

Newborn Hearing Screening: Current Best Practice and Potential Improvements

Yvonne S. Sininger PhD

Professor Emeritus, UCLA

Consultant, C&Y Consultants, Santa Fe, NM

ysininger@cnyconsult.com



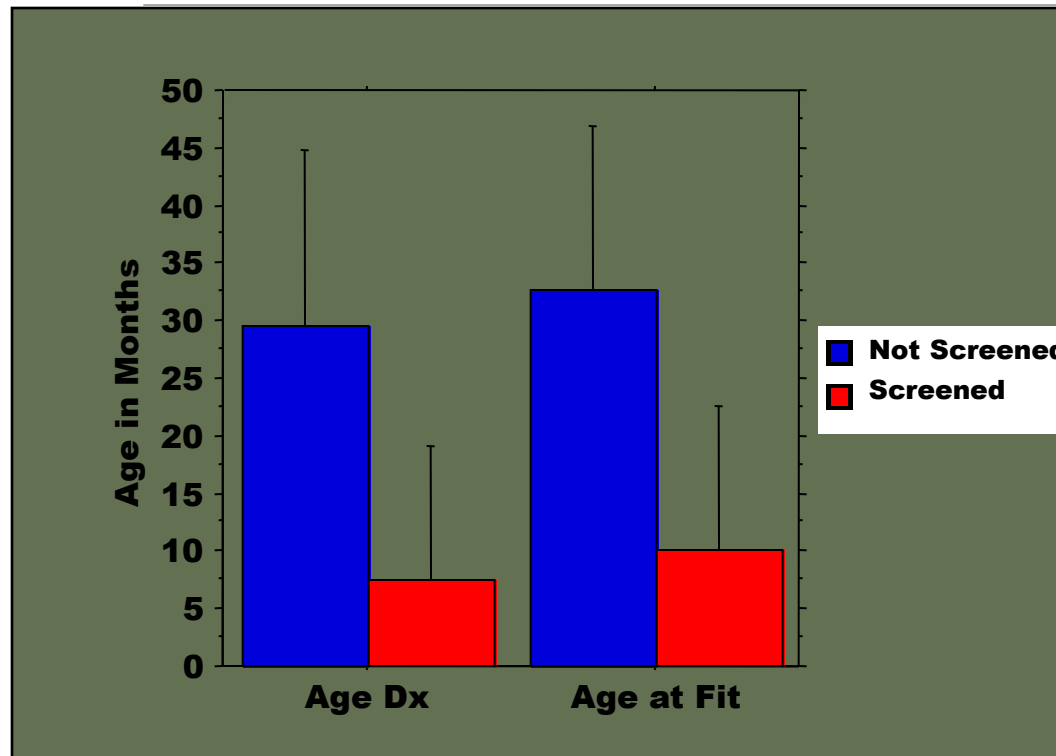
All infants have access to hearing screening using a physiologic measure during their hospital birth admission. (UNHS) (*ONE*)

All infants who do not pass the screening begin appropriate audiologic and medical evaluations to confirm the presence of hearing loss before 3 months of age. (*THREE*)

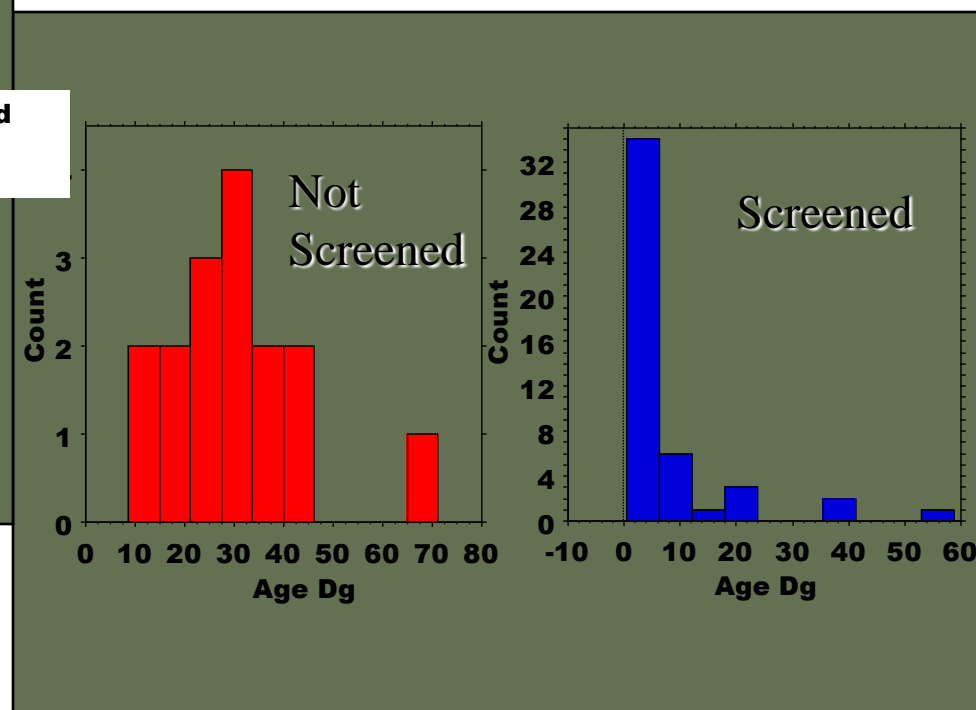
All infants with confirmed permanent hearing loss receive services before 6 months of age. (*SIX*)

Screening leads to Earlier ID and Intervention

SININGER, et al., (2009), Journal of American Academy of Audiology 20:49-57

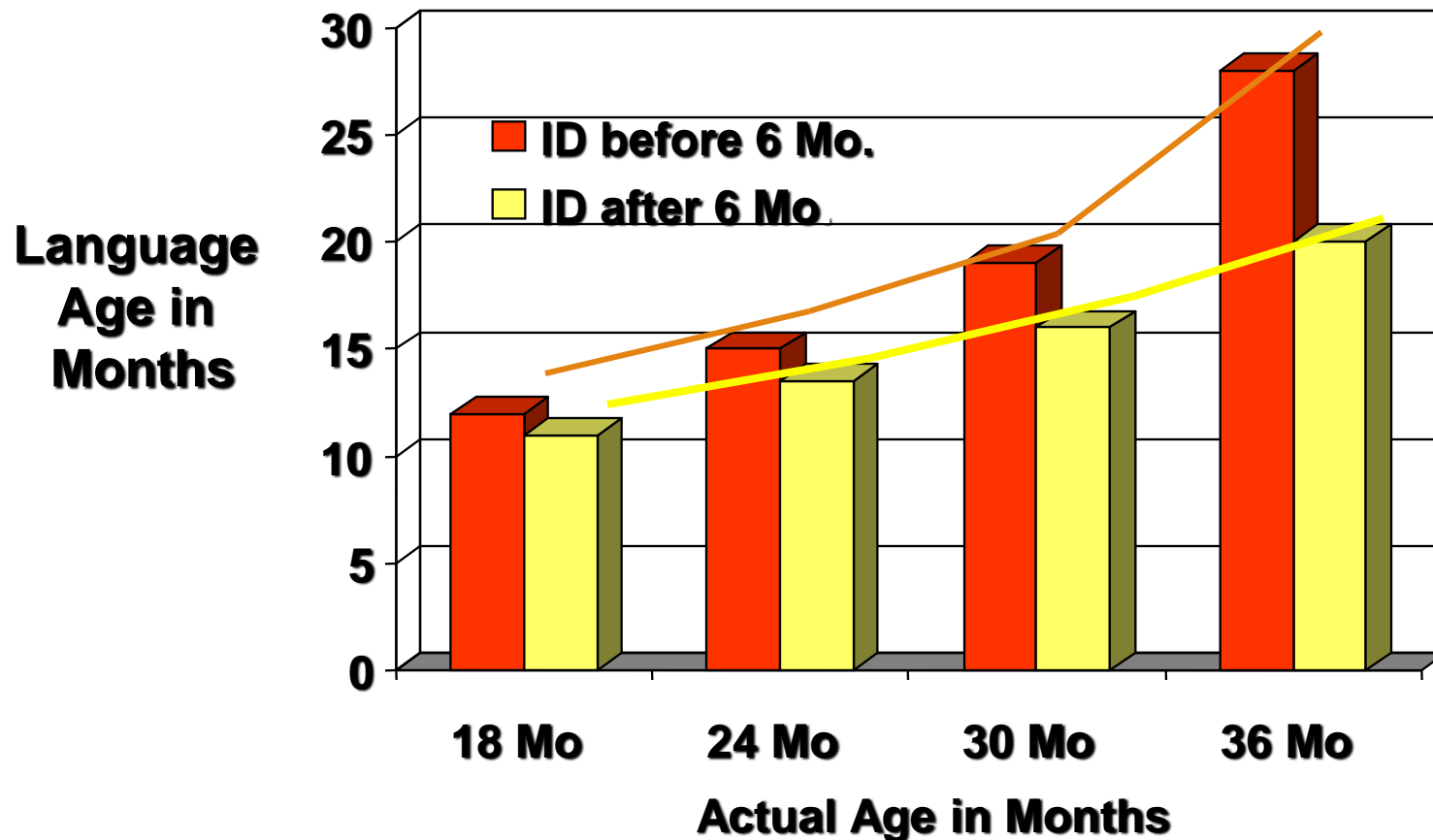


Data from prospective study of 62 children with hearing loss, 16 not screened, 46 screened.



•UCLA Study/ Sininger Auditory Development in Early-Amplified Children

Intervention before 6 Months Leads to Near-Normal Language Skills Yoshinaga-Itano et al.



Auditory Development in Early Amplified Children

Predictive Measures:

- Age at Amplification
- Degree of Hearing Loss
- Cochlear Implant Status
- Intensity of Intervention
- Parent/Child Interaction-*NCAST*
 - Multi-lingual Home

Outcome Measures:

Speech Perception

Pediatric Speech Intelligibility

IMSPAC (Imitative Test of Speech Pattern Contrast Perception-On Line)

Speech Production

Arizona 3

Language

**Reynell Language
Expressive & Receptive**

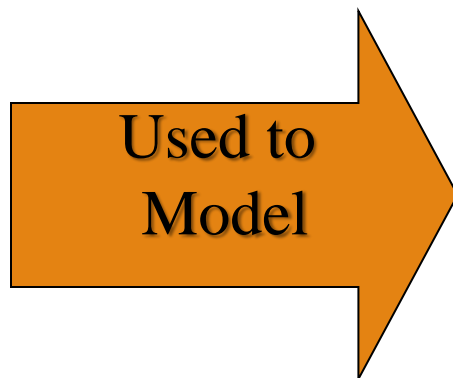
SININGER, Y., GRIMES, A., CHRISTENSEN, E., (2010) Auditory Development in Early Amplified Children: Factors Influencing Auditory-Based Communication Outcomes in Children with Hearing Loss. Ear and Hearing 31(2): 166-85.



Multivariate Least Squares Regression Analysis

Factors

Age at Amplification
Degree of Loss
Cochlear Implant
Intensity of Intervention
Parent/Child Interaction
Multi-lingual Home



Outcomes

Speech Production
Spoken Language
Expressive
Receptive
Speech Perception in Noise
Speech Feature Perception

The factor that is most important in predicting overall outcomes:

Age at Fitting of Hearing Aids

Each month delay in fitting is associated with:

- 3/4 month delay in Speech Feature Perception
- 3/4 months delay in Speech in Noise Perception
- .02 Z Score points decrease in Speech Production
 - 1/3 months delay in Expressive Language
 - .2 months delay in Receptive Language

2) *Hearing Level*

Each 10 dB of additional loss is associated with:

- Loss of .3 Z-score points on Speech Production
 - 5.2 months lag in Expressive Language
 - 5.9 months lag in Receptive Language

NB Hearing Screening in the US



Where do we stand?

2013 JCIH POSITION STATEMENT UPDATE TO 2007

PEDIATRICS Volume 131, Number 4, April 1, 2013

Principles and Guidelines for Early Intervention After Confirmation That a Child Is Deaf or Hard of Hearing

EHDI in the United States



- Every state has its own laws and guidelines regarding screening but all are based on JCIH Principles
- 98 or 99 percent of all children born in the United States are screened for hearing loss by age 1 month.
- NICU infants generally are screened with ABR but otherwise there is no directive as to method of screening

Technology & Protocols



- No standardized protocols exist except that ABR is recommended for high risk infants to detect AN.
- Well baby nurseries use ABR/ASSR or OAE (transient or dpoae) or a combination of both.
- A common strategy is to screen with OAE and retest, if necessary with ABR.

California Testing Protocol



No specific technology or equipment.

All infants screened before discharge.

Hospital pass rate standards:

>90% for OAE

>95% for ABR

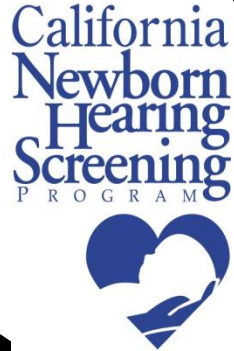
**Two (NICU) or three screens
before diagnostic hearing test.**

**Diagnostic hearing test before
3 months**

Intervention before 6 months

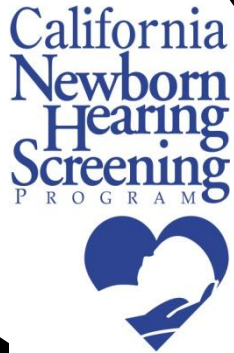


Features of California's NHS Program



- ✓ All Hospitals must be trained and certified.
- ✓ Hospitals **MUST** make a follow up appointment for all failed screens!
- ✓ Hospital reports all findings to parents and to primary care physicians.
- ✓ All fails and follow-up times are sent to the local HCC.
- ✓ HCC monitors results of follow-up as well as no-shows.
- ✓ Dx centers and HCC work on contacting families.

Features of California's NHS Program



- ✓ Mandated in all birthing Hospitals
- ✓ \$30 payment for uninsured or Medicaid.
- ✓ Standards for hearing health services.
- ✓ Statewide infant tracking
- ✓ Geographically-based Hearing Coordination Centers
- ✓ 5% Loss to Follow-up due to State-wide tracking system

Follow-up materials in >25 languages!

What is a Diagnostic Hearing Evaluation?

A diagnostic hearing evaluation is another step in checking your baby's hearing. The evaluation includes a number of tests to get a complete picture of your baby's hearing. The evaluation will be completed by an audiologist, a health care professional who specializes in hearing.

How is the Diagnostic Hearing Evaluation Done?

While your baby is resting or sleeping, special equipment is used to play soft sounds through earphones specially made for testing babies' hearing. The whole process is painless. Your baby's responses to the sounds are electronically recorded either through the ear pieces or through little wires attached by sticky pads on the head. Because more tests are done, a diagnostic hearing evaluation takes more time than newborn hearing screening. It is possible that you may be at the office for an hour or more and may need to return for a second visit.



Your Baby's Diagnostic Evaluation Appointment:

Baby's name: _____

Appointment Date & Time: _____

Appointment Location: _____

Appointment Contact Number: _____

(Please call if you need to re-schedule your appointment.)

The California Newborn Hearing Screening Program:

The goal of California's Newborn Hearing Screening Program is to identify babies with hearing loss and link them with services by six months of age. The program has Hearing Coordination Centers that work with families, health care providers and hospitals to make sure children get needed services.

The Newborn Hearing Screening Program collects information about your baby's hearing screenings as per Section 124119 of the Health and Safety Code. The Hearing Coordination Centers may use this information to assist you and your baby in getting to services you may need. It is possible that the Hearing Coordination Center may contact you about follow-up services.

Newborn Hearing Screening Program Toll Free 1-877-388-5301

Children's Medical Services
714 P Street
Sacramento, CA 95814

Gray Davis
Governor
State of California

Grantland Johnson
Secretary
Health and Human Services Agency

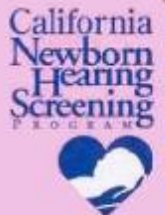
Diana M. Bonta, R.N., Dr. P.H.
Director
Department of Health Services

CMS Contract 89-00110

Publication Number 856

Rev. 3/2001

Diagnostic Hearing Evaluation Referral



State of California, Department of Health Services,
Children's Medical Services

Prevalence and referral rates in neonatal hearing screening program using two step hearing screening protocol in Chennai – A prospective study

S.S. Vignesh V. Jaya_B.I. Sasireka_Kamala Sarathy_M. Vanthana

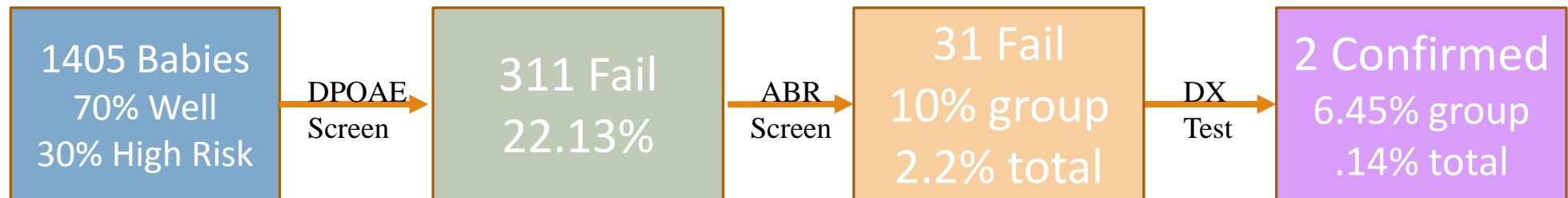
Intl J. Ped Otolaryngol. October 2015 Volume 79, Issue 10, Pages 1745–1747

Method

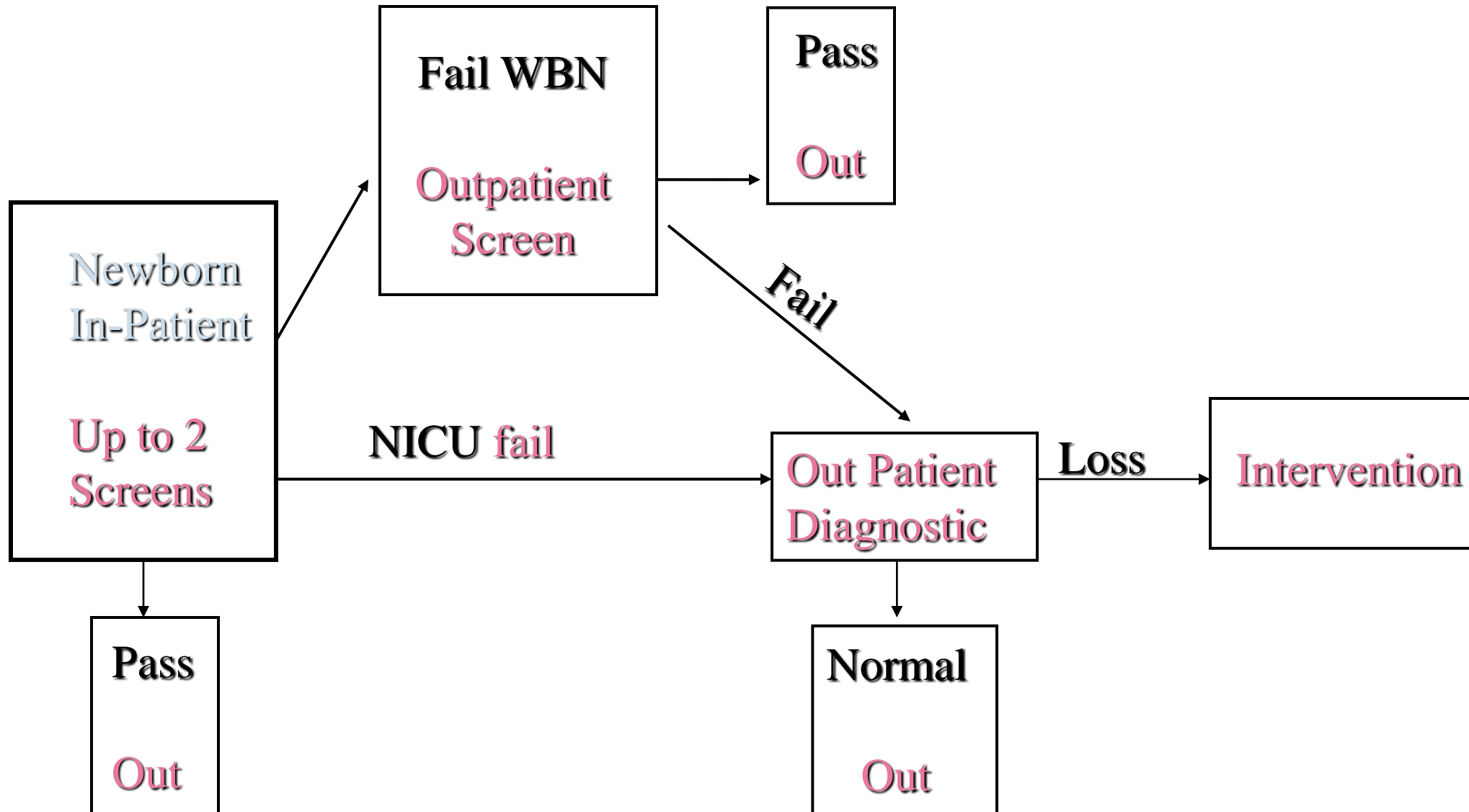
A prospective study was carried out on 1405 neonates (983 well born babies and 422 high risk babies) who were screened during May 2013 to January 2015 at Institute of Obstetrics and Gynecology, Madras Medical College, Chennai. All neonates were screened using two step screening protocol. They were initially tested with DPOAE. Referred babies in DPOAE were screened with AABR subsequently.

Results

Among 1405 (100%) neonates 983 (69.96%) were well born babies and 422 (30.03%) were high risk babies. Total referral rate in DPOAE was found to be 311 (22.13%) among which 195 (13.87%) were well born babies and 116 (8.25%) were high risk babies. Out of 311 babies 31 (2.20%) babies were referred in AABR screening. In 31 babies referred in AABR 11(0.78%) were from well born group and 20 (1.42%) were from the high risk group. Further diagnostic evaluation of these babies, 2 (0.14%) were confirmed to have hearing loss. This study reveals, the prevalence of congenital hearing loss in our population is 1.42 per 1000 babies.



California Screening Flow Chart



Protocols



- Two Screenings at birth will reduce referral rate.
- In US, most babies go home early (1 day) increasing the middle ear false positives seen with OAE.
- Some states require an “outpatient” rescreen to reduce referral rates. This may be only for well babies.
- Over-referral is a major issue for audiology clinics in US.

Protocol Choices/Technology

OTOACOUSTIC EMISSIONS

- +Lower initial cost for supplies
- +Less patient preparation (time)
- Higher refer rate (up to 20%)
- Intolerant to Ambient Noise
- Insensitive to Neural Dysfunction

ELECTROPHYSIOLOGY ABR/ASSR

- Higher disposable supply costs
- Electrode application time
- +Lower refer rate <5%
- +Less sensitive to acoustic noise
- +Will detect auditory nerve & brainstem dysfunction

EHDI in the United States



- The 2011 statistics indicate that 65.1 percent of the children referred for additional testing will have an Audiological Diagnostic Evaluation.
- Of those, 71.8 percent were identified by 3 months of age. So there still a significant number of infants with hearing loss not diagnosed by 3 months of age.
- Loss to follow-up and delays in fitting of amplification are still **significant** problems in the US.

Problems



- Loss to follow-up, insufficient tracking.
- SIGNIFICANT delays for diagnostic appointments and need for multiple test dates.
- Delays in funding for hearing aids.
- Lack of standards for Early Intervention.

Problems/Solutions?

Late identification of AN in Well Babies



- Education of professionals on short-comings of some protocols.
- Ensure that infants who refer from ABR are not rescreened with otoacoustic emissions.
- Reduce the time and cost of Electrophysiologic Screening.
- Expand Genetic Testing protocols

Fitting of Amplification by six months:

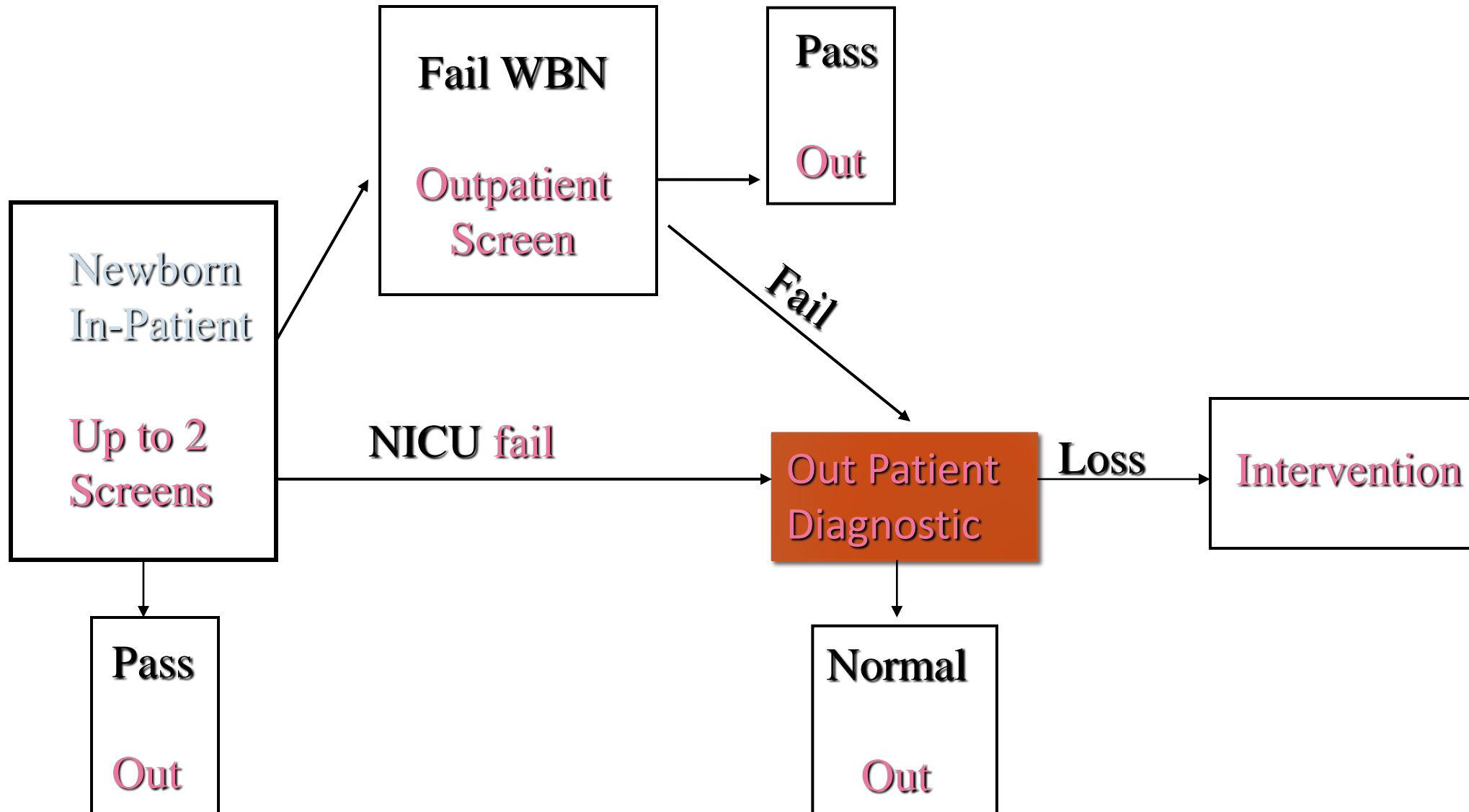


Christie Yoshinaga-Itano:



“we're happy to have financial support from some of the hearing aid manufacturers, such as Oticon and Phonak, Starkey, and Widex. Their donations and hearing aid loaner banks make a world of difference with regard to fitting babies with hearing aids—but that only happens when the centers taking care of the babies know these opportunities are available.”

Biggest Problem Area in US



Problems

Delays at Diagnostic Stage



- Long test times prevent diagnostic assessment from being completed in one session.
- Multiple sessions reduce the confidence of family and increase stress.
- Added sessions increase the risk of loss to follow up and missed appointments.

Problems

Delays at Diagnostic Stage



- Cost to the families, health care systems and audiology providers increases with multiple sessions.
- Systems pay by test and not by time so clinics lose \$.
- Long appointment times and need for specialized skills limits the number of clinics that perform diagnostic evaluations.

Which Problems would be reduced by faster test times?



- Long test times prevent the assessment from being completed in one session.
- Multiple sessions decrease the confidence of family and increase stress.
- Added sessions increase the risk of loss to follow up and missed appointments.

Which Problems would be reduced by faster test times?



- Cost to the family and health systems and audiology practice increases with multiple sessions.
- Systems pay by test time so clinics lose \$.
- Long appointment times and need for specialized skills limits the number of clinics that perform Dx evals

Problems

Delays at Diagnostic Stage



- **Leads to delays in fitting of amplification and enrollment into early intervention!!**



Solutions?

Delays at Diagnostic Stage



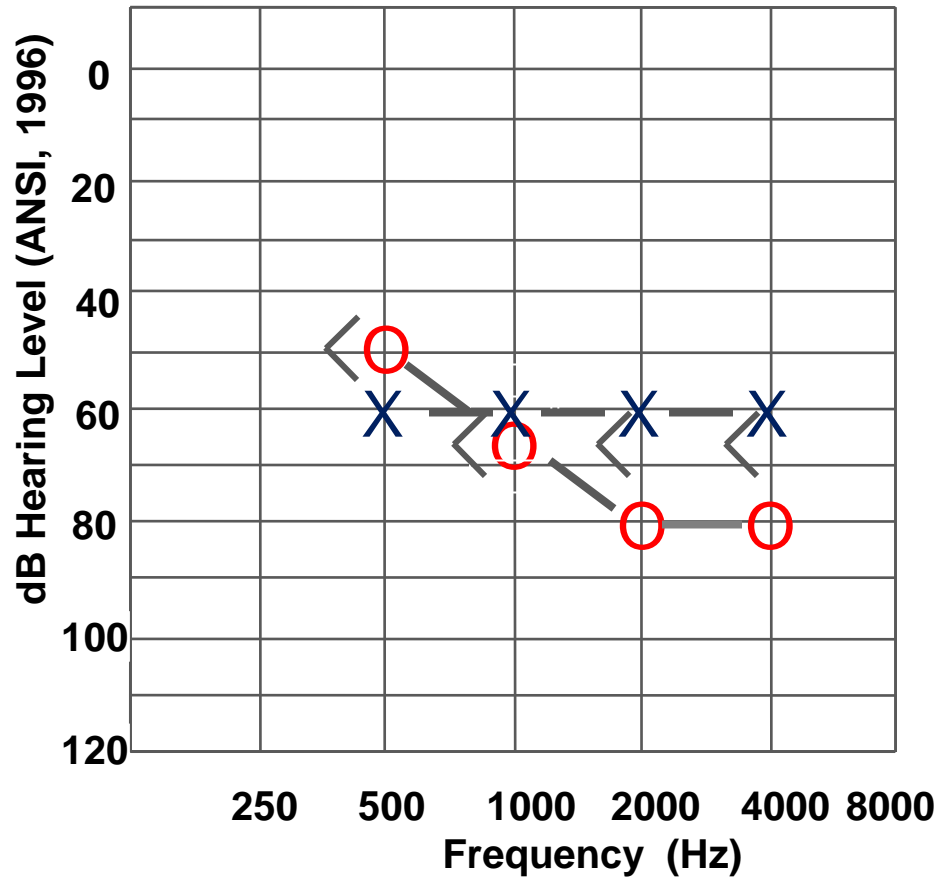
Reduce false positive referrals.

Better tracking and follow-up procedures.

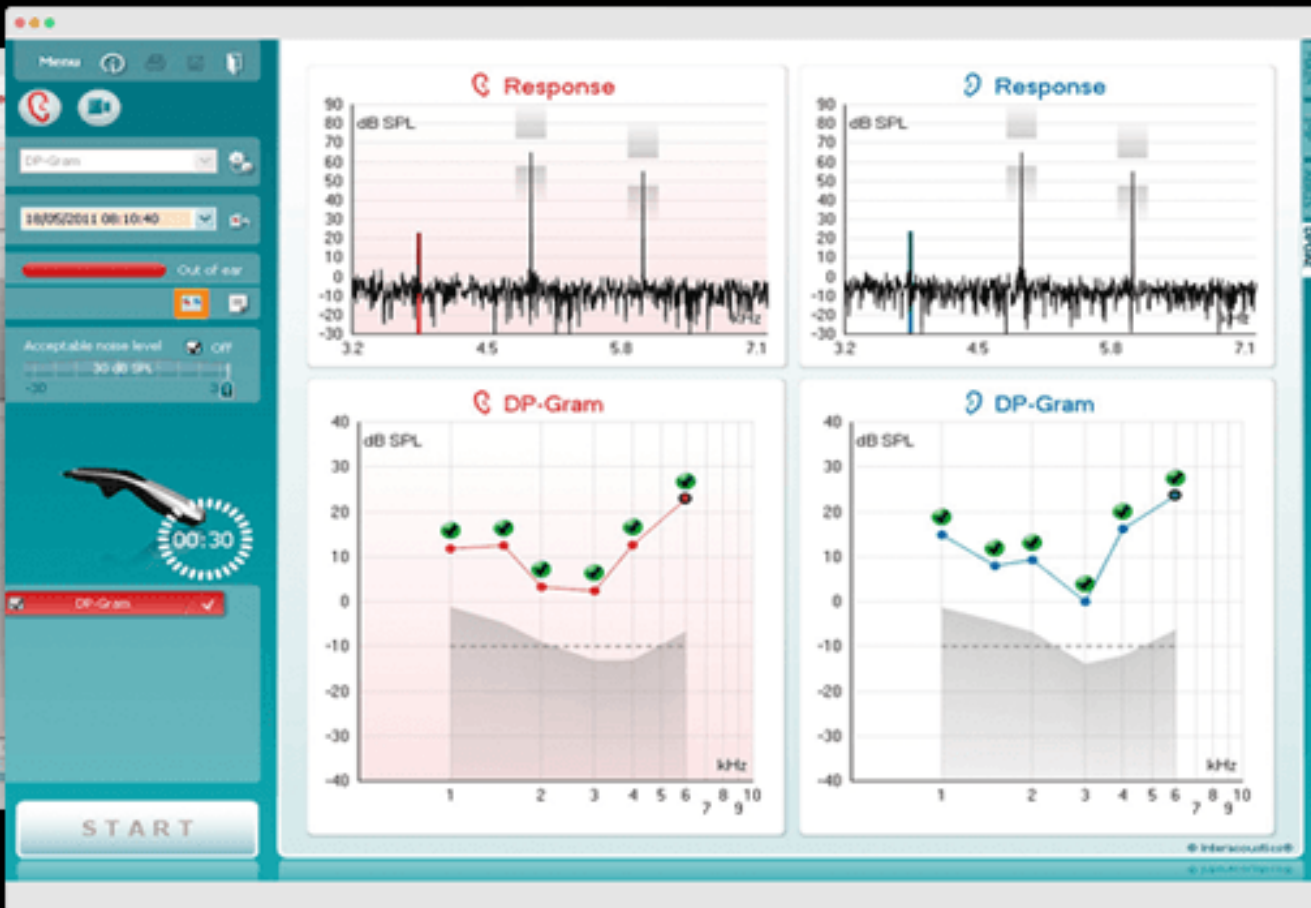
Parent Education.

Reduce diagnostic test time. (One session in < 2 hours).

Audiology Diagnostics Following NBHS

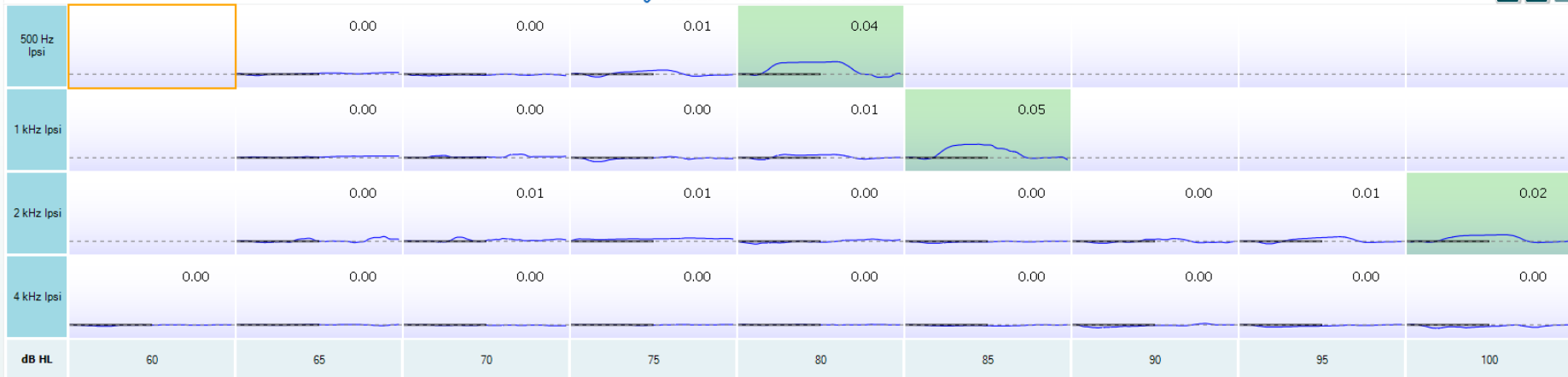


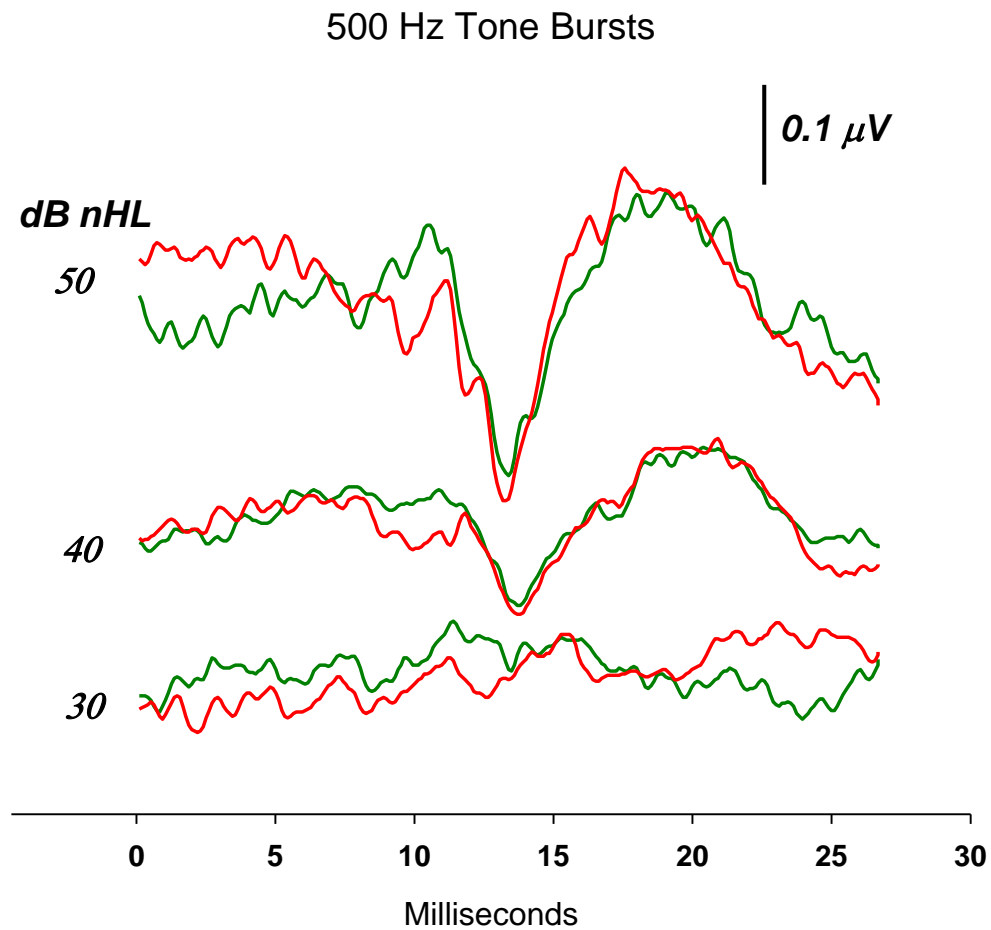
1. Electrophysiology to predict thresholds for air and BONE Conduction
2. Diagnostic OAE
3. Immittance (acoustic reflex)



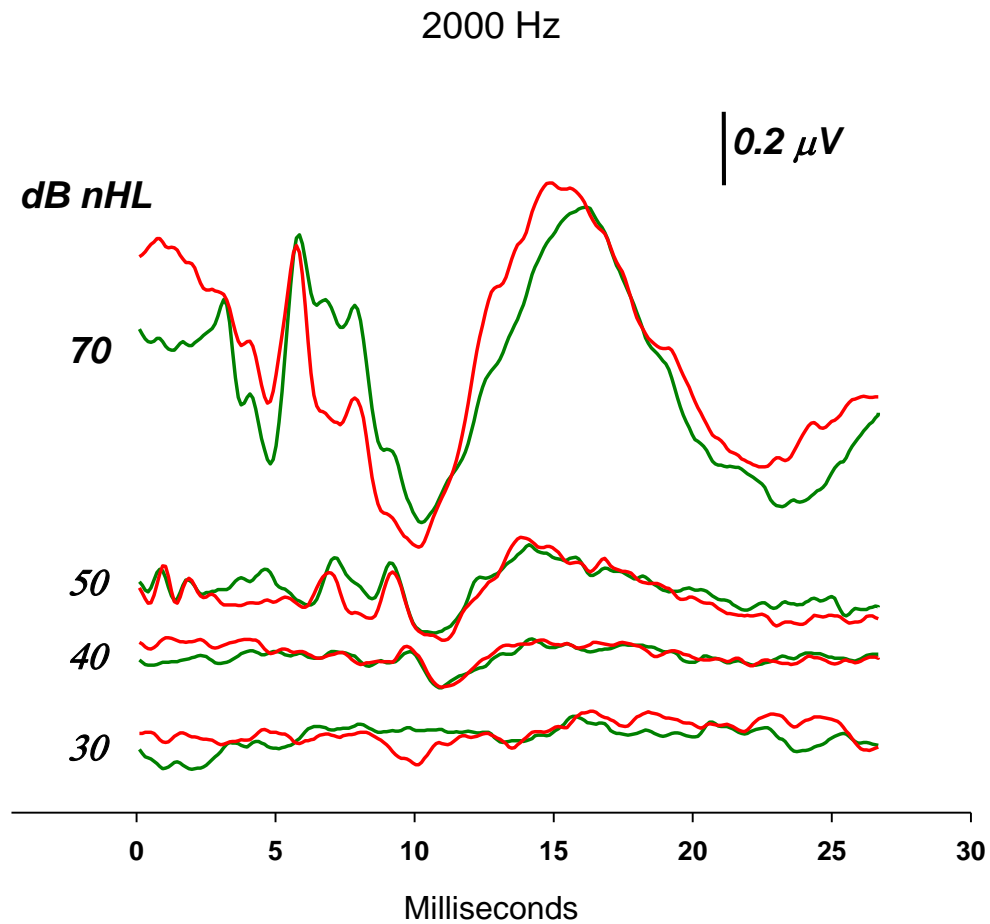


Reflex F: 226 Hz P: -4 daPa

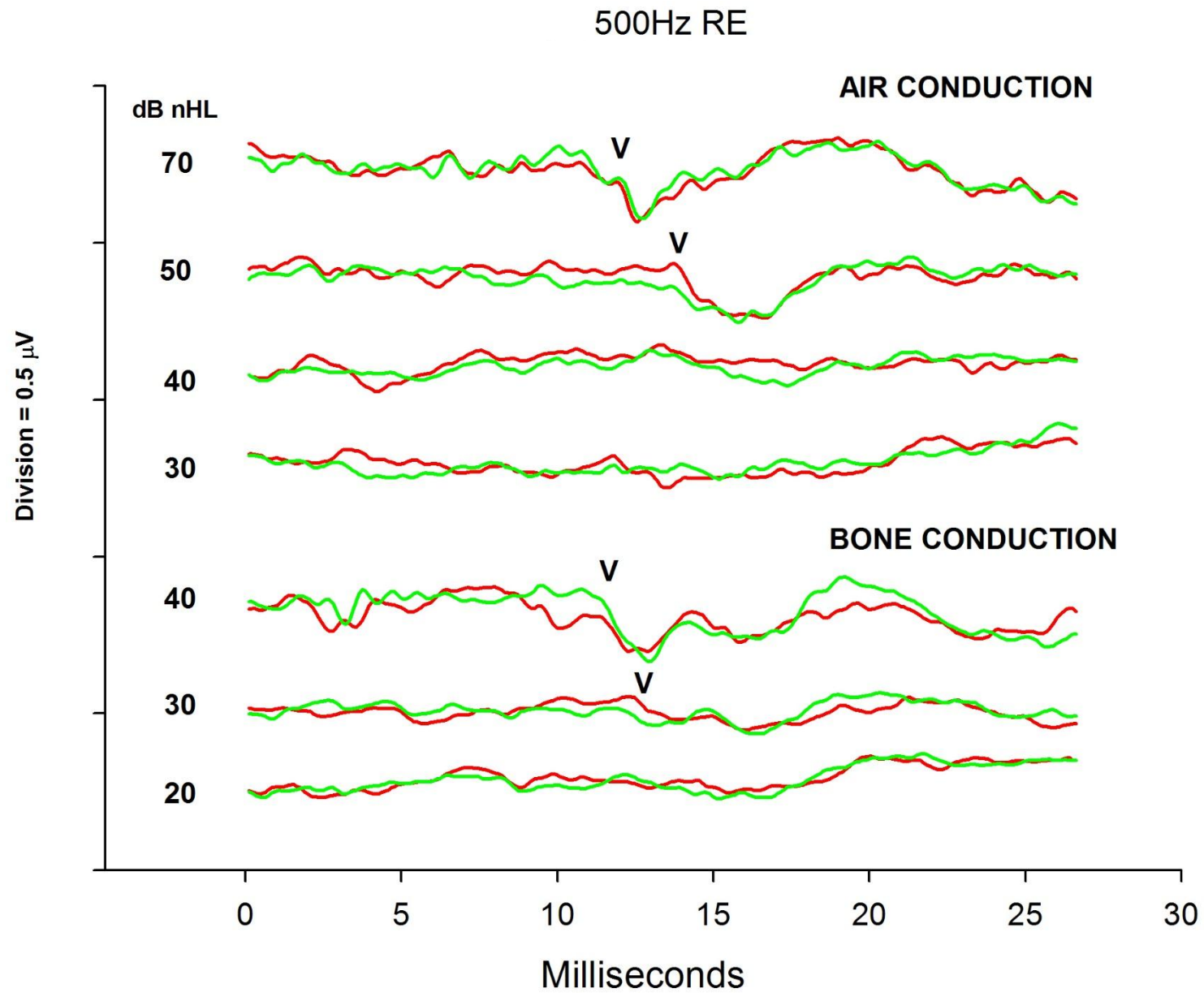




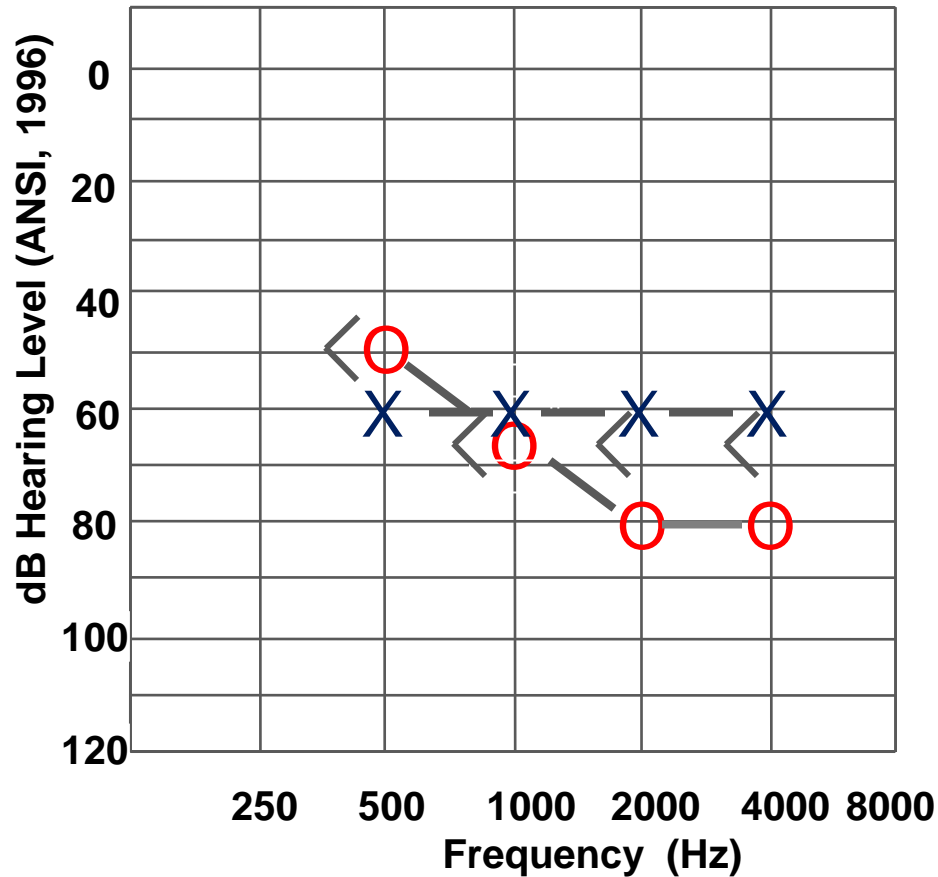
Fsp	Noise	Sweeps
7.25	33.7	1536
3.27	32.5	4352
0.93	28.3	3072



Fsp	Noise	Sweeps
7.25	33.7	1536
3.27	32.5	4352
3.19	23.8	2560
0.93	28.3	3072



Audiology Diagnostics Following NBHS

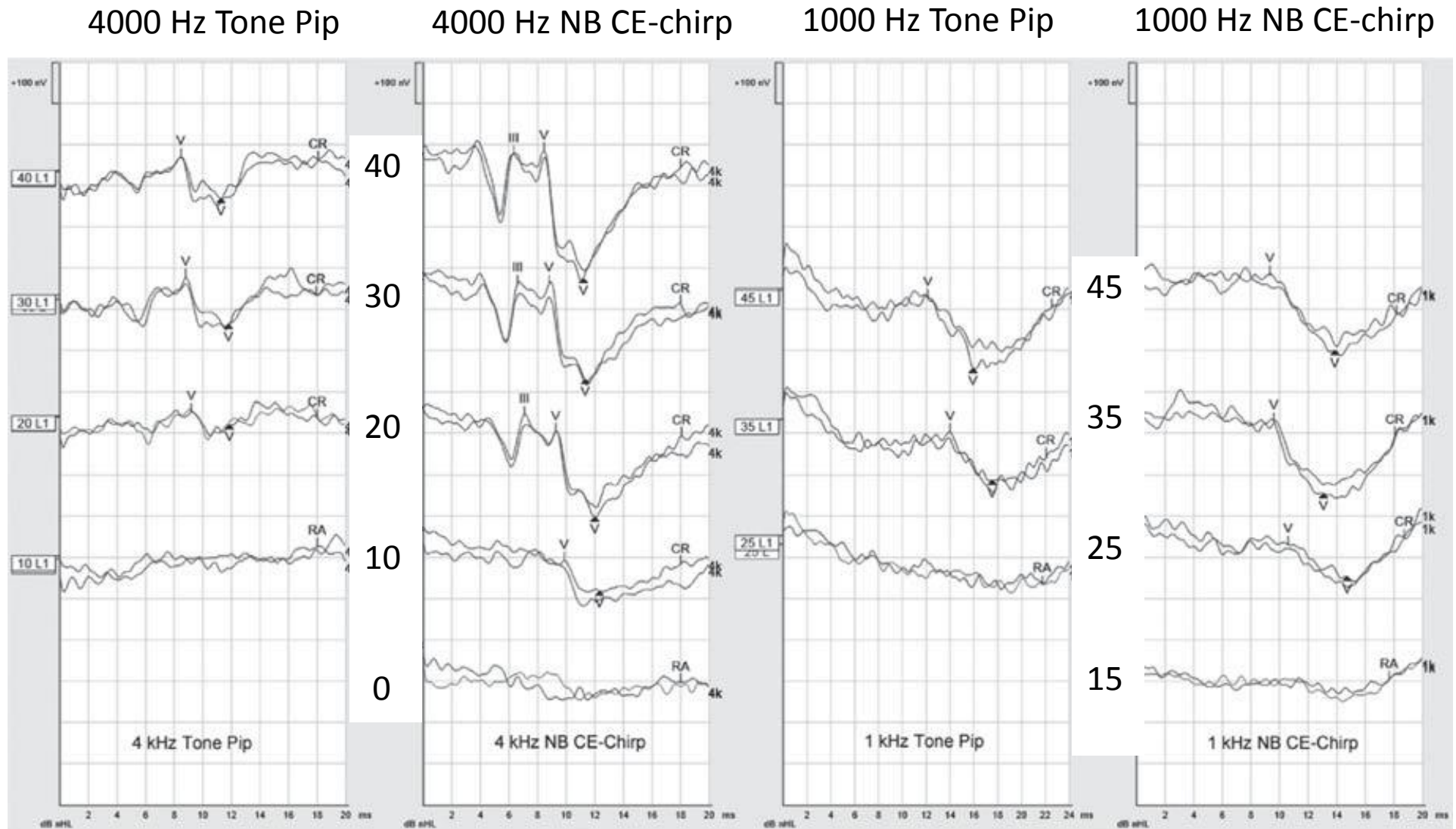


PREDICTED THRESHOLDS

- Up to 4 Frequencies
- Both ears
- Bone conduction

HOW CAN THIS BE
ACCOMPLISHED MORE
QUICKLY??

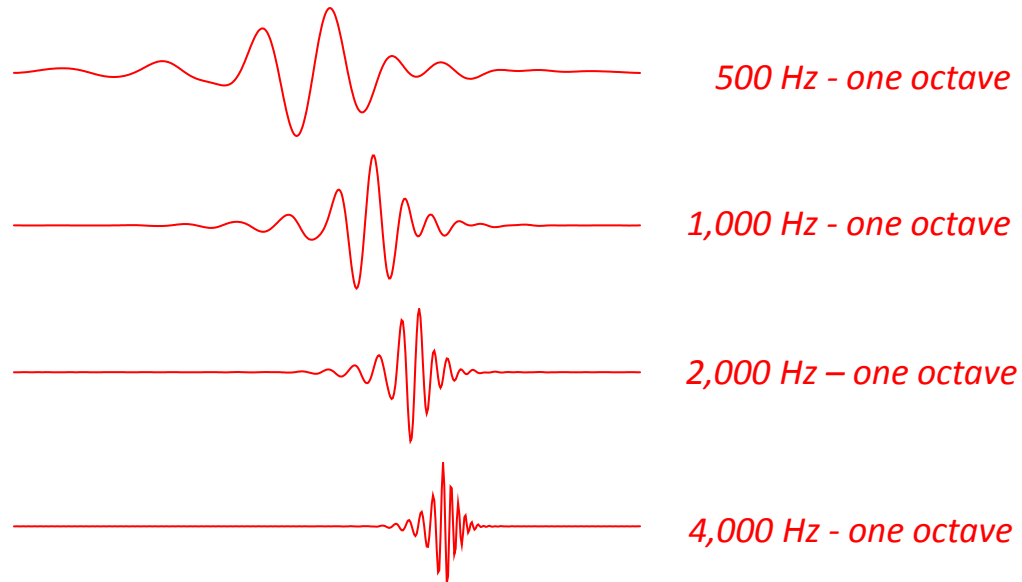
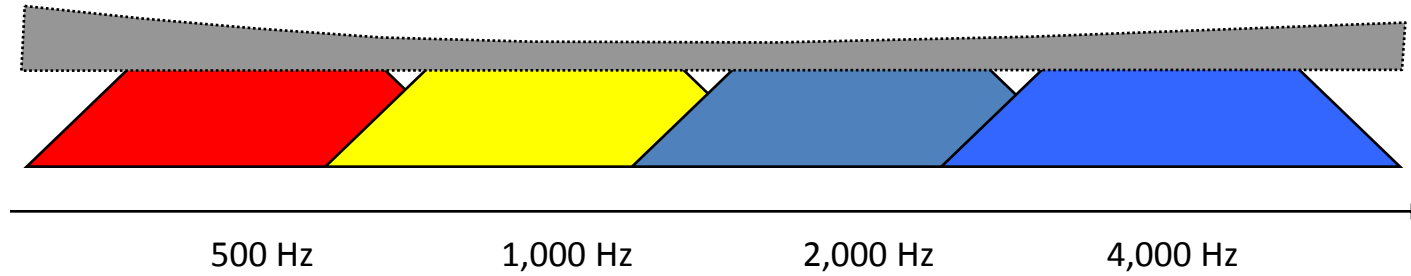
NB CE-Chirps Deliver More Amplitude than Tone Pips



Ferm, Lightfoot & Stevens International Journal of Audiology 2013;

Simultaneous multi-frequency ASSR-testing

Band-limited Chirps



Research Article

Fast Hearing-Threshold Estimation Using Multiple Auditory Steady-State Responses with Narrow-Band Chirps and Adaptive Stimulus Patterns

Roland Mühler, Katrin Mentzel, and Jesko Verhey

*Department of Experimental Audiology, Otto-von-Guericke University Magdeburg, Leipziger Street 44,
39120 Magdeburg, Germany*

*“The present study supports the findings of other groups, showing that multiple-frequency 40Hz ASSRs **accurately predict** behavioural audiograms in adults with normal hearing and moderate sensorineural hearing loss.”*

“The use of optimized octave-band chirp stimuli and a semi-automatic adaptive recording algorithm reduces the total test duration considerably.”

The average test time (threshold, 4 frequencies, both ears) reported: 18.6 minutes

Note: These patients were sedated

ECLIPSE ASSR – examples of test time. (4 freq. down to threshold in both ears)

Deborah Carlson (in progress)*:

Adults NH 40Hz (n=50): 30 min

Adults NH 90Hz (n=50): 30 min

Rodrigues and Lewis (in press)*:

Natural sleeping NH neonates (n=30): 21,1 min

Rebiero and Chapchap 2011:

Natural sleeping term babies (n=28): 51 min

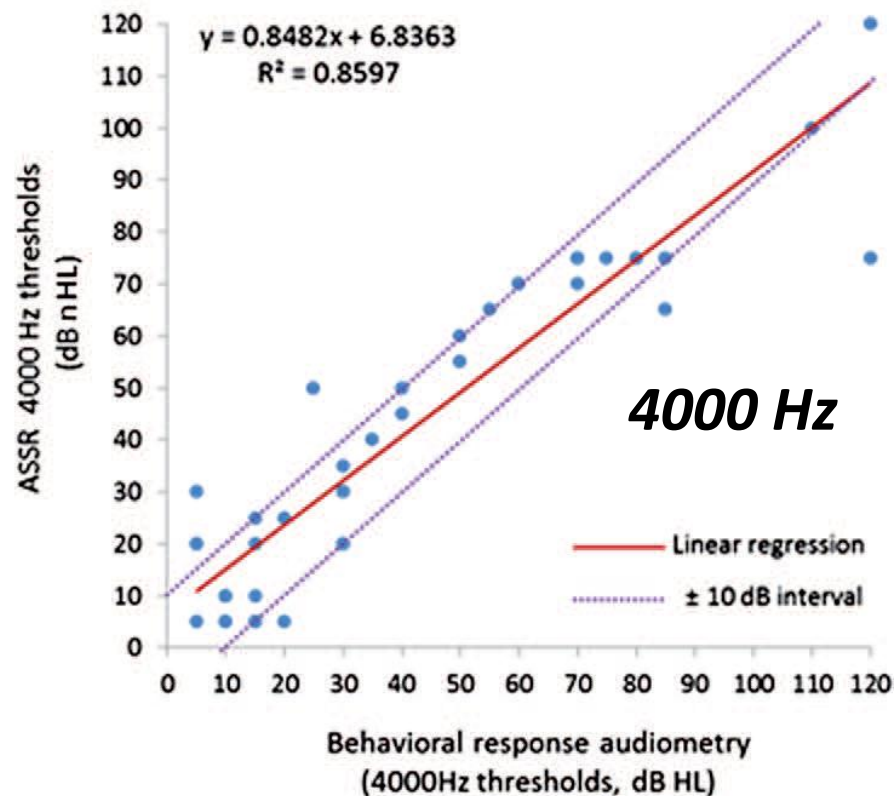
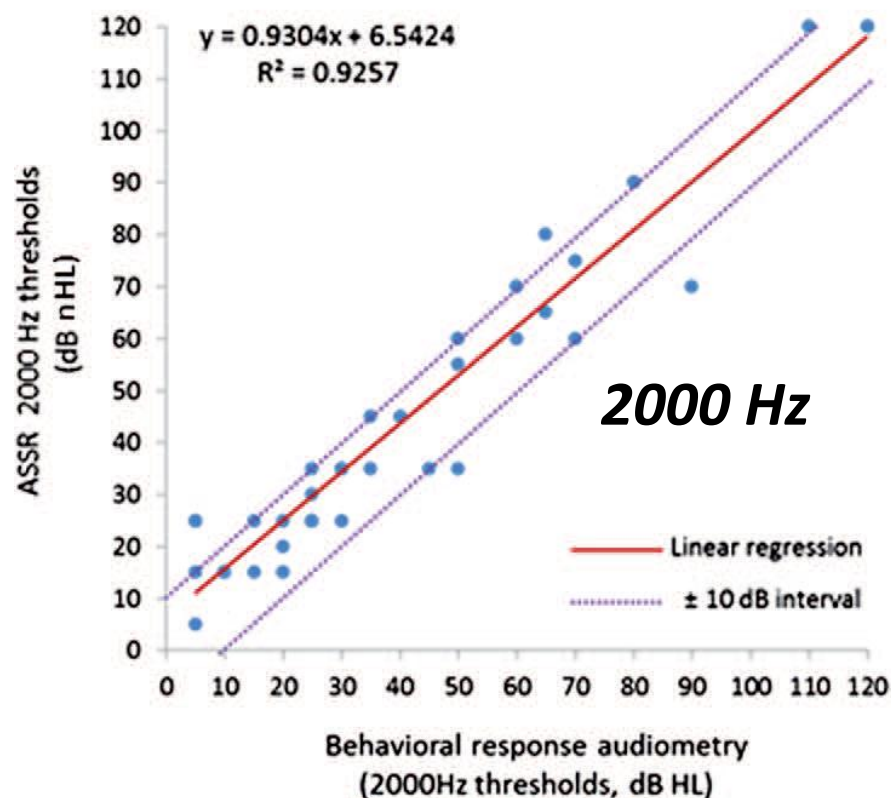
Natural sleeping preterm babies (n=17): 33 min

**) Also sources of nHL-eHL corrections:*

Similar for infants and adults (90Hz) and approx:

500Hz: 25dB 1kHz: 15dB 2kHz: 10dB 4kHz: 5dB

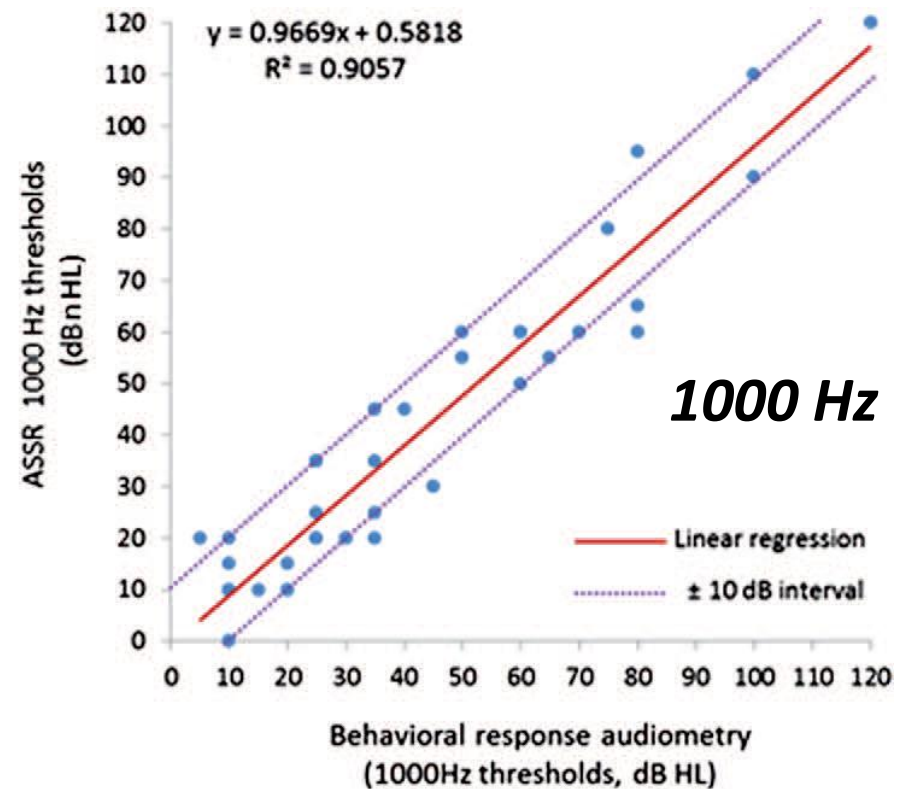
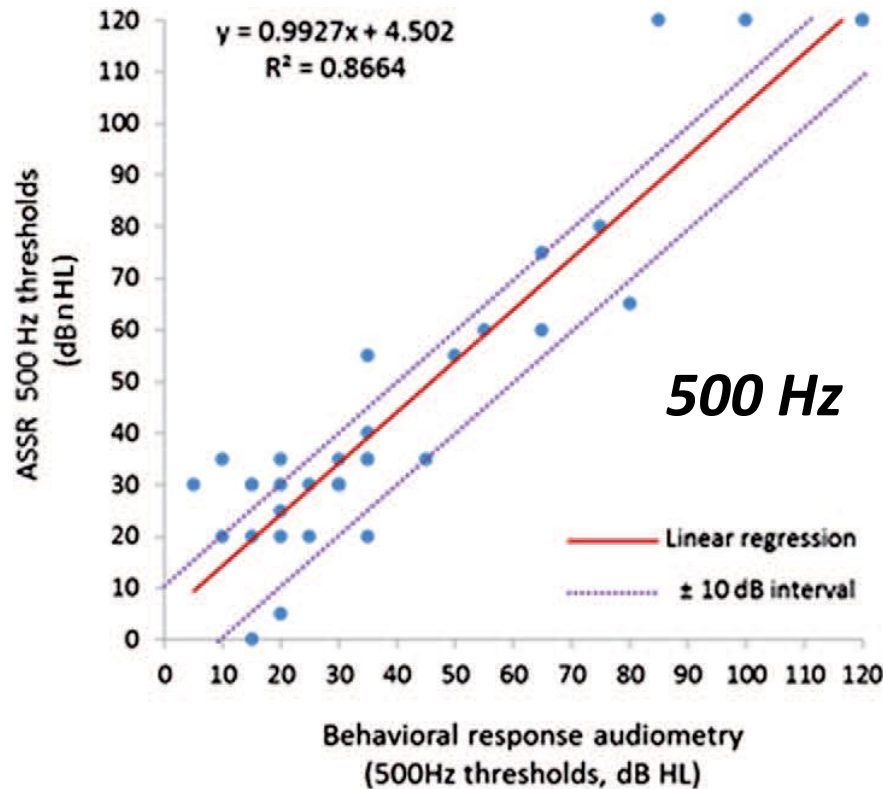
French Study Shows Excellent Prediction of Infant/Toddler Thresholds Using Enhanced ASSR Detection & NB CE-Chirps



F. Venail et al. Narrow band CE-Chirps evoked ASSR in Children International Journal of Audiology 2014; Early Online: 1–8

French Study

Average time for 8 Frequencies with ASSR is 22 minutes;
for click ABR - 13 minutes



F. Venail et al. Narrow band CE-Chirps evoked ASSR in Children
International Journal of Audiology 2014; Early Online: 1–8

QUESTIONS?



2013 JCIH POSITION STATEMENT UPDATE TO 2007

PEDIATRICS Volume 131, Number 4, April 1, 2013

Principles and Guidelines for Early Intervention After Confirmation That a Child Is Deaf or Hard of Hearing

Goal 1: All Children Who Are D/HH and Their Families Have Access to Timely and Coordinated Entry Into EI Programs Supported by a Data Management System Capable of Tracking Families and Children From Confirmation of Hearing Loss to Enrollment Into EI Services

Goal 2: All Children Who Are D/HH and Their Families Experience Timely Access to Service Coordinators Who Have Specialized Knowledge and Skills Related to Working With Individuals Who Are D/HH

Goal 3: All Children Who Are D/HH From Birth to 3 Years of Age and Their Families Have EI Providers Who Have the Professional Qualifications and Core Knowledge and Skills to Optimize the Child's Development and Child/Family Well-being

Goal 3a: Intervention Services to Teach ASL Will Be Provided by Professionals Who Have Native or Fluent Skills and Are Trained to Teach Parents/Families and Young Children

Goal 3b: Intervention Services to Develop Listening and Spoken Language Will Be Provided by Professionals Who Have Specialized Skills and Knowledge

Goal 4: All Children Who Are D/HH With Additional Disabilities and Their Families Have Access to Specialists Who Have the Professional Qualifications and Specialized Knowledge and Skills to Support and Promote Optimal Developmental Outcomes

Goal 5: All Children Who Are D/HH and Their Families From Culturally Diverse Backgrounds and/or From Non-English-Speaking Homes Have Access to Culturally Competent Services With Provision of the Same Quality and Quantity of Information Given to Families From the Majority Culture

Goal 6: All Children Who Are D/HH Should Have Their Progress Monitored Every 6 Months From Birth to 36 Months of Age, Through a Protocol That Includes the Use of Standardized, Norm-Referenced Developmental Evaluations, for Language (Spoken and/or Signed), the Modality of Communication (Auditory, Visual, and/or Augmentative), Social-Emotional, Cognitive, and Fine and Gross Motor Skills

Goal 7: All Children Who Are Identified With Hearing Loss of Any Degree, Including Those With Unilateral or Slight Hearing Loss, Those With Auditory Neural Hearing Loss (Auditory Neuropathy), and Those With Progressive or Fluctuating Hearing Loss, Receive Appropriate Monitoring and Immediate Follow-up Intervention Services Where Appropriate

Goal 8: Families Will Be Active Participants in the Development and Implementation of EHDI Systems at the State/Territory and Local Levels

Goal 9: All Families Will Have Access to Other Families Who Have Children Who Are D/HH and Who Are Appropriately Trained to Provide Culturally and Linguistically Sensitive Support, Mentorship, and Guidance

Goal 10: Individuals Who Are D/HH Will Be Active Participants in the Development and Implementation of EHDI Systems at the National, State/Territory, and Local Levels; Their Participation Will Be an Expected and Integral Component of the EHDI Systems

Goal 11: All Children Who Are D/HH and Their Families Have Access to Support, Mentorship, and Guidance From Individuals Who Are D/HH

Goal 12: As Best Practices Are Increasingly Identified and Implemented, All Children Who Are D/HH and Their Families Will Be Ensured of Fidelity in the Implementation of the Intervention They Receive