Should I Be Worried About Repeated Newborn Hearing Screening with Otoacoustic Emissions?

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Judging the Value of a Screening Protocol/Test

- Cost (time and $$$)
- Ease of Use
- Family and Baby “Friendliness”
- Accuracy
# Accuracy of the Screening Test

<table>
<thead>
<tr>
<th>Results of Screening Test</th>
<th>True Hearing Status</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DHH</td>
<td>Hearing</td>
</tr>
<tr>
<td>FAIL</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>PASS</td>
<td>2</td>
<td>4,245</td>
</tr>
</tbody>
</table>

- **False Negative**: A child who is DHH passes the screening test
- **False Positive**: A child with normal hearing fails the screening test

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specificity = ( \frac{d}{b+d} ):</td>
<td>4,245 ( \div ) (100 + 4,245) = 97.7%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity = ( \frac{a}{a+c} ):</td>
<td>10 ( \div ) (10 + 2) = 83.3%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive Predictive Value = ( \frac{a}{a+b} ):</td>
<td>10 ( \div ) (10 + 100) = 9.1%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Recommendations about Repeated Testing

The likelihood of obtaining a pass outcome by chance alone is increased when screening is performed repeatedly.\textsuperscript{46–48} This principle must be incorporated into the policies.

--- Joint Committee on Infant Hearing (JCIH)

“If you repeat the test enough, a DHH baby will eventually pass.”

Recommendations about Repeat Testing (continued)

“Do not screen patient more than **three times per ear**. Over screening can result in a false negative result.”

--- Welch Allyn Quick Reference Guide

The initial hearing screening . . . . should consist of **no more than 2 attempts** using the same screening technique on each ear.

Washington EHDI Guidelines
Recommendations about Repeat Testing (continued)

For infants who fail the initial screen, hospitals should attempt to re-screen the infant prior to discharge. Inpatient hearing screening will consist of no more than two attempts using the same screening technique on each ear, assuming the infant is in an appropriate state for testing and there are neither equipment problems nor environmental interference during the test. The likelihood of obtaining a pass by chance alone is increased when screening is performed repeatedly.

--Minnesota EHDI Guidelines
Recommendations about Repeat Testing (continued)

“… take caution to avoid over-screening newborns! Although there may be factors that require the screen to be repeated, it is **not recommended that babies be screened more than three times.**”

--- Connecticut EHDI Guidelines

“…excessive re-screening can increase the false negative rate (passing babies with actual hearing loss)...OAE Screening in the well-bay nursery – Two screening sessions of **no more than three screens per ear** are recommended, for a total of six screens per ear.”

--- Iowa EHDI Guidelines
Recommendations about Repeat Testing
(continued)

Screening too many times isn’t recommended and it can lead to false results. . . . We all have a natural tendency to want babies to pass, but remember - don’t screen repeatedly. Your goal is not to pass every baby. **With multiple screenings, babies with hearing loss may falsely pass.**

--- NCHAM Newborn Hearing Screening Training Curriculum
Estimating False Negative Rate of OAE Screening

Probe tested in coupler 1,000 times with no passes

3 ears tested 1,000 times with Biologic AuDx TEOAE using default protocol

One ear had severe hearing loss, two had moderate to severe hearing loss

Testing was done in a very quiet room

Probe was not removed after each test

Results:
- Ear #1: 1 pass, 999 fails
- Ear #2: 0 pass, 1,000 fails
- Ear #3: 2 pass, 998 fails
If only screening babies who are DHH, one baby will be missed for every 1,000 tested.

In the general population, only 3 per 1,000 are DHH. Thus, to find probability of a false negative, you multiply the incidence in the DHH population by 3/1,000.

\[
3000 \div 1000 = 300 \\
10,000,000 \div 1000 = 100,000
\]

Based on these results, we estimate a false negative rate of 1 per 1,000.
How Many Children Who Are DHH Will Be Missed By Repeat Testing if the True False Negative Rate is 1 per 1,000?

We expect 300 newborns who are DHH each year in this sample. Thus, less than 1% of DHH would be missed due to repeated testing...if every newborn were tested 10 times!!
Conclusions

✓ Screening programs should not be concerned about missing babies who are DHH because of the statistical problems associated with repeated OAE testing.

✓ But, there are other reasons we should be thoughtful about how many times each baby is tested.
What constitutes a “test”? 

- Fussy baby
- Probe inserted wrong
- Probe tip blocked against canal wall
- Debris in probe
- Noisy test environment
What are the consequences of over-testing (repeating the test too often)?

- Not an efficient use of time
- Can be alarming to parents
- Annoys the nursery staff
- Health care providers may lose confidence in equipment and procedures
What are consequences of under-testing (not repeating the test enough)?

- More children need to be followed
  - Increased costs
  - Overloads the system
- More parents are unnecessarily alarmed
- Leads to mistrust of results among health care providers
Can fail rates be too low in a newborn hearing screening program?
Recommendations

1. Ensure that screeners are well trained
   - Consider using NCHAM’s Newborn Hearing Screening Training Curriculum
   - Practice make permanent . . . so check regularly to ensure screening is being done correctly

2. The goal is not to pass every baby – the goal is to identify babies who need audiologic diagnosis.

3. Repeat testing as often as needed to get a “good test” without wasting your time, bothering the baby, or upsetting parents or health care providers.
THANK YOU!
How Many Children Who Are DHH Will Be Missed By Repeat Testing if the True False Negative Rate is 1 per 1,000?

But, what if the true false negative rate for deaf ears is 1 per 100?

<table>
<thead>
<tr>
<th>Probability of finding a true hearing loss</th>
<th># of tests</th>
<th>False Negatives per 10,000 with DHH</th>
<th>False Negatives per 10,000,000 in general population</th>
<th>False Negatives per 100,000 in general population</th>
<th>% of &quot;missed&quot; DHH Newborns</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9900</td>
<td>1</td>
<td>100.00</td>
<td>300.00</td>
<td>3.00</td>
<td>1.0%</td>
</tr>
<tr>
<td>0.9801</td>
<td>2</td>
<td>199.00</td>
<td>597.00</td>
<td>5.97</td>
<td>2.0%</td>
</tr>
<tr>
<td><strong>0.9791</strong></td>
<td><strong>3</strong></td>
<td><strong>208.80</strong></td>
<td><strong>626.40</strong></td>
<td><strong>6.26</strong></td>
<td><strong>2.1%</strong></td>
</tr>
<tr>
<td>0.9781</td>
<td>4</td>
<td>218.59</td>
<td>655.78</td>
<td>6.56</td>
<td>2.2%</td>
</tr>
<tr>
<td>0.9772</td>
<td>5</td>
<td>228.37</td>
<td>685.12</td>
<td>6.85</td>
<td>2.3%</td>
</tr>
<tr>
<td><strong>0.9723</strong></td>
<td><strong>10</strong></td>
<td><strong>277.13</strong></td>
<td><strong>831.40</strong></td>
<td><strong>8.31</strong></td>
<td><strong>2.8%</strong></td>
</tr>
<tr>
<td>0.9674</td>
<td>15</td>
<td>325.65</td>
<td>976.95</td>
<td>9.77</td>
<td>3.3%</td>
</tr>
<tr>
<td>0.9578</td>
<td>25</td>
<td>421.96</td>
<td>1265.88</td>
<td>12.66</td>
<td>4.2%</td>
</tr>
</tbody>
</table>

Even with this unrealistically high false-negative rate, AND testing every baby 10 times, less than 3% of the DHH babies would be missed due to repeated testing.