident*)).ti,ab.
5.	"brain attack*".ti,ab.
6.	or/1-5
7.	letter/
8.	editorial/
9.	news/
10.	exp historical article/
11.	Anecdotes as Topic/
12.	comment/
13.	case report/
14.	(letter or comment*).ti.
15.	or/7-14
16.	randomized controlled trial/ or random*.ti,ab.
17.	15 not 16
18.	animals/ not humans/
19.	exp Animals, Laboratory/
20.	exp Animal Experimentation/
21.	exp Models, Animal/

22.	exp Rodentia/
23.	(rat or rats or mouse or mice or rodent*).ti.
24.	or/17-23
25.	6 not 24
26.	Economics/
27.	Value of life/
28.	exp "Costs and Cost Analysis"/
29.	exp Economics, Hospital/
30.	exp Economics, Medical/
31.	Economics, Nursing/
32.	Economics, Pharmaceutical/
33.	exp "Fees and Charges"/
34.	exp Budgets/
35.	budget*.ti,ab.
36.	cost*.ti.
37.	(economic* or pharmaco?economic*).ti.
38.	(price* or pricing*).ti,ab.
39.	(cost* adj2 (effective* or utilit* or benefit* or minimi* or unit* or estimat* or variable*)).ab.
40.	(financ* or fee or fees).ti,ab.
41.	(value adj2 (money or monetary)).ti,ab.
42.	or/26-41
43.	quality-adjusted life years/
44.	sickness impact profile/
45.	(quality adj2 (wellbeing or well being)).ti,ab.
46.	sickness impact profile.ti,ab.
47.	disability adjusted life.ti,ab.
48.	(qal* or qtime* or qwb* or daly*).ti,ab.
49.	(euroqol* or eq5d* or eq 5*).ti,ab.
50.	(qol* or hql* or hqol* or h qol* or hrqol* or hr qol*).ti,ab.
51.	(health utility* or utility score* or disutilit* or utility value*).ti,ab.
52.	(hui or hui1 or hui2 or hui3).ti,ab.
53.	(health* year* equivalent* or hye or hyes).ti,ab.
54.	discrete choice*.ti,ab.
55.	rosser.ti,ab.
56.	(willingness to pay or time tradeoff or time trade off or tto or standard gamble*).ti,ab.
57.	(sf36* or sf 36* or short form 36* or shortform 36* or shortform36*).ti,ab.
58.	(sf20 or sf 20 or short form 20 or shortform 20 or shortform20).ti,ab.
59.	(sf12* or sf 12* or short form 12* or shortform 12* or shortform12*).ti,ab.
60.	(sf8* or sf 8* or short form 8* or shortform 8* or shortform8*).ti,ab.
61.	(sf6* or sf 6* or short form 6* or shortform 6* or shortform6*).ti,ab.

62.	or/43-61
63.	25 and 42
64.	25 and 62
65.	limit 63 to English language
66.	limit 64 to English language

Embase (Ovid) search terms

1.	exp Cerebrovascular accident/
2.	exp Brain infarction/
3.	(stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident").ti,ab.
4.	((cerebro* or brain or brainstem or cerebral*) adj3 (infarct* or accident*)).ti,ab.
5.	"brain attack*".ti,ab.
6.	Intracerebral hemorrhage/
7.	or/1-6
8.	letter.pt. or letter/
9.	note.pt.
10.	editorial.pt.
11.	case report/ or case study/
12.	(letter or comment*).ti.
13.	or/8-12
14.	randomized controlled trial/ or random*.ti,ab.
15.	13 not 14
16.	animal/ not human/
17.	nonhuman/
18.	exp Animal Experiment/
19.	exp Experimental Animal/
20.	animal model/
21.	exp Rodent/
22.	(rat or rats or mouse or mice).ti.
23.	or/15-22
24.	7 not 23
25.	health economics/
26.	exp economic evaluation/
27.	exp health care cost/
28.	exp fee/
29.	budget/
30.	funding/
31.	budget*.ti,ab.
32.	cost*.ti.
33.	(economic* or pharmaco?economic*).ti.
34.	(price* or pricing*).ti,ab.
35.	(cost* adj2 (effective* or utilit* or benefit* or minimi* or unit* or estimat* or variable*)).ab.

36.	(financ* or fee or fees).ti,ab.
37.	(value adj2 (money or monetary)).ti,ab.
38.	or/25-37
39.	quality adjusted life year/
40.	"quality of life index"/
41.	short form 12/ or short form 20/ or short form 36/ or short form 8/
42.	sickness impact profile/
43.	(quality adj2 (wellbeing or well being)).ti,ab.
44.	sickness impact profile.ti,ab.
45.	disability adjusted life.ti,ab.
46.	(qal* or qtime* or qwb* or daly*).ti,ab.
47.	(euroqol* or eq5d* or eq 5*).ti,ab.
48.	(qol* or hql* or hqol* or h qol* or hrqol* or hr qol*).ti,ab.
49.	(health utility* or utility score* or disutilit* or utility value*).ti,ab.
50.	(hui or hui1 or hui2 or hui3).ti,ab.
51.	(health* year* equivalent* or hye or hyes).ti,ab.
52.	discrete choice*.ti,ab.
53.	rosser.ti,ab.
54.	(willingness to pay or time tradeoff or time trade off or tto or standard gamble*).ti,ab.
55.	(sf36* or sf 36* or short form 36* or shortform 36* or shortform36*).ti,ab.
56.	(sf20 or sf 20 or short form 20 or shortform 20 or shortform20).ti,ab.
57.	(sf12* or sf 12* or short form 12* or shortform 12* or shortform12*).ti,ab.
58.	(sf8* or sf 8* or short form 8* or shortform 8* or shortform8*).ti,ab.
59.	(sf6* or sf 6* or short form 6* or shortform 6* or shortform6*).ti,ab.
60.	or/39-59
61.	limit 24 to English language
62.	38 and 61
63.	60 and 61

NHS EED and HTA (CRD) search terms

#1.	MeSH DESCRIPTOR Stroke EXPLODE ALL TREES
#2.	MeSH DESCRIPTOR Cerebral Hemorrhage EXPLODE ALL TREES
#3.	(stroke* or cva or poststroke* or apoplexy or "cerebrovascular accident")
#4.	(((cerebro* or brain or brainstem or cerebral*) adj3 (infarct* or accident*)))
#5.	("brain attack*")
#6.	#1 OR #2 OR #3 OR #4 OR #5

INAHTA search terms

1.	(brain attack*) OR (((cerebro* or brain or brainstem or cerebral*) and (infarct* or accident*))) OR ((stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident")) OR ("Cerebral Hemorrhage"[mhe]) OR ("Stroke"[mhe])

CINAHL search terms

1.	MH "Economics+"
2.	MH "Financial Management+"
3.	MH "Financial Support+"

4.	MH "Financing, Organized+"
5.	MH "Business+"
6.	S2 OR S3 or S4 OR S5
7.	S1 not S6
8.	MH "Health Resource Allocation"
9.	MH "Health Resource Utilization"
10.	S8 OR S9
11.	S7 OR S10
12.	(cost or costs or economic* or pharmacoeconomic* or price* or pricing*) OR AB (cost or costs or economic* or pharmacoeconomic* or price* or pricing*)
13.	S11 OR S12
14.	PT editorial
15.	PT letter
16.	PT commentary
17.	S14 or S15 or S16
18.	S13 NOT S17
19.	MH "Animal Studies"
20.	(ZT "doctoral dissertation") or (ZT "masters thesis")
21.	S18 NOT (S19 OR S20)
22.	PY 2014-
23.	S21 AND S22
24.	MW Stroke or MH Cerebral Hemorrhage
25.	stroke* or cva or poststroke* or apoplexy or "cerebrovascular accident"
26.	(cerebro* OR brain OR brainstem OR cerebral*) AND (infarct* OR accident*)
27.	"brain attack*"
28.	S24 OR S25 OR S26 OR S27
29.	S23 AND S28

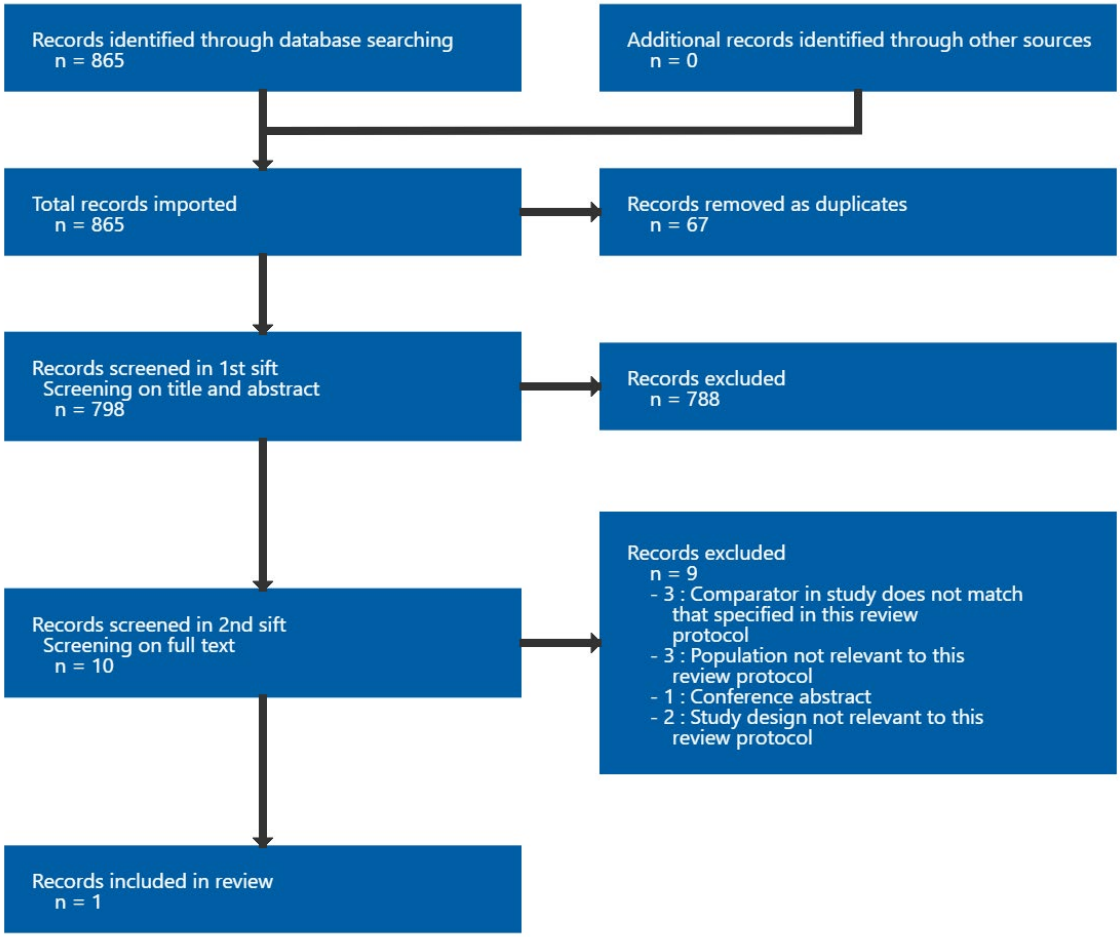
PsycINFO search terms

1.	exp Stroke/
2.	exp Cerebral hemorrhage/
3.	(stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident").ti,ab.
4.	((cerebro* or brain or brainstem or cerebral*) adj3 (infarct* or accident*)).ti,ab.
5.	"brain attack*".ti,ab.
6.	Cerebrovascular accidents/
7.	exp Brain damage/
8.	(brain adj2 injur*).ti.
9.	or/1-8
10.	Letter/
11.	Case report/
12.	exp Rodents/
13.	or/10-12
14.	9 not 13

15.	limit 14 to (human and english language)
16.	First posting.ps.
17.	15 and 16
18.	15 or 17
19	"costs and cost analysis"/
20.	"Cost Containment"/
21.	(economic adj2 evaluation$).ti,ab.
22.	(economic adj2 analy$).ti,ab.
23.	(economic adj2 (study or studies)).ti,ab.
24.	(cost adj2 evaluation$).ti,ab.
25.	(cost adj2 analy$).ti,ab.
26.	(cost adj2 (study or studies)).ti,ab.
27.	(cost adj2 effective$).ti,ab.
28.	(cost adj2 benefit$).ti,ab.
29.	(cost adj2 utili$).ti,ab.
30.	(cost adj2 minimi$).ti,ab.
31.	(cost adj2 consequence$).ti,ab.
32.	(cost adj2 comparison$).ti,ab.
33.	(cost adj2 identificat$).ti,ab.
34.	(pharmacoeconomic$ or pharmaco-economic$).ti,ab.
35.	or/19-34
36.	(0003-4819 or 0003-9926 or 0959-8146 or 0098-7484 or 0140-6736 or 0028-4793 or 1469-493X).is.
37.	35 not 36
38.	18 and 37

Appendix C –Diagnostic evidence study selection

Figure 1: Flow chart of clinical study selection for the review of the optimal tool for the assessment of hearing



Appendix D –Diagnostic evidence

Reference	**Koohi 2019[2]**
Study type	Prospective diagnostic accuracy study
Study methodology	Data source: People recruited to the department of Neuro-otology at NHNN Queen Square London Recruitment: Stroke patients recruited and tested at the department of Neuro-otology, NHNN Queen Square London, within 3-12 months post-onset stroke
Number of patients	n = 42
Patient characteristics	Age, mean (SD): 58.2 (15.1) years Gender (male to female ratio): 33:9 Ethnicity: Not stated/unclear Type of stroke: Ischaemic cortical = 18 Ischaemic subcortical = 6 Ischaemic cortical/subcortical = 6 Ischaemic subcortical/brainstem = 2 Ischaemic brainstem = 5 Haemorrhagic cortical = 1 Haemorrhagic subcortical = 1 Haemorrhagic brainstem = 3 Side of stroke: Right = 22 Left = 18 Both = 2 Days since stroke, mean (SD): 171.9 (76.4) days

Reference	Koohi 2019[2]
	Setting: Outpatient follow up Country: United Kingdom Inclusion criteria: Age between 18 and 80 years; clinical history of stroke verified by magnetic resonance imaging (MRI) of the brain. Exclusion criteria: Severe aphasia; cognitive impairment as shown on the MoCA with a score <25; significant psychiatric illnesses; other neurological disorders (Except stroke); severe concurrent medical illnesses.
Target condition(s)	Peripheral and central auditory disorders for people after stroke
Index test(s) and reference standard	Index tests [Insert details of the index test, including cut-off levels (describe how determined) for a positive test if relevant] Handheld hearing screener A handheld hearing screener (ROTO, Otovation) for determination of peripheral audiometry hearing loss. Failure at one of the measured frequencies (pure-tones at 25 dB at the frequencies of 1000, 2000 and 4000 Hz) would be considered to indicate hearing problems. Passing all frequencies in both ears would indicate no hearing problems. Handicap Hearing Inventory in the Elderly A self-assessment questionnaire of hearing problems comprising 25 items. Of them, 13 deal with emotional aspects and 12 deal with social and situational aspects. For each item or situation, subjects are asked to give one of the following response: “yes” (4 points); “sometimes” (2 points), or “no” (0 points). Scores for the total scale range from 0, suggesting no perceived problems, to 100, indicating significant perceived problems. Compared against two different definitions of hearing loss: a) the criteria of Ventry and Weinstein; patients considered having hearing impairment if they had a loss at 40 dB for either the 1000 or 2000 Hz frequencies in both ears of they had a 40 dB loss of 1000 or 2000 Hz frequencies in one ear. b) Average hearing loss at 1000, 2000 and 4000 Hz was at least 25 dB in the better ear. If the total score was at least 16, then no hearing disability was identified; if the total score was 17 or more, the subject was considered to have a hearing disability. Amsterdam Inventory Auditory of Disability A 28 question questionnaire that assesses auditory disability in five key domains: intelligibility of speech in noise; intelligibility of speech in quiet; auditory localisation; recognition of sound; detection of sound. The inventory was designed to identify factors related to hearing disability that affected the individual in daily life and to assess the impact the disability had on quality of life. The response scale consists

Reference	Koohi 2019[2]				
	of “almost always” (3 points), “frequently” (2 points), “occasionally” (1 point) and “almost never” (0 points). A lower score indicated a greater problems; a score of 84 corresponds to no hearing problems. Hearing disability was defined by the criteria of Meijer et al. Pass was defined as Amsterdam Inventory Auditory of Disability scores ranging from 64 to 84 (no disability) and fail was defined as a total score of <64. Combined handheld hearing screener and Amsterdam Inventory Auditory of Disability Details For those with CAPD, auditory disability was defined according to the criteria of departmental normative data for CAPD in conjunction with Barniou’s studies in CAPD and stroke patients: fail if the total score of the AIAD was at least 58 or if the total score of the AIAD was >58 but the localisation subscore was at least 10 and/or the speech in noise sub-score was at least 7 AND pass hearing screener. <u>Reference standard</u> Pure-tone audiometry. Threshold assessment made at 250, 500, 1000, 2000, 4000, 6000 and 7000 Hz and a pure-tone audiometry average was calculated. The severity of hearing loss was determined using the British Society of Audiology audiometric descriptors. Also, high frequency hearing loss was defined as the air-conduction average of frequencies 4, 6 and 8kHz exceeding 20 dB hearing loss. Mild hearing loss was defined as PTA at least 20 and no more than 40 dB hearing loss, moderate 41-70 dB hearing loss, severe 71-95 hearing loss and profound >95 dB hearing loss. The peripheral hearing loss was defined as a) “cochlear type” hearing loss: abnormal pure-tone average, reduced or absent Transient-evoke otoacoustic emission, present and normal acoustic reflex threshold, and normal auditory brainstem response or normal interwave interval auditory brainstems response; b) “neural type” hearing loss, that is, consistent with VIIIth nerve damage: normal or raised PTA average, normal TEOAEs, or delayed I-III or I-V interwave interval or absent wave I (Showing the damage to the distal portion of the auditory nerve) and/or abnormal ART with inverted or vertical pattern. Time between measurement of index test and reference standard: On the same day (the reference standard was conducted last).				
2×2 table		Reference standard +	Reference standard −	Total	
	Handheld hearing screener +	25	0	25	
	Handheld hearing screener −	11	6	17	
	Total	36	6	42	

Reference	**Koohi 2019[2]**				
	HHIE +	16	0	16	
	HHIE -	20	6	26	
	Total	36	6	42	
	AIAD +	12	0	12	
	AIAD -	24	6	30	
	Total	36	6	42	
	Combined handheld screener and AIAD +	Cannot extract this information from the study (does not report the results for the localization subscore of AIAD)	Cannot extract this information from the study (does not report the results for the localization subscore of AIAD)	-	
	Combined handheld screener and AIAD -	Cannot extract this information from the study (does not report the results for the localization subscore of AIAD)	Cannot extract this information from the study (does not report the results for the localization subscore of AIAD)	-	
	Total	-	-	-	
Statistical measures	Index text: Handheld hearing screener using the ASHA protocol (*considering only people with peripheral hearing loss as a component of their hearing loss) Sensitivity (95% CI): 92.59 (75.71-99.09) Specificity (95% CI): 100.00 (78.20-100.00) PPV (95% CI): 100.00 (86.28-100.00) NPV (95% CI): 88.24 (63.56-98.54) Index text: HHIE Sensitivity (95% CI): 44.44 (27.94-61.90) Specificity (95% CI): 100.00 (54.07-100.00) PPV (95% CI): 100.00 (79.41-100.00) NPV (95% CI): 23.08 (8.97-43.65) Index text: AIAD Sensitivity (95% CI): 36.11 (20.82-53.78)				

Reference	Koohi 2019[2]
	Specificity (95% CI): 100.00 (54.07-100.00) PPV (95% CI): 100.00 (75.29-100.00) NPV (95% CI): 20.69 (7.99-39.72) Index text: Handheld hearing screener and AIAD Sensitivity (95% CI): 50.00 (15.70-84.30) Specificity (95% CI): 88.89 (51.75-99.72) PPV (95% CI): 80.00 (28.36-99.49) NPV (95% CI): 66.67 (34.89-90.08)
Source of funding	This study was funded by the British Medical Association Helen Lawson grant.
Limitations	Risk of bias: None Indirectness: Serious (due to population indirectness as people with aphasia and cognitive difficulties were excluded from the protocol. This population is important for this review, as effective identification and management of hearing problems can help to remove barriers to receiving care and improve outcome. Therefore, it would be important to not exclude this population)
Comments	When testing the handheld hearing screener only cases where peripheral hearing loss was a component of the hearing loss (therefore either peripheral or mixed hearing loss) were included in the calculation of parameters in the study. In this review we did not stratify by type of hearing loss. Therefore, we have used the data provided to calculate parameters for all types of hearing loss. The value of the tool in peripheral hearing loss was reported to the committee for their consideration.

Appendix E – Forest plots

E.1 Coupled sensitivity and specificity forest plots

Figure 2: Sensitivity and specificity of index text handheld hearing screener for people with hearing loss after stroke

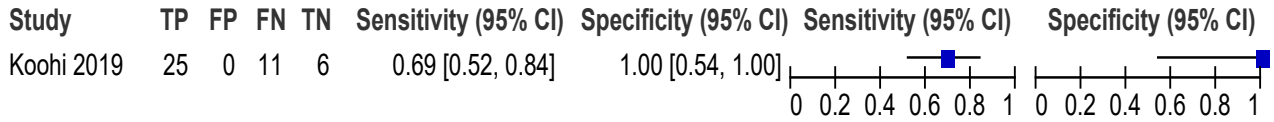


Figure 3: Sensitivity and specificity of index text Handicap Hearing Inventory in the Elderly for people with hearing loss after stroke

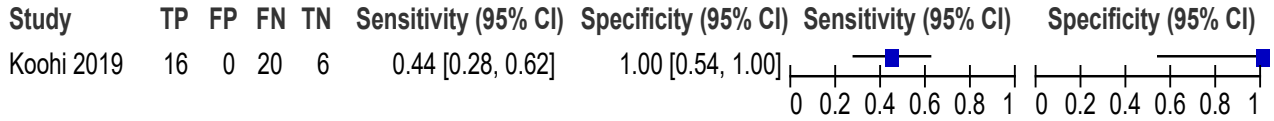
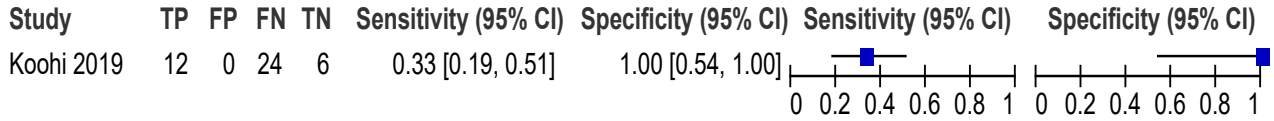


Figure 4: Sensitivity and specificity of index text Amsterdam Inventory Auditory of Disability for people with hearing loss after stroke



A forest plot could not be generated for the index test of a combination of the handheld hearing screener and the Amsterdam Inventory Auditory of Disability questionnaire as raw data to calculate the parameters was not reported.

E.2 ROC curves

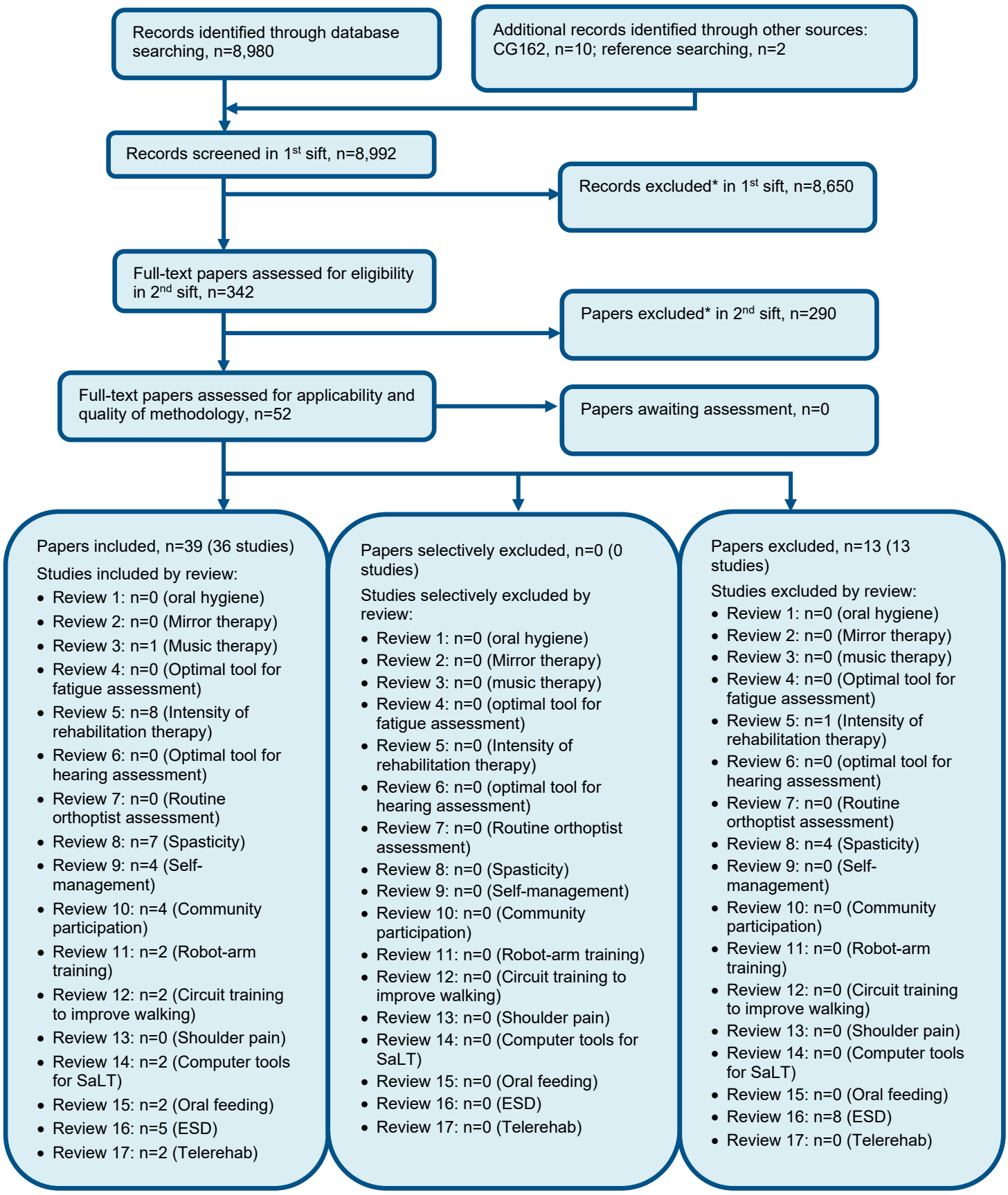
Meta-analysis was not possible due to insufficient data. Therefore, ROC curves have not been produced.

E.3 Area under the curve

No additional data reported.

Appendix F – Economic evidence study selection

Figure 5: Flow chart of health economic study selection for the guideline



* Non-relevant population, intervention, comparison, design or setting; non-English language

Appendix G – Economic evidence tables

There are no included health economic studies in this review.

Appendix H – Health economic model

New cost-effectiveness analysis was not conducted in this area.

Appendix I – Excluded studies

Clinical studies

Table 7: Studies excluded from the clinical review

Study	Code [Reason]
Bamiou, D. E., Werring, D., Cox, K. et al. (2012) Patient-reported auditory functions after stroke of the central auditory pathway. Stroke 43(5): 1285-9	- Population not relevant to this review protocol
Campbell, P.; Pollock, A.; Brady, M. (2014) Should hearing be screened in the first 30 days after an acute stroke? A systematic review. International Journal of Stroke 9(campbellppollockabradymnmahpresearchunitglasgowcaledonianuniversityglasgowunitedkingdom): 38	- Conference abstract
Formby, C.; Phillips, D. E.; Thomas, R. G. (1987) Hearing loss among stroke patients. Ear & Hearing 8(6): 326-32	- Study design not relevant to this review protocol *Non-comparative study investigating the use of pure tone audiometry only*
Graves, D. (1995) Is hearing screening needed for all admissions to a stroke rehabilitation unit?. Perspectives 19(2): 9-14	- Study design not relevant to this review protocol *Retrospective analysis of people who passed and failed hearing tests identifying the types of hearing loss, not investigating*

Study	Code [Reason]
	diagnostic accuracy
Koohi, N., Vickers, D. A., Lakshmanan, R. et al. (2017) Hearing Characteristics of Stroke Patients: Prevalence and Characteristics of Hearing Impairment and Auditory Processing Disorders in Stroke Patients. Journal of the American Academy of Audiology 28(6): 491-505	- Comparator in study does not match that specified in this review protocol
Koohi, N., Vickers, D., Chandrashekar, H. et al. (2017) Auditory rehabilitation after stroke: treatment of auditory processing disorders in stroke patients with personal frequency-modulated (FM) systems. Disability & Rehabilitation 39(6): 586-593	- Comparator in study does not match that specified in this review protocol
Nosrati-Zarenoe, R.; Hansson, M.; Hultcrantz, E. (2010) Assessment of diagnostic approaches to idiopathic sudden sensorineural hearing loss and their influence on treatment and outcome. Acta Oto-Laryngologica 130(3): 384-91	- Population not relevant to this review protocol
Onoue, S. S., Ortiz, K. Z., Minett, T. S. et al. (2014) Audiological findings in aphasic patients after stroke. Einstein 12(4): 433-9	- Comparator in study does not match that specified in this review protocol
Wall, K. J.; Cumming, T. B.; Copland, D. A. (2017) Determining the Association between Language and Cognitive Tests in Poststroke Aphasia. Frontiers in neurology [electronic resource]. 8: 149	- Population not relevant to this review protocol

Health Economic studies

Published health economic studies that met the inclusion criteria (relevant population, comparators, economic study design, published 2006 or later and not from non-OECD country or USA) but that were excluded following appraisal of applicability and methodological quality are listed below. See the health economic protocol for more details.

Table 8: Studies excluded from the health economic review

Reference	Reason for exclusion
None.	

Appendix J – Research recommendations – full details

J.1 Research recommendation

What is the clinical and cost-effectiveness, and the diagnostic test accuracy, of using handheld hearing screeners to assess hearing in people after stroke?

J.1.1 Why this is important

Hearing problems are thought to be a common occurrence after stroke. These problems may be identified by the person, their family members and/or carers and healthcare professionals. However, some problems may not be identified for an extended period of time and may have effects on the person's ability to engage with rehabilitation. Hearing problems may be factors contributing to problems with communication and cognition and so identifying problems in these populations is of particular importance. Currently there is limited evidence discussing the use of different hearing screening tools, with the study identified in this review being conducted in a limited population of people who were already believed to be at high risk of hearing problems. Handheld hearing screeners were investigated and showed positive results but given the potential costs of the intervention and the limitations identified, further evidence was required before the committee could recommend their use. A study investigating the use of handheld hearing screeners for people after stroke would be useful to know what the most effective tool is to identify hearing problems and the clinical and cost-effectiveness of these strategies.

J.1.2 Rationale for research recommendation

Importance to 'patients' or the population	Hearing problems are thought to be a common occurrence after stroke, which can affect the person's ability to engage with rehabilitation. This can lead to delayed recovery which can reduce health-related quality of life. These problems may be factors that contribute to problems with communication and cognition and so if identified may help to reduce these problems.
Relevance to NICE guidance	This evidence included in this review was very limited. The review identified one study investigating the diagnostic accuracy of different tools for assessing hearing problems. No evidence was identified using test-and-treat randomised controlled trials. Evidence discussing the clinical and cost-effectiveness would be important for gaining a more complete evaluation of the different tools in particular handheld hearing screeners. Cost-effectiveness information, in particular with tools currently available to the NHS, would be useful to understand whether this is tool that would be useful to recommend in the future.
Relevance to the NHS	Hearing problems may affect a person's ability to engage with rehabilitation that may lead to them requiring more support in the future. Handheld hearing screeners would incur additional costs to purchase and provide to staff, as well as training costs to ensure staff could use and interpret the results effectively.

	Therefore, understanding the clinical and cost-effectiveness would be important to ensure that they can be recommended with full understanding of the implications of their use.
National priorities	Developing high intensity care models for stroke rehabilitation is an aim in the NHS Long Term Plan. Identifying hearing problems effectively may aid delivery of high intensity rehabilitation.
Current evidence base	This review identified one diagnostic accuracy study investigating the use of different hearing screening tools. No test-and-treat randomised control trials were identified. Additional research may be important for gaining a more complete understanding of the topic.
Equality considerations	People with communication and cognitive difficulties were excluded from the included study, which given the potential impacts from identifying and correcting hearing problems would be more significant for this population, makes it harder to assess the benefits of the tools. Including people from these populations would be important for gaining a more complete understanding of the effectiveness of the tools.

J.1.3 Modified PICO table

Population	Inclusion: • Adults (age ≥16 years) who have had a first or recurrent stroke (including people after subarachnoid haemorrhage) ○ This should include people with communication difficulties and people with cognitive difficulties Exclusion: • Children (age <16 years) • People who have had a transient ischaemic attack
Intervention	Handheld hearing screeners (currently available in the NHS) and asking the person after stroke and their family member and/or carers
Comparator	Usual care (hearing questionnaires, such as the Handicap Hearing Inventory in the Elderly or Amsterdam Inventory of Disability and asking the person after stroke and their family member and/or carers)
Outcome	Diagnostic test-and-treat outcomes: At time period • <1 year • ≥1 year

	• Person/participant generic health-related quality of life (continuous outcomes will be prioritised)
	• Carer generic health-related quality of life (continuous outcomes will be prioritised)
	• Activities of daily living (continuous outcomes will be prioritised)
	• Participation in leisure activities/social groups scores (continuous outcomes will be prioritised)
	• Psychological distress (continuous outcomes will be prioritised)
	  ○ Depression
	  ○ Anxiety
	  ○ Distress
	• Stroke-related scales of cognition (continuous outcomes will be prioritised) (including non-spatial attention and working memory, spatial attention, memory and executive function scores)
	• Speech perception (continuous outcomes will be prioritised)
	• Functional communication (continuous outcomes will be prioritised)
	• Stroke-specific Patient-Reported Outcome Measures (continuous outcomes will be prioritised)
	• Withdrawal due to adverse events (dichotomous outcome)

Study design	Randomised controlled trial (test-and-treat randomised controlled trial)
Timeframe	Long term (at least 1 year)
Additional information	Subgroups that will be investigated if heterogeneity is present: Time after stroke when performing test • Hyperacute <72 hours • Acute 72 hours – 7 days • Subacute 7 days – 6 months • Chronic >6 months Presence of communication difficulties • Communication difficulties present • Communication difficulties not present • Mixed People who are bi/multilingual (capable of speaking and understanding at least two different languages) • People who are bi/multilingual • People who are not bi/multilingual

J.2 Research recommendation

What is the prevalence of hearing problems after stroke?

J.2.1 Why this is important

Hearing problems are thought to be a common occurrence after stroke. When completing this review, limited information was available discussing the prevalence of hearing problems after stroke. In addition, information available indicated that hearing problems may be present early after stroke but may resolve spontaneously and be less common in the chronic period after stroke. Given the limited information available in this area, it is difficult to understand the effect hearing problems have after stroke. Additional prevalence information at different time periods after stroke would be useful for gaining a greater understanding of the problem, allowing for more accurate recommendations in the future.

J.2.2 Rationale for research recommendation

Importance to 'patients' or the population	Hearing problems are potentially a common occurrence after stroke, which can affect the person's ability to engage with rehabilitation. This can lead to delayed recovery which can reduce health-related quality of life. These problems may be factors that contribute to problems with communication and cognition and so if identified may help to reduce these problems. Gaining a more substantial understanding of who is affected by hearing problems can allow treatments to be better tailored to people after stroke.
Relevance to NICE guidance	Limited information is available discussing the prevalence of hearing problems after stroke. Additional information will help to understand the size of the problem and better inform health economic work and consideration of resource impact in the future.
Relevance to the NHS	Hearing problems may affect a person's ability to engage with rehabilitation that may lead to them requiring more support in the future. Hearing screening may require additional staff time to complete. Gaining a more detailed understanding of the prevalence at different time points after stroke can allow a better understanding of how important hearing screening can be to better inform economic work in the area.
National priorities	None.
Current evidence base	Limited evidence on prevalence of stroke was identified during this review. Evidence investigated specific types of hearing problems at specific time periods and so gave varied answers. Gaining answers about the prevalence at different time periods would be relevant to giving more detailed information.
Equality considerations	No specific equality considerations were identified.

J.2.3 Modified PEO table

Population	Inclusion: • Adults (age ≥16 years) who have had a first or recurrent stroke (including people after subarachnoid haemorrhage) Exclusion: • Children (age <16 years) • People who have had a transient ischaemic attack
Exposure	Time period after stroke: • Acute 72 hours – 7 days • Subacute 7 days – 6 months • Chronic >6 months
Outcome	At time period • Overall presence of hearing problems • Presence of sensorineural hearing problems • Presence of conductive hearing problems • Presence of mixed hearing problems
Study design	Cross-sectional study
Timeframe	7 days, 6 months and 1 year (1 time point for each time period after stroke)
Additional information	No additional information