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RESEARCH ARTICLE

AHEAD Emotional Health: Behavioral Subsection—A Digital, Culturally Adapted Tool for Behavioral Disorder Screening

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Abstract:

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INTRODUCTION

Emotional and behavioral development in the first five years of life lays the foundation for lifelong mental health, social functioning, and learning capacity. Difficulties emerging during this period, such as persistent aggression, hyperactivity, or withdrawal, are not merely transient phases but may signal underlying behavioral disorders. When left unrecognised, these problems often persist into adolescence and adulthood, contributing to academic underachievement, poor peer relationships, and heightened risk of mental illness later in life[1,2].

Globally, behavioral disorders represent a substantial public health challenge. Recent WHO estimates indicate that 13–20% of children and adolescents experience a diagnosable mental disorder, with conduct disorder, oppositional defiant disorder, and attention-deficit/hyperactivity disorder among the most common behavioral conditions[3].3 The Global Burden of Disease Study highlights that these disorders rank among the leading causes of years lived with disability in this age group. In India, the National Mental Health Survey and more recent school-based studies report prevalence rates for behavioral disorders ranging from 5% to 15%, depending on the setting and diagnostic criteria[4,5].
The early identification of behavioral difficulties offers the best opportunity for intervention, yet screening for emotional and behavioral health remains under-prioritised in routine paediatric care, particularly in low- and middle-income countries. Barriers include lack of trained personnel, time constraints in busy clinical settings, and limited access to validated, culturally appropriate tools[6].

The Strengths and Difficulties Questionnaire (SDQ) is one of the most widely used behavioral screening tools worldwide. It is brief, freely available, and validated across diverse populations, including in South Asia[7]. However, the SDQ's reliance on caregiver literacy, paper-based administration, and subjective reporting can restrict its use in low-resource contexts, especially where frontline health workers rather than specialists perform the screening.

Digital innovations in child mental health assessment offer potential solutions to these challenges. Tools designed for mobile or tablet-based use can incorporate culturally relevant examples, allow offline functionality in rural areas, and provide automated scoring with built-in referral recommendations. The AHEAD Emotional Health Module was developed as part of a broader digital platform to screen multiple domains of child development. It is intended for use by trained non-specialist health workers, offering a structured, culturally adapted, and accessible format for identifying early emotional and behavioral concerns.

This study aims to evaluate the diagnostic accuracy of the AHEAD Emotional Health Module in comparison with the SDQ for detecting emotional and behavioral difficulties in children aged 1 month to 5 years, thereby assessing its potential for integration into large-scale screening programmes in both clinical and community settings.

Material and Methods

Study Design An exploratory sequential study design

Study Design and Setting

This study employed a sequential mixed-methods design, consisting of a qualitative phase for item development and validation, followed by psychometric assessment and large-scale field testing. All phases were conducted at the Department of Pediatrics, Saveetha Institute of Medical and Technical Sciences, a tertiary care teaching hospital in South India. Ethical approval was obtained from the Institutional Ethics Committee (IEC No: 010/09/2024/IEC/SMCH). Written informed

consent was obtained from parents or primary caregivers prior to participation.

Study Population and Sampling

Participants were children aged 1 year to 18 years attending routine outpatient clinics, immunisation services, or community health programmes, accompanied by a primary caregiver.

Inclusion criteria:

- Children aged 1 year – 18 years.
- Accompanied by a caregiver familiar with the child's development and behavior.
- Caregiver provided written informed consent.

Exclusion criteria:

- Children with severe neurodevelopmental disorders already diagnosed and under treatment.
- Acute illness requiring hospitalisation at the time of screening.

A convenience sampling method was used for all phases. For the field-testing phase, participants were recruited consecutively until the target sample size was achieved.

Sample Size Calculation

For the mood and behavioral disorders module, the sample size for sensitivity and specificity was calculated using Buderer's formula:

$$n = \frac{Z^2_{1-\alpha/2} \times P \times (1-P)}{d^2}$$

Assuming a 95% confidence level ($Z_{1-\alpha/2}$ = 1.96), expected sensitivity/specificity (P), and a margin of error (d). Given a behavioral disorder prevalence of 3%, the required sample size was 43 for both sensitivity and specificity. After adjusting for prevalence (assumed 10%), the total required was 1,467 (~ 1,500 participants). Following pilot validation, large-scale testing was conducted in 1,500 children.

Description of Screening Tools

AHEAD Emotional Health Module: A digital, culturally adapted screening instrument designed to assess early emotional and behavioral concerns in children aged 1 year – 18 years. Each of the 13 Items are age-banded, covering domains such as mood regulation, social interaction, and behavioral control. Responses are caregiver-reported, recorded by a trained assessor, and scored automatically by the application, generating domain and overall results.

Strengths and Difficulties Questionnaire (SDQ): A widely validated 25-item screening tool assessing emotional symptoms, conduct problems, hyperactivity, peer relationship problems, and prosocial behavior. Parent-report version was used; standardised cut-offs classified results as normal, borderline, or abnormal.

Data Collection Procedure

In the field-testing phase, children were assessed in a quiet setting. The AHEAD Emotional Health Module and SDQ were administered independently by different assessors, blinded to each other's results. Both tools were completed during the same visit, with no exchange of responses between assessors.

Development, Validation, and Testing Phases

1. Qualitative Phase

The qualitative phase aimed to generate culturally relevant items for the Emotional Health module of the AHEAD screening tool.

- **Item pool generation:** An initial set of items was developed by reviewing existing behavioral screening tools, including the Strengths and Difficulties Questionnaire (SDQ) and internationally recognised diagnostic criteria, alongside consultation with developmental paediatricians and child psychologists.
- **Caregiver input:** Semi-structured interviews were conducted with 20 parents from diverse socioeconomic backgrounds to assess relevance, clarity, and cultural appropriateness.
- **Expert review:** Feedback from experts was incorporated to refine item wording, simplify language, and ensure alignment with the target age group (1 year to 18 years).

2. Psychometric Assessment of the Screening Tool (Face and Content Validity)

Face validity was assessed by a panel of five developmental paediatricians, two child psychologists, and three paediatric residents, focusing on item clarity, age appropriateness, and comprehensiveness.

Content validity was quantified using the Content Validity Index (CVI) for each item and the scale overall. Items with a CVI below 0.80 were revised or replaced based on panel recommendations. The process ensured inclusion of both problem behaviors and indicators of positive socio-emotional functioning.

3. Factor Analysis

Following initial pilot testing, **Exploratory Factor Analysis (EFA)** was conducted to examine the underlying factor structure of the Emotional Health module.

- **Sampling:** Data from the pilot sample (n = 250) were used.
- **Extraction method:** Principal Component Analysis with Varimax rotation was applied.
- **Factor retention:** The Kaiser criterion (eigenvalues > 1) and scree plot analysis determined the number of retained factors. Items with factor loadings below 0.40 were considered for removal or revision.

4. Reliability Testing

Internal consistency reliability was assessed using Cronbach's α for the overall module and each identified factor. A Cronbach's α value ≥ 0.70 was considered acceptable, ≥ 0.90 excellent.

Test–retest reliability was evaluated in a subsample of 30 children who were reassessed after a 2-week interval. Reliability coefficients (intraclass correlation) ≥ 0.75 were considered good.

A receiver operating characteristic (ROC) curve analysis was performed to identify the optimal cut-off score for the AHEAD Emotional Health:

Behavioral Subsection, which was determined to be 12.

5. Testing in the General Population

The refined module was evaluated in a cross-sectional diagnostic accuracy study involving 800 children aged 1 year to 18 years, recruited during routine outpatient visits, immunisation sessions, and community outreach clinics.

- **Reference standard:** The Strengths and Difficulties Questionnaire (SDQ), parent-report version, served as the comparator.
- **Administration:** The AHEAD module and SDQ were administered independently by trained paediatric residents blinded to each other's results.

Data Management and Quality Control

Data from the AHEAD Emotional Health Module and SDQ assessments were recorded on paper forms during field administration and subsequently entered into a secure, password-protected database using IBM SPSS Statistics v29.

Routine data cleaning included:

- **Completeness checks** to identify and resolve missing values by cross-verifying original records.
- **Range and logic checks** to detect implausible or inconsistent responses (e.g., mutually exclusive items marked simultaneously).
- **Outlier detection** using descriptive statistics and graphical inspection (box plots, histograms), followed by verification against source data.

Only cleaned, finalised datasets were used for statistical analyses. Data backups were maintained on encrypted institutional servers.

Statistical Analysis

Categorical variables were summarised as frequencies and percentages, while continuous variables were expressed as mean ± SD or median (IQR) based on distribution (Shapiro–Wilk test). Psychometric properties were assessed using Cronbach's α (≥0.70 acceptable, ≥0.90 excellent) and test–retest reliability with ICC (two-way mixed-effects model; ≥0.75 good). Exploratory factor analysis (Principal Component Analysis, Varimax rotation) was performed after confirming sampling adequacy (KMO) and factorability (Bartlett's test, $p<0.05$); factors with eigenvalues >1 were retained and items with loadings <0.40 revised or removed. Diagnostic accuracy was determined using SDQ classification as the reference, calculating sensitivity, specificity, PPV, NPV, LR^+, LR^-, and agreement via Cohen's Kappa and PABAK. Analyses were performed in IBM SPSS v29, with $p < 0.05$ considered significant.

Results

A total of 1,500 children participated in the mood and behavioral disorders module analysis. Of these, 688 (45.9%) were females and 812 (54.1%) were males, giving a slightly higher proportion of male participants. The age of children ranged from 1 year to 18 years, with an even distribution across both younger (1–5 years) and older (6–18 years) age groups.

Age Distribution

Figure 1 illustrates the age distribution of children classified with and without behavioral disorders according to both the AHEAD Emotional Health: Behavioral Subsection and the SDQ. The distribution curves for both tools revealed that the majority of participants without behavioral disorders were concentrated in early to middle childhood, with a gradual decline in frequency in older age groups. Children with behavioral disorders were distributed across all age groups, but their frequency was lower compared to those without disorders.

Two Mann–Whitney U tests were performed to assess age differences between children with and without behavioral disorders. According to SDQ classification, the median age was 7.15 years (n = 340) for the abnormality group and 6.75 years (n = 1,160) for the non-disorder group, with no statistically significant difference ($U = 188{,}991.00$, $z = –1.169$, $p = 0.243$, $r = –0.030$). Similarly, the AHEAD module identified no significant age differences, with a median age of 7.08 years (n = 362) in the behavioral disorder group and 6.98 years (n = 1,138) in the non-disorder group ($U = 205{,}847.50$, $z = –0.018$, $p = 0.985$, $r = –0.0005$). The effect sizes in both cases were negligible, indicating that age was not a differentiating factor in behavioral disorder classification for either tool.

Sex Distribution

Sex-wise distribution of behavioral disorders according to the AHEAD module is shown in Table 41. Among females, 151 (10.1%) were classified as having a behavioral disorder, compared to 211 males (14.1%). Despite the proportion being higher in males, the association between sex and behavioral disorder status was not statistically significant ($\chi^2(1, N = 1{,}500) = 3.316$, $p = 0.069$). (Table 1)

Similarly, the SDQ (Table 42) identified behavioral disorders in 143 females (9.5%) and 197 males (13.1%). The chi-square test again showed no statistically significant association between sex and behavioral disorder classification ($\chi^2(1, N = 1{,}500) = 2.567$, $p = 0.109$). (Table 2)

Odds ratio analysis indicated that males had slightly higher odds of being diagnosed with a behavioral disorder compared to females for both the AHEAD module (OR = 1.249, 95% CI: 0.983–1.586) and the SDQ (OR = 1.221, 95% CI: 0.956–1.559), though neither reached statistical significance. These findings suggest a trend toward higher detection rates in males, consistent with general epidemiological patterns, but without strong statistical evidence in this cohort.

Diagnostic Accuracy of AHEAD Emotional Health: Behavioral Subsection (Table 3)

The diagnostic accuracy of the AHEAD module was assessed against the GST reference standard (Table 46). The module demonstrated a sensitivity of 79.1% (95% CI: 74.6%–83.2%) and a specificity of 92.0% (95% CI:

90.3%–93.5%), indicating strong performance in correctly identifying both positive and negative cases.
The Positive Predictive Value (PPV) was 74.3%, meaning that nearly three-quarters of children flagged by the AHEAD module as having a behavioral disorder were confirmed by the GST. The Negative Predictive Value (NPV) was 93.8%, indicating that children classified as not having a behavioral disorder by the AHEAD module were very likely to be free of the condition according to the reference standard.

The likelihood ratios further reinforced the strength of the AHEAD module as a diagnostic tool. The positive likelihood ratio (LR^+) was 9.88, showing that individuals with a behavioral disorder were almost ten times more likely to be correctly identified as such by the tool. The negative likelihood ratio (LR^-) was 0.23, suggesting a low probability of false negatives.

Agreement analysis demonstrated substantial concordance between the AHEAD module and GST, with a Cohen's Kappa of 0.695 ($p < 0.001$) and a PABAK of 0.79, confirming high reliability and low susceptibility to prevalence or bias effects.

Comparison with SDQ
The AHEAD module showed a slightly higher specificity and comparable sensitivity to SDQ, along with marginally improved PPV and NPV values. These findings highlight the potential of the AHEAD module to reduce false positives without compromising the detection of true cases.

Binary Logistic Regression
Binary logistic regression analysis examined the predictive value of the total AHEAD module score on the likelihood of a behavioral disorder diagnosis. The model was statistically significant ($\chi^2(1, N = 1,500) = 828.47$, $p < 0.001$) and correctly classified 88.9% of cases. The model accounted for 42.4% (Cox & Snell R^2) to 64.6% (Nagelkerke R^2) of the variance in behavioral disorder classification.

Although the Hosmer–Lemeshow test suggested poor fit ($\chi^2(8) = 40.31$, $p < 0.001$), the total score remained a significant predictor ($B = 0.644$, $SE = 0.036$, Wald = 315.44, $p < 0.001$), with an odds ratio of 1.90 (95% CI: 1.77–2.04). This indicates that each unit increase in the AHEAD module score was associated with a 90% increase in the odds of a behavioral disorder diagnosis. The constant term ($B = –7.998$, $SE = 0.423$) was also significant ($p < 0.001$), corresponding to a very low baseline risk when the score was zero.

Discussion

The present study evaluated the diagnostic accuracy of the AHEAD Emotional Health: Behavioral Subsection in comparison with the Strengths and Difficulties Questionnaire (SDQ) and the GST reference standard in a large, diverse paediatric population. The AHEAD module demonstrated high specificity (92.0%), good sensitivity (79.1%), and substantial agreement with GST (Kappa = 0.695, PABAK = 0.79), indicating its potential as a robust screening tool for behavioral disorders in children and adolescents.

The sensitivity and specificity values obtained in this study align with, and in some cases exceed, the performance of the SDQ reported in both Indian and international settings. Goodman et al. reported SDQ sensitivity and specificity values ranging from 70–85% and 80–90%, respectively[7]. The higher specificity of the AHEAD module compared to SDQ suggests its ability to reduce false positives—an important consideration in resource-constrained settings where unnecessary referrals can strain services.

The absence of significant age differences between children with and without behavioral disorders in both tools suggests that the prevalence of behavioral concerns is relatively stable across childhood and adolescence in this sample. This contrasts with some epidemiological data indicating higher rates of certain externalising disorders in younger children and a rise in internalising disorders during adolescence[8]. This discrepancy may reflect cultural and contextual factors in the study population or the broad-spectrum nature of the AHEAD module.

Sex distribution analyses revealed a trend toward higher behavioral disorder prevalence in males, although the difference was not statistically significant. This finding is consistent with prior literature reporting that boys exhibit higher rates of externalising behaviors such as hyperactivity and conduct problems[9], while girls may be under-identified due to the subtler presentation of internalising symptoms[10]. The comparable odds ratios across the AHEAD module and SDQ suggest that both tools are equally sensitive to these sex-based patterns, though further refinement may enhance detection of internalising difficulties in females.

The predictive validity of the AHEAD module was supported by binary logistic regression, which showed that each unit increase in score corresponded to a 90% increase in the likelihood of a behavioral disorder diagnosis. This strong association mirrors findings from similar developmental-behavioral screening studies, where higher total scores on validated tools significantly predicted clinical diagnoses[11]. The high classification accuracy (88.9%) further reinforces the module's suitability for use in both clinical and community-based screening initiatives.

A key advantage of the AHEAD module over the SDQ is its digital, culturally adapted format, which allows automated scoring and language localisation. Prior research has emphasised that culturally adapted screening instruments improve parental comprehension and reporting accuracy[12]. The integration of local idioms and contextually relevant examples in the AHEAD module likely contributed to its diagnostic accuracy.

From a public health perspective, the combination of high specificity and good sensitivity makes the AHEAD

module an appropriate first-line screening tool. High specificity minimises false positives, reducing unnecessary referrals, while good sensitivity ensures that most children with genuine concerns are identified. The LR^+ of 9.88 observed in this study is well above the commonly accepted threshold of 5 for a "strong" diagnostic test[13], and the LR^- of 0.23 approaches the desired value of ≤0.1 for ruling out disease.

These findings are consistent with international recommendations that behavioral screening be integrated into routine paediatric practice[14]. However, current implementation in India remains limited due to time constraints, lack of training, and inadequate referral systems. The AHEAD module addresses these barriers by providing a rapid, automated, and easily deployable tool that can be used by non-specialist health workers, potentially increasing screening coverage.

Limitations of this study include the use of convenience sampling, which may limit generalisability, and the reliance on caregiver report, which can be influenced by social desirability bias. Additionally, while the GST served as a reference standard, it is not equivalent to a full clinical diagnostic interview, which may have led to some misclassification. Future research should assess the module's performance against gold-standard diagnostic tools and explore longitudinal predictive validity.

In conclusion, the AHEAD Emotional Health: Behavioral Subsection demonstrated strong diagnostic accuracy, substantial agreement with an established reference standard, and several practical advantages over existing tools such as the SDQ. Its high specificity, combined with good sensitivity and digital adaptability, make it a promising candidate for integration into large-scale developmental and behavioral screening programmes in diverse paediatric populations.

Conclusion

The AHEAD Emotional Health: Behavioral Subsection demonstrated high specificity, good sensitivity, and substantial agreement with the GST reference standard, performing comparably or better than the widely used SDQ. Its digital format, cultural adaptability, and automated scoring make it a practical and scalable screening solution for diverse paediatric populations. By effectively identifying children at risk for behavioral disorders while minimising false positives, the AHEAD module has the potential to streamline referral pathways and optimise the use of specialist resources. Integrating this tool into routine clinical practice and community health programmes could enhance early detection and intervention efforts, ultimately improving developmental and mental health outcomes in children and adolescents. Future studies should evaluate its performance against gold-standard diagnostic interviews and explore its applicability in varied cultural and linguistic contexts.

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Figures:

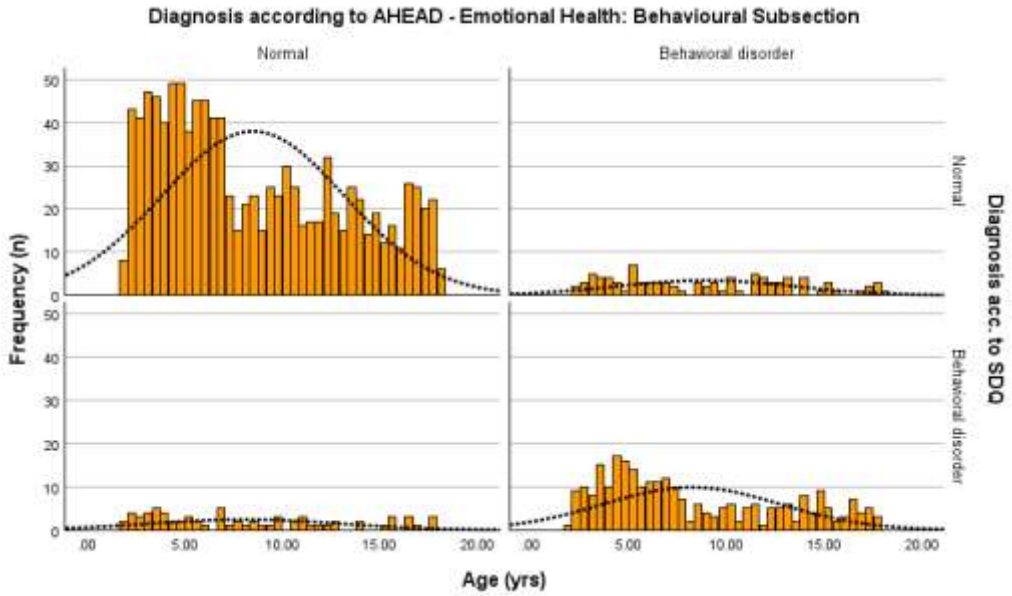

Figure 1: Age distribution of children with and without developmental delay according to SDQ and the New AHEAD - Emotional Health: Behavioural Subsection respectively

Tables:

		Sex				Total	
		Female		Male			
		N	%	N	%	N	%
Behavioural disorder acc. to AHEAD	No	537	35.80%	601	40.10%	1138	75.90%
	Yes	151	10.10%	211	14.10%	362	24.10%
	Total	688	45.90%	812	54.10%	1500	100%
Chi – Square Statistic: 3.316							
p Value: .069							

Table 1: Sex Distribution by Behavioural disorder According to AHEAD - Emotional Health: Behaviour subsection

		Sex				Total	
		Female		Male			
		N	%	N	%	N	%
Behavioural disorder acc. to SDQ	No	545	36.30%	615	41%	1160	77.30%
	Yes	143	9.50%	197	13.10%	340	22.70%
	Total	688	45.90%	812	54.10%	1500	100.00%
Chi – Square Statistic: 2.567							
p Value: .109							

Table 2: Sex Distribution by Behavioural disorder According to SDQ

AHEAD – Emotional Health: Behaviour Subsection		
Criterion for test positivity	Statistic value	95% CI
Sensitivity	79.10%	74.6% - 83.2%
Specificity	92%	90.3% - 93.5%
Positive Predictive Value	74.30%	69.6% - 78.6%
Negative Predictive value	87.20%	92.3% - 95.1%
LR+ (Likelyhood ratio positive)	9.88	
LR- (likelyhood ratio negative)	0.23	
Kappa	0.695	.651 – .739
PABAK	0.79	

Table 3: Diagnostic accuracy analysis of AHEAD - Emotional Health: Behaviour Subsection