Evaluating speech outcomes assessed in paediatric NAL and DSL research: a scoping review

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Introduction:

Audibility is an underpinning principle of audiological rehabilitation as improved audibility results in better speech and language outcomes (Tomblin et al., 2015b). Hearing aid prescriptions contribute to audibility, as they prescribe gain targets across a frequency range (Ching et al., 2017).

NAL and DSL are the most common prescriptions used, aiming to prescribe a comfortable level of sound whilst maximising speech performance (Seewald et al., 2005). Although their goals are alike different approaches are adopted:

- **NAL** prioritises speech intelligibility whilst avoiding loudness discomfort by prescribing more gain in low and high frequencies relative to mid frequencies (Keidser et al., 2012).
- **DSL** prescribes increased gain at mid and low frequencies aiming to normalise loudness and maintain audibility of quieter sounds as they assume this supports paediatric speech outcomes (Seewald et al., 2005).

Guidelines recommend the use of either NAL-NL2 or DSLv5 for paediatric patients.(Notably, DSLv5 is the most recent iteration from DSL but NAL-NL2 is not the latest formula from NAL. However, NAL NL3 does not have current widespread clinical implementation) therefore, this review adopts a pragmatic approach considering NAL-NL2 and DSLv5 as the most recent clinically relevant prescriptions)

Current literature:
Extensively reviews how speech outcomes are affected by NAL and DSL but it overlooks **what outcomes have been assessed or evaluating the rationale for their selection.** Consequently, there is a need to understand and critically evaluate why different speech outcomes are chosen. Addressing this gap will allow the suitability and relevance of the evidence to be determined relative to guidelines.

Objectives:
1.To identify the nature and extent of research investigating how NAL and DSL impact speech outcomes in paediatric populations.

2.To compare studies investigating the effects of NAL and DSL on speech in children with hearing loss.

3.To critically evaluate why different outcomes are tested; assessing their suitability and relevance.

Methods:

Study design

A scoping review was conducted based on the Arksey and O'Malley (2005) framework and was reported according to the PRISMA–ScR guidelines (PRISMA, 2018).

Search strategy

Search terms: paediatric, pediatric (American spelling included to widen the scope of research), children, NAL, DSL, NAL-NL2, DSLv5, speech intelligibility, speech, PEACH, loudness, audibility. These were used in combination with the Boolean operators OR and AND to search Embase, MEDLINE, CINAHL and the Cochrane library. Google scholar was used to search for grey literature.

Eligibility

Inclusion criteria:

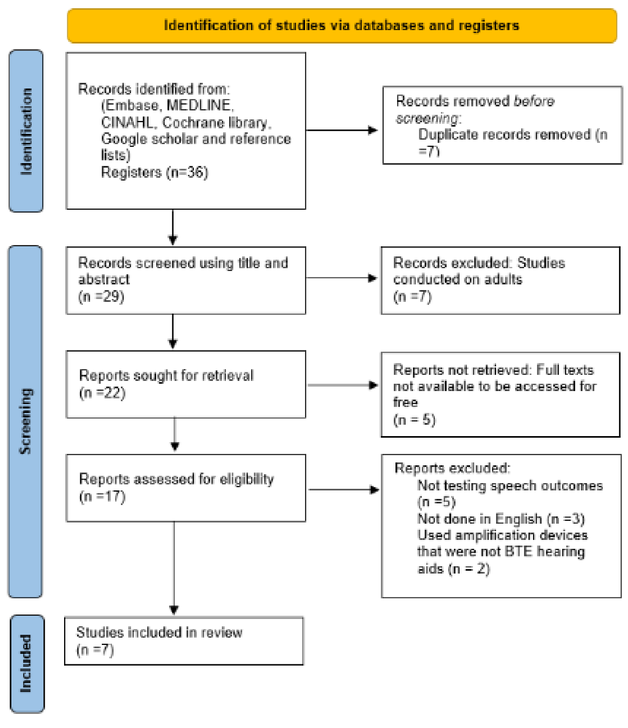
- Nonlinear prescriptions such as NAL NL2
- Participants ≤19 years
- Mild to severe hearing loss
- REM targets met within a mean value of ± 5 dB
- Free access
- English studies
- Assessed speech outcomes whether predicted or directly measured

Exclusion Criteria:

- Linear prescriptions such as NAL R
- Participants used hearing aids other than BTE aids
- Adult participants
- REM targets not met
- Not conducted in English
- Assessed outcomes other than speech .

Study selection and appraisal:

Eligibility was determined by screening titles and abstracts before reviewing the full texts. Studies were excluded based on the exclusion criteria or if they were duplicates. Although Arksey and O'Malley's (2005) framework does not require critical appraisal, it was deemed appropriate to identify the quality of the research to allow for study comparison. Critical appraisals were conducted using the CASP checklists



Speech outcome categories

Speech can be considered a multidimensional construct made up of receptive and expressive language processes interacting to shape communication and psychosocial outcomes. Successful speech and language outcomes are dependent on contextual factors, audibility and the individual listener, this review explores speech outcomes in **three distinct, interrelated categories:**

- **Primary speech and language outcomes (PSLO)**
  Reflect features such as speech production and recognition representing core speech performance goals for each prescription (Vance et al., 2009).

- **Psychoacoustic and predicted outcomes**
  Highlight aspects of auditory experience that may not be directly observed by testing PSLO. Predicted outcomes model theoretically accessible speech, Psychoacoustic outcomes use a combination of theoretical and behavioural measures to facilitate a nuanced understanding of attributes influencing speech, such as loudness and temporal resolution (Rossing, 2014).

- **Functional outcomes**
  Reflect communication ability, enabling an understanding of how controlled laboratory results translate into real world environments (Bagatto et al., 2011).

Results:

- The most recent and clinically relevant prescriptions are NAL-NL2 and DSLv5;, heterogeneity within prescription comparisons limits direct comparisons.
- . The impact of NAL and DSL on paediatric speech outcomes has been researched using a variety of study designs, measures and participant characteristics.
- The evidence base is characterised by RCTs, particularly from the LOCHI study (Ching et al., 2012; Ching et al., 2013; Ching et al., 2017).
- They are supported by smaller experimental and crossover studies providing moderate quality evidence through within subject comparisons of prescriptions (Ching et al., 2010; Marriage et al., 2018; Pittman and Stewart, 2023; Scollie et al., 2010).

Key findings:

1. Studies focusing on PSLO preferred DSL for lower input levels but overall, there was no significant differences between prescriptions.
2. Psychoacoustic and predicted outcomes reflected that DSL had better results overall for predicted speech intelligibility and loudness, but loudness differences were insignificant after acclimatisation.
3. Functional outcomes highlighted that both prescriptions led to similar positive results and differences were found depending on individual preference and contextual settings.
4. Findings across different speech outcomes are usually consistent, but in some instances, there are discrepancies,highlighting the need for multidimensional assessment methods that capture theoretical lab controlled and behavioural outcomes

Conclusion:

Ultimately, to provide a holistic understanding of each prescriptions effectiveness all three outcome categories are necessary and must be considered. By integrating a range of speech outcomes researchers and clinicians can appreciate the multi-layered nature of speech processing in children with hearing loss. This integrated approach supports more informed clinical decisions, thus allowing progression towards creating a standardised framework for assessing future prescriptions in relation to paediatric audiological rehabilitation. (Connor, 2023).

Key Message:
Speech is a complex construct and the impact of prescriptions on speech should be researched using a multimodal approach to provide a comprehensive evaluation of a prescription

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