Accuracy and Use of the Reflexive Behavioral ("Baah") Test and Risk Factor Questionnaire for Hearing Screening in Infants Six Months Old and Below

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ABSTRACT

Objective. To determine the accuracy, sensitivity, specificity, positive predictive values, and use of the Reflexive Behavioral "Baah" Test and NHSRC Level 1 and Level 2 Questionnaires in detecting hearing impairment in rural health communities.

Methods. This was a prospective cross-sectional study conducted at the rural health unit of five municipalities. Infants less than six months old were screened for hearing impairments using the OAE device (standard), the Reflexive Behavioral "Baah" test, and the NHSRC Level 1 and Level 2 Questionnaires. The "Baah" test and the filling out of the NHSRC Level 1 and 2 Questionnaires were done by trained health workers while OAE was done by an audiologist.

Results. A total of 103 babies, with a mean age of 41.9 days at the time of testing and a male to female ratio of 1.02:1 (52 males and 51 females) were tested. A hearing impairment prevalence of 4.9% (5 out of 103) was noted. The "Baah" test showed to have a sensitivity of 60%, specificity of 97.96% and an accuracy rate of 96.12%. The NHSRC Level 1 and Level 2 Questionnaires showed sensitivity, specificity, and accuracy rate of 40%, 67.35% and 66.02%, respectively for the former and 40%, 85.71% and 83.50%, respectively for the latter. Analysis of the complimentary use of the NHSRC Level 1 and Level 2 Questionnaires with the "Baah" test also showed no significant improvement to using the "Baah" test as a stand-alone screening tool with sensitivity, specificity, and accuracy of 60%, 67.35% and 66.99%, respectively for the "Baah" test and Level 1 Questionnaire, and 60%, 83.67% and 82.52%, respectively for the "Baah" test and Level 2 Questionnaire.

Conclusion. The Reflexive Behavioral "Baah" test is a potentially accurate, sensitive, specific, and acceptable stand-alone hearing screening test to identify infants with higher risk of hearing impairment in the rural health community setting. On the other hand, the use of the NHSRC Questionnaires as a stand-alone or complementary tool for "Baah" is unnecessary as it results to more false positive and false negative results.

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INTRODUCTION

In developing countries, approximately 6 out of 1000 live births are noted to have permanent bilateral congenital or early onset hearing loss.[1] Late detection leads to severe lifelong impairments on speech, language, academic performance, emotional, and personal-social development. Neonatal hearing screening policies coupled with regular surveillance was found to prevent or lessen such impairments.[2]

The World Health Organization (WHO), as well as the Joint Committee on Infant Hearing (JCIH), recommended two methodologies for hearing screening: the Otoacoustic Emissions (OAE) test and the Automated Auditory Brainstem Response (AABR).[3,4] On the other hand, protocols using the said methodologies have been varied depending on institution standards: a two-stage OAE then AABR for initial screen or one-stage AABR in Germany; one-stage OAE initial screen then one-stage AABR re-screen in Nigeria and United Kingdom; and both initial and re-screen using OAE in the Philippines; to cite a few.[4,5]

In the Philippines, 1.38 for every 1,000 live births are noted to have bilateral profound congenital hearing loss. This estimate increases to 22 per 1,000 live births when cases of unilateral and milder forms of hearing loss are also included.[6] In order to address the burden of untreated hearing loss, Republic Act No. 9709 also known as the Universal Newborn Hearing Screening and Intervention Act of 2009 was passed into law mandating access to hearing screening to all newborns prior to discharge or before three months old. In accordance to its manual of operations, two tests are currently accepted as screening methods: Otoacoustic Emissions (OAE) test and the Automatic Auditory Brainstem Response (AABR).[5] Currently, primary utilization of OAE is being observed for its advantages on cost, test duration, and availability.

Despite the enactment of this law, coverage and implementation remains relatively low with only about 10% of babies born each year being appropriately screened. This challenge has been consistent with other developing countries where the lack of an economical, reliable, and simple-to-use methodology that can be deployed in geographically-challenging areas remain as a primary barrier. In addition, investment in these instruments is often not seen as a government priority.[1] In fact, the WHO has acknowledged these barriers and has proposed two interim approaches aside from using the aforementioned physiological measures: (1) guided Family Questionnaires asking the parents/ caregivers on the neonate's response to loud sounds and language use and (2) use of behavioral measuring devices.[7] In the Philippines, these two have also been adapted as seen in the utilization of the UNHS High Risk Questionnaire for Community-Based Facilities Questionnaire Level 1 and 2 and the Reflexive Behavioral "Baah" Test.[5,8,9]

To address the unavailability of objective hearing screening tests in areas that are geographically-challenging or isolated, low-income, and with inadequate health care facilities, Gloria-Cruz et al. explored the possibility of using generic Filipino words commonly used to call attention, namely: "Psst" and "Baah". In this study which included adult participants, it was found out that the "Baah" sound when done after two deep breaths with sudden and maximal effort can be reproducible, hits a wide variety of frequencies, and can be vocalized at a higher intensity than 90dB SPL, which is the cut off for profound deafness in newborns. Building on this, the researchers introduced the possibility of using the "Baah" sound as a cost-effective, valid, and feasible hearing screening test.[8]

This was further substantiated by the study of Garcia et al., where the reflexive behavioral "Baah" test was compared to the standard OAE as a hearing screening test in infants less than six months old in a tertiary hospital. In this study, 101 infants were blindly tested using both techniques yielding a sensitivity of 71.4%, specificity of 95.7%, positive predictive value of 55.6%, and negative predictive value of 97.8% for the "Baah" test (P value <0.0001). In addition, an accuracy of 94% was also noted, with the "Baah" test giving 95 out of the 101 infants the correct diagnosis. In conclusion, the "Baah" test was noted to have potential as an acceptable, accurate, and cost-effective screening tool, especially for areas without available OAE or AABR. For this purpose and as recommended by Garcia et al., the reflexive behavioral "Baah" test is suggested to be administered in a community setting to test its utility as part of a community-based newborn hearing screening program.[9] This study aims to compare the use of the Reflexive Behavioral "Baah" Test and the NHSRC High Risk Questionnaire for Community-Based Facilities Level 1 and Level 2 against the Otoacoustic Emission (OAE) test in a community-based setting.

MATERIALS AND METHODS

Study Design

This was a prospective, cross-sectional study.

Participants

Participants came from five out of six municipalities who participated in the 1st and 2nd Newborn Hearing Screening and Teleaudiology Course held last June 25 to 27 in Iloilo City, and August 9 to 11 in Manila City. All infants among the five municipalities who were considered as participants in this study were able to satisfy the following criteria at the time of data collection: (1) infants below six months old, of both sexes; (2) consent from parents/legal guardian; (3) with developed ear canal. Excluded participants from this study were those: (1) above six months of age; (2) already screened; (3) without consent from parents/legal guardian; (3) with active ear infection; and (4) external ear deformities (i.e., atresia, agenesis) where the OAE probe cannot be inserted.

Setting

Hearing screening tests were done in two separate rooms. To facilitate the patient flow during testing, the first room was assigned for the Reflexive "Baah" test while the second room was for the OAE test. Since layout of rural health units differed for each municipality, this set-up was pre-planned during the ocular of the testing site prior to the hearing screening day. The screening environment for OAE must be consistent with the National Hearing Screening Reference Center's (NHSRC) technical standards, including: (1) minimal noise of ≤40 dB; (2) presence of curtains or dividers; (3) turned off

cellphones, radio, TV, or any other audio devices; and (4) done post-nursing and separate from other participants.

Testing Procedure

After registration and collection of general data, the baby was directed to the first room where the trained health personnel/ professional and partner observer will be administering the Reflexive "Baah" Test. The tester positioned himself/herself at the vertex of the patient's head with his/her mouth about one foot away while the observer was positioned at the side so as to easily observe behavioral responses. When ready, the tester took two deep breaths and suddenly produced the "Baah" sound. The sound level meter value was checked and recorded (value must be in between 80 to 95 dB). Upon production of the stimulus, the observer then waited and recorded the response of the infant which may include: blinking, sudden and forceful shutting of already closed lids, and stirring and startling reflex. If any of the mentioned responses were observed, the observer recorded "present", otherwise "absent" if none were noted. After the first test, the patient was led to another quiet room designated for the OAE test. The OAE test was administered by a designated blinded audiologist. Once ambient noise and seal of the probe to the ear canal was acceptable, testing automatically commenced. The machine then indicated either a "pass" or "refer" result. For the latter result, ear probe was removed, ear was massaged to relax ear canal retraction and a review of the previously employed techniques was done to determine confounding factors. The test was then repeated following the stop criteria for an outpatient OAE screening. Final recording was then written down in the case report form.[9]

Focus Group Discussion

After all the patients were tested, a short focus group discussion was done with the trained health personnel to evaluate the conduct of the "Baah" test. A topic guide was used to extract data on experiences and perceptions on the tool's utility, specifically on the hindrances or challenges encountered in doing the test.

Primary and Secondary Outcome Measures

The primary outcome measures for this study are the presence or absence of the following: (1) response to the OAE test, (2) response in the reflexive behavioral "Baah" test, and (3) risk classification based on the UNHS Level 1 and 2 Questionnaires.

Data analysis

Data was tabulated using a 3 x 6 table to quickly compare the Reflexive "Baah" Test and UNHS Questionnaires with the OAE test result. Qualitative data from the focus group discussion was analyzed by identifying common themes.

RESULTS AND DISCUSSION

A total of 103 babies, with a mean age of 41.9 days at the time of testing and a male to female ratio of 1.02:1 (52 males and 51 females) were tested in the months of August and September 2018. The average birthweight and age of gestation are seen in Table 1.

Results for the 103 participant's OAE compared to the results from the "Baah" test and NHSRC Level 1 and Level 2 Questionnaires are reflected in Table 2. Two were screened to have bilateral refer results in OAE, both of which reflected a positive result in the "Baah" test (no response). On the other hand, only one of the OAE positive patients were flagged positive in both the Level 1 and Level 2 questionnaires. The same observation may be seen for the three infants screened with unilateral refer results in OAE where only one showed a positive finding for both Level 1 and Level 2 questionnaires. Using the questionnaires as stand-alone screening tools may therefore miss 60% of potential hearing-impaired infants in the community that would need an objective hearing screening/ confirmatory test.

The observation is parallel to the calculated sensitivity of the "Baah" test and NHSRC Level 1 and Level 2 Questionnaires of 60%, 40%, and 40%, respectively and specificity of 96.12%, 67.35%, and 85.71%, respectively (Table 3). Among the three screening tools, the "Baah" test exhibited the highest specificity which translates to a low false positive rate for bilaterally impaired patients. This indicates that patients who tested positive for "Baah" have a high probability

Table 1. Demographics of Infants Screened at Rural Health Units

Variable	Mean ± SD
Age at time of screening (in days)	41.90 ± 31.46
Male to Female Ratio*	1.02:1
Birth Weight (in grams)	2,892 ± 508
Age of Gestation at Birth (in weeks)	38.78 ± 1.42

**Results are reported as ratio*

Table 2. Results of Behavioral "Baah" Test, WHO Level 1 and 2 Questionnaires versus Distortion Product Otoacoustic Emission Testing (N=103)

		"Baah" Test		NHSRC Level 2 Questionnaire		NHSRC Level 2 Questionnaire	
		No response	With response	Positive findings	No findings	Positive findings	No findings
DPOAE	Bilateral pass	1.94% (2)	93.20% (96)	31.07% (32)	64.08% (66)	13.59% (14)	81.55% (84)
	Unilateral refer	0% (0)	2.91% (3)	1% (1)	1.94% (2)	1% (1)	1.94% (2)
	Bilateral refer	1.94% (2)	0% (0)	1% (1)	1% (1)	1% (1)	1% (1)

of having bilateral hearing impairment. Unfortunately, the rather low sensitivity (60%) coupled with the positive predictive value of 60% means that there may be "Baah" negative infants who have hearing impairment. In this study, it is exhibited by the false negative result for two patients who have unilateral refer results in OAE, failing to identify such patients is one of the limitations of the "Baah" test (Table 3). Thus, counselling of parents to continue monitoring hearing milestones or any indication of poor language development is still needed. On the other hand, as indicated in the likelihood ratio (Table 4), a positive "Baah" test is 29x more likely to appear compared to someone without hearing loss. In addition, the "Baah" test was able to identify 97.96% of infants with normal hearing (negative predictive value). In itself, the "Baah" test exhibited an accuracy rate of 96.12%.

The same cannot be observed for the NHSRC Level 1 and 2 Questionnaires as a stand-alone screening test (Table 4). Both have shown a relatively lower specificity of 67.35% and 85.71%. This means that there is a higher possibility that infants with hearing impairment will not be correctly identified. With a relatively lower sensitivity of 40% for both and a positive predictive value of 5.88% and 12.5%, it can be noted that a significant number of false positive results were identified. This may lead to the unnecessary allocation of resources and stress for confirmatory testing of normal hearing infants. In detail, it was noted that 1.94% (n=3; 2 unilateral refer) or 40% of OAE positive infants (n=5) were missed by both Questionnaires.

The results from the OAE test were also analyzed against the Reflexive "Baah" test coupled with each of the NHSRC Questionnaire (Table 5). In using the "Baah" test with the Level 1 Questionnaire, the number of infants correctly screened was only 69 out of 103 infants. This was a miniscule improvement from the results if the NHSRC questionnaire was used alone and a decrease from the results of the "Baah" test if used alone. When the "Baah" test with the Level 2 Questionnaire was used, the number of infants correctly screened decreased to 85 out of 103 infants. This was also lower than the number of correctly screened infants if each test was used independently. Moreover, for both combinations, two infants with unilateral refer OAE results were missed.

To further analyze the combinations, the accuracy of the "Baah" test with the NHSRC Level 1, and "Baah" test plus the NHSRC Level 2 Questionnaire (Table 6) were determined. Although the sensitivity, specificity, positive and negative predictive values, accuracy, and likelihood ratios increased, such were still non-superior to the "Baah" test when used alone.

The likelihood ratios for the positive and negative test results for the "Baah" test and NHSRC Level 1 and Level 2 Questionnaires are in Table 7.

Table 3. 2x2 Table for the Reflexive "Baah" test, Level 1 Questionnaire and Level 2 Questionnaire vs. OAE test

	OAE (+) (n)	OAE (-) (n)	
"Baah" (+) (n)	**3** *(a= true positive)*	**2** *(b= false positive)*	*Positive Predictive Value =True positive/ Test Outcome positive =a/(a+b) = 60%*
"Baah" (-) (n)	**2** *(c= false negative)*	**96** *(d=true negative)*	*Negative Predictive Value =True negative/ Test Outcome negative =d/(c+d) = 97.96%*
	Sensitivity =a/ (a+c) = 60%	*Specificity =d/(d+b) =97.96%*	*Accuracy =a+d/(a+b+c+d) =96.12%*
NHSRC Level 1 (+) (n)	**2** *(a= true positive)*	**32** *(b= false positive)*	*Positive Predictive Value =True positive/ Test Outcome positive =a/(a+b) = 5.88%*
NHSRC Level 1 (-) (n)	**3** *(c= false negative)*	**66** *(d=true negative)*	*Negative Predictive Value =True negative/ Test Outcome negative = d/(c+d) = 95.65%*
	Sensitivity =a/ (a+c) = 40%	*Specificity =d/(d+b) = 67.35%*	*Accuracy =a+d/(a+b+c+d) =66.02%*
NHSRC Level 2 (+) (n)	**2** *(a= true positive)*	**14** *(b= false positive)*	*Positive Predictive Value =True positive/ Test Outcome positive =a/(a+b) = 12.5%*
NHSRC Level 2 (-) (n)	**3** *(c= false negative)*	**84** *(d=true negative)*	*Negative Predictive Value =True negative/ Test Outcome negative = d/(c+d) = 96.55%*
	Sensitivity =a/ (a+c) = 40%	*Specificity =d/(d+b) = 85.71%*	*Accuracy =a+d/(a+b+c+d) =83.50%*

OAE (+) includes both unilateral and bilateral refer results

Table 4. Likelihood Ratios and Posttest Probabilities for the Reflexive "Baah" Test and NHSRC Level 1 and Level 2 Questionnaire

	"Baah" Test	NHSRC Level 1	NHSRC Level 2
Likelihood ratio for a positive test (LR +)	=29.41	=1.225	=2.8
Likelihood ratio for a negative test (LR -)	=0.2857	=0.8909	=0.7
Posttest Probability for a positive test (PosttestProb+)	=60%	=5.88%	=12.5%
Posttest Probability for a negative test (PosttestProb-)	=1.44%	=4.45%	=3.45%

In summary, if individually used, the "Baah" test was able to correctly screen 101 out of 103 infants (accuracy of 96.12%) while the NHSRC level 1 and level 2 Questionnaires were only able to do so in 68 (accuracy of 66.02%) and 86 (accuracy of 83.50%) infants out of 103, respectively. If the "Baah" test was combined with either one of the NHSRC Questionnaires, 40% potential unilaterally hearing-impaired infants may be missed.

The frequency of observed responses to the "Baah" test (Table 8) was also recorded with the auropalpebral reflex being exhibited 123 times, followed by the startle reflex at 110, and the generalized provoked arousal at 3. Since more than one response may be seen in response to the "Baah" stimulus, a discordance between the total number of observations and the total number of infants tested may be noted.

Table 5. Combined Results of Behavioral "Baah" Test with WHO Questionnaire-based Screening versus Distortion Product Otoacoustic Emission Testing (N=103)

		"Baah" Test		"Baah" Test plus NHSRC Level 1 Questionnaire		"Baah" Test plus NHSRC Level 2 Questionnaire	
		Positive Findings	No Findings	Positive Findings	No Findings	Positive Findings	No Findings
DPOAE	Bilateral pass	1.94% (2)	93.20% (96)	31.07% (32)	64.08% (66)	15.53% (16)	79.61% (82)
	Unilateral refer	0% (0)	2.91% (3)	1% (1)	1.94% (2)	1% (1)	1.94% (2)
	Bilateral refer	1.94% (2)	0% (0)	1.94% (2)	0% (0)	1.94% (2)	0% (0)

Table 6. 2x2 Table for the Reflexive "Baah" test, Level 1 Questionnaire and Level 2 Questionnaire vs. OAE test

	OAE (+) (n)	OAE (-) (n)	
"Baah" (+) (n)	**3** *(a= true positive)*	**2** *(b= false positive)*	*Positive Predictive Value =True positive/ Test Outcome positive =a/(a+b) = 60%*
"Baah" (-) (n)	**2** *(c= false negative)*	**96** *(d=true negative)*	*Negative Predictive Value =True negative/ Test Outcome negative =d/(c+d) = 97.96%*
	Sensitivity =a/ (a+c) = 60%	*Specificity =d/(d+b) =97.96%*	*Accuracy =a+d/(a+b+c+d) =96.12%*
"Baah" and NHSRC Level 1 (+) (n)	**3** *(a= true positive)*	**32** *(b= false positive)*	*Positive Predictive Value =True positive/ Test Outcome positive =a/(a+b) = 8.57%*
"Baah" and NHSRC Level 1 (-) (n)	**2** *(c= false negative)*	**66** *(d=true negative)*	*Negative Predictive Value =True negative/ Test Outcome negative = d/(c+d) = 97.06%*
	Sensitivity =a/ (a+c) = 60%	*Specificity =d/(d+b) = 67.35%*	*Accuracy =a+d/(a+b+c+d) =66.99%*
"Baah" and NHSRC Level 2 (+) (n)	**3** *(a= true positive)*	**16** *(b= false positive)*	*Positive Predictive Value =True positive/ Test Outcome positive =a/(a+b) = 15.79%*
"Baah" and NHSRC Level 2 (-) (n)	**2** *(c= false negative)*	**82** *(d=true negative)*	*Negative Predictive Value =True negative/ Test Outcome negative = d/(c+d) = 97.62%*
	Sensitivity =a/ (a+c) = 60%	*Specificity =d/(d+b) = 83.67%*	*Accuracy =a+d/(a+b+c+d) =82.52%*

OAE (+) includes both unilateral and bilateral refer results. "Baah" (+) includes only bilateral

Table 7. Likelihood Ratios and Posttest Probabilities for the Reflexive "Baah" Test and NHSRC Level 1 and Level 2 Questionnaire

	"Baah" Test	"Baah" Test and NHSRC Level 1	"Baah" Test and NHSRC Level 2
Likelihood ratio for a positive test (LR +)	=29.41	=1.83	=3.67
Likelihood ratio for a negative test (LR -)	=0.2857	=0.5939	=0.4781
Posttest Probability for a positive test (PosttestProb+)	=60%	=8.54%	=15.77%
Posttest Probability for a negative test (PosttestProb-)	=1.44%	=2.94%	=2.38%

Table 8. List of Observed Infant Responses to "Baah" Test (N=103)

Observed Infant Behavior	Frequency
Provoked Arousal	3
Startle Reflex	110
Auropalpebral Reflex	123

Table 9. Variables Measured in the Conduct of "Baah" Test

Variable	Mean ± SD
Number of Trials Done (per baby)	2.59 ± 1.18
Maximum Intensity Recorded (in dB SPL)	82 ± 3
Duration of Testing (in minutes)	4.04 ± 11.14

Table 10. Frequency of Positive Results of NHSRC Level 1 Questionnaire among Screened Infants (N=103)

Observed Infant Behavior	Frequency
Presence of Risk Factors	33
Maternal Concern	1
Healthcare Concern	0

Table 11. Frequency of WHO-NHSRC Level 2 Questionnaire Risk Factors Present among Screened Infants

Observed Infant Behavior	Percentage (N)
Birth weight <1500 grams	2% (2)
APGAR score <5 in five minutes	7.07% (7)
History of NICU admission for ≥48 hours	0% (0)
History of mechanical ventilation use >5 days	0.97% (1)
History of bacterial meningitis or neonatal sepsis	4.95% (5)
Administration of ototoxic drugs	0% (0)
Congenital Infections (TORCH)	0% (0)
Hyperbilirubinemia requiring exchange transfusion	0% (0)
Defects of the head and neck	1.01% (1)
Features and other findings associated with hearing loss	0% (0)
Family history of permanent hearing loss in childhood	2.97% (3)

In doing the "Baah" test, each examiner did an average of 2.59 trials to get the desired result, reaching a maximum intensity of 82 dB and consuming an average of 4.04 minutes per baby (Table 9). These were within the parameters of doing the "Baah" test 2-4 times and producing a sound between 80 to 95 decibels. The consumed duration was notably attributed to the preparation at the start and in between trials. Nonetheless, with the average duration of 4 minutes per baby, the "Baah" test exhibits a relatively fast screening tool compared to the OAE and AABR.

As for the Level 1 Questionnaire (Table 10), determination of a positive assessment was noted to be detected most in the presence of risk factors with 33 out of 34.

In using the Level 2 Questionnaire (Table 11), the most common risk factor encountered was an APGAR score <5 in five minutes (7.07%, n=7) followed by any history of bacterial meningitis or neonatal sepsis (4.9%, n=5), and family history of permanent hearing loss in childhood (2.97%, n=3). Some items like the history of NICU admission ≥ 48H, administration of ototoxic drugs, TORCH infection, hyperbilirubinemia, and features or other findings associated with hearing loss all got 0 %. While such may be the case, it should be noted that these items may sometimes be unknown to the caregiver and/or to the healthcare personnel conducting the interview.

The adaptability of the "Baah" test and the NHSRC Level 1 and 2 Questionnaires are also evaluated through a focus group discussion (Table 12) with the trained health personnel. In the focus group discussion, identified strengths of the "Baah" test centered on its ease-of-use, ease-of-learning, applicability in the community setting, portability, and economic impact. Disadvantages were centered mostly on exhaustion secondary to vocal/ physical exertion and the "Baah" test's own limitation of only being able to identify infants with bilateral hearing impairment. On the other hand, such disadvantages can be easily addressed with proper training, constant practice, and specific guidelines on test administration. All members of the FGD expressed a positive attitude in adapting the "Baah" test as a hearing screening tool especially for areas without access to an OAE/ AABR device.

As for the NHSRC's Level 1 and Level 2 Questionnaires, comments centered on the language barrier, presence of jargons, and questions not readily answerable in RHU level. Aside from answering the form itself, confusion was also noted in terms of interpreting the results of the questionnaire. The criteria of whether the questionnaire is positive or negative was unclear and easily confusing for the healthcare workers.

Thus, among the three hearing screening tools evaluated in this study, the "Baah" test exhibited the best sensitivity, specificity, accuracy, and adaptability in the local community setting. This opens an opportunity to its use as an accessible screening tool to detect infants with potential hearing impairment which facilitates early referral for further assessment and confirmatory testing in higher centers.

Table 12. Focus Group Discussion Common Themes on the Use of the "Baah" Test and the NHSRC's Database

	Responses
"Baah" test Advantages	• Good positioning of patient, tester, and observer • Simple • Comparably easy to do • Free • Can be done anywhere • Results are known instantly • Easy to learn • Device-independent • Low maintenance
"Baah" test Disadvantages	• Needs observer to focus to be able to spot the reaction • Needs to reach certain decibel level • Tiring since it requires physical and vocal exertion • Cannot test individual ears • Difficult if baby is irritable • Needs practice • Needs to do by pair
Recommendations for "Baah" test	• Set guidelines on healthy testing number and intervals • Breastfeed prior to testing to calm the baby • Practice • Do by pair • Follow guidelines on how to properly do it (i.e., Inhale two deep breaths before vocalizing "Baah")
NHSRC Level 1 Questionnaire	• Appropriate for RHU level • Translate to local language • Unclear what Parts II and III are • Unclear on how to interpret the responses into positive or negative
NHSRC Level 2 Questionnaire	• Some questions are unknown: APGAR score, some risk factors (TORCH, Mechanical ventilation, NICU admission, features) • Needs further training to be applicable to RHU level

CONCLUSION

This study exhibited the potential of the Reflexive Behavioral "Baah" Test as an accurate and acceptable hearing screening tool at the rural health unit's level. The use of the Reflexive Behavioral "Baah" test as an alternate hearing screening tool for areas without any available objective test (i.e., OAE or AABR) may lead to an earlier detection of potential hearing-impaired infants who will need referral to a higher level facility for confirmation and intervention. On the other hand, the use of the NHSRC Level 1 and Level 2 Questionnaires, either as a stand-alone tool or as a complimentary tool to the Behavioral "Baah" test may unnecessarily increase the number of projected hearing-impaired children and may thus lead to unnecessary use of resources. In addition, both questionnaires fail to identify all infants with possible unilateral and bilateral hearing impairment. Thus, the use of such Questionnaires as a stand-alone or as a complementary hearing screening tool to the "Baah" test is not recommended.

Statement of Authorship

All authors certified fulfillment of ICMJE authorship criteria.

Author Disclosure

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