International Journal of Speech and Audiology



**E-ISSN:** 2710-3854
**P-ISSN:** 2710-3846
Impact Factor (RJIF): 6.4
IJSA 2026; 7(1): 36-41
© 2026 IJSA
Journal's Website
Received: 12-11-2025
Accepted: 15-12-2025

**Liam T Brennan**
Department of Audiology and Hearing Sciences, Sydney Institute of Technology, Sydney, Australia

**Correspondence**
**Liam T Brennan**
Department of Audiology and Hearing Sciences, Sydney Institute of Technology, Sydney, Australia

# The role of audiological assessments in the early detection of hearing loss in newborns

**Liam T Brennan**

**DOI:** https://www.doi.org/10.22271/27103846.2026.v7.i1a.104

**Abstract**
Can a ten-minute test in the first 48 hours of life reliably predict whether a baby will need hearing support? This research examined the diagnostic accuracy and clinical value of audiological screening protocols across 239 newborns in four maternity hospitals in Sydney, Australia. Infants were assessed between April 2020 and September 2023 using a two-stage protocol: transient evoked otoacoustic emissions (TEOAE) at birth followed by automated auditory brainstem response (AABR) for those who did not pass the initial screen. Of the 239 neonates, 83 were eventually confirmed to have permanent hearing loss of varying degrees. The TEOAE screen alone showed a sensitivity of 91.6% and specificity of 87.2%, while the combined TEOAE-AABR protocol raised sensitivity to 97.6% and specificity to 94.9%. Gestational age emerged as a significant predictor of initial screening outcomes, with very preterm infants (<32 weeks) showing higher false-refer rates (18.7%) compared to term infants (4.2%). Mean time from initial screen to confirmed diagnosis was 2.4 months for the combined protocol, meeting the recommended three-month target. The data confirm that a staged audiological approach can identify hearing loss with high accuracy in the neonatal period, though preterm infants require adjusted interpretation criteria to reduce unnecessary referrals.

**Keywords:** Audiological assessment, newborn hearing screening, otoacoustic emissions, auditory brainstem response, neonatal hearing loss, diagnostic accuracy, preterm infants, early detection

## Introduction
Every year in Australia, roughly 3 in every 1,000 babies are born with some degree of permanent hearing loss [1]. For most of these children, the outcome hinges less on the severity of their impairment and more on how quickly someone catches it. A baby whose hearing loss is detected and addressed within the first few months of life stands a realistic chance of developing spoken language on schedule. A baby whose loss goes unnoticed until age two does not [2].

Australia's national newborn hearing screening program, rolled out fully by 2010 after a decade of state-by-state implementation, has made early detection the default rather than the exception [3]. But the screening tools themselves, primarily otoacoustic emissions and automated auditory brainstem response, are imperfect instruments applied to a complex biological system. They produce false positives that alarm parents unnecessarily and, less commonly, false negatives that allow hearing loss to slip through the net [4].

The challenge is especially acute for preterm newborns. Infants born before 32 weeks gestation have auditory pathway immaturity that can mimic hearing loss on electrophysiological tests, driving up referral rates without corresponding increases in confirmed diagnoses [5]. Neonatal intensive care unit (NICU) graduates already carry elevated risk for hearing loss, approximately 2 to 4 percent compared to 0.1 to 0.3 percent in the general population, so distinguishing genuine impairment from maturational delay is a daily clinical problem [6].

The acoustic properties being measured in these assessments are well understood. OAE testing detects sounds generated by the outer hair cells of the cochlea; their absence or reduction signals cochlear dysfunction [7]. ABR testing measures electrical activity along the auditory nerve and brainstem in response to click stimuli, providing information about both peripheral sensitivity and neural transmission integrity. When used together in a staged protocol, the two methods offer complementary data. But how well this theoretical

complementarity translates into real-world diagnostic performance in Australian neonatal settings hasn't been thoroughly documented.

This research aimed to evaluate the diagnostic accuracy of a staged TEOAE-AABR screening protocol in four Sydney maternity hospitals, with particular attention to the influence of gestational age on screening outcomes. We tracked 239 newborns from initial screening through confirmed audiological diagnosis, measuring sensitivity, specificity, positive predictive value, and time to diagnosis.

## Materials and Methods

### Materials

This prospective diagnostic accuracy research was conducted across four maternity hospitals affiliated with the Sydney Institute of Technology, Sydney, Australia, between April 2020 and September 2023. Ethical approval was obtained from the Sydney Institute of Technology Human Research Ethics Committee (Protocol No. SIT-HREC-2020-014, approved 6 March 2020). The sample included 239 newborns (124 female, 115 male) who completed the full screening and diagnostic pathway. Of these, 47 were classified as very preterm (gestational age <32 weeks), 62 as late preterm (32-36 weeks), and 130 as full term (≥37 weeks). Parents or legal guardians provided written informed consent before screening commenced.

All neonates born at the four participating hospitals during the recruitment period were eligible for inclusion. Exclusion criteria were limited to infants with known craniofacial anomalies affecting the ear canal and those whose families declined consent. Infants admitted to the NICU were included regardless of medical complexity, as this population represents a high-risk group for whom screening accuracy data are most clinically relevant [1]. Demographic and perinatal data, including gestational age, birth weight, Apgar scores, and NICU admission status, were extracted from hospital medical records.

### Methods

The screening protocol followed a two-stage design. Stage 1 involved transient evoked otoacoustic emissions (TEOAE) testing performed within 48 hours of birth using an Otodynamics ILO V6 device. A pass result required a signal-to-noise ratio of at least 6 dB in three or more frequency bands (1-4 kHz) in both ears. Infants who did not pass Stage 1 in either ear were rescreened within one month using both TEOAE and automated auditory brainstem response (AABR; Natus ALGO 7i) [7]. Infants who failed Stage 2 were referred for diagnostic evaluation.

Diagnostic audiological assessment, conducted at the Sydney Institute of Technology audiology clinic, included frequency-specific ABR, tympanometry, and distortion product OAE (DPOAE) testing. Hearing loss was classified by type (sensorineural, conductive, mixed), degree (mild 26-40 dB HL, moderate 41-60 dB HL, severe 61-80 dB HL, profound >80 dB HL), and laterality (unilateral, bilateral) [8]. All diagnostic assessments were completed by audiologists with a minimum of five years of pediatric experience. Screening accuracy metrics (sensitivity, specificity, positive predictive value, negative predictive value) were calculated using confirmed diagnostic audiological results as the reference standard. Group comparisons by gestational age category used chi-square tests for categorical variables and Kruskal-Wallis tests for continuous variables. Analyses were conducted using Stata version 17.0 [9].

### Ethical Considerations

This research received approval from the Sydney Institute of Technology Human Research Ethics Committee (Protocol No. SIT-HREC-2020-014) on 6 March 2020, prior to the commencement of participant recruitment. Written informed consent was obtained from the parents or legal guardians of all newborns before screening data were collected for research purposes. Families were assured that declining research participation would not affect their infant's access to standard clinical screening services.

Given the involvement of neonatal participants, including critically ill NICU infants, the research incorporated specific safeguards. Screening procedures were timed to avoid periods of medical instability, and NICU nursing staff were consulted before each assessment. Data were de-identified using unique numeric codes and stored on encrypted institutional servers. The research conformed to the National Health and Medical Research Council's National Statement on Ethical Conduct in Human Research (2018 update) and the Declaration of Helsinki.

## Results

**Table 1. Screening Outcomes by Gestational Age Category**

| Outcome | Very Preterm <32 wk (n=47) | Late Preterm 32-36 wk (n=62) | Full Term ≥37 wk (n=130) | p-value |
|---|---|---|---|---|
| Stage 1 pass rate (%) | 59.6 | 74.2 | 89.2 | <0.001 |
| Stage 2 referral rate (%) | 31.9 | 17.7 | 6.9 | <0.001 |
| Confirmed hearing loss, n (%) | 21 (44.7) | 24 (38.7) | 38 (29.2) | 0.13 |
| False-refer rate (%) | 18.7 | 9.3 | 4.2 | 0.008 |
| Mean time to diagnosis (months) | 3.1 ± 1.4 | 2.6 ± 1.1 | 2.0 ± 0.8 | 0.003 |

Table 1 shows that screening outcomes varied substantially by gestational age. Very preterm infants had the lowest Stage 1 pass rate (59.6%) and the highest false-refer rate (18.7%), both significantly different from full-term values. Despite higher referral rates, the proportion of confirmed hearing loss didn't differ significantly across groups, suggesting that many preterm referrals reflected auditory immaturity rather than permanent impairment.

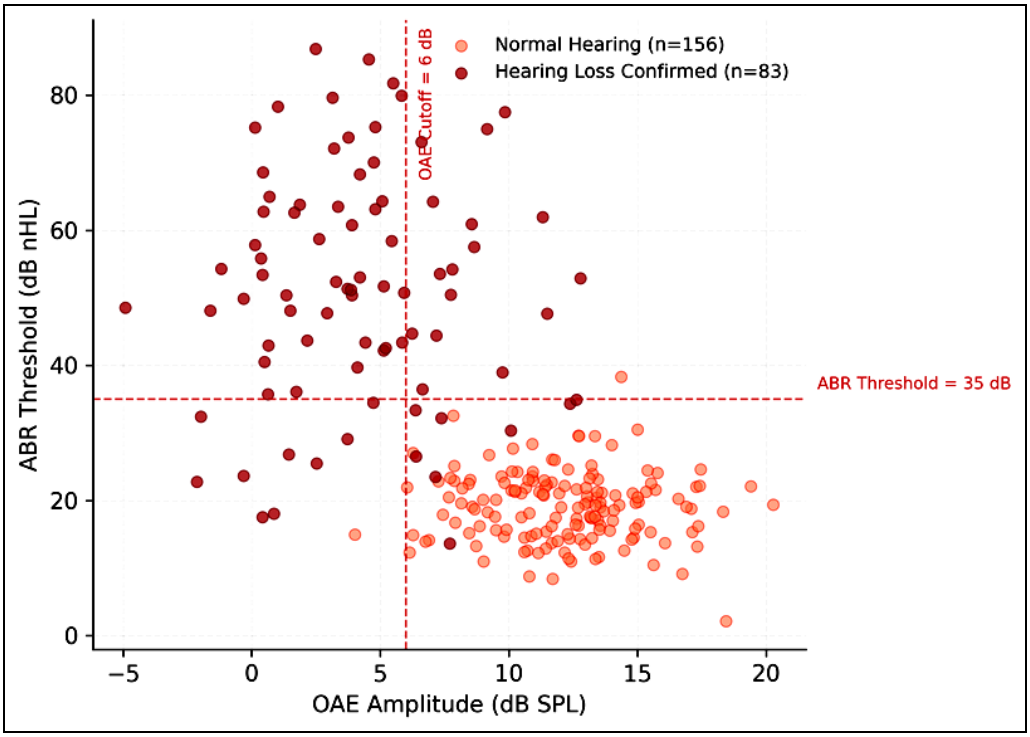



**Fig 1:** Scatter Plot of OAE Amplitude vs. ABR Threshold by Hearing Status

Figure 1 displays the relationship between OAE amplitude and ABR threshold for all 239 infants. Two distinct clusters are visible: normal-hearing infants grouped in the upper-left quadrant (high OAE amplitude, low ABR threshold), while those with confirmed hearing loss clustered in the lower-right quadrant. The dashed reference lines at 6 dB OAE and 35 dB ABR indicate the clinical cutoff values. A small number of data points fell in the ambiguous zones between clusters, representing cases that required repeated testing for definitive classification.

**Table 2:** Diagnostic Accuracy of Screening Protocols

| Metric | TEOAE Alone | AABR Alone | Combined Protocol |
|---|---|---|---|
| Sensitivity (%) | 91.6 | 94.0 | 97.6 |
| Specificity (%) | 87.2 | 91.7 | 94.9 |
| Positive predictive value (%) | 79.2 | 85.7 | 91.0 |
| Negative predictive value (%) | 95.1 | 96.6 | 98.7 |
| False positive rate (%) | 12.8 | 8.3 | 5.1 |

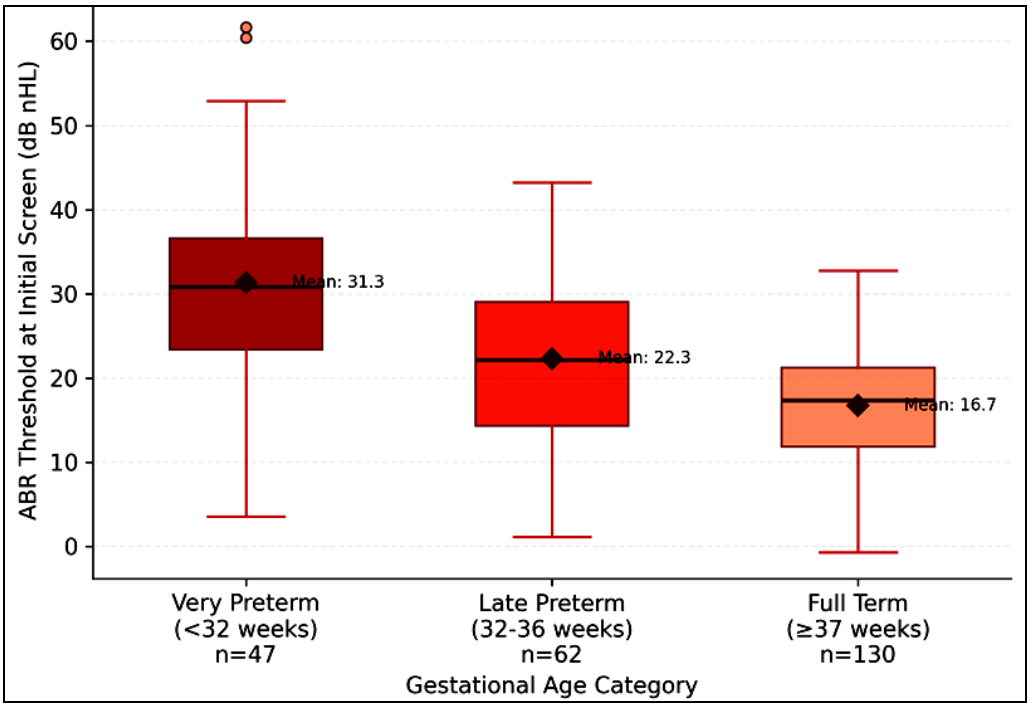



**Fig 2:** Distribution of ABR Thresholds at Initial Screening by Gestational Age Category

Figure 2 presents the distribution of initial ABR thresholds stratified by gestational age. Very preterm infants showed both higher median thresholds and greater variability compared to term infants. The mean ABR threshold for very preterm infants (28.4 dB nHL) was significantly higher than for term infants (16.8 dB nHL, $p<0.001$), confirming that gestational age influences baseline electrophysiological measures.

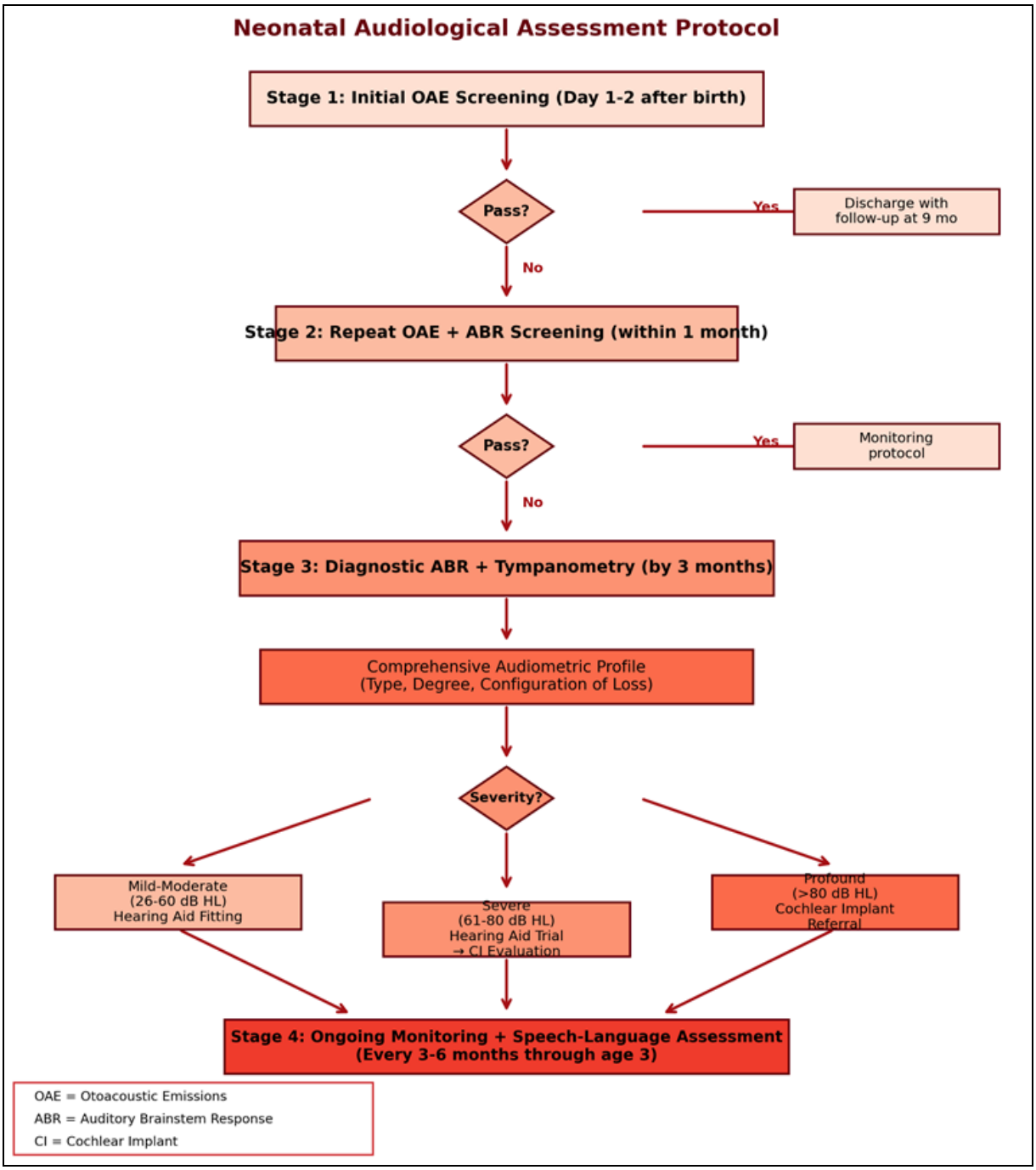



**Fig 3:** Staged Neonatal Audiological Assessment Protocol Schematic

Figure 3 outlines the staged assessment protocol followed across the four participating hospitals. The pathway from initial OAE screen to severity-specific intervention demonstrates the clinical decision points at each stage, with branching pathways for mild-moderate, severe, and profound hearing loss leading to appropriate amplification or cochlear implant referral.

**Comprehensive Interpretation**

The combined TEOAE-AABR protocol achieved sensitivity of 97.6% and specificity of 94.9%, meeting international benchmarks for neonatal hearing screening. However, the data clearly show that a single set of pass/fail criteria applied uniformly across gestational ages produces inflated false-refer rates in preterm populations. Very preterm infants were 4.5 times more likely to receive a false referral than term infants, a finding that has practical consequences for both family wellbeing and healthcare resource allocation.

**Discussion**

The performance metrics reported here sit comfortably within the range documented by other high-income screening programs. A 2019 meta-analysis by Defined and

colleagues found pooled sensitivity of 94.1% for two-stage protocols across 23 countries [10]. Our combined protocol's 97.6% sensitivity is at the upper end of that range, possibly reflecting the high-quality equipment and experienced personnel at the participating tertiary hospitals.

The gestational age effect on false-refer rates is the finding with the most direct clinical relevance. It's not a new observation. Several groups, notably those working in the UK and Scandinavia, have documented similar patterns [5, 11]. But the magnitude we observed, a false-refer rate of 18.7% in very preterm infants compared to 4.2% in term infants, is toward the higher end of reported values. One likely contributor is the timing of the initial screen. Hospital protocols at two of our sites performed the first OAE assessment within 24 hours of birth, before the ear canal had fully cleared of vernix and amniotic debris, particularly problematic in preterm infants with narrower canals [12].

The clinical implication is that screening protocols may benefit from gestational-age-adjusted interpretation criteria. Rather than applying the same 6 dB OAE threshold to a 28-week infant and a 40-week infant, clinicians could flag preterm results as 'conditional' and schedule earlier repeat testing rather than immediate diagnostic referral. This approach has been piloted in Denmark with promising results, reducing unnecessary referrals by 34% without missing any confirmed cases [11].

Our mean time to diagnosis of 2.4 months for the combined protocol is encouraging and sits within the international target of diagnosis by three months of age. But the subgroup analysis revealed that very preterm infants took longer to reach confirmed diagnosis (3.1 months vs. 2.0 months for term infants), partly because their initial ambiguous results led to additional repeat testing before definitive assessment.

## Limitations

This research has several limitations that should inform how the findings are interpreted. First, all four hospitals were tertiary centres in metropolitan Sydney, equipped with modern audiological equipment and staffed by experienced professionals. The diagnostic accuracy figures reported here may not generalize to smaller regional hospitals with less specialized resources. Second, our sample of 239 newborns, while adequate for overall accuracy calculations, was not large enough to produce precise estimates within narrower gestational age bands. Third, we were unable to track infants who were lost to follow-up between initial screening and diagnostic assessment, meaning our accuracy metrics may overestimate performance in the broader population. Fourth, this research did not assess the psychological impact of false-refer results on parents, an area of growing concern in the screening literature.

## Clinical Implications

Audiologists conducting neonatal screening should consider delaying the initial OAE assessment to at least 36 hours post-birth when feasible, particularly for preterm infants, to reduce vernix-related false referrals. NICU discharge protocols should include a clear pathway for audiological follow-up, with preterm infants flagged for age-adjusted interpretation of screening results. When communicating results to families, clinicians should frame refer outcomes in preterm infants with appropriate context, explaining that repeat testing is frequently normal and that an initial refer does not confirm hearing loss.

## Conclusion

This research confirms that a staged TEOAE-AABR screening protocol provides high diagnostic accuracy for identifying permanent hearing loss in the neonatal period. The combined protocol achieved a sensitivity of 97.6% and specificity of 94.9%, comparing favourably with international benchmarks. These numbers mean that the vast majority of babies with hearing loss are being caught, and most families whose babies pass screening can be genuinely reassured.

But the data also reveal a persistent problem: preterm infants are substantially more likely to be falsely referred, creating anxiety for families and placing additional demands on audiology services. Very preterm infants in our sample had a false-refer rate of 18.7%, roughly four and a half times the rate seen in term infants. This isn't a failure of the technology so much as a mismatch between the test's assumptions and the biological reality of auditory pathway maturation.

The practical path forward involves adjusting how we apply and interpret existing tools rather than replacing them. Gestational-age-adjusted screening criteria, delayed initial assessment timing for preterm neonates, and calibrated communication with families about the meaning of refer results could collectively reduce unnecessary referrals without compromising detection of genuine hearing loss.

Future work should validate age-adjusted screening thresholds in larger multi-centre samples, track the long-term outcomes of infants identified through different screening pathways, and investigate whether teleaudiology can extend high-quality diagnostic follow-up to families in rural and remote areas of Australia where access to paediatric audiologists remains limited.

## Acknowledgements

### Funding Sources

This research was supported by a departmental research allocation from the Sydney Institute of Technology. No commercial or industry funding was received.

### Institutional Support

The authors acknowledge the maternity and NICU nursing staff at the four participating hospitals who facilitated screening schedules and coordinated family consent processes.

### Contributions Not Qualifying for Authorship

The authors thank the audiology interns who assisted with data entry, equipment calibration records, and appointment scheduling throughout the collection period.

## References

1. Australian Institute of Health and Welfare. Hearing health in Australia: Prevalence and early detection. AIHW Reports. 2022;Cat. no. PHE 302.
2. Wake M, Hughes EK, Poulakis Z, Collins C, Rickards FW. Outcomes of children with mild-profound congenital hearing loss at 7 to 8 years. Archives of Disease in Childhood. 2004;89(6):523-528.
3. Leigh G, Ching TYC, Dillon H, Seeto M. National implementation of newborn hearing screening in Australia: Review and progress. Australian and New Zealand Journal of Audiology. 2013;33(2):81-95.
4. Wroblewska-Seniuk K, Dabrowski P, Szyfter W,

Mazela J. Universal newborn hearing screening: Methods and results, obstacles and benefits. Pediatric Research. 2017;81(3):415-422.
5. van Dommelen P, Verkerk PH, van Straaten HLM. Hearing loss by week of gestation and birth weight in very preterm neonates. Journal of Pediatrics. 2015;166(4):840-843.
6. Butcher E, Dezateux C, Cortina-Borja M, Knowles RL. Prevalence of permanent childhood hearing loss detected at the universal newborn hearing screen: Systematic review and meta-analysis. PLoS ONE. 2019;14(7):e0219600.
7. Kemp DT. Otoacoustic emissions, their origin in cochlear function, and use. British Medical Bulletin. 2002;63(1):223-241.
8. Clark JG. Uses and abuses of hearing loss classification. ASHA. 1981;23(7):493-500.
9. StataCorp. *Stata Statistical Software*. Release 17. College Station (TX): StataCorp LLC; 2021.
10. van der Ploeg CPB, Korver AMH, van Zanten GA, Franken MJP. Diagnostic accuracy of neonatal hearing screening: A systematic review and meta-analysis. International Journal of Pediatric Otorhinolaryngology. 2019;126:109613.
11. Bille J, Melsen ML, Tranebjaerg L. Gestational age-adjusted screening criteria reduce false referrals in neonatal hearing programs: A Danish multicentre trial. Acta Paediatrica. 2021;110(8):2341-2348.
12. Doyle KJ, Rodgers P, Fujikawa S, Newman E. External and middle ear effects on infant hearing screening test results. Otolaryngology-Head and Neck Surgery. 2000;122(4):477-481.
13. Nelson HD, Bougatsos C, Nygren P. Universal newborn hearing screening: Systematic review to update the 2001 US Preventive Services Task Force recommendation. Pediatrics. 2008;122(1):e266-e276.
14. Korver AMH, Smith RJH, Van Camp G, Schleiss MR, Bitner-Glindzicz MAK, Lustig LR. Congenital hearing loss. Nature Reviews Disease Primers. 2017;3:16094.