Use of Personal Remote Microphone Technology for Birth to Three: Evidence & Recommendations

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Remote Microphones

-Benefits are well documented for school-age kids & adults but what about the littlest "littles"?

-Rationale
-Considerations

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Arguments for RM Use

- The world is a dynamic & noisy place + learning happens everywhere
- Noise is especially distracting to young developing brains
  - Then add distance & reverberation!
- Difficulty is amplified when a child is deaf or hard-of-hearing
- Hearing aids & cochlear implants alone are not enough

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The World is a Noisy Place

Children and noise

CHILDREN AND NOISE: SETTINGS

Noise at home	50-80 dBA
Home appliances	78-102 dBA
Noise in incubators	60 - 75 dBA, peak sounds 120 dBA
Noise in hospitals	>70 dBA
Day-care institutions	75-81 dBA
Noise from toys peak sounds	79-140 dBA
Background noise in schools	46.5—77.3dBA

WHO

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Australian Study (n=36)

Table 2. Descriptive statistics.

Measure	Mean	SD	Range
Occupied room in dBA	67.43	3.55	60.10 – 73.45
Unoccupied room in dBA	48.51	6.30	34.70 – 61.20
Occupied versus unoccupied decibels	18.75	6.84	3.85 – 30.60
Reverberation time	0.60	0.25	0.27 – 1.49
Number of people in group	17.25	6.67	7 – 48
Room size m^2	80.08	50.75	12 – 224
	Frequency		
Floor type - hard	8		
Floor type - mixed	28		
Group constitution – birth-24 months	28		
Group constitution – birth-36+ months	8		

Degotardi et al, 2025

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UK Study (n=40)

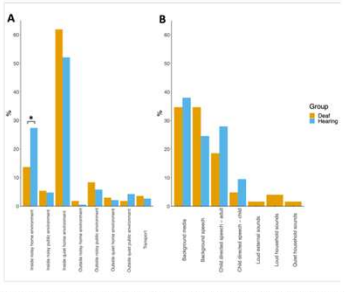

Figure 1 *Panel A shows the main sound environments children were in. Panel B shows subsidiary sound environments and backgrounds.*

Cooper et al., 2025

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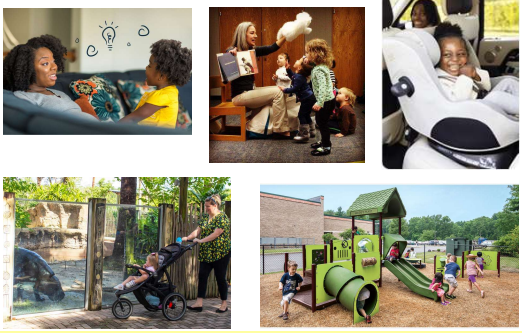
Noise is Distracting to Young Brains



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Noise is Distracting to Young Brains

Normal Auditory Development takes time

- Werner (2007):
  - Sound Coding (0-6 months)
  - Selective Listening/Discovering New Details (~5 years)
  - Perceptual Flexibility (~Adolescence)

- Immaturities in young children's hearing affect the ability to learn from sound in the environment

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Noise is Distracting to Young Brains

- Language development critically depends on receiving language input in a way that it can be encoded by the developing brain
- Background noise may impair the ability to learn either by leaving fewer resources available or making listening effortful, even when the signal is still audible (Hornsby, 2013; Rabbitt, 1968)
- Background noise may also cause attentional shifts and information encoding failures

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Noise is Distracting to Young Brains

- Infants and children struggle with listening in noise, particularly when the background noise consists of speech
- Infants and young children require higher SNRs than adults to successfully perceive speech (Trehub et al., 1981)

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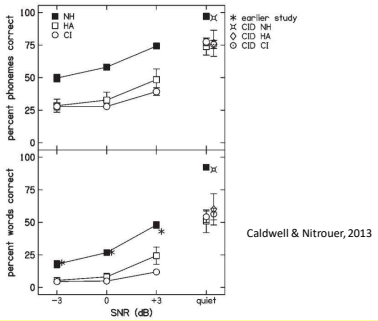
Deaf & HOH Kindergartners



Caldwell & Nitrouer, 2013

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Deaf & HOH Kiddos

- Difficulties listening in noise likely influenced by knowledge level
  - Children who are Deaf & HOH may have significant speech & language delays
- Listeners with more language knowledge or larger vocabularies can fill in gaps more easily when information is degraded or missing (Newman, 2006)

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Deaf & HOH Kiddos

- Need higher SNRs vs Normal Hearing
- Hearing speech in noise, at a distance, and in reverberant spaces are all major challenges for those who are deaf/hard of hearing.
- May need greater quality & quantity re: exposure to spoken language

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HAs & CIs Have Limitations

- HAs & CIs are limited in their capacity to increase speech audibility in noisy, distant, or reverberant situations
  - Work best at 1-2 metres in quiet non-reverberant rooms (Benítez-Barrera et al., 2020)
- Use of digital features such as noise reduction and directional microphones in children under 18 months is limited, and guidelines tend to suggest that some of these features be deactivated for young children (AAA, 2013)
  - Directional microphones may impair localization abilities as well as reducing sound awareness and interfering with the ability to overhear in young children
  - Noise reduction is generally considered not to impair speech recognition in children (Crukley & Scollie, 2014; Pittman, 2014) but more studies needed

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Enter Remote Microphones

- The benefits of using remote microphone technology with young children (~2-4 years old) are becoming increasingly appreciated
  - Positive gains in relation to speech perception and speech and language development with this age group (Allen, Mulla, Yen Ng, et al., 2017; Benítez-Barrera et al., 2018; Mulla & McCracken, 2014)
- Studies have also demonstrated acceptability of this technology to parents to overcome the challenges of distance and noise, thereby enabling enhanced access to speech in a variety of settings (Allen, Mulla, Ng, et al., 2017; Statham & Cooper, 2013).
  - There has however been little focus on the use of this technology with infants and young children under 18 months of age

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Remote Microphones

- Allow access to more words with less repetitions
- More Words = Better language, stronger reading skills down the road

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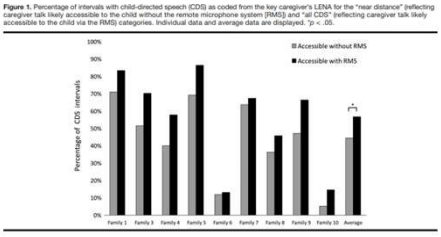
Benitez Barrera et al. (2019)



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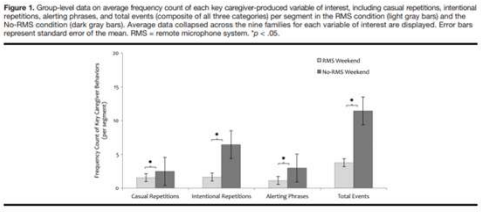
Thompson et al. (2020)



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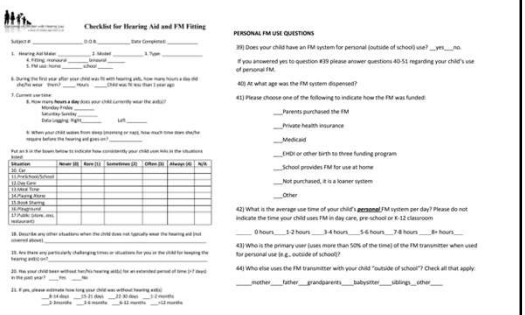
Walker et al. (2019)



Checklist for Hearing Aid and FM Fitting

PERSONAL FM USE QUESTIONS

39) Does your child have an FM system for personal (outside of school) use? ___yes___no.

If you answered yes to question #39 please answer questions 40-51 regarding your child's use of personal FM.

40) At what age was the FM system dispensed?

41) Please choose one of the following to indicate how the FM was funded:

___Parents purchased the FM
___Private health insurance
___Medicaid
___EHDI or other birth to three funding program
___School provides FM for use at home
___Not purchased, it is a loaner system
___Other

42) What is the average use time of your child's **personal** FM system per day? Please do not indicate the time your child uses FM in day care, pre-school or K-12 classroom

_____ 0 hours_____ 1-2 hours _____3-4 hours_____5-6 hours_____7-8 hours _____8+ hours_____

43) Who is the primary user (uses more than 50% of the time) of the FM transmitter when used for personal use (e.g., outside of school)?

44) Who else uses the FM transmitter with your child "outside of school"? Check all that apply:

_____mother____father____grandparents____babysitter_____siblings____other_____

Walker et al. (2019)

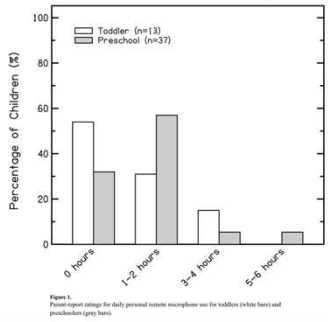


Figure 1.
Parent-report ratings for daily personal remote microphone use for toddlers (white bars) and preschoolers (gray bars).

Walker et al. (2019)

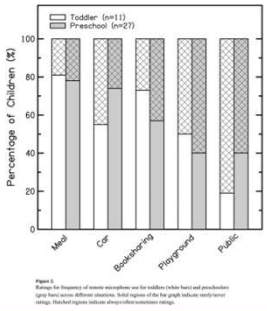


Figure 2.
Ratings for frequency of remote microphone use for toddlers (white bars) and preschoolers (gray bars) across different situations. Solid regions of the bar graph indicate rarely/never ratings. Hatched regions indicate always/often/sometimes ratings.

Walker et al. (2019)

- 95% of families who had RM for home use reported benefit
  - Not having to raise voice to be heard
  - Gaining/maintaining child's attention
  - Ensuring safety at distance
  - Behavior management in public
  - Connecting to Bluetooth
  - Easier picking up new words & concepts

Walker et al. (2019)

- 41% reported some problems with using RM
  - "Scared" the child
  - Difficulty with the connection to the HAs
  - "Not working"– sent for repair
  - Drained HA batteries
  - "Child did not like"

Arguments Against RM Use

- Perception that child will become overly reliant on the RM & will not learn to listen in noise
  - Strategic vs. Full-time use
- Localization Issue:
  - Similar when thinking about when to use directional mics
  - All sounds in the environment (including but not only speech) may be pertinent to a child's development and learning

Localization

- RM may alter spatial perception
  - RM signal is presented to both ears at the same time
  - HA processing often delays the RM signal relative to the HA microphone signals.
  - Level of the RM signal is independent of the distance from the RM to HA.

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Localization

- Kates et al. (2010)
  - RM improved intelligibility but reduced the spatial impression
  - Trade-offs: Increasing the vent diameter reduced clarity but increased the spatial impression
- Selby et al. (2017)
  - Localization was best when the RM gain was small & delays short

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Fitting Considerations: Candidacy

- All children who are D/HOH should be considered candidates for remote microphone technology
- Consider types of environments child is in & who child interacts with

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Fitting Considerations: Device Use

- When to use device?
- Where to use device?
- Who can use device?
- Tech support
  - Device orientation & troubleshooting

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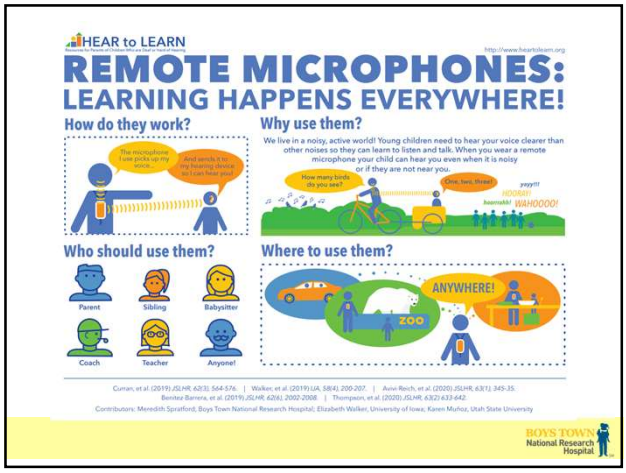

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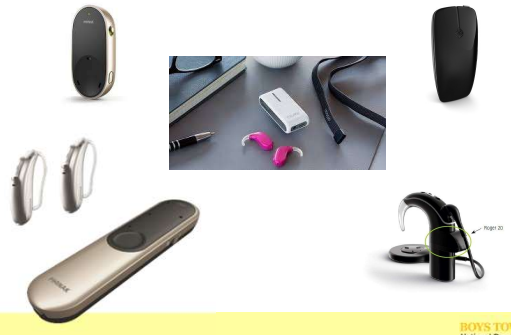
Fitting Considerations: Today's devices



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Considerations: Funding

Table 1.

Descriptive data regarding funding sources for RM systems.

N=49	*n*	%
EHDI or other birth to three funding program	29	59
Medicaid	9	18
Out of pocket	7	14
School provides RM for use at home	3	6
Private health insurance	1	2

Walker et al., 2019

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Fitting Considerations: HA/CI Settings

- Research shows device settings can influence performance with RM (Wolfe et al. group)
  - Mixing ratios to ensure device mics are unattenuated
  - Cochlear implant sensitivity settings (ASC)
- Important to work with Audiologist to ensure optimal settings

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Fitting Considerations: HA/CI Settings

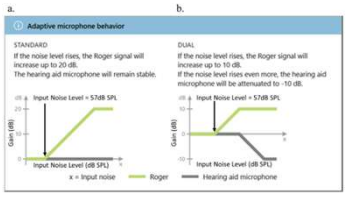

Figure 1. Adaptive RM behavior for the standard (left) and dual adaptive (right) RM systems (used with permission from Phonak, LLC.).

Wolfe et al., 2021

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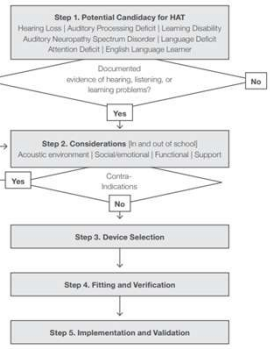
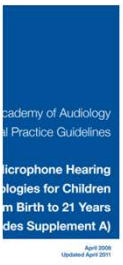
Fitting Considerations





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MiniMic with N7 Processor

Electroacoustic Evaluation

Initial FM Receiver Settings				
	750 Hz	1000 Hz	2000 Hz	Average
EPM/HA65$_{SPL}$ (FM setting ____)				
EHA/PM65$_{SPL}$				
Difference				

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Questions?

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