Hearing Thresholds, Speech Recognition, and Audibility as Indicators for Modifying Intervention in Children with Hearing Aids

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Disclosures

- Salary and funding from Boys Town National Research Hospital
- Funding from NIH-NIDCD, Sonova, ASHFoundation
- Travel funding for this conference

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Learner outcomes



Discuss how audiologic assessment and measures of auditory experience can be used to inform changes in intervention for children who are hard of hearing.



Identify the levels of auditory access that is needed to support spoken language development for children who are hard of hearing.



Define auditory dosage.

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Goal: optimize audibility

Audibility = access to speech sounds

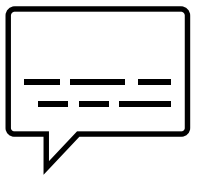
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Reduced audibility is associated with poorer outcomes in children who are hard of hearing

↓ Aided audibility



↓ Spoken communication



Reduced audibility is associated with poorer outcomes in children who are hard of hearing

Speech perception in quiet

Davidson & Skinner 2006
McCreery et al. 2015
Scollie 2008

Vocabulary

Stiles et al. 2012
Walker et al. 2018

Auditory skills

McCreery et al., 2015

Speech perception in noise

Brennan et al. 2021
McCreery et al. 2015
Nickerson et al. 2019

Global speech and language

Tomblin et al. 2015
Tomblin et al. 2014

Does a child have enough audibility to support development of language?

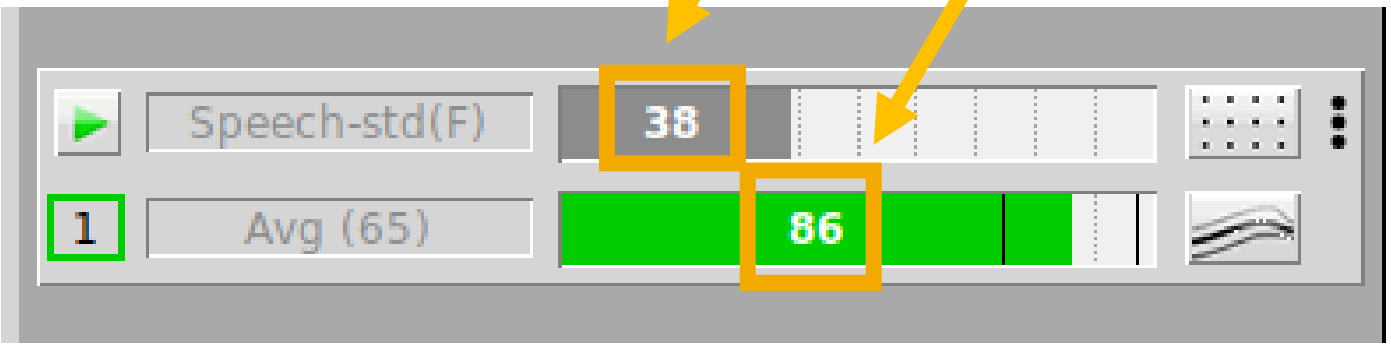
Speech Intelligibility Index (SII)

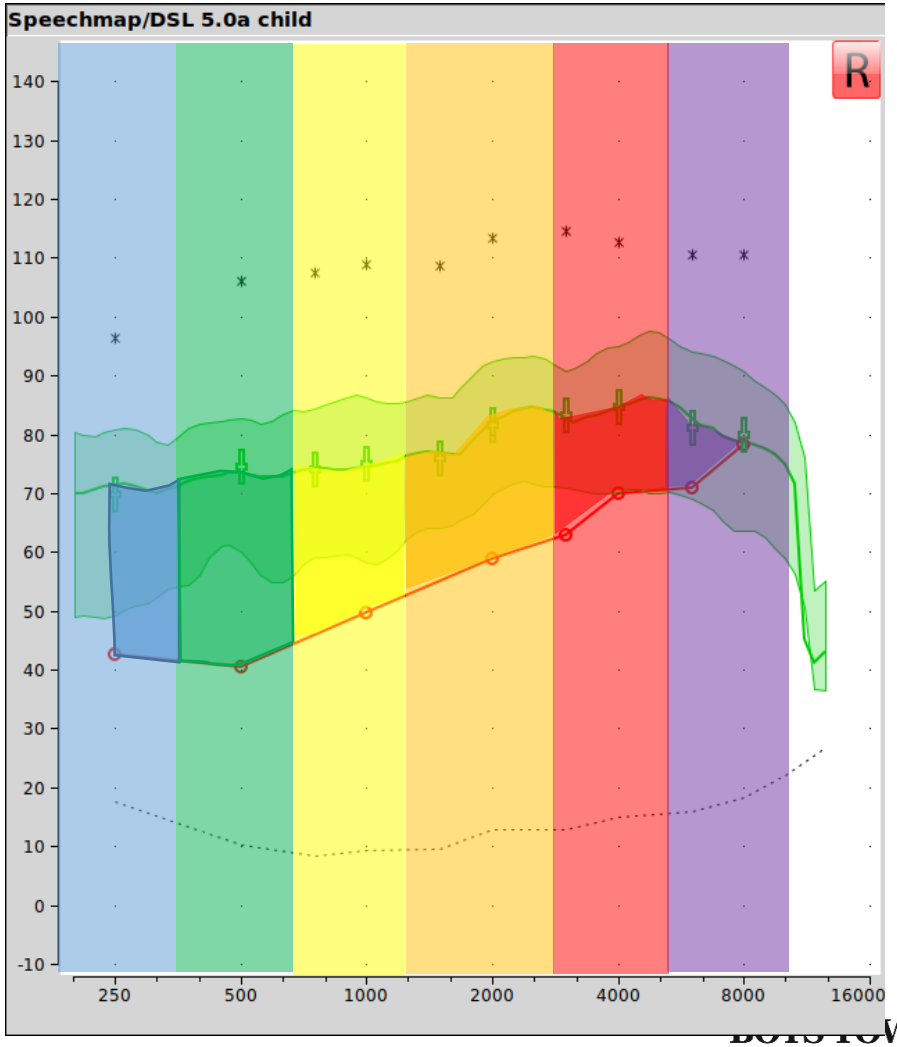
Percentage of audible speech weighted by importance of frequency region

Unaided SII

Aided SII

0% = completely inaudible
100% = completely audible





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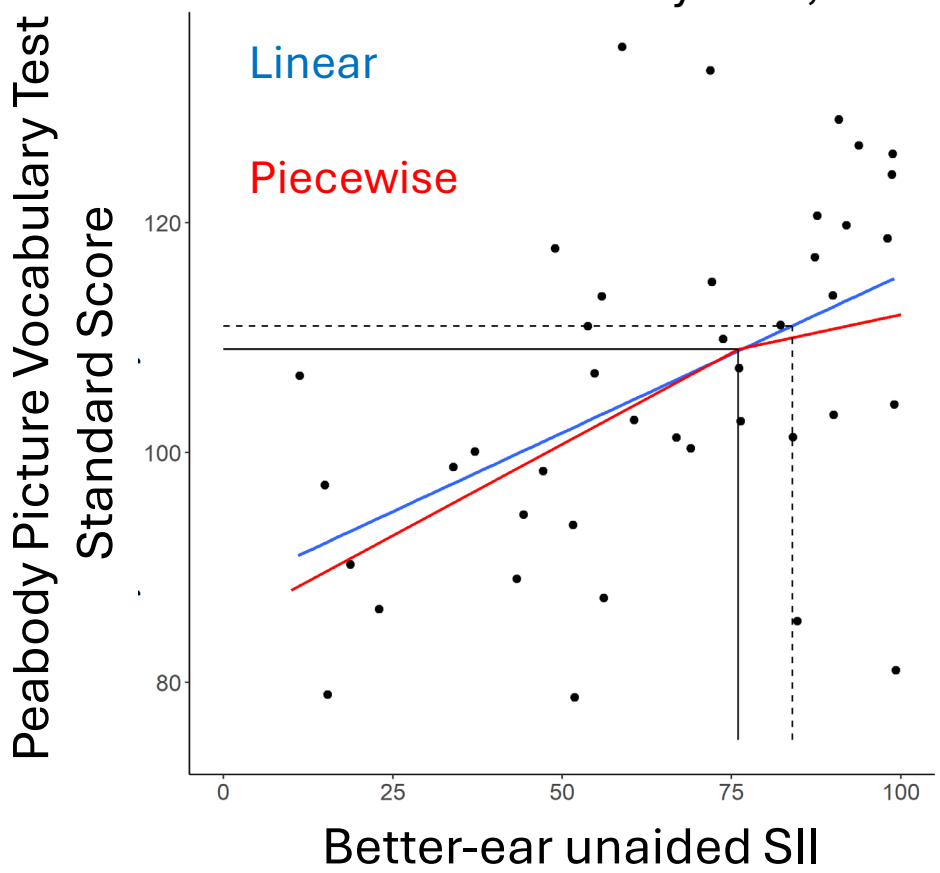
Does a child have appropriate audibility without hearing technology?

Unaided SII

Mild/minimal hearing loss

Unaided SII < 80

McCreery et al., 2020

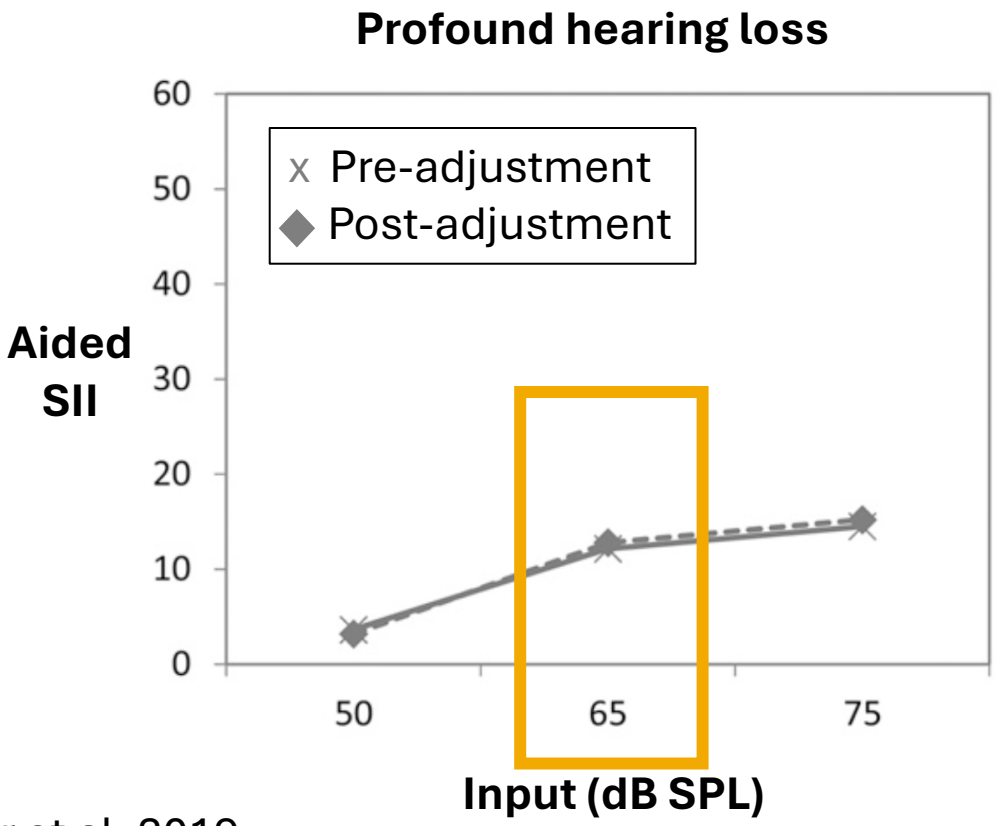


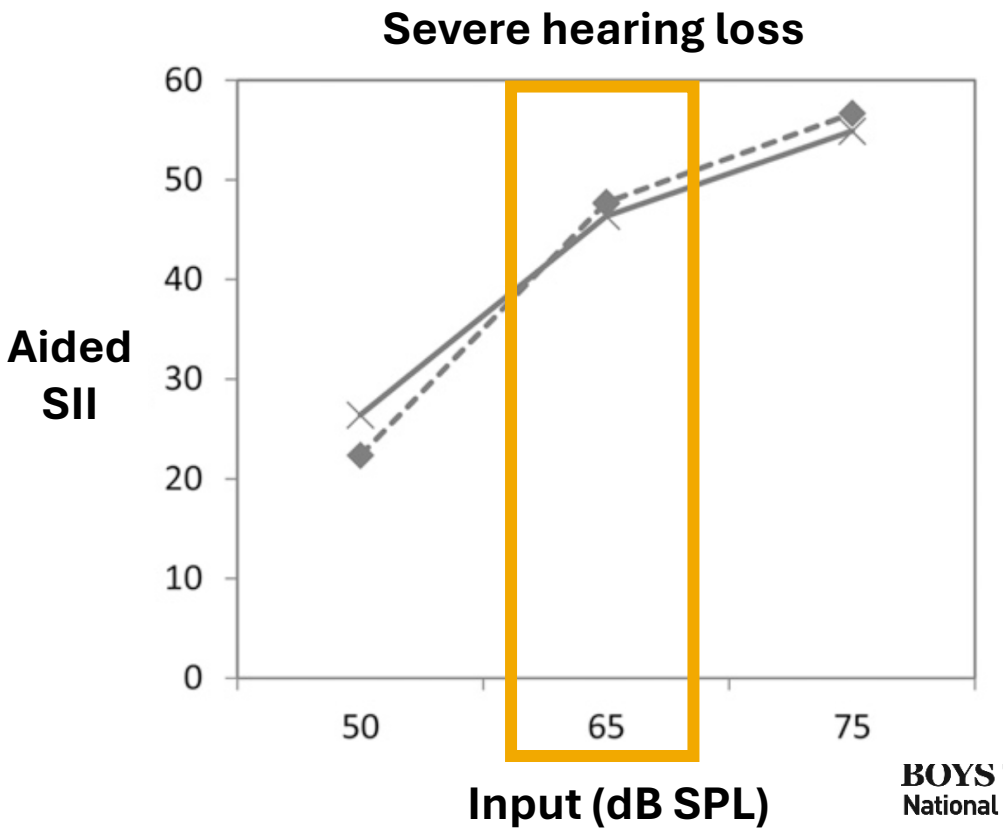
What about aided SII?

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How much aided audibility is enough?

Aided audibility in children with severe to profound hearing loss





Quar et al. 2019

Stiles, Bentler & McGregor (2012)

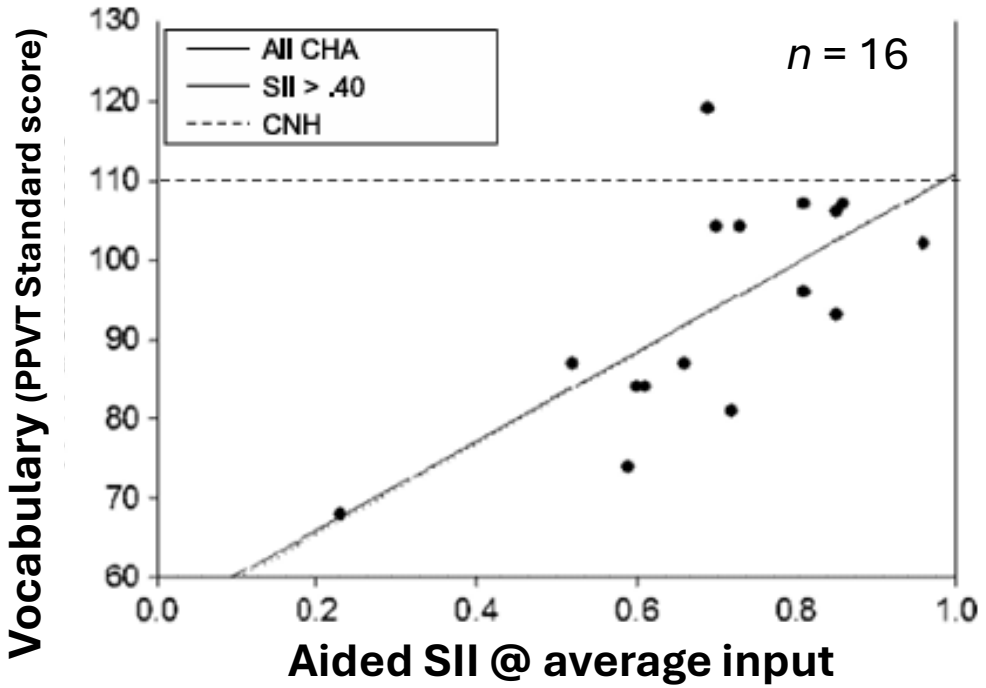
JSLHR

Article

The Speech Intelligibility Index and the Pure-Tone Average as Predictors of Lexical Ability in Children Fit With Hearing Aids

Derek J. Stiles,[a] Ruth A. Bentler,[a] and Karla K. McGregor[a]

65% aided SII

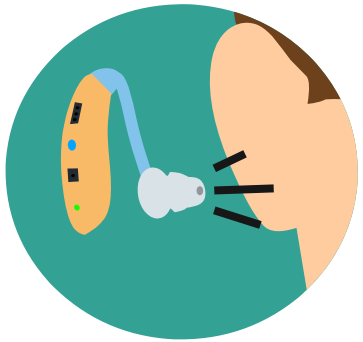


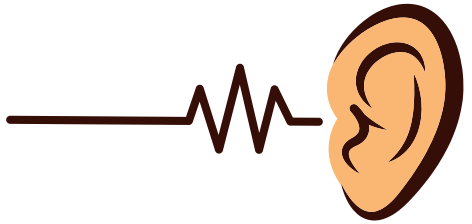
Aided SII predicted outcomes above and beyond unaided PTA

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What SII tells us beyond the audiogram

Hearing aid output

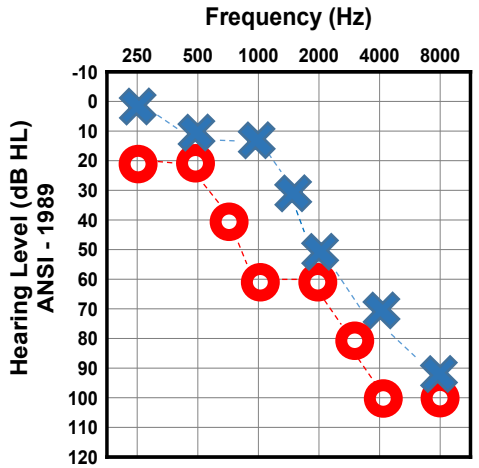




Effect of ear canal acoustics on threshold



Impact of hearing loss on speech audibility



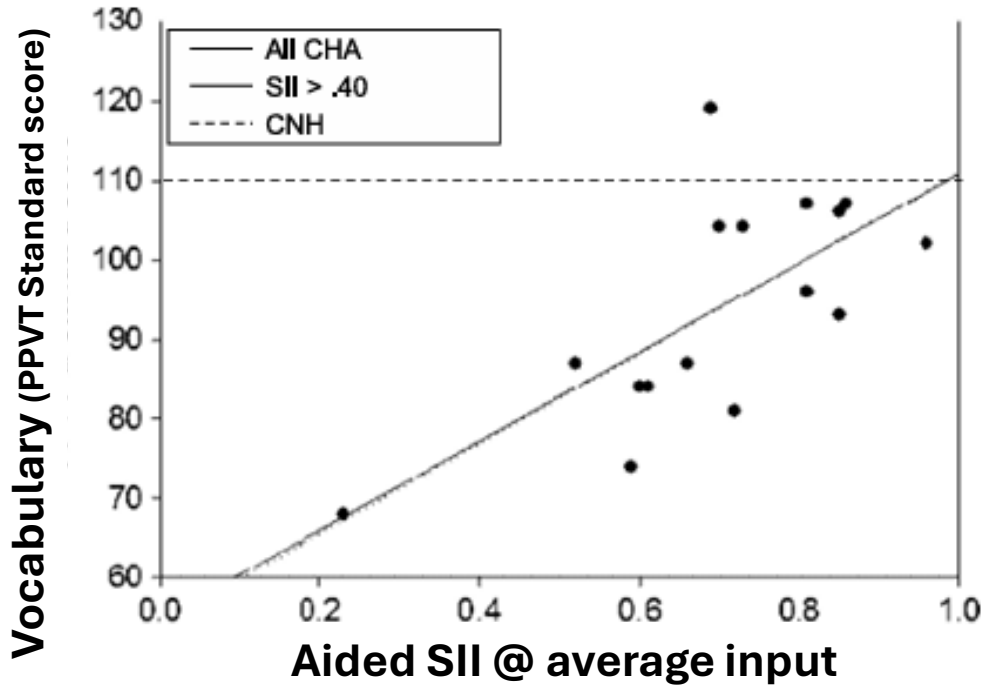
Hearing loss configuration

Leal et al., 2016; Nickerson et al., 2019

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What's the research missing?

- Limitations of sample size
- Language outcomes
- Other predictors



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EAR and HEARING
The Official Journal of the American Auditory Society

Hearing Thresholds, Speech Recognition, and Audibility as Indicators for Modifying Intervention in Children With Hearing Aids

Kathryn B. Wiseman[1], Ryan W. McCreery[1], and Elizabeth A. Walker[2]

What audiometric and audibility-based measures signals risk for language delay in children with hearing aids?

Signals need for change in intervention



Ryan McCreery



Elizabeth Walker

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What measures signal risk for delay in children with hearing aids?

- **Audiometric measures**
  - Unaided thresholds
  - Speech recognition in quiet
  - Speech recognition in noise
- **Audibility-based measures**
  - Unaided SII
  - Aided SII
  - Auditory dosage

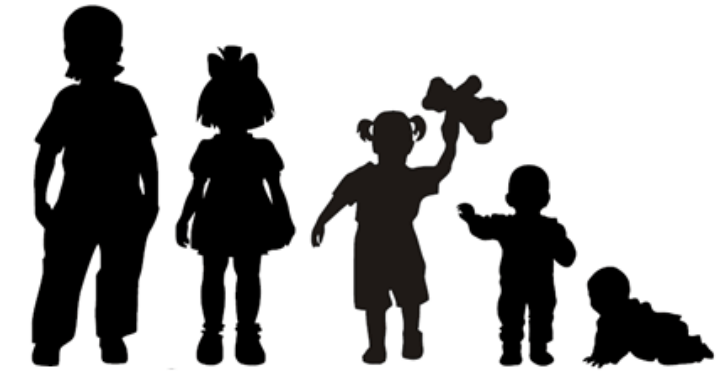


Language composite:
Receptive vocabulary (PPVT-4)
Syntax (CASL)
Pragmatics (CASL)

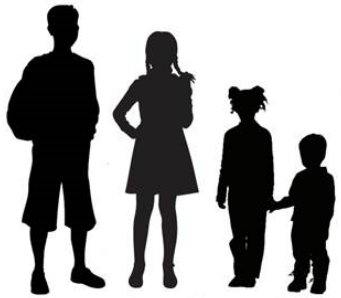
PPVT-4 = Peabody Picture Vocabulary Test
CASL = Comprehensive Assessment of Spoken Language

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Outcomes of Children with Hearing Loss Consortium



Outcomes of Children with Hearing Loss



Outcomes of School Age Children who are Hard of Hearing



Complex Listening Skills in School-Age Hard of Hearing Children

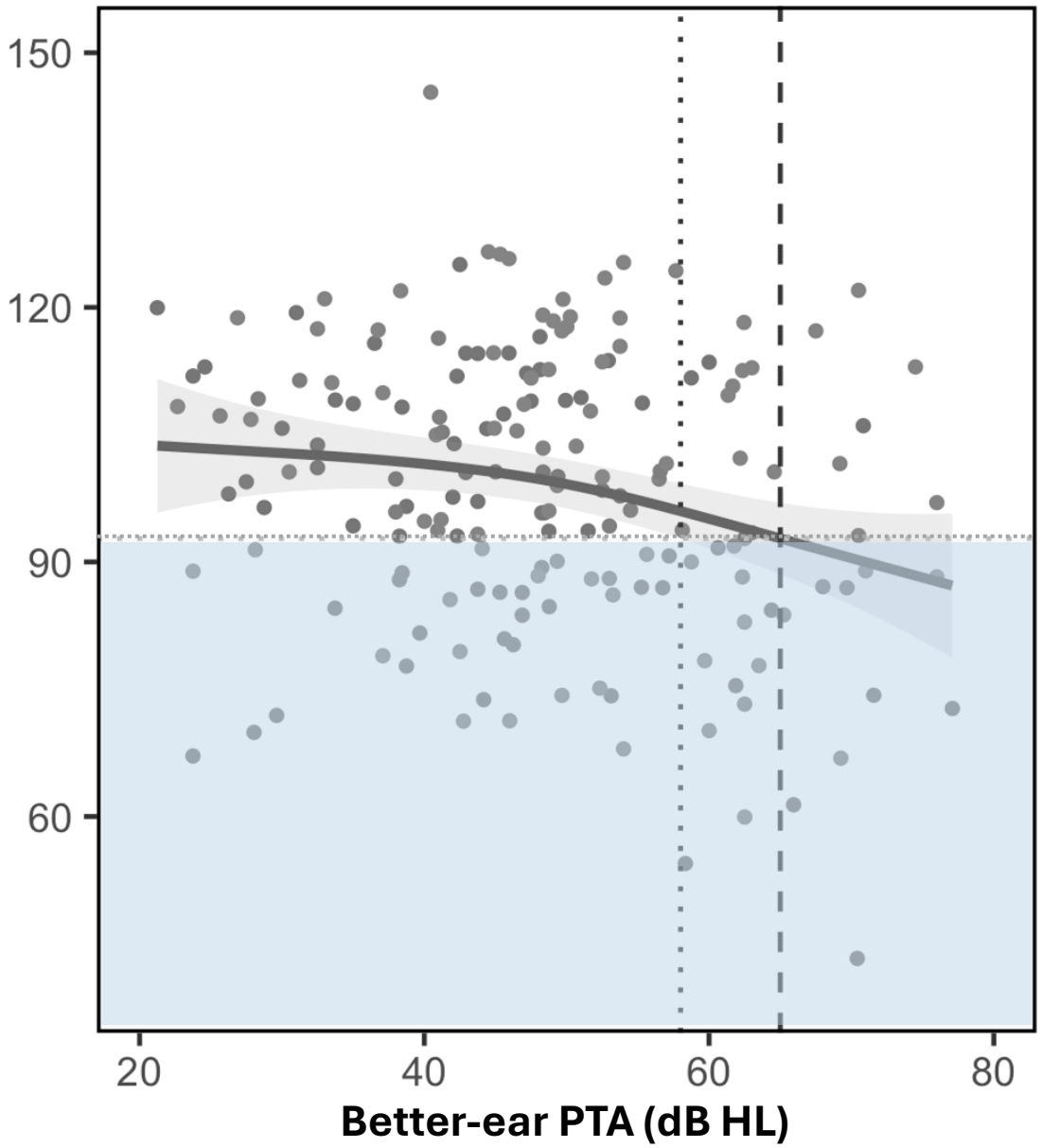


Longitudinal Outcomes of Literacy in Adolescents who are Hard of Hearing

FASTRAK

What measures signals risk for delay in children with hearing aids?

Language composite:
Receptive vocabulary (PPVT)
Syntax (CASL)
Pragmatics (CASL)



N = 182 children with hearing aids
N = 78 children with typical hearing

3.8-9.2 years old
Early identified children (M = 8 mo)

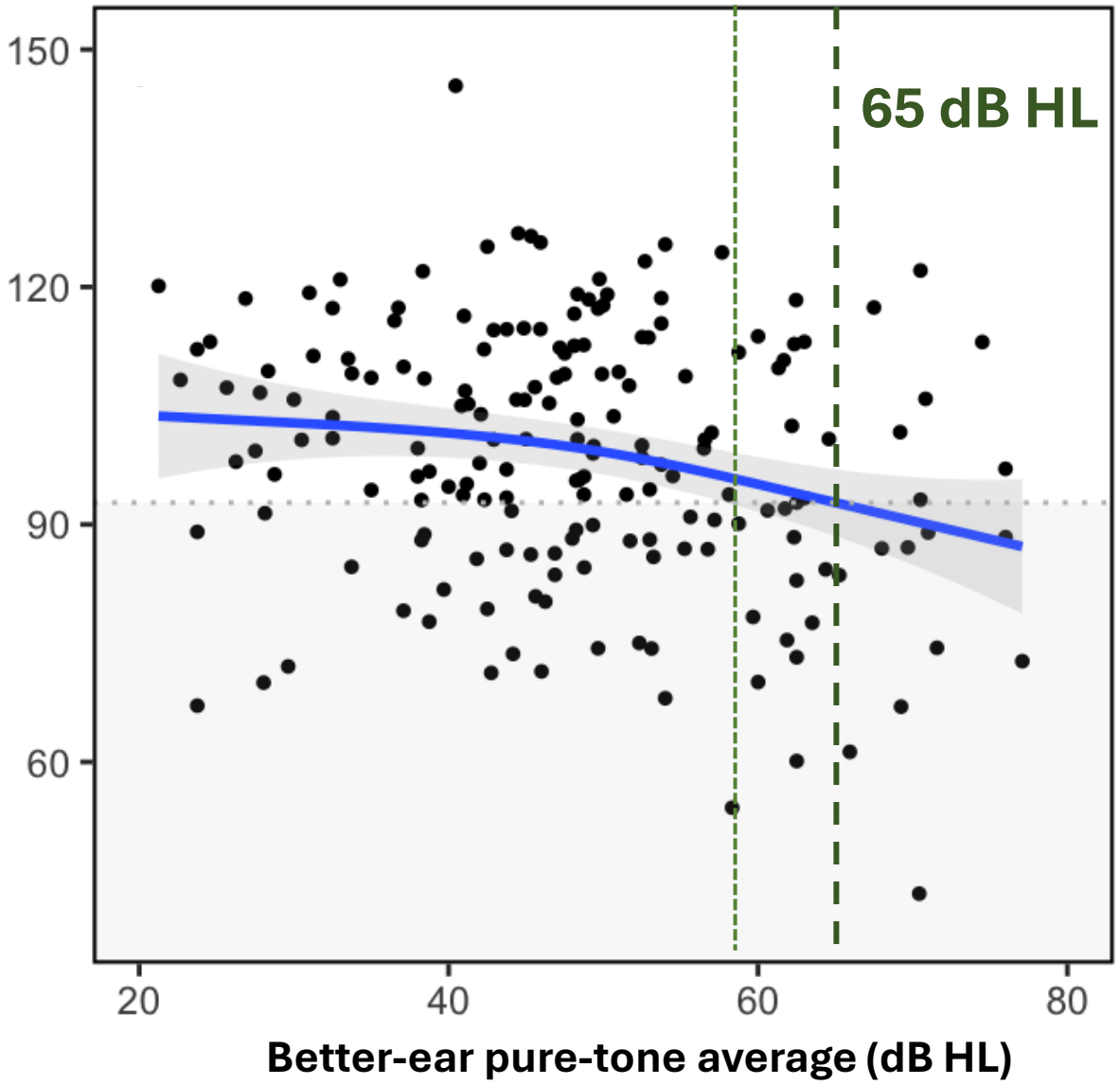
1.5 SD below CTH mean

GAM = Generalized Additive Modeling
linear or nonlinear functions depending on which function best fits the data

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Audiometric measures: Unaided pure-tone average

Language composite:
Receptive vocabulary
Syntax
Pragmatics

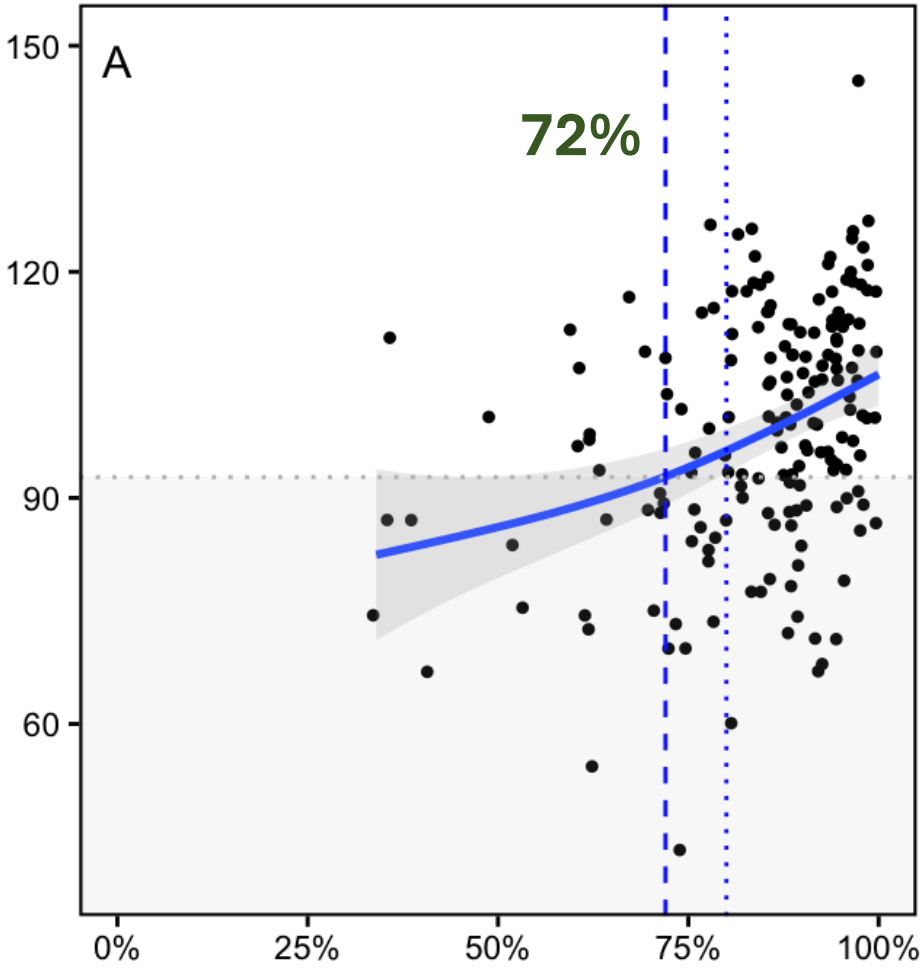


1.5 SD below CTH mean

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Audiometric measures: Speech recognition in quiet

Language composite
Receptive vocabulary
Syntax
Pragmatics

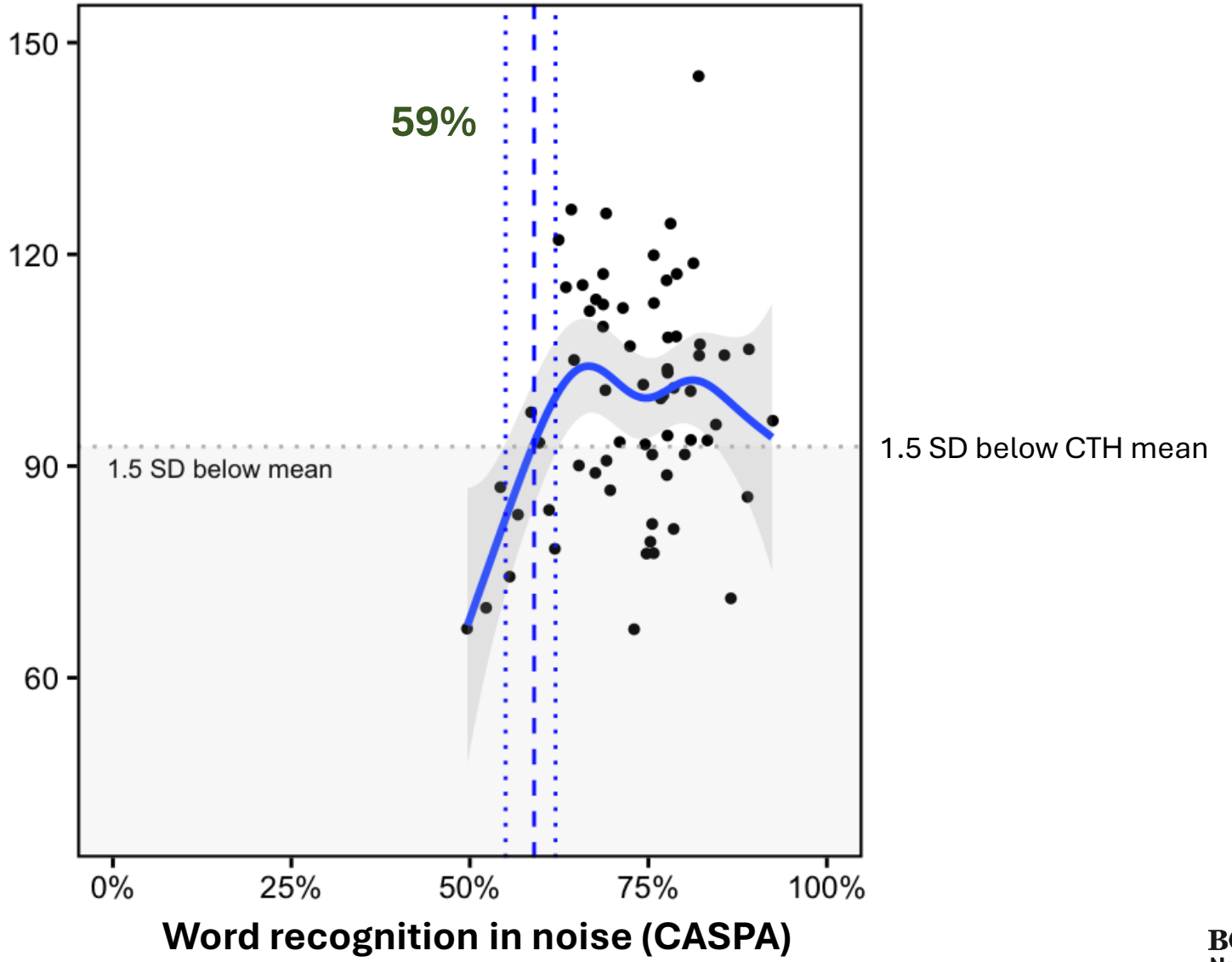


50 monosyllable words presented at 65 dB SPL at 0-degree azimuth

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Audiometric measures: Speech recognition in noise

Language composite
Receptive vocabulary
Syntax
Pragmatics

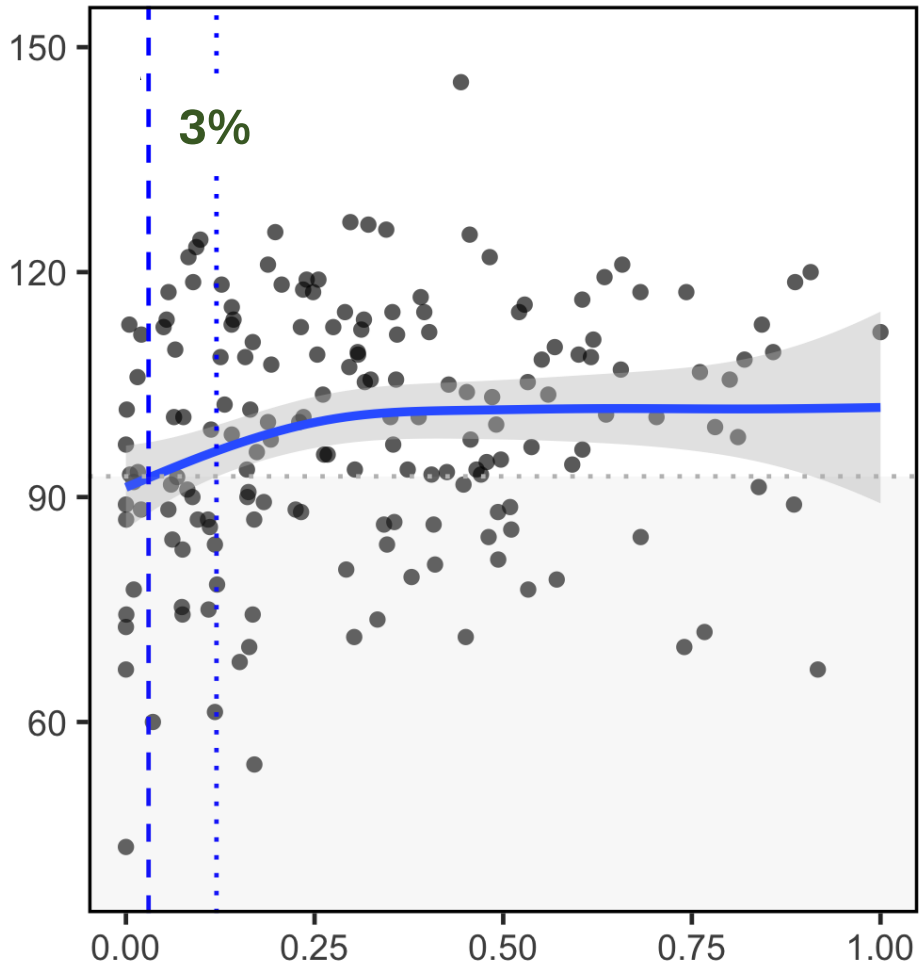


CASPA = Computer-Assisted Speech Perception Assessment

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Audibility-based measures: Unaided SII

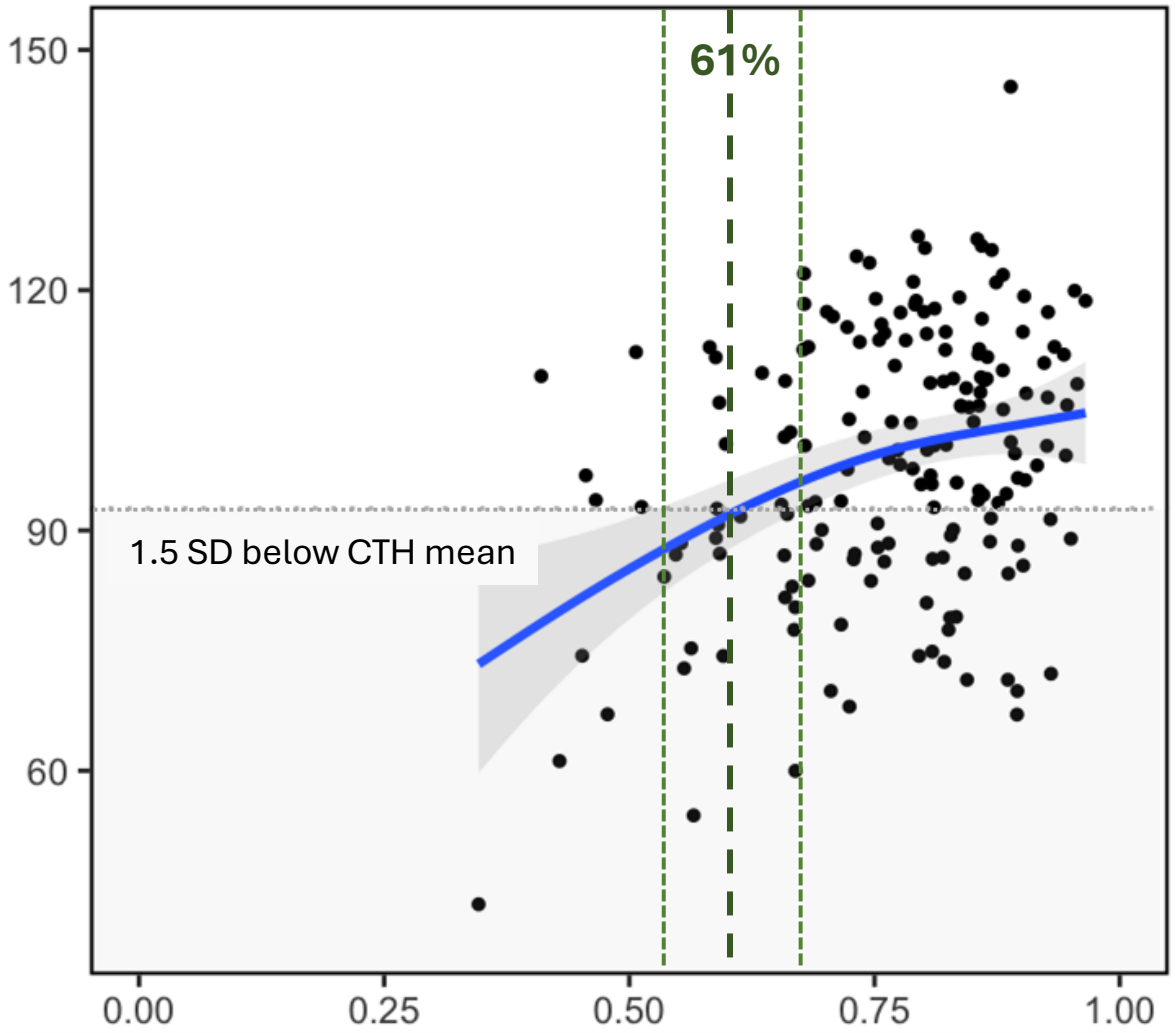
Language composite:
Receptive vocabulary
Syntax
Pragmatics



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Audibility-based measures: Aided SII

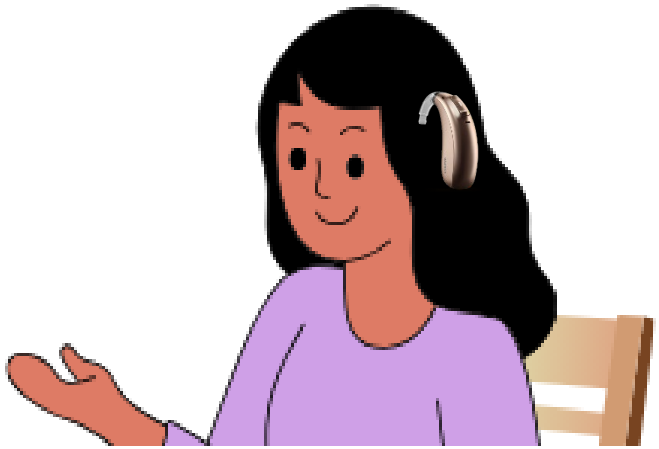
Language composite:
Receptive vocabulary
Syntax
Pragmatics



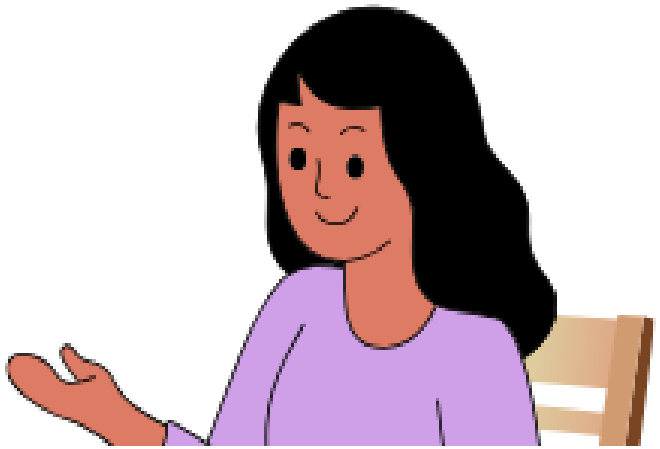
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What is auditory dosage?

Aided audibility not constant for children with hearing aids



Access = aided audibility



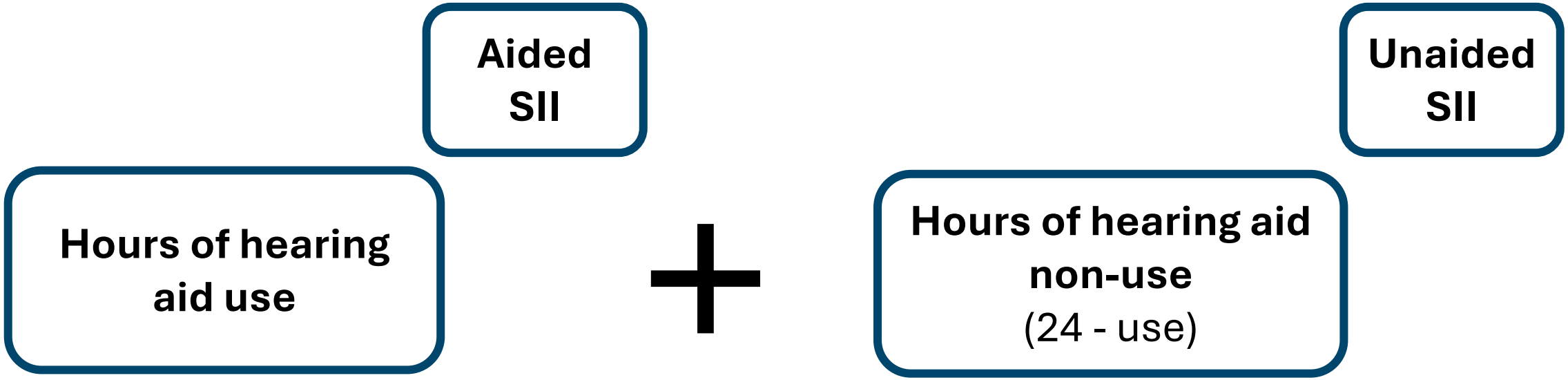
Access = unaided audibility

McCreery & Walker, 2022

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What is auditory dosage?

Metric weights hearing aid use by SII

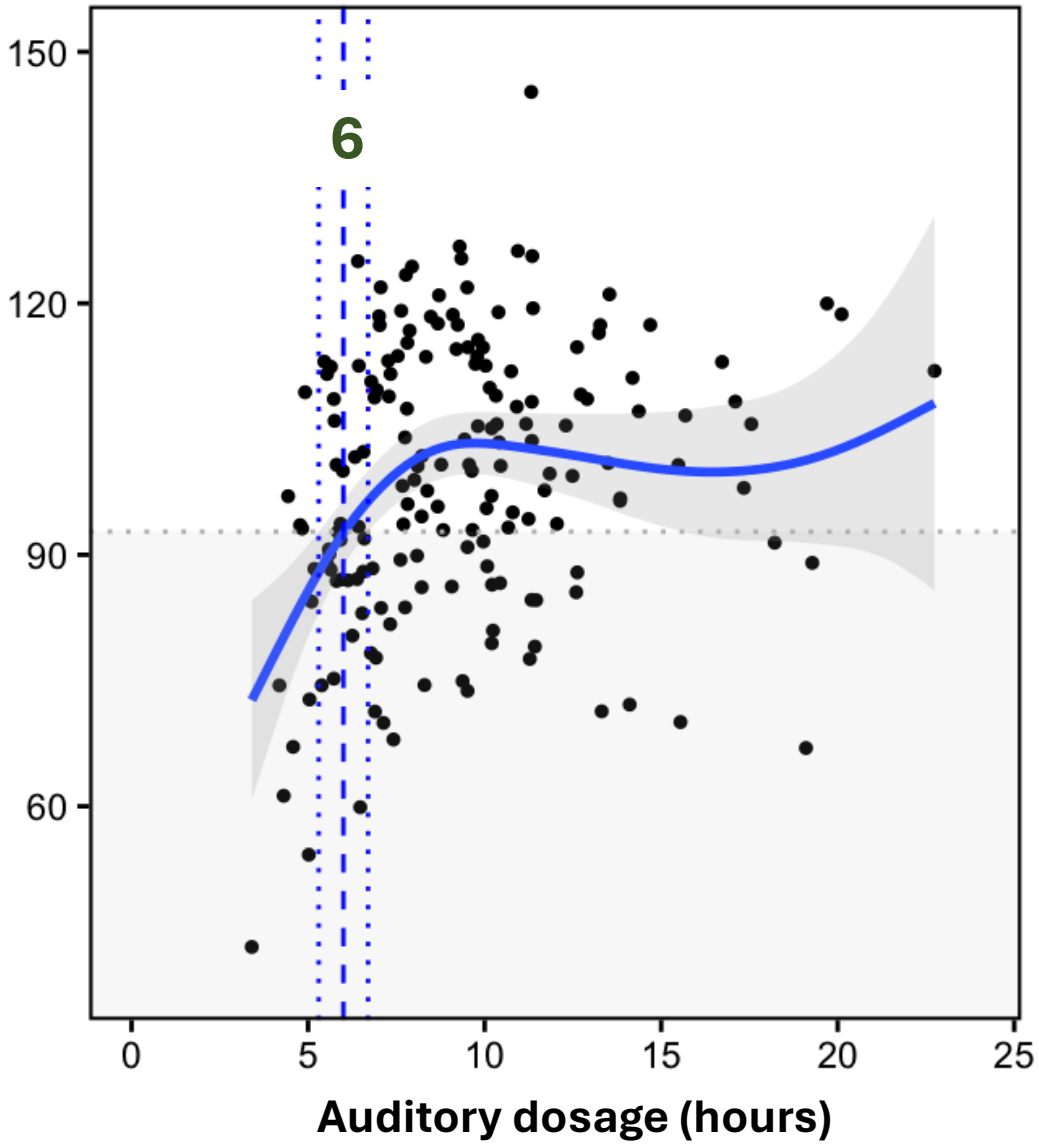


McCreery & Walker 2022

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Audibility-based measures: Auditory dosage

Language composite:
Receptive vocabulary
Syntax
Pragmatics



1.5 SD below CTH mean

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Study conclusions

- Aided SII, speech recognition in noise, and auditory dosage gave us clearest estimates of risk for delay
  - Aided SII: 61% [53-68%]
  - Speech recognition in noise: 59% [55-62%]
  - Auditory dosage: 6 hours [5.3 - 6.7]

- Audibility-based measures can help us clarify access with hearing aid intervention

Concerned about aided audibility?

Within-technology changes

(to meet targets!)

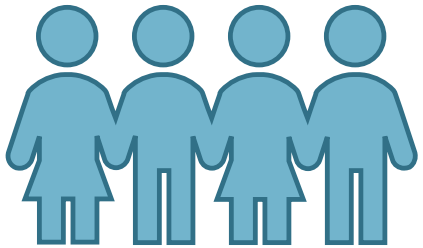
- Reprogramming
  - Change in ear canals
  - Change in hearing
- More powerful hearing aid?

Across-technology changes

- Cochlear implant candidacy

Other supports

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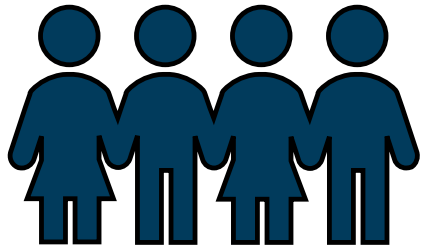


Hearing aid candidates





?



Cochlear implant candidates

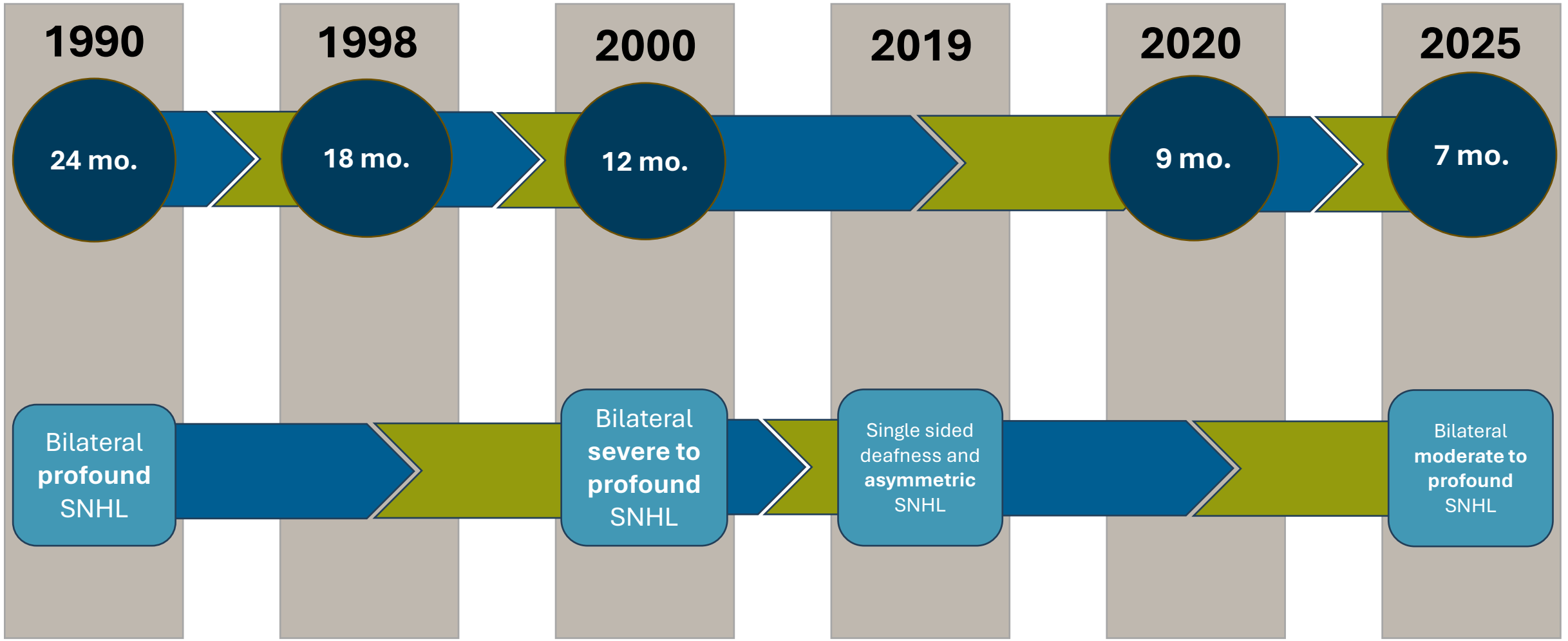


Candidacy is expanding: residual hearing

- 78% of surgeons reported implanting outside of FDA guidelines in US (Carlson et al., 2018)
  - 31% of surgeons implanted children with more acoustic hearing
- 26% of implanted children had residual hearing in Canada (Na et al., 2021)
  - Of those, 43% had better than severe hearing thresholds in better ear

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US FDA indications for pediatric CI

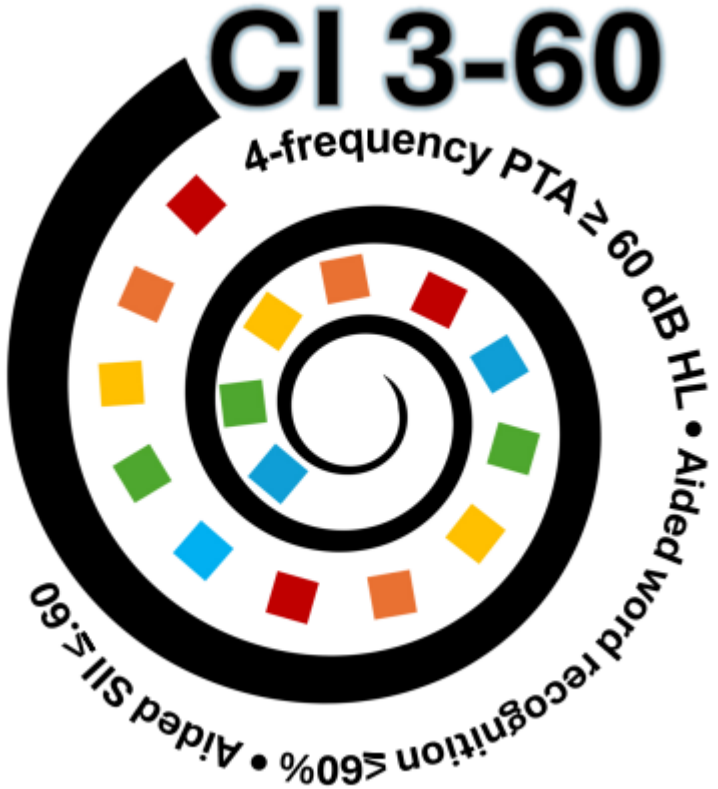


SNHL = sensorineural hearing loss

Updates to FDA indications for bilateral hearing loss

	Age	Degree of HL	Speech perception	Hearing aids
MED-EL	7 – 12 mos	Profound	Lack of progress on auditory skills development	Limited benefit Hearing aid trial
	1 year – 5 years	Moderately-severe to profound	< 40% on developmentally-appropriate test of word recognition	Limited benefit Hearing aid trial
	6 years – 17 years	Moderate to profound	<= 50 % on CNC words	Limited benefit Hearing aid trial

Newest pediatric guideline: CI 3-60



≥ 60 dB HL 4-frequency PTA

and/or

≤ 60% aided word recognition

and/or

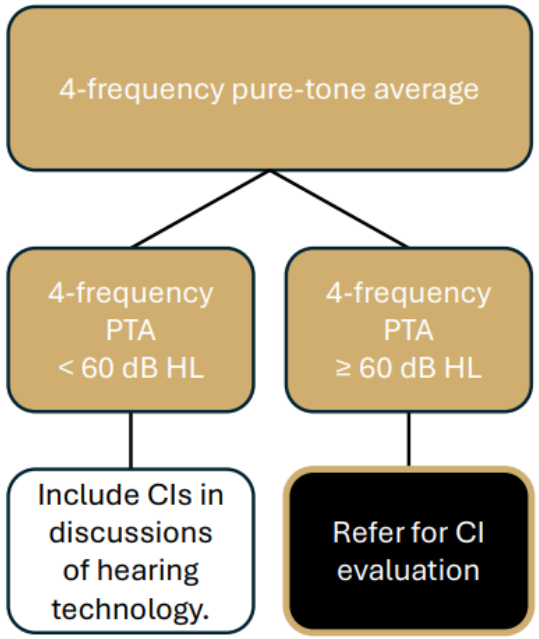
≤ 60% Aided Speech Intelligibility Index (SII)

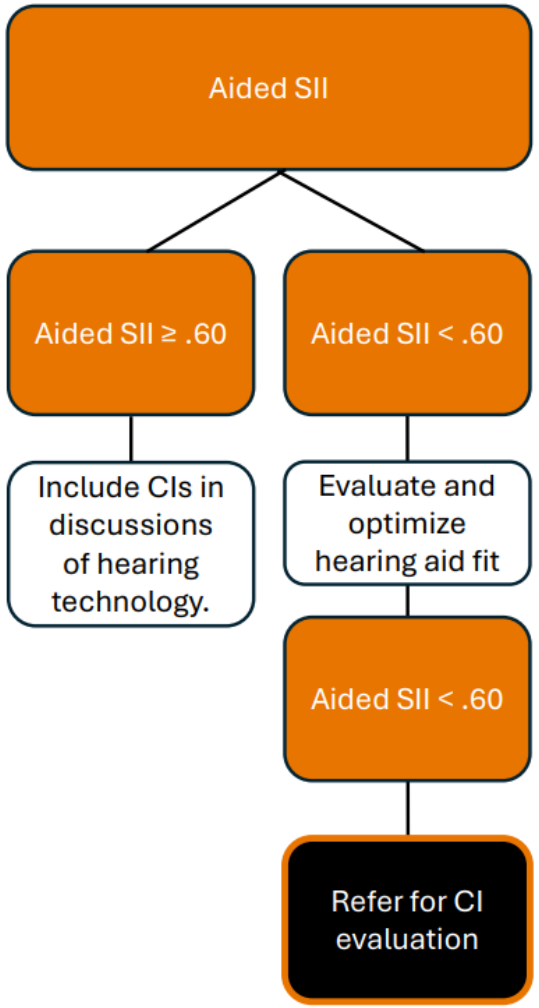
cipath.org

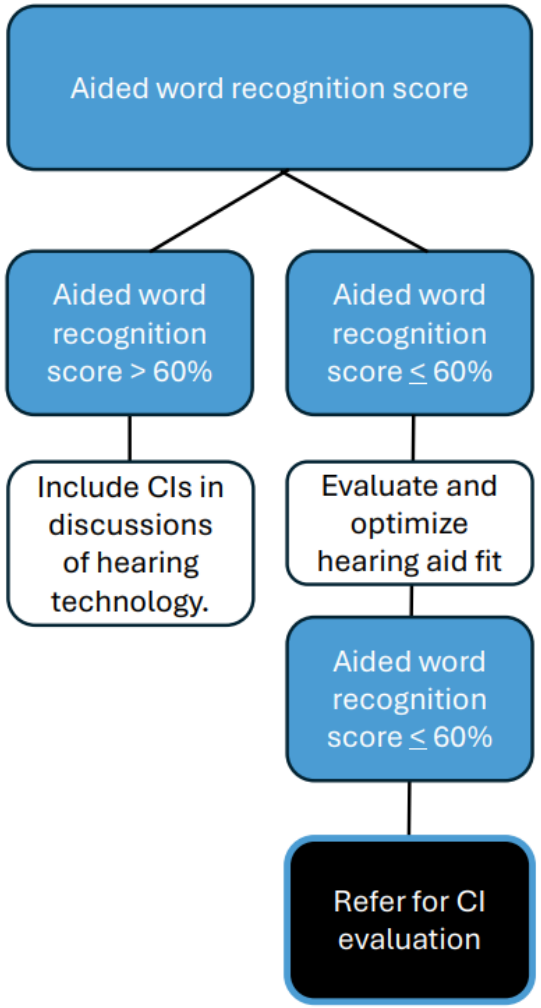
Holder et al. 2026

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CI 3-60
4-frequency PTA ≥ 60 dB HL • Aided word recognition <60% • Aided SII <.60

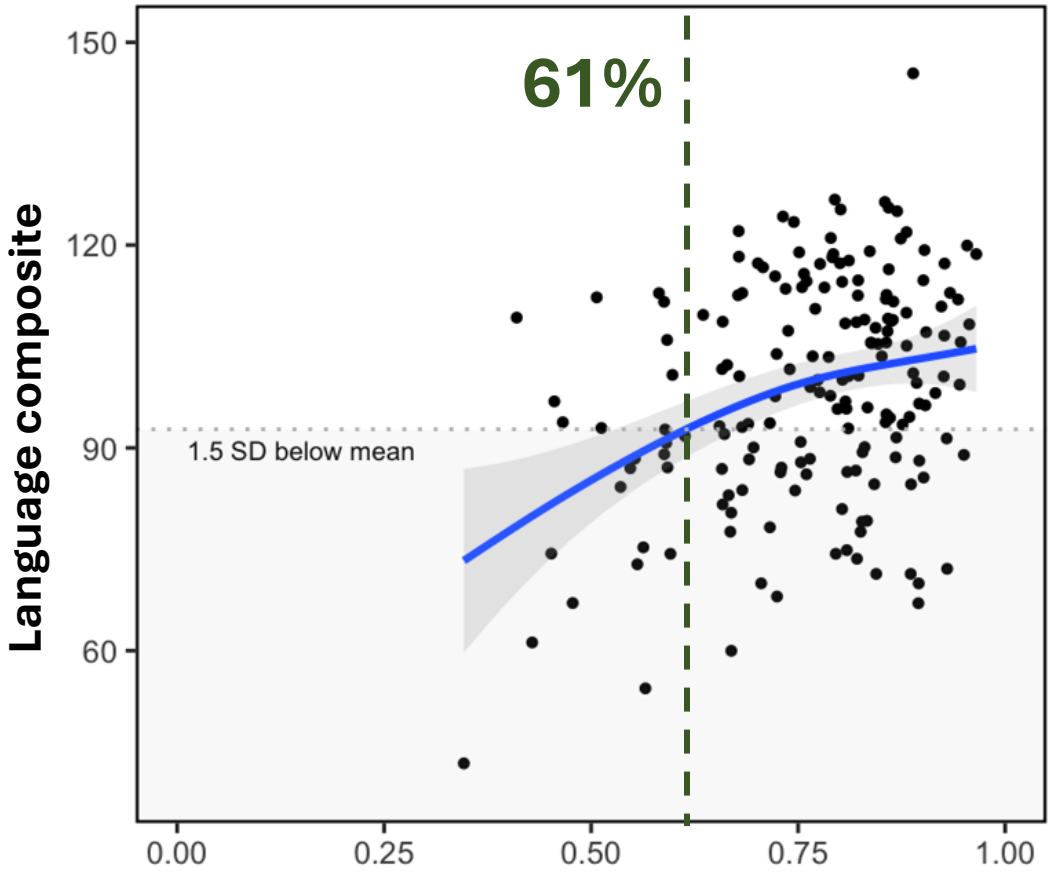

4-frequency pure-tone average
4-frequency PTA < 60 dB HL
4-frequency PTA ≥ 60 dB HL
Include CIs in discussions of hearing technology.
Refer for CI evaluation


Aided SII
Aided SII ≥ .60
Aided SII < .60
Include CIs in discussions of hearing technology.
Evaluate and optimize hearing aid fit
Aided SII < .60
Refer for CI evaluation


Aided word recognition score
Aided word recognition score > 60%
Aided word recognition score ≤ 60%
Include CIs in discussions of hearing technology.
Evaluate and optimize hearing aid fit
Aided word recognition score ≤ 60%
Refer for CI evaluation

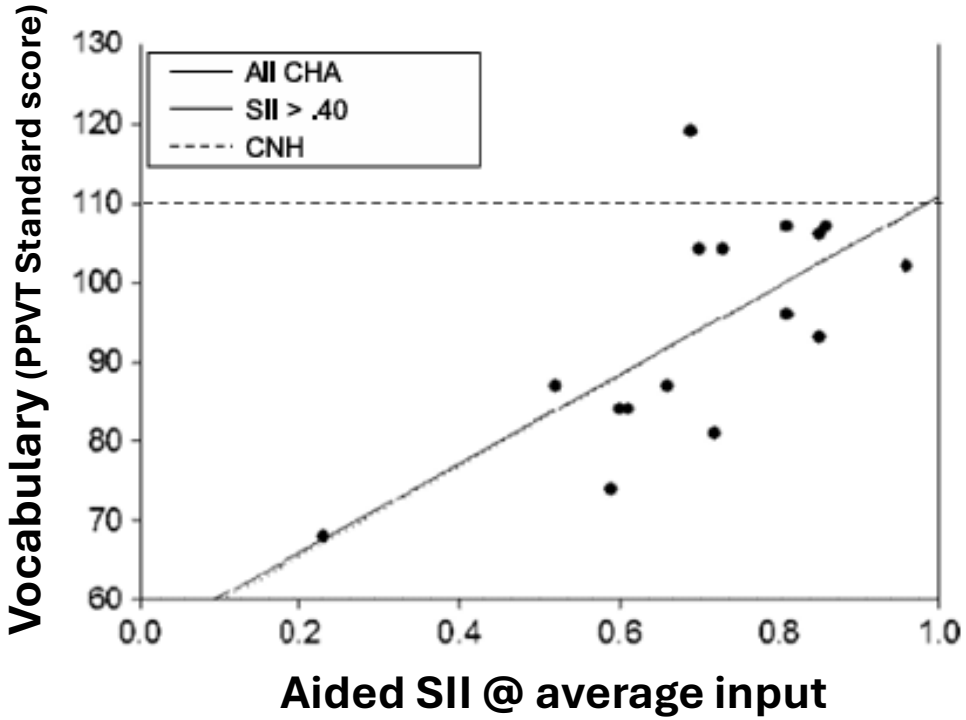
≤ 60 aided SII

Wiseman, McCreery & Walker (2023)



Stiles, Bentler & McGregor (2012)

65%



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For children with residual hearing…

- …other measures to help characterize auditory access in these children?
- Not only thinking about unaided hearing, but also considering aided hearing

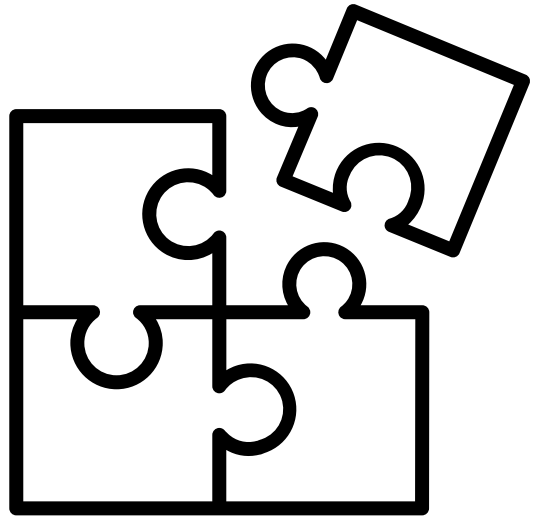
Clinical hearing aid verification measures characterize aided hearing.

Pignac et al. (2024)

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Audibility-based measures are another piece of the puzzle

- Audibility-based tools don’t replace other measures.
  - Doesn’t replace the audiogram
- Can support decisions around candidacy along with other metrics
  - SII isn’t a hard cut off for device candidacy

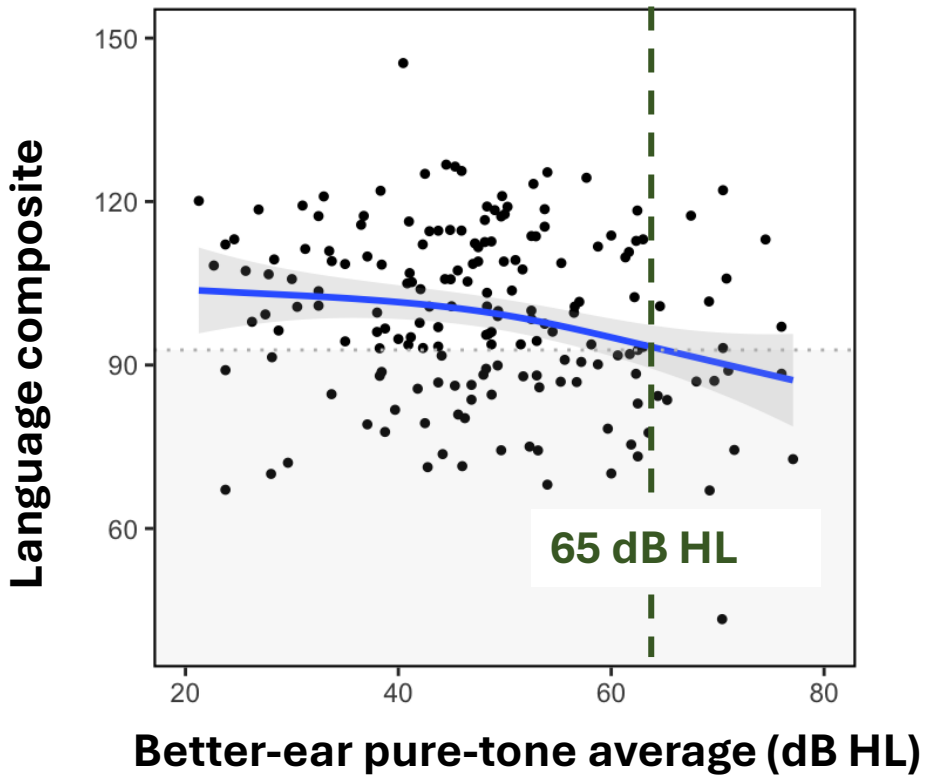


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≥ 60 db HL PTA

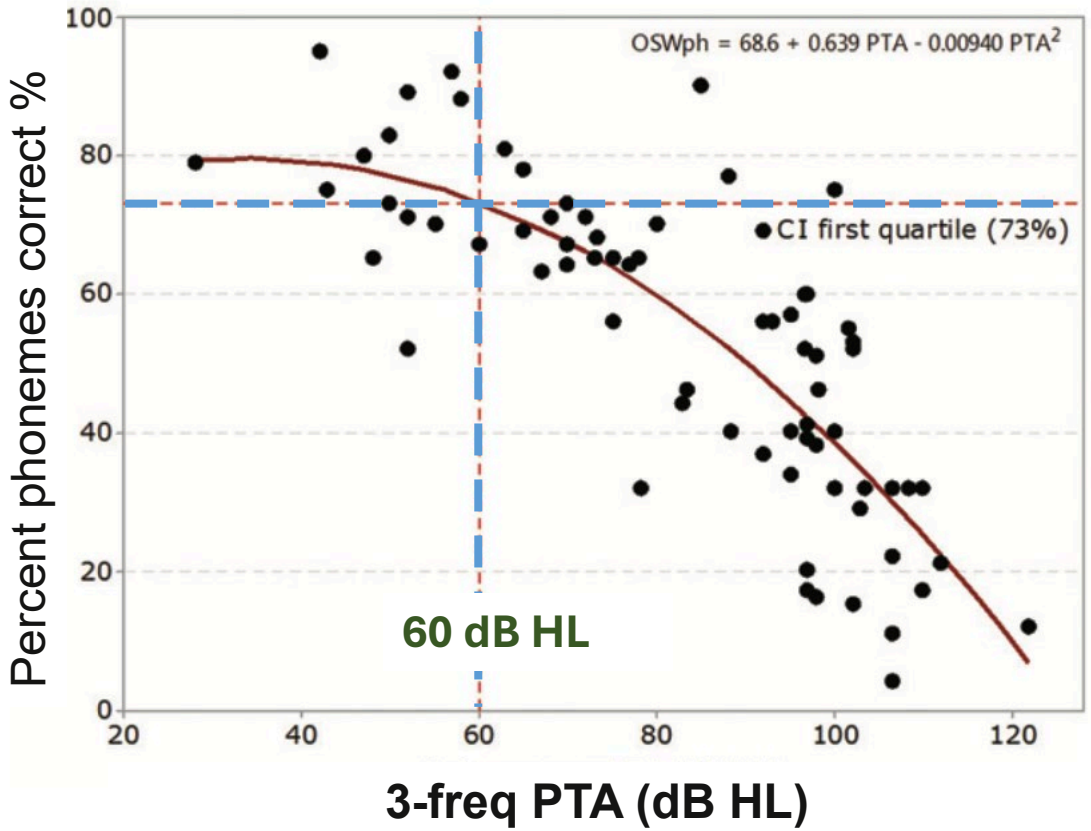
Wiseman, McCreery & Walker (2023)

Hearing aid vs Typical Hearing



Leigh et al. (2016)

Hearing aid vs Cochlear implant



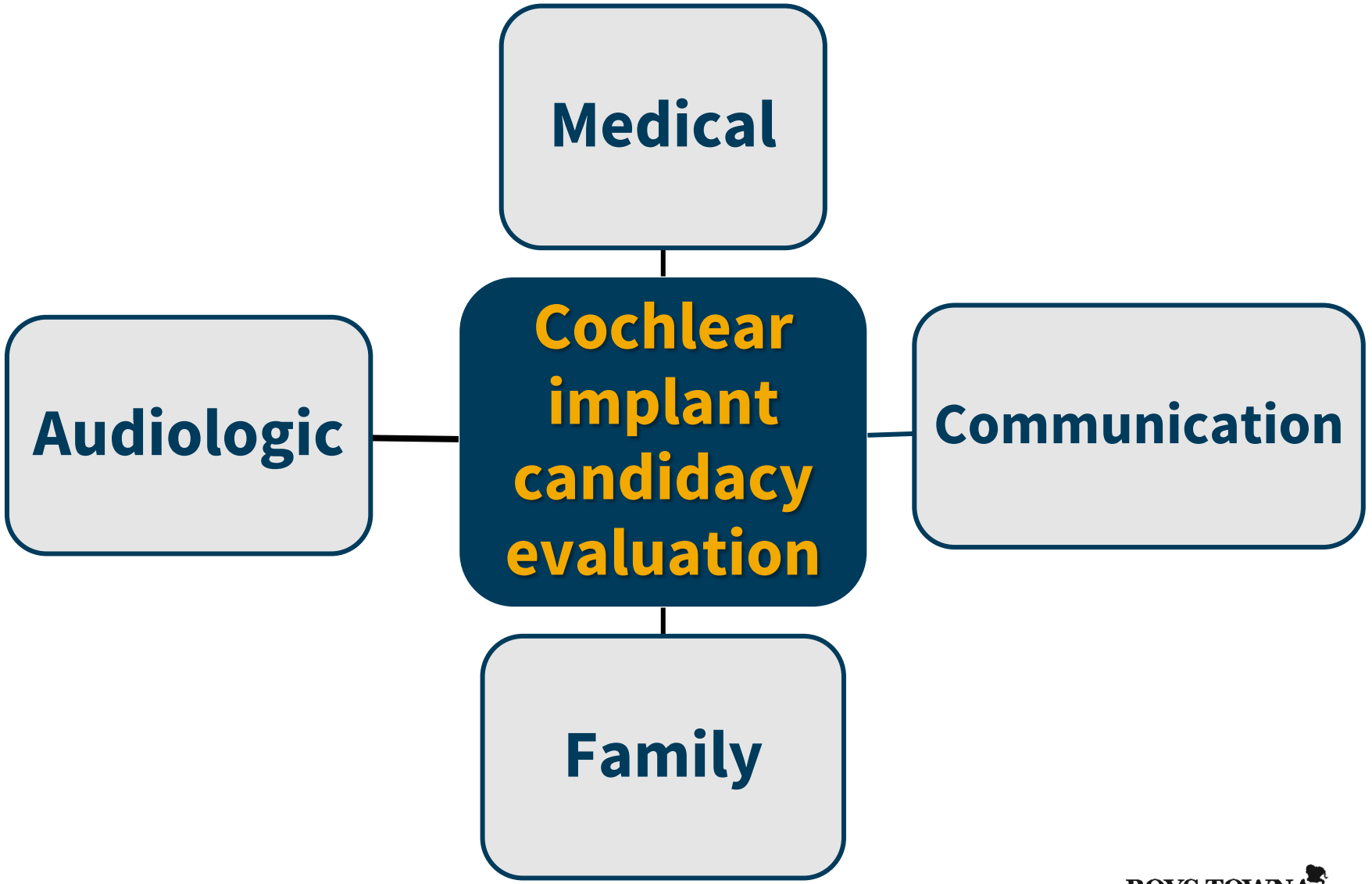
Referral

vs

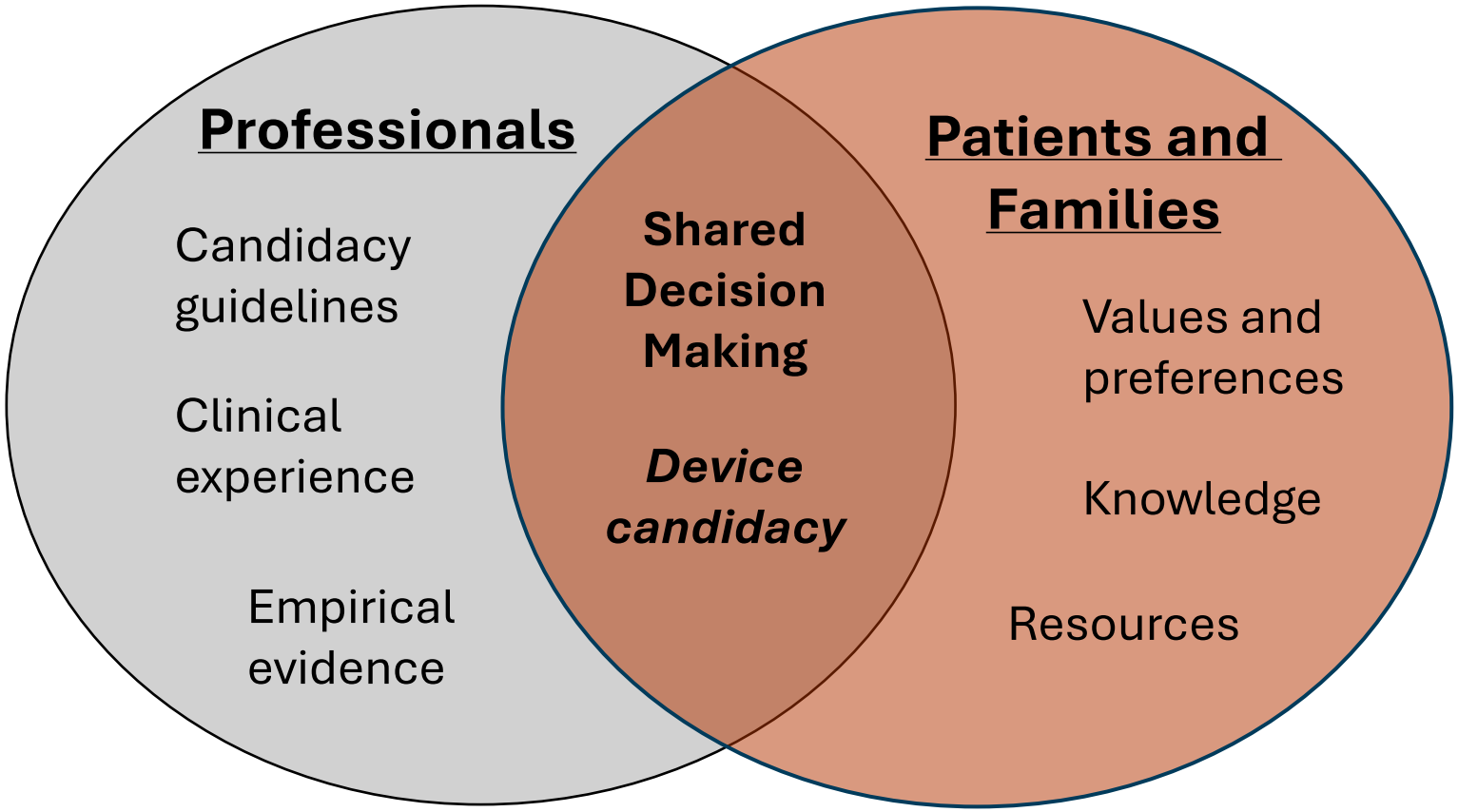
Evaluation

vs

Candidate



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Professionals
Candidacy guidelines
Clinical experience
Empirical evidence
Shared Decision Making
Device candidacy
Patients and Families
Values and preferences
Knowledge
Resources

Parental and professional uncertainty for cochlear implantation in children with residual hearing

- **Concerns:**
  - What will happen to residual hearing?
  - Will outcomes get worse?

- **Factors that led to decision to implant:**
  - Progression of hearing loss
  - Limited social integration

Na et al., 2021a,b

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How do parents of children with hearing aid view cochlear implantation?

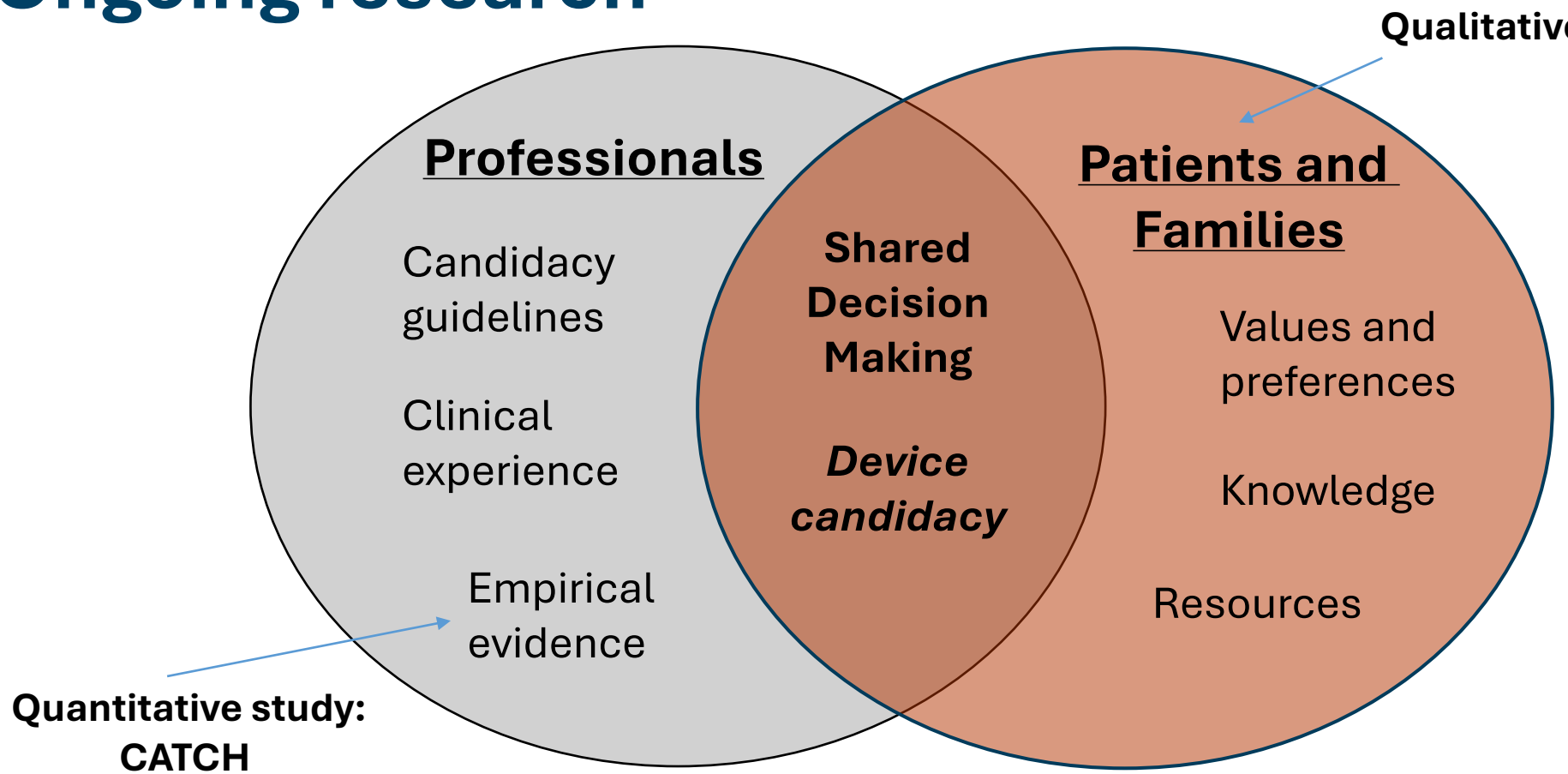
- Families are unprepared to discuss cochlear implants when candidacy comes up
  - When to talk about CI?
- Cochlear implantation seen as a “worst case scenario”
  - What language do we use when we talk about hearing aids and cochlear implants?
- Providing families with resources to avoid misinformation
  - “I thought it was brain surgery”

Take home message

Include audibility-measures when considering whether child has appropriate access to speech with hearing aids.

- CI candidacy for children with residual hearing

Ongoing research



Thank you!

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LABORATORY

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