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Diagnostic Accuracy of the LittlEARS Auditory Questionnaire Against Auditory Steady-State Response for Detecting Hearing Loss in Infants Aged 6–24 Months

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A B S T R A C T

Introduction: Hearing loss is among the most common congenital conditions in childhood, yet most affected infants in Indonesia are identified late because objective audiometry is centralized and preverbal infants show few overt signs. This study aimed to determine the diagnostic accuracy of the parent-completed LittlEARS Auditory Questionnaire against the auditory steady-state response (ASSR) for detecting hearing loss in infants aged 6–24 months.

Methods: In this single-center, cross-sectional diagnostic-accuracy study, 28 children aged 6–24 months (median 9.0 months; 71.4% male) attending a tertiary otorhinolaryngology clinic were enrolled by consecutive sampling. Parents independently completed the Indonesian LittlEARS, and each child underwent ASSR as the reference standard (hearing loss >25 dB HL across 0.5–4 kHz). Diagnostic indices were computed with Wilson 95% confidence intervals (CI); agreement, likelihood ratios, receiver-operating-characteristic analysis, and Firth penalized logistic regression were performed.

Results: ASSR confirmed hearing loss in 19 children (67.9%), of whom 18 had bilateral loss. Referenced to ASSR, LittlEARS yielded a sensitivity of 89.47% (95% CI 68.6–97.1), specificity 77.78% (95% CI 45.3–93.7), positive predictive value 89.47%, negative predictive value 77.78%, and accuracy 85.71% (95% CI 68.5–94.3). Agreement was substantial (Cohen kappa 0.673), the positive likelihood ratio 4.03 and negative likelihood ratio 0.14, and the area under the curve 0.836 (95% CI 0.688–0.985). A suspected-hearing-loss result independently predicted ASSR-confirmed loss (adjusted odds ratio 13.98, 95% CI 1.68–116.25; p=0.015; Nagelkerke R^2=0.469).

Conclusion: The LittlEARS questionnaire is an accurate, low-cost screening adjunct for early childhood hearing loss but, given moderate specificity, a positive screen should be confirmed by objective audiometry.

1. Introduction

Hearing loss is one of the most frequent conditions affecting young children, and sensory impairment is among the most prevalent childhood disabilities worldwide; permanent loss is detected in roughly one to several per thousand children and accumulates through infancy and childhood as late-onset and acquired losses emerge.[1,2] In Indonesia the burden is substantial: a nationwide survey of school children found that otitis media contributed to more than half of all childhood hearing loss, and hearing impairment is a recognized but under-served problem in Balinese children.[3-5]

The vulnerability of young children to undetected hearing loss is rooted in the biology of the developing auditory system. During the first two years of life the infant is preverbal, so a hearing deficit produces few overt signs until speech and language delay become apparent, frequently after the optimal window for intervention has passed.[6,7] The infant Eustachian tube

is short, horizontal, and compliant, predisposing to middle-ear effusion and conductive overlay, while genetic, congenital cytomegalovirus, and perinatal factors account for most permanent sensorineural loss.[8] Because the first years are the critical period for auditory and language maturation, early identification and intervention strongly influence later speech, cognition, and social development.[6,9]

Objective electrophysiological tests anchor infant diagnosis. The auditory steady-state response (ASSR) provides frequency-specific thresholds across 0.5–4 kHz using automated detection, removing observer subjectivity and guiding amplification; recent studies confirm close agreement between ASSR and behavioral or auditory brainstem response thresholds in children.[10,11] Complementing objective testing, the LittlEARS Auditory Questionnaire — a 35-item yes/no parent-report instrument developed from auditory-language milestones in children younger than two years — captures real-world auditory behavior, and validation studies across many languages report high internal consistency and strong score–hearing-age correlations.[12-16]

Objective and behavioral measures are complementary: objective tests quantify the integrity of the peripheral and brainstem pathway but cannot describe how a child uses sound in daily life, whereas parent-report milestone inventories capture functional listening yet are susceptible to reporting variability.[10] A screen combining low cost, cultural acceptability, and rapid administration with acceptable accuracy could widen early hearing detection where objective audiology is centralized, as has been proposed for other low-resource settings.[15]

Despite this evidence base, parent-report screens remain underused in low- and middle-income settings where they could most expand reach, and few studies have quantified their diagnostic accuracy against an objective threshold reference standard in routine clinical infants.[15,17] In Indonesia, hearing impairment in children has been described mainly in school-age and tertiary-care contexts, and the Indonesian-language LittlEARS has not been validated against ASSR in a tertiary population in Bali, where access to objective audiology is limited and many infants are still identified late.[4,5]

To our knowledge, this is among the first studies in pediatric patients at a tertiary center in Bali to validate the Indonesian LittlEARS Auditory Questionnaire against ASSR as an objective reference standard for early childhood hearing loss. The purpose of this study was to determine the diagnostic accuracy — sensitivity, specificity, predictive values, agreement, likelihood ratios, and discriminative performance — of the parent-completed LittlEARS Auditory Questionnaire for detecting hearing loss, referenced to ASSR, in children aged 6 months to 2 years, and to assess whether a suspected-hearing-loss result independently predicts ASSR-confirmed loss after adjustment for age and gender.

2. Methods

Study design and setting

This single-center, cross-sectional diagnostic-accuracy study was conducted in accordance with STROBE and STARD reporting principles at the Department of Otorhinolaryngology and Head/Neck Surgery, Faculty of Medicine, Universitas Udayana/Prof. Dr. I.G.N.G. Ngoerah General Hospital, Denpasar, Bali, Indonesia. Consecutive children attending the otorhinolaryngology–audiology outpatient clinic who underwent ASSR testing and whose parents completed the LittlEARS questionnaire were assessed for eligibility over the study period.

Participants

Eligible participants were children aged 6 to 24 months whose parents or legal guardians consented and independently completed the Indonesian LittlEARS questionnaire and who underwent ASSR assessment. Children with incomplete questionnaires, with intercurrent acute otitis media or external-canal obstruction precluding valid testing, or with conditions preventing ASSR acquisition were excluded. Consecutive sampling enrolled all eligible children in order of presentation until the required sample was reached. This pragmatic strategy was chosen for efficient data collection within a limited study window while preserving an unselected referral sample.

Sample size

The sample size was calculated using the formula for a diagnostic test applied to the whole population, assuming an expected sensitivity of 0.90, a desired absolute precision of 0.10, alpha of 0.05 (two-tailed), and the anticipated proportion of children with hearing loss in this referral setting. The calculation yielded a minimum of 28 participants, providing power of at least 0.80 to estimate sensitivity with the prespecified precision; the study was, however, less precise for specificity because fewer children without hearing loss were expected.

Index test: LittlEARS auditory questionnaire

The LittlEARS Auditory Questionnaire is a validated 35-item parent-report instrument covering receptive, semantic, and expressive auditory-language milestones in children with a hearing age of 0–24 months; parents answer yes or no, and the total yes score (maximum 35) is interpreted against age-referenced norm curves.[12,13] The Indonesian translation was completed independently by each parent. The classification threshold was prespecified using the published age-referenced norm curve: a score at or above the normal value for hearing age was classified as normal hearing, and a score below it as suspected hearing loss. Because formal Indonesian-population norms have not been separately established, the original validated norm curve was applied as the best available reference. Parents completed the questionnaire masked to the ASSR result, reflecting intended real-world use.

Reference standard: auditory steady-state response

ASSR testing was performed by trained audiologists with the child in natural sleep or, when required for infants who could not settle, under light medically supervised sedation per protocol and with parental consent. After skin preparation, electrodes were placed at the vertex (Cz, non-inverting), mastoids or earlobes (A1, A2, inverting), and forehead (Fpz, ground), with inter-electrode impedance below 3 kΩ. Insert earphones delivered mixed amplitude- and frequency-modulated tonal stimuli at carrier frequencies of 500, 1000, 2000, and 4000 Hz with modulation frequencies of 75–110 Hz, optimal for the sleeping state. Responses were detected automatically by F-test after Fast Fourier Transform; intensity was decreased in 10–20 dB steps until threshold and increased by 10 dB when no response was present. Estimated thresholds were classified as normal hearing (0–25 dB HL) or hearing loss (greater than 25 dB HL); for asymmetric results the better-hearing ear defined overall hearing status.

Outcomes

The primary outcome was the diagnostic accuracy of the LittlEARS categorical result (suspected hearing loss vs normal) referenced to the ASSR classification (hearing loss vs normal). Secondary outcomes were age-stratified diagnostic performance and the independent association between a suspected-hearing-loss result and ASSR-confirmed loss.

Data handling and quality control

Questionnaire responses and ASSR thresholds were recorded on a standardized case-record form, double-entered, and cross-checked for transcription errors. The index test and reference standard were performed and interpreted independently: parents completed the LittlEARS without knowledge of the ASSR outcome, and audiologists interpreting ASSR were not shown the questionnaire score. Every enrolled child underwent both tests irrespective of either result, avoiding partial-verification bias, and there were no missing data for the primary analysis.

Statistical analysis

Analyses were performed in SPSS version 24.0 with supplementary computation in Python 3 (statsmodels and SciPy) for the Firth regression and the receiver-operating-characteristic analysis. Categorical variables were summarized as frequencies and percentages and continuous variables as mean ± standard deviation or median with interquartile range (IQR) after Shapiro–Wilk testing of normality. A 2×2 contingency table generated sensitivity, specificity, positive and negative predictive values, and accuracy, each with Wilson 95% confidence intervals (CI). Chance-corrected agreement was quantified with Cohen kappa, and positive and negative likelihood ratios and the diagnostic odds ratio were calculated

with 95% CIs. Receiver-operating-characteristic analysis yielded the area under the curve (AUC) with 95% CI and the Youden index. To identify independent predictors of ASSR-confirmed hearing loss while accommodating the small sample and quasi-complete separation, a Firth penalized logistic regression model included the LittlEARS result, age, and gender, reporting adjusted odds ratios (aOR), 95% CIs, and the Nagelkerke R^2. Age-stratified (6–12 vs 13–24 months) and sex-stratified diagnostic performance were explored as secondary, hypothesis-generating analyses. A two-tailed $p<0.05$ was considered significant.

Ethics

The study was approved by the Research Ethics Committee of the Faculty of Medicine, Universitas Udayana / Prof. Dr. I.G.N.G. Ngoerah Hospital, Denpasar, and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from the parents or legal guardians of all participants.

3. Results

Participant characteristics

Twenty-eight children aged 6–24 months were enrolled. The median age was 9.0 months (IQR 7.0–22.75), and the mean age was 13.50 ± 7.50 months. Most children were aged 6–12 months (16/28, 57.14%) and male (20/28, 71.43%). Parental education was senior high school in 16/28 (57.14%) and university degree in 12/28 (42.86%), with no parent below senior-high-school level. No child had ever used a hearing aid. ASSR confirmed hearing loss in 19 children (67.86%), of whom 18 (94.7%) had bilateral loss and one had unilateral (left-ear) loss; within the hearing-loss group, 12/19 (63.16%) were aged 6–12 months. The full demographic and clinical profile of the cohort is detailed in Table 1.

Table 1. Demographic and clinical characteristics of participants (n = 28).

Characteristic	Total (n=28)	Hearing loss (n=19)	Normal (n=9)
Age group			
6–12 months	16 (57.14)	12 (63.16)	4 (44.44)
13–18 months	3 (10.71)	3 (15.79)	0 (0)
19–24 months	9 (32.14)	4 (21.05)	5 (55.56)
Age, median (IQR), months	9.0 (7.0–22.75)	—	—
Gender			
Male	20 (71.43)	13 (68.42)	7 (77.78)
Female	8 (28.57)	6 (31.58)	2 (22.22)
Parental education			
Senior high school	16 (57.14)	11 (57.89)	5 (55.56)
University degree	12 (42.86)	8 (42.11)	4 (44.44)
Hearing-loss laterality			
Bilateral	—	18 (94.74)	—
Unilateral	—	1 (5.26)	—
Prior hearing-aid use			
Never used	28 (100)	19 (100)	9 (100)

Notes: ASSR, auditory steady-state response; IQR, interquartile range. Data are n (%) unless otherwise indicated.

Diagnostic accuracy of LittlEARS referenced to ASSR

On the parent-completed LittlEARS, 19 children scored below the age-referenced threshold (suspected hearing loss) and 9 scored at or above it (normal). As shown by the cross-tabulation in Table 2, this produced 17 true positives, 2 false positives, 2 false negatives, and 7 true negatives. The questionnaire

achieved a sensitivity of 89.47% (95% CI 68.61–97.06), specificity of 77.78% (95% CI 45.26–93.68), positive predictive value of 89.47% (95% CI 68.61–97.06), negative predictive value of 77.78% (95% CI 45.26–93.68), and overall accuracy of 85.71% (95% CI 68.51–94.30); all diagnostic indices with their confidence intervals are presented together in Table 2 and the performance profile is illustrated in Figure 1.

Table 2. Cross-tabulation and diagnostic performance of LittlEARS versus ASSR.

LittlEARS result	ASSR: hearing loss	ASSR: normal	Total
Suspected hearing loss	17 (TP)	2 (FP)	19
Normal	2 (FN)	7 (TN)	9
Total	19	9	28
Diagnostic index	**Value (95% CI)**	**Diagnostic index**	**Value (95% CI)**
Sensitivity	89.47% (68.6–97.1)	Specificity	77.78% (45.3–93.7)
PPV	89.47% (68.6–97.1)	NPV	77.78% (45.3–93.7)
Accuracy	85.71% (68.5–94.3)	Cohen kappa	0.673 (0.38–0.97)
LR+	4.03 (1.17–13.80)	LR−	0.14 (0.03–0.53)
Diagnostic OR	29.75 (3.47–255.0)	AUC	0.836 (0.69–0.99)

Notes: ASSR, auditory steady-state response; CI, confidence interval; LR, likelihood ratio; PPV/NPV, positive/negative predictive value; OR, odds ratio; AUC, area under the curve. 95% CIs are Wilson intervals; LR and OR CIs are log-based.

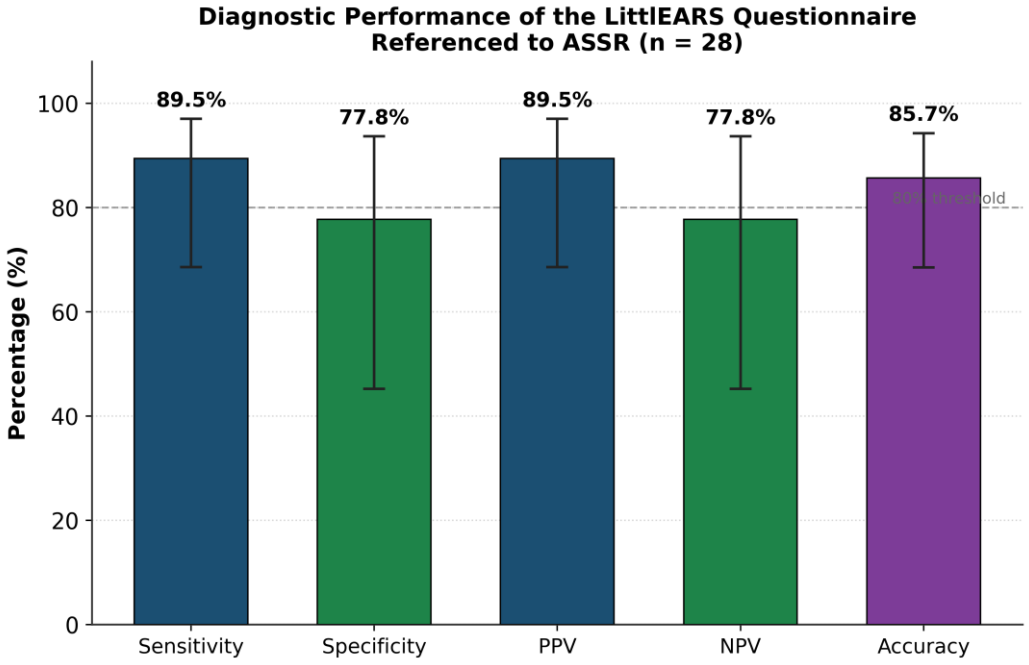

Figure 1. Diagnostic performance of the LittlEARS questionnaire referenced to ASSR (error bars = 95% CI).

As also summarized in Table 2, chance-corrected agreement between LittlEARS and ASSR was substantial (Cohen kappa 0.673, 95% CI 0.375–0.970). The positive likelihood ratio was 4.03 (95% CI 1.17–13.80) and the negative likelihood ratio 0.14 (95% CI 0.03–0.53), and the diagnostic odds ratio was 29.75

(95% CI 3.47–255.04). The association between the two tests was significant on Fisher exact testing (p<0.001). The receiver-operating-characteristic curve, shown in Figure 2, gave an area under the curve of 0.836 (95% CI 0.688–0.985), with the operating point at sensitivity 89.5% and specificity 77.8% (Youden index 0.673).

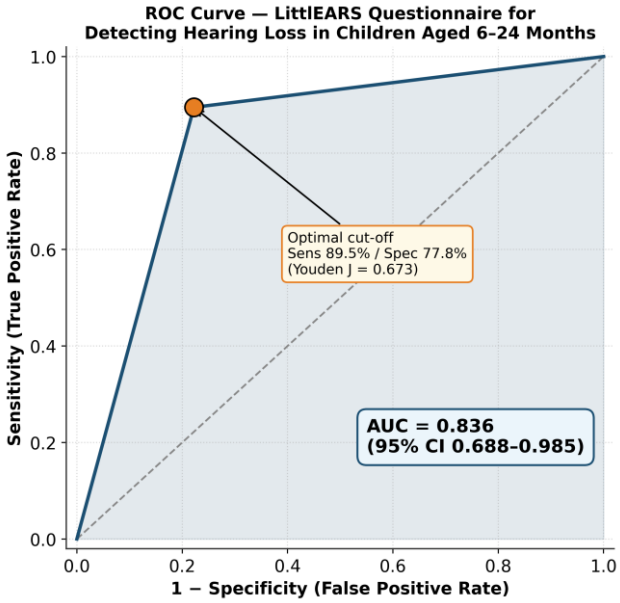

Figure 2. Receiver-operating-characteristic curve for the LittlEARS questionnaire in detecting hearing loss (AUC 0.836).

Independent predictors and subgroup analysis

The independent predictors of ASSR-confirmed hearing loss are summarized in Table 3. In the Firth penalized logistic regression model, a suspected-hearing-loss result on LittlEARS independently predicted ASSR-confirmed hearing loss after adjustment for age and gender (adjusted odds ratio 13.98, 95% CI 1.68–116.25; p=0.015), whereas age (aOR 0.99 per month; p=0.881) and male gender (aOR 0.31; p=0.319) were not significant; the model explained a substantial share of variance (Nagelkerke R^2 0.469). The age-stratified performance, depicted in Figure 3, showed higher sensitivity in infants aged 6–12 months (100%) than in those aged 13–24 months (71.4%), with specificity of 60.0% and 80.0% respectively; the small stratum sizes warrant cautious interpretation of these exploratory estimates.

Table 3. Firth penalized multivariable logistic regression for ASSR-confirmed hearing loss.

Variable	aOR	95% CI	p-value
LittlEARS suspected hearing loss	13.98	1.68–116.25	0.015
Age (per month)	0.99	0.87–1.13	0.881
Male gender	0.31	0.03–3.09	0.319

Notes: aOR, adjusted odds ratio; CI, confidence interval. Model Nagelkerke R^2 = 0.469; Firth penalization applied for small-sample bias and quasi-complete separation.

4. Discussion

In this tertiary-center study of 28 infants and toddlers aged 6–24 months, the parent-completed Indonesian LittlEARS Auditory Questionnaire detected ASSR-confirmed hearing loss with high sensitivity (89.47%) and good overall accuracy (85.71%),

substantial agreement with the objective reference standard (Cohen kappa 0.673), and strong discrimination (AUC 0.836). A suspected-hearing-loss result independently predicted ASSR-confirmed loss almost fourteen-fold after adjustment for age and gender. These findings position the LittlEARS questionnaire as an accurate, low-cost screening adjunct for early childhood hearing loss in a setting where objective audiology is scarce, while its moderate specificity (77.78%) indicates that a positive screen requires objective confirmation.

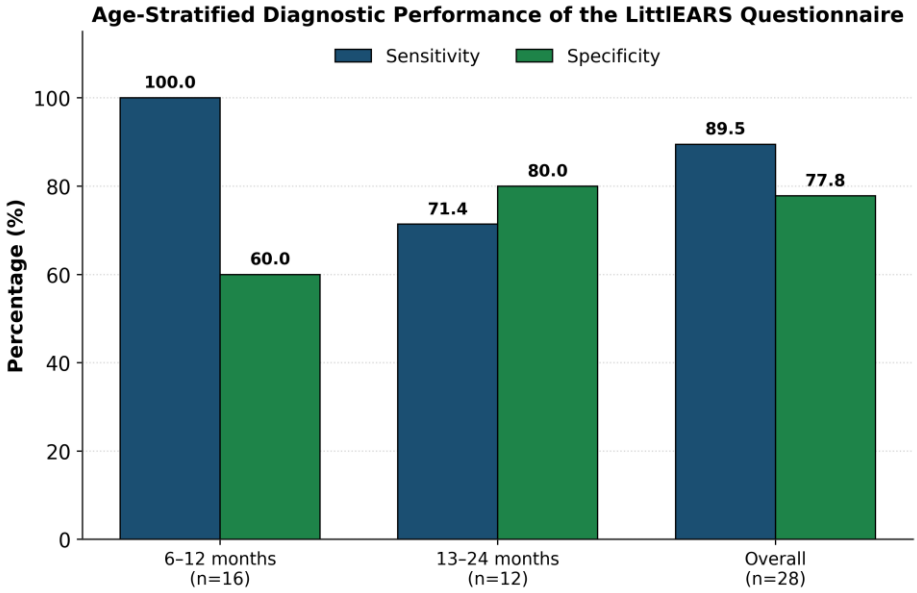

Figure 3. Age-stratified sensitivity and specificity of the LittlEARS questionnaire.

The high sensitivity observed here is consistent with international LittlEARS validations. Among 398 children aged 0–36 months the Maltese LittlEARS showed excellent internal consistency and predictive accuracy, and Kannada, Kiswahili/Lingala, Romanian, and cochlear-implant cohorts have likewise reported high internal consistency with strong score–hearing-age relationships.[13-16,18] Reports using the questionnaire to track auditory development after amplification or implantation similarly demonstrate that caregiver-observed milestones reflect true auditory access, supporting the external validity of the present result.[9,19]

Our finding that hearing loss was overwhelmingly bilateral (94.7%) agrees with Indonesian and international series in which most congenitally affected children present with bilateral loss, reflecting both the greater developmental impact that prompts referral and the genetic and perinatal etiologies that predominate in this age group.[3,5,8] The slight male predominance echoes some cohorts, although the evidence linking biological sex to childhood hearing-loss risk remains inconsistent and our sample was too small to test this association.[6]

In contrast to reports in which children with hearing loss are frequently identified only beyond the second year, the majority of affected children in this study were identified at 6–12 months.[7,17] This earlier detection may reflect improving screening practice and the relatively high parental education in our sample, factors that plausibly increase awareness of auditory milestones, and underscores the value of accessible parent-report tools in shortening the path to diagnosis.[4,5]

The higher sensitivity in infants aged 6–12 months (100%) than in older toddlers (71.4%) may relate to the steeper, more discriminating slope of the LittlEARS age-norm curve at younger hearing ages, where small deficits in auditory milestones are more readily flagged; however, the small stratum sizes warrant cautious

interpretation of this exploratory subgroup difference, and the slightly lower specificity in the youngest group is consistent with the broad behavioral variability of normally developing infants.

Several child-specific mechanisms explain why parent observation tracks true hearing status in this age band. The first years of life are a period of rapid maturation of the cochlea, auditory brainstem, and central auditory pathways during which auditory experience drives synaptic refinement; a child with reduced audibility fails to reach the receptive and expressive milestones that attentive caregivers observe in daily life.[6,9] At the same time, the immaturity and horizontal orientation of the infant Eustachian tube favor middle-ear effusion and conductive overlay, and the preverbal state masks deficits until language delay appears, so a structured milestone inventory captures functional hearing that a single objective measurement may not contextualize.[8] ASSR complements this by providing frequency-specific thresholds that remove observer subjectivity, making the two approaches naturally synergistic rather than redundant.

The choice of ASSR as the reference standard strengthens interpretation, because ASSR estimates frequency-specific thresholds across the speech range and correlates closely with behavioral and auditory brainstem response thresholds in children.[10,11] Benchmarking a parent-report screen against this threshold-level standard therefore yields a clinically meaningful estimate of how well caregiver observation reflects audiometric status, and the substantial agreement observed (kappa 0.673) indicates that the questionnaire captures genuine audiometric signal rather than incidental correlation.

For pediatricians and otolaryngologists, these results support embedding the LittlEARS questionnaire into routine well-child and ENT encounters as a first-line screen, particularly where objective audiology is not immediately available. A score below the age-referenced threshold should trigger prompt referral for ASSR or auditory brainstem response confirmation rather than a definitive diagnosis, given the moderate specificity and the harm of false reassurance. Conversely, the low negative likelihood ratio (0.14) means a normal questionnaire substantially lowers the probability of significant loss, helping clinicians prioritize limited diagnostic capacity toward children most likely to benefit.

From a health-systems perspective, a validated parent-report screen offers favorable cost and scalability: it requires no equipment, can be completed in minutes by a literate caregiver, and can be deployed at primary-care, community, and immunization contacts that already reach most infants. Used as a triage step, it can expedite screen-positive children to objective testing and improve the yield of scarce ASSR and auditory-brainstem-response capacity, shortening the interval from suspicion to confirmation and amplification.[15,17]

Environmental and contextual factors specific to the Indonesian and broader Asian setting deserve emphasis. A high community prevalence of otitis media, uneven access to neonatal screening, and the geographic dispersal of the population shape both the epidemiology and the screening pathway, and parent-report tools are well suited to bridging gaps where objective testing is centralized in referral hospitals.[3,5,20] Cultural acceptability and the low cost of a translated questionnaire further favor scale-up in community and primary-care settings across the archipelago.

Two implementation considerations temper enthusiasm. First, although the LittlEARS has high internal consistency, its test-retest and inter-rater reliability for the dichotomous screening classification were not assessed here; because two caregivers of the same child may answer differently, reliability should be characterized before wide deployment, and our findings should be read as evidence of accuracy under favorable single-rater conditions.[12,19] Second, the instrument must be positioned as complementary to, not a replacement for, universal newborn hearing screening: administered from six months of age it can capture late-onset, progressive, and acquired losses that pass a newborn screen and can reach infants never screened at birth, but it does not substitute for objective neonatal screening in high-risk infants.[7,17]

On the basis of these findings we propose a pragmatic pathway. The questionnaire can be administered by primary-care or community health workers at routine infant contacts from six months; a score below the age-referenced threshold should prompt referral for ASSR or auditory brainstem

response confirmation within a defined interval rather than a diagnosis, while a normal score, supported by the low negative likelihood ratio, can reasonably reassure a low-risk child without replacing newborn screening. Such a pathway would direct scarce objective-testing capacity toward children most likely to benefit and could shorten the interval to amplification.

Generalizability must be considered carefully. Bali differs from many Indonesian provinces in health-service density and caregiver education — no caregiver in this sample had less than senior-high-school education — and because the accuracy of a parent-report tool depends on the caregiver's capacity to observe and interpret auditory behavior, performance may be lower in populations with lower literacy and health awareness. These results should therefore be regarded as preliminary evidence of feasibility and promising accuracy that requires confirmation in larger, multi-site, community-based studies with prespecified thresholds, deliberate enrolment of mild and unilateral losses, and prospective follow-up.

The pathophysiology underlying these findings is distinctly pediatric. In early infancy the cochlea and central auditory pathways undergo rapid, experience-dependent maturation, and adequate audibility during this sensitive period is required for the normal unfolding of receptive and expressive auditory-language milestones; when audibility is reduced, the very milestones that the LittlEARS items enumerate fail to appear, which is why a structured parental inventory can track audiometric status so closely in this age band.[6,9] Superimposed on this developmental substrate are anatomical features that make the young child especially prone to hearing fluctuation: the short, horizontal, and highly compliant infant Eustachian tube predisposes to middle-ear effusion, while immature mucosal and innate immune defences increase susceptibility to the recurrent otitis media that is common in Indonesian children and can add a conductive component to an underlying sensorineural loss.[3,8] These mechanisms explain both the high sensitivity of the questionnaire against the predominantly bilateral, moderate-to-profound losses seen here and the expectation that milder or purely high-frequency losses, which perturb everyday auditory behavior less, will be harder for any behavioral screen to detect.

The clinical implications extend across the tiers of the health system. For the otolaryngologist, a positive questionnaire in an infant referred for speech delay or parental concern is an indication to prioritise objective testing and, where loss is confirmed, to expedite amplification or implant candidacy assessment within the developmental window during which intervention most benefits language.[6,9] For the pediatrician and primary-care worker, the questionnaire offers a structured, low-cost way to convert vague parental worry into an actionable referral decision, and its favourable negative likelihood ratio provides reassurance that is grounded in data rather than impression. Embedding the tool within the existing early hearing detection and intervention framework, rather than treating it as a stand-alone test, is the configuration most likely to shorten the interval from suspicion to confirmed diagnosis and to reduce the loss to follow-up that erodes the effectiveness of screening programs everywhere.[17,20,21]

Placed in the wider regional context, these findings address a recognized gap between the demand for and the supply of infant audiology across much of Southeast Asia. Objective testing such as ASSR and auditory brainstem response remains concentrated in a small number of urban referral centres, neonatal screening coverage is uneven, and many children therefore reach diagnosis only after language delay has become apparent.[7,17] A validated, culturally adapted, parent-completed instrument is well matched to this reality: it can be distributed through the immunisation and well-child contacts that already reach the great majority of infants, it imposes negligible marginal cost, and it returns a result that meaningfully reorders the pre-test probability of hearing loss. Used as the first step of a tiered pathway, it can concentrate scarce objective-testing capacity on the children most likely to benefit while sparing families with normally hearing children unnecessary travel to distant centres, an efficiency that is particularly valuable in an archipelagic health system serving a geographically dispersed population.[5,15]

Future research should prioritize a multicenter design that deliberately balances the number of

children with and without confirmed hearing loss, since the present imbalance toward affected children is the principal factor limiting the precision of specificity and the false-positive estimates that matter most for community screening. Such a study should prespecify the questionnaire threshold, establish Indonesian-population norms, analyze the full continuous score with a properly estimated receiver-operating-characteristic curve, and enroll mild and unilateral losses that a behavioral instrument is most likely to miss. Incorporating otoacoustic emissions and auditory brainstem response alongside ASSR, documenting middle-ear status with tympanometry, and following children prospectively to capture progressive and late-onset losses would further clarify where a parent-report screen adds value within the early hearing detection and intervention pathway.

The strengths of this study include the use of ASSR as an objective, frequency-specific reference standard; the prospective, masked, parent-completed administration of the index test reflecting real-world use; and the application of a comprehensive analytic framework with confidence intervals, agreement statistics, likelihood ratios, ROC analysis, and small-sample-robust Firth regression rather than point estimates alone. A further strength is that the index test was administered exactly as it would be in practice — independently by parents, before and masked to the objective result — so the estimates reflect real screening conditions rather than idealised research administration.

This study has limitations. The sample of 28 children, although meeting the diagnostic sample-size calculation, yields wide confidence intervals — particularly for specificity — and limits the precision of subgroup estimates. The single tertiary-center, consecutive-sampling design and the high proportion with confirmed hearing loss (67.9%) reflect a referral population and may inflate predictive values relative to community screening, constraining external validity. ASSR cannot detect auditory neuropathy spectrum disorder and can be insensitive to retrocochlear and brainstem dysfunction, so a small number of such cases could be misclassified.[21] Continuous LittlEARS scores were dichotomized against age norms rather than analyzed across their full range, and predictive values depend on the high referral-clinic prevalence; larger multicenter community studies incorporating otoacoustic emissions and auditory brainstem response are needed to confirm these findings.[2]

5. Conclusion

The parent-completed Indonesian LittlEARS Auditory Questionnaire detected ASSR-confirmed hearing loss in children aged 6–24 months with high sensitivity (89.47%), good accuracy (85.71%), substantial agreement (kappa 0.673), and strong discrimination (AUC 0.836), and a suspected-hearing-loss result independently predicted confirmed loss (adjusted odds ratio 13.98). These findings support the LittlEARS questionnaire as an accurate, low-cost screening adjunct that pediatricians and otolaryngologists can use to expand early hearing detection in resource-limited settings. Because specificity was moderate, a positive screen should prompt objective audiometric confirmation rather than a definitive diagnosis. Larger multicenter, community-based studies that prespecify the screening threshold, establish Indonesian-population norms, and deliberately enrol mild and unilateral losses are warranted to confirm diagnostic performance and to guide the integration of parent-report screening into national early hearing detection and intervention pathways. Until such evidence is available, the questionnaire is best regarded as a sensitive, low-cost first-line screen that complements, but does not replace, objective infant audiometry.

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