A FEASIBILITY STUDY:

DEVELOPING A NEW HEARING SCREENING PROTOCOL FOR PRESCHOOLERS AGED 2 YEARS – 5 YEARS 11 MONTHS OLD

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OUTLINE

Background and Aims of the Study

Methodology

Results

Discussion and Recommendations for Future Studies

BACKGROUND

34 MILLION

children are currently living with hearing loss.

(World Health Organization, 2021)

In Singapore,

4 in 1000 infants are born with hearing loss.
1.7 in 1000 are born with severe to profound degrees of hearing loss.
(Low et. al, 2005)

Impact

- Communication
- Educational outcomes
- Quality of life

Universal Newborn Hearing Screening (UNHS)

- Coverage rate of >99%
- Referral rate of 0.5%

(Lim, 2008)

1-3-6 Early Hearing Detection and Intervention (EHDI) guidelines (The Joint Committee on Infant Hearing)

- 1 month – hearing screening
- 3 months - diagnosis
- 6 months - intervention

HOWEVER..

- Late onset hearing loss (0.15% - 0.25%)
  (Bhatia et. al., 2013; Eiserman et. al., 2008).

- Lost to follow up (24.6%)
  (Centers for Disease Control and Prevention, 2019).

➢ Present with speech and language delay

School hearing screenings in Primary 1 (6-7 years)

- Critical age for brain development is 3 ½ years

Preschool hearing screening

➢ Recommended by
- Centres for Disease Control and Prevention (CDC)
- The Joint Committee on Infant Hearing (JCIH)
- American Academy of Audiology (AAA)

AIMS OF THE STUDY

Effectiveness of the proposed screening protocol

Feasibility in a non-soundproof environment

Sensitivity and Specificity

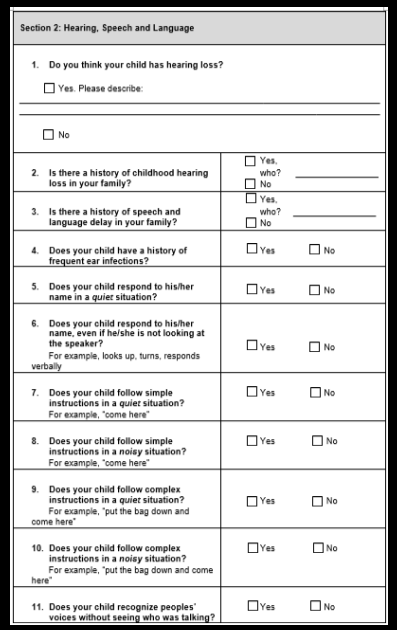
1. Questionnaire

2. Otoscopy

3. Tympanometry

4. Transient Evoked Otoacoustic Emissions (TEOAE)

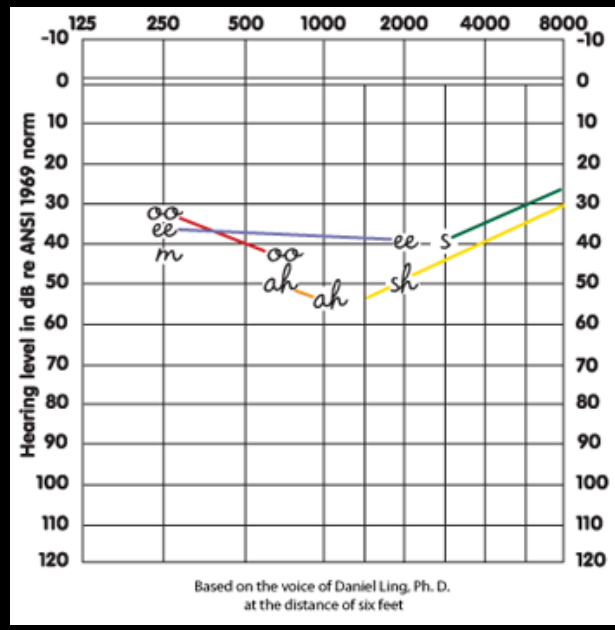
5. Ling 6 Sound Test



Section 2: Hearing, Speech and Language

1. Do you think your child has hearing loss?
☐ Yes. Please describe:
☐ No

2. Is there a history of childhood hearing loss in your family?	☐ Yes, who? ☐ No	
3. Is there a history of speech and language delay in your family?	☐ Yes, who? ☐ No	
4. Does your child have a history of frequent ear infections?	☐ Yes	☐ No
5. Does your child respond to his/her name in a *quiet* situation?	☐ Yes	☐ No
6. Does your child respond to his/her name, even if he/she is not looking at the speaker? For example, looks up, turns, responds verbally	☐ Yes	☐ No
7. Does your child follow simple instructions in a *quiet* situation? For example, "come here"	☐ Yes	☐ No
8. Does your child follow simple instructions in a *noisy* situation? For example, "come here"	☐ Yes	☐ No
9. Does your child follow complex instructions in a *quiet* situation? For example, "put the bag down and come here"	☐ Yes	☐ No
10. Does your child follow complex instructions in a *noisy* situation? For example, "put the bag down and come here"	☐ Yes	☐ No
11. Does your child recognize peoples' voices without seeing who was talking?	☐ Yes	☐ No



1. Are these measures relevant, effective and time efficient ?

AIMS OF THE STUDY

Effectiveness of the proposed screening protocol

Feasibility in a non-soundproof environment

Sensitivity and Specificity

2. Is it feasible to conduct a basic hearing screening in a non-sound proof environment, e.g. consultation room in NUH?

AIMS OF THE STUDY

Effectiveness of the proposed screening protocol

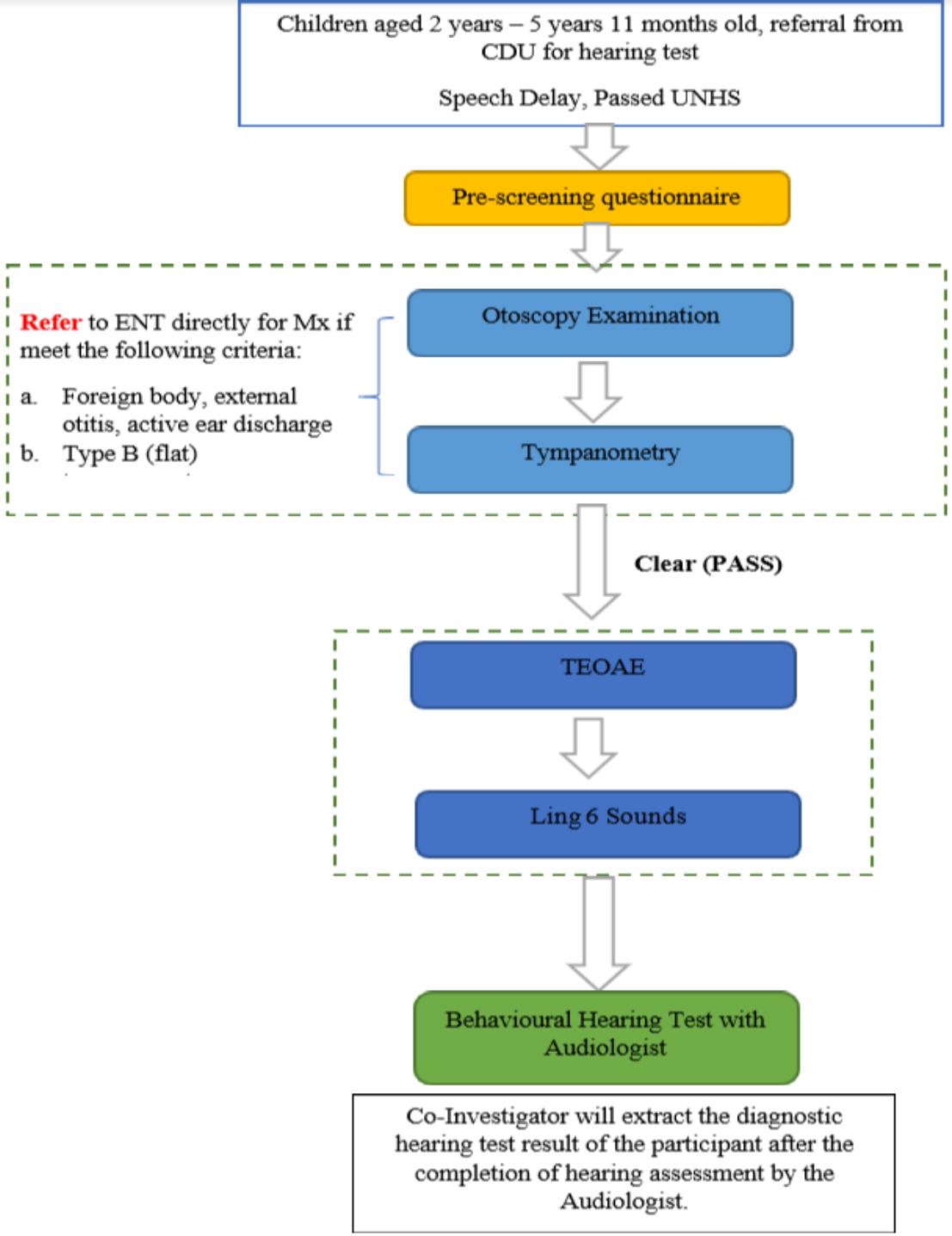
Feasibility in a non-soundproof environment

Sensitivity and Specificity

3. Does it yield high sensitivity and specificity?

METHODOLOGY

- 30 participants
- Aged 2 years – 5 years 11 months
- Referral from Child Developmental Unit, NUH
- Speech delay
- Screening conducted on the same day as their behavioural hearing test appointment (45 mins prior)



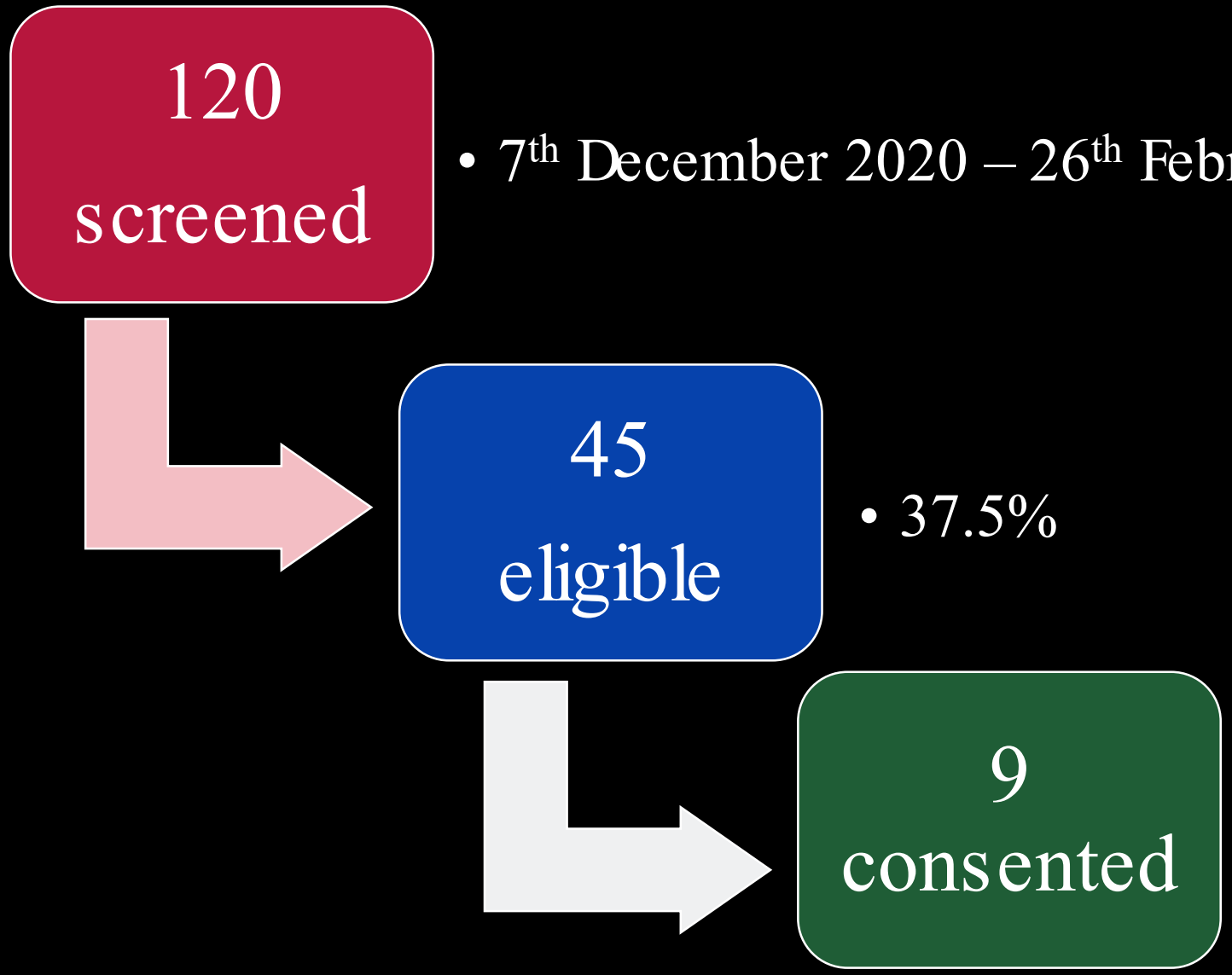
Inclusion criteria

- Developmentally and cognitively ready for listening tasks.
- Passed universal newborn hearing screening (UNHS).

Exclusion criteria

- Developmental/congenital/genetic disorders – e.g., Autism Spectrum Disorder, Global Developmental Delay.
- Known Outer and Middle ear pathologies.

RESULTS


120 screened
• 7th December 2020 – 26th February 2021
45 eligible
• 37.5%
9 consented

Ambient Noise Levels

- In quiet: 40.5dBA (38.3 – 47.1)
- In noise: 63.5dBA (52.7 – 85.3)

- TEOAE: 47.9dBA & 46.3dBA (Test 1 & 2)

Screening Time

- 32 minutes

Screening Test Results

Subject	Gender	Age	Reason for referral	Medical history (Questionnaire)			Parental concern of HL	Clinical Observation	Otoscopy	TEOAE Screen		Tympanometry Screen		Ling 6 Sounds
				NICU Stay	Fam Hx of HL	Fam Hx of SD				RE	LE	RE	LE	
S1	Male	2.5	Language delay	N	N	N	N	Uncooperative/fleeting eye contact	Partial	P	P	A	A	CNT (Cannot test)
S2	Male	2.0	Speech delay	N	N	N	N	Cooperative	Partial	p	p	As	A	CNT (Cannot test)
S3	Female	4.3	Articulation difficulties	N	N	N	N	Uncooperative/clingy/ squirming	Partial Wax LE>RE	P	R	A	A	Y
S4	Male	4.6	Speech and Language delay	N	N	N	N	Cooperative	Clear	P	P	A	A	Y
S5	Male	4.9	Articulation difficulties	N	Y	N	N	Cooperative	Clear	P	P	A	A	Y
S6	Male	4.0	Language delay	N	N	Y	N	Cooperative	Clear	P	P	A	A	Y
S7	Male	3.0	Language delay	N	N	Y	N	Cooperative/shy	Clear	P	P	A	As	Y
S8	Male	2.3	Speech delay	N	N	N	N	Uncooperative/cranky	Clear	P	P	A	A	R
S9	Male	2.6	Expressive speech delay	N	N	N	N	Cooperative	Clear	P	P	A	A	Y

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S1	Male	2.5	Language delay	N	N	N	N	Uncooperative/fleeting eye contact	Partial	P	P	A	A	CNT (Cannot test)
S2	Male	2.0	Speech delay	N	N	N	N	Cooperative	Partial	p	p	As	A	CNT (Cannot test)
S3	Female	4.3	Articulation difficulties	N	N	N	N	Uncooperative/clingy/ squirming	Partial Wax LE>RE	P	R	A	A	Y
S4	Male	4.6	Speech and Language delay	N	N	N	N	Cooperative	Clear	P	P	A	A	Y
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				NICU Stay	Fam Hx of HL	Fam Hx of SD				RE	LE	RE	LE	
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Behavioural Hearing Test Results

Subject	Age	Otoscopy	Tympanometry		BHT (Type of Test)	Result	TEOAE	
			RE	LE			RE	LE
S1	2.5	Partial	A	A	NT	NT	NT	NT
S2	2.0	Partial	A	As	Play + VRA (Freefield)	Minimum response levels at 30dBHL to 50dBHL in the better ear. Unable to rule out mild hearing loss in both ears.	P	P
S3	4.3	Partial	A	A	Play Audiometry (insertphones)	Normal hearing	NT	NT
S4	4.6	Clear	A	A	Play Audiometry (insertphones)	Normal hearing	NT	NT
S5	4.9	Clear	A	A	Play Audiometry (insertphones)	Normal hearing	NT	NT
S6	4.0	Clear	A	As	Play Audiometry (insertphones)	Normal hearing	NT	NT
S7	3.0	Clear	A	A	Play Audiometry (insertphones)	Normal hearing	NT	NT
S8	2.3	Clear	A	A	VRA (insertphones)	Normal hearing	NT	NT
S9	2.6	Clear	A	A	VRA (insertphones)	Normal hearing	NT	NT

DISCUSSION

EFFECTIVENESS OF THE SCREENING PROTOCOL

Questionnaire

Otoscopy and Tympanometry

TEOAE

Ling 6 Sound Test

Questionnaire

- Identify risk factors for hearing loss and speech delay.
  - Parental concern, maternal education, family history etc.
- Information on child's responses to sounds in the 'real world'.

- Need for a validated hearing screening questionnaire.

Otoscopy and Tympanometry

- Assesses integrity of outer and middle ear.
  - Screening result is influenced by presence of outer and middle ear anomalies.
- Highlight need for referral to ENT.

TEOAE

- Widely used objective measure.
- Reliable and quick.

- Inability to rule out Auditory neuropathy spectrum disorder (ANSD) and mild hearing losses.

Ling 6 Sound Test

- Useful as an additional tool for children >2.5 years.
- Subject to child's cooperation and presentation level.
- Variable results for children ≤2.5 years.

FEASIBILITY

Environmental Factors

- Hearing screening using TEOAE is possible if ambient noise levels are controlled (<61dBA, Salina et al,
- Environmental modifications can be made to attenuate noise e.g., carpets, acoustic tiles etc.

Child Related Factors

- Parental consent.
- Inclusion criteria.
  - 62.5% excluded from study.
- Challenging age group. Results can vary depending on child's cooperation.

FUTURE STUDIES

1. Larger sample sizes
   - Establish sensitivity and specificity

2. Wider inclusion criteria
   - Children with additional disabilities and developmental delays (ASD, GDD etc.)
   - Children that failed UNHS (lost to follow up)

3. Explore additional tests like Auditory Brainstem Response to rule out ANSD (especially those with risk factors for ANSD)

CONCLUSION

- Results from this study look promising.
  - Further research must be conducted.
  - Preschool hearing screening programme should be introduced in Singapore.

- All 7 participants had normal hearing.
  - Pass → referral to other medical professionals.
  - Refer → reduced waiting time for BHT appointments → early intervention.

Thank you

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REFERENCES

1. American Academy of Audiology (AAA). (2011). Childhood Hearing Screening Clinical Practice Guidelines.
2. American Speech-Language-Hearing Association. (2020). Newborn Hearing Screening.
3. Bhatia, P., Mintz, S., Hecht, B. F., Deavenport, A. & Kuo, A. A. (2013). Early identification of young children with hearing loss in federally qualified health centers. Journal of Developmental & Behavioral Pediatrics, 34(1), 15-21.
4. Centres for Disease Control and Prevention. (2019). Annual Data Early Hearing Detection and Intervention (EHDI) Programme Summary. https://www.cdc.gov/ncbddd/hearingloss/2017-data/documents/01-2017-HSFS-Data-Summary.pdf.
5. Centres for Disease Control and Prevention. (2019). Summary of 2017 National CDC EHDI Data.
6. Lim, L. (2008). A Multidisciplinary Approach to Paediatric Hearing Loss: Programme at the Centre for Hearing Intervention and Language Development, National University Hospital, Singapore. Ann Acad Med Singpore, 37, 57-59.
7. Low WK, P. K., Ho LY, Lim SB, Joseph R. (2005). Universal newborn hearing screening in Singapore: the need, implementation, and challenges. Annals of the Academy of Medicine, Singapore, 2005, 34(4), 301-306.
8. Reyes, R. (2008). Early Intervention For Hearing Impairment Appropriate Accessible.pdf. Annals of the Academy of Medicine, Singapore, 2008, 37(12), 55-56.
9. Salina, H., Abdullah, A., Mukari, S. Z., & Azmi, M. T. (2010). Effects of background noise on recording of portable transient-evoked otoacoustic emission in newborn hearing screening. Eur Arch Otorhinolaryngol, 267(4), 495-499. doi:10.1007/s00405-009-1080-y
10. The Joint Committee on Infant Hearing (2019). Year 2019 Position Statement: Principles and Guidelines for Early Hearing Detection and Intervention Programmes. The Journal of Early Hearing Detection and Intervention, 4, 1-44. doi:10.15142/fptk-b748
11. World Health Organisation. (2021). https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss.