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CLINICAL BRIEF

Use of Portable Automated Auditory Brainstem Responses in Universal Neonatal Hearing Screening: A Mixed-Method Study in Odisha, India

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Abstract
Hearing loss in children affects cognitive development, so early detection is crucial. It is because of the lack of portable technology that the majority of hearing problems go undetected. The authors conducted a mixed-method study in India to examine the concurrent validity and operational feasibility of portable automated brainstem response (P-AABR) and otoacoustic emissions (OAE) in universal neonatal hearing screening. They screened 198 children's ears using ABR and OAE devices. Additionally, 60 observations were recorded during the 'portable automated ABR' screening process. The hearing screening could be performed with P-AABR by any health care staff with basic skill-based training. However, the interpretation of the graphical wave required an audiologist. If the baby was quiet, the test could be performed in 20 min, including electrode implantation, impediment setting, earphone installation, and swipe counts. The P-AABR device can be used in the universal health coverage of hearing screening among infants in outreach areas due to its portability and minimal infrastructural requirements.

Keywords Hearing impairment · Universal hearing screening · Newborn · Digital health

Introduction

About 60% of congenital hearing loss in children can be prevented with early detection and treatment [1–4]. The World Health Organization (WHO) recommends newborn hearing screening within a month. All neonates whose initial and subsequent screenings necessitate diagnostic testing should have an audiologic examination by 3 mo. Early intervention should begin within 6 mo of a hearing loss diagnosis [1–4]. However, the universal newborn hearing screening (UNHS) is not a common practice in many low- and middle-income countries (LMICs) due to a lack of infrastructure [2, 3, 5]. Currently, there are two types of technology used for screening for hearing disorders among infants: the auditory brainstem response (ABR) and otoacoustic emissions (OAE) [6]. In several LMICs, the brainstem auditory evoked response (BAER) is used for confirmatory testing in a limited number of health facilities, and the OAE is used for universal screening [5, 7]. The limitations of the OAE are that it requires a professional audiologist and a soundproof room [5, 7]. The portable automated brainstem response (P-AABR) screening device has several advantages [7, 8]. In many LMICs, the birth rate is high and resources are scarce, so the majority of hearing loss remains undetected due to a lack of low-cost technologies. BAER is challenging to implement in LMICs due to high implementation costs. This study examined P-AABR and OAE's concurrent validity and operational feasibility in UNHS.

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Table 1 Correlation between the 'portable automated auditory brainstem responses' and 'otoacoustic emissions' hearing screening devices test outcomes

	Test outcomes				Concurrent validity	
	Portable automated auditory brainstem responses (P-AABR)		Otoacoustic emissions (OAE)		*r*	*p* value
	n	%	*n*	%		
Left ear ($n=198$)						
Pass	179	90.4	177	89.4	0.33	< 0.001
Refer	19	9.6	21	10.6		
Right ear ($n=198$)						
Pass	180	90.9	179	90.4	0.49	< 0.001
Refer	18	9.1	19	9.6		

Material and Methods

A mixed-method study was conducted at two district early intervention centers under the Rashtriya Bal Swasthya Karyakram in Odisha, India. The required sample size was 388 (194 of each screening device: P-AABR and OAE) with significance level (0.05), 80% power, probability P1 = 0.3 and P2 = 0.4, assuming a 40% prevalence, null hypothesis (Ho = 0.7), and alternative hypothesis (Ha = 0.8). Each child's screening results were reported as 'Pass' indicating the child had no hearing problems, or 'Refer' indicating the child had hearing problems. Concurrent validity approach: the amount of agreement between the test results of the P-AABR and OAE screening devices was calculated using the phi-correlation coefficient.

In addition, a total of 60 observations (40 in health care facilities and 20 in the community) were recorded using the standard checklist during the P-AABR hearing. Field notes were taken during observation and analyzed using content analysis methods.

Results

A total of 198 infants—equal numbers of male and female infants—participated. Among them, 85% were neonates and 69% were delivered by cesarean section, and 22% had low birth weight. Four children's fathers and six children's mothers had a hearing impairment. A total of 19 parents had consanguineous marriages – marriages in between close relatives/cousins. Hearing impairment was diagnosed in 13% ($n=26$) of the children. According to OAE, 7% ($n=14$) had bilateral and 6% ($n=12$) had unilateral hearing impairment. However, the P-AABR revealed that 5% ($n=11$) had bilateral hearing impairment and 8% ($n=15$) had unilateral hearing impairment. The detailed test outcomes of the P-AABR and OAE devices are presented in Supplementary Table S1. Table 1 explains the relationship between P-AABR and OAE. The degree of association between each 'Pass' measure and 'Refer' hearing screening was (left ear: $r=0.33$, $p<0.001$; right ear: $r=0.49$, $p<0.001$; and both ears: $r=0.33$, $p<0.001$) significant at soft sound hearing activity limitations.

In OAE, no technical issues were found. The audiologists argued that the OAE required a soundproof room. The P-AABR does not need a soundproof room but needs a quiet atmosphere. The P-AABR device often requires the infant to be pacified, as a slight movement interferes with the test result. As per the authors' observation report, the average duration of the test was 20 min—preparation of the electrode sites, impediment setup, placement of the earphones, and a swipe count. Tracking the children for more than 6 mo was difficult because they woke up with a simple touch and even removed the electrode. In both devices, the presence of any electronic device—a mobile charger or electrical equipment—during the test affects the testing process. The audiologists are expected to perform the screening with the OAE. However, a nurse can provide P-AABR hearing screening with limited skill-based training (2–3 d).

Discussion

In the absence of UNHS, infants with hearing loss are often diagnosed with a language delay and cognitive development [1–4]. Infants with hearing loss frequently exhibit a high degree of environmental alertness, making it difficult for caregivers and specialists. Without early care, hearing-impaired children exhibit predictable, irreversible deficiencies in communication, psychosocial skills, cognition, and literacy [9, 10]. Depending on the screening protocol, OAE and AABR may be conducted alone or sequentially. Both the OAE and AABR tests are automated versions of more comprehensive hearing loss assessment procedures [9, 10].

The hearing screening could be performed with P-AABR by any health care staff with basic skill-based training, including infection control practice during the test. However, the interpretation of the graphical wave required an audiologist.

Conclusion

The P-AABR device can be used as a part of universal health coverage for hearing screening among infants in outreach areas due to its portability and minimal infrastructural requirements.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s12098-022-04435-2.

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Authors' Contributions KCS, RA, RD, SP conceptualized the study; DB, RKS, LWA facilitated the data collection; KCS and RA analyzed the data and prepared draft manuscript. All authors read and finalized the final draft. SP will act as the guarantor for this paper.

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Declarations

Ethics Approval Institutional ethics committee approval was obtained before the commencement of the study.

Consent to Participate Written informed consent was obtained from either parents or legal guardians before enrollment in the study.

Consent for Publication Consent for publication was obtained from the parents or legal guardian before enrollment in the study.

Conflict of Interest None.

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