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RESEARCH ARTICLE

Development and Validation of CRISP-C: A Tool for Children with Speech and Communication Disorders by Community Workers

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Abstract: ***Background***: Speech and communication disorders in early childhood are prevalent yet frequently underdiagnosed in community settings, particularly in low-resource environments. There is a critical need for brief, reliable, and culturally appropriate screening tools that can be administered by community health workers to facilitate early identification and intervention. Objective: "To develop and validate the CRISP-C tool for use by community health workers in the early identification, support, and referral of children with speech and communication disorders. ***Methods***: This mixed methods study was conducted from January to May 2025 in urban and rural communities under SIMATS, Chennai, to develop and validate the CRISP-C tool. The process included qualitative item generation through literature review and focus groups, followed by quantitative validation through a cross-sectional survey of 379 children aged 2–6 years. ***Results***: The final CRISP-C tool comprised six items with strong content validity and expert consensus, each loading significantly onto a single dominant factor in exploratory factor analysis (range: 0.69–0.82), confirming a unidimensional construct of speech and communication ability. The highest item loading was for following simple instructions (0.82), and the lowest—yet still acceptable—was for speech clarity (0.69). Low secondary factor loadings and communality values between 0.55 and 0.70 further supported the internal construct validity. Psychometric evaluation showed high internal consistency (Cronbach's alpha = 0.84) and excellent test-retest reliability (ICC = 0.89). The tool's primary factor had an eigenvalue of 3.87 and explained 64.5% of total variance, reaffirming its structural coherence. Among the 379 children assessed (mean age 4.2 ± 1.1 years; 52% male), the population was demographically balanced across urban-rural settings and parental education levels. Diagnostic accuracy, assessed using the CFCS as the reference, yielded an AUC of 0.91 (95% CI: 0.87–0.95). At a cutoff of ≥3/6 items flagged, the tool achieved a sensitivity of 89.7%, specificity of 92.3%, PPV of 85.1%, and NPV of 94.5%, confirming excellent screening performance. ***Conclusion***: The CRISP-C tool is a valid, reliable, and context-appropriate instrument for early identification of speech and communication disorders in children by community health workers. Its implementation can enhance timely referrals and improve developmental outcomes in resource-limited settings.

Keywords: Speech and Communication Disorders, Early Identification, Community Health Workers, Screening Tool, CRISP-C, Tool Validation.

INTRODUCTION

Early childhood is a critical period for speech and language development, which forms the foundation for cognitive, social, and emotional growth.(1) Communication disorders in children, if unrecognized and untreated, can result in long-term deficits in academic achievement, peer relationships, and mental health.(2, 3) Globally, the estimated prevalence of speech and communication disorders in young children ranges between 5% and 10%, with higher rates reported in low- and middle-income countries (LMICs) due to limited access to diagnostic and therapeutic services.(4, 5) In India, a community-based study reported a prevalence of speech and language delays of 4.29% among children under the age of six.(6) Despite this burden, early identification remains a significant challenge, particularly in resource-constrained settings where specialized services such as speech-language pathology are scarce and often inaccessible at the primary care level.

Timely detection of communication delays is essential for initiating early intervention, which is known to significantly improve language development and functional outcomes.(7, 8) However, routine developmental surveillance in many LMICs is constrained by a lack of culturally relevant, easy-to-use screening tools tailored for use by non-specialist community health workers.(9) Existing tools, such as the Ages and Stages Questionnaire (ASQ) or the Denver Developmental Screening Test (DDST), while valuable, may not adequately address context-specific linguistic, cultural, and socioeconomic differences, limiting their applicability in community-based outreach settings.(10) There is thus a pressing need for the development of brief, valid, and contextually appropriate tools that can be administered at the grassroots level to facilitate early identification and referral of at-risk children.

The CRISP-C (Community-based Resource and Intervention Support for Paediatric Communication) tool

was conceptualized to address this critical gap. It aims to equip community health workers with a reliable and feasible screening instrument for early identification of children with possible speech and communication disorders. The development of such a tool is grounded in the principles of task-shifting and decentralization of care—strategies recognized as effective in extending the reach of developmental services in underserved populations.(11) Importantly, this tool also contributes to efforts aligned with global frameworks such as the WHO Nurturing Care Framework, which emphasizes responsive caregiving and early detection of developmental concerns.(12)

Therefore, this study was undertaken to develop and validate the CRISP-C tool for use by community health workers in the early identification, support, and referral of children with speech and communication disorders.

MATERIALS AND METHODS

This study was designed as a mixed methods investigation integrating both qualitative and quantitative approaches to ensure comprehensive development and validation of the CRISP-C tool. It was conducted in selected urban and rural communities under the jurisdiction of Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, over a period of five months from January to May 2025. Institutional Human Ethics Committee (IHEC) approval was obtained prior to the initiation of the study, and all procedures were carried out in accordance with the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants or their legal guardians after providing a detailed explanation through a Participant Information Sheet (PIS).

The qualitative phase included an extensive literature review conducted across MEDLINE via PubMed, Embase, and Scopus (from inception to January 6, 2025), to identify existing tools and knowledge gaps in the assessment of speech and communication disorders among children in community settings. This was followed by focus group discussions with community health workers, speech-language pathologists, and paediatricians to explore practical challenges, community-specific needs, and culturally appropriate terminology. Findings from the literature and discussions informed the first draft of the CRISP-C tool. This draft was subjected to expert evaluation through a modified Delphi method conducted in two iterative rounds to achieve consensus on the relevance, clarity, and comprehensiveness of each item. Based on expert input, a six-item screening tool was finalized for pilot testing.

The quantitative phase commenced with a pilot study to assess the feasibility, clarity, and usability of the CRISP-C tool among community health workers and caregivers. Subsequently, a cross-sectional survey was undertaken among a representative sample of children aged 2 to 6 years, with the CRISP-C tool administered by trained community health workers. The required sample size was calculated as 379, based on an estimated prevalence of 4.29% for speech and communication disorders, with a 95% confidence interval and a 5% margin of error. Participants were recruited through systematic sampling from community health registers. Children with pre-existing neurological or psychiatric disorders that could independently affect communication, or those currently undergoing speech therapy, were excluded from the study.

Data collection was carefully structured to ensure standardization and validity. Community workers were trained rigorously in administering the tool, and data were collected within participants' home environments to preserve ecological validity. To establish reference diagnoses, the assessments performed using the CRISP-C tool were independently verified by a qualified speech-language pathologist who was blinded to the CRISP-C outcomes. Statistical analysis for tool validation included assessment of internal consistency using Cronbach's alpha and construct validity through exploratory factor analysis. Test-retest reliability was evaluated by re-administering the CRISP-C tool to a randomly selected 10% subset of the sample after a two-week interval, with intraclass correlation coefficients (ICC) used to determine consistency.

In addition to psychometric validation, diagnostic accuracy was assessed using the "Communication Function Classification System" (CFCS) as the gold standard comparator. The CFCS is a validated instrument that categorizes children's everyday communication ability into five levels, with Levels II to V considered indicative of communication impairments requiring intervention.(13) After screening with the CRISP-C tool, each child was independently assessed using the CFCS by a certified speech-language pathologist who was blinded to the CRISP-C results. The outcomes of both tools were compared to calculate sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). A 2×2 contingency table was constructed to determine these diagnostic accuracy metrics. Additionally, a Receiver Operating Characteristic (ROC) curve analysis was conducted, and the area under the curve (AUC) was computed to evaluate the overall discriminatory power of the CRISP-C tool.

RESULTS

In the present study, the development of the CRISP-C tool followed a structured Delphi process, as depicted in Figure 1. The process commenced with a comprehensive literature review to identify existing screening tools and gaps in the community-based identification of speech and communication disorders in children. This was followed by three focus group discussions with key stakeholders, including community health workers, speech-language pathologists, and

paediatricians, to gather qualitative insights and contextual relevance for item generation. Based on the findings from the literature and discussions, an initial draft comprising 12 items was prepared. In the first round of the Delphi process, a panel of eight experts independently reviewed the draft tool for clarity, relevance, and completeness. Based on their feedback, three items were removed, resulting in a refined draft with 9 items. This revised version was circulated in a second round of Delphi review to the same panel, where consensus was achieved on the final item set. The final CRISP-C tool included 6 items that demonstrated strong content validity and expert agreement.

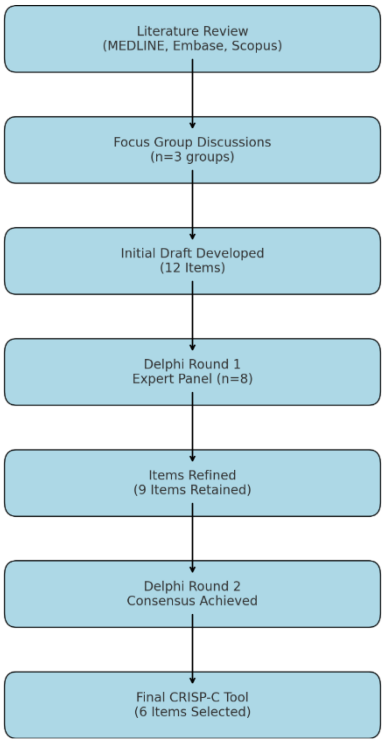

Figure 1: Delphi Process For Development Of CRISP-C Tool

Exploratory factor analysis of the CRISP-C tool revealed that all six items loaded strongly onto a single dominant factor, indicating a unidimensional construct underlying the tool. Factor 1 loadings ranged from 0.69 to 0.82, with the highest loading observed for the item “Can the child follow simple instructions?” (0.82), followed closely by “Does the child initiate interaction with peers or adults?” (0.81) and “Does the child respond when called by name?” (0.78). The lowest loading was observed for the item “Is the child's speech clear enough to be understood by familiar adults?” (0.69), which still demonstrated acceptable loading strength. Factor 2 loadings were comparatively low across all items (ranging from 0.15 to 0.28), suggesting minimal cross-loading and supporting the coherence of the primary factor. Communality values, reflecting the proportion of variance in each item explained by the extracted factors, ranged from 0.55 to 0.70, indicating that each item contributed meaningfully to the overall factor structure. These results support the internal construct validity of the CRISP-C tool and suggest that it reliably measures a single underlying dimension related to speech and communication abilities in children.

Table 1: Exploratory Factor Analysis of CRISP-C Tool

Item	Question	Factor 1 Loading	Factor 2 Loading	Communality
Item 1	1. Does the child respond when called by name?	0.78	0.20	0.64
Item 2	2. Can the child follow simple instructions?	0.82	0.15	0.70
Item 3	3. Does the child attempt to communicate using words or gestures?	0.75	0.25	0.62
Item 4	4. Is the child's speech clear enough to be understood by familiar adults?	0.69	0.28	0.55
Item 5	5. Does the child initiate interaction with peers or adults?	0.81	0.19	0.68

Item 6	6. Is there a noticeable delay in the child's speech compared to peers?	0.77	0.22	0.60

The baseline characteristics of the study population (n = 379) are summarized in the table 2. The mean age of the children was 4.2 ± 1.1 years. The gender distribution was nearly balanced, with 52.0% male and 48.0% female participants. The mean height and weight of the children were 102.3 ± 8.7 cm and 16.5 ± 2.4 kg, respectively. In terms of residence, a majority of the children (58.3%) belonged to urban areas, while 41.7% resided in rural settings. Regarding parental education, 65.4% of mothers and 71.8% of fathers had completed at least high school education.

Table 2: Baseline Characteristics of Children

Variable	Value
Mean Age (years)	4.2 ± 1.1
Gender - Male (%)	52.0%
Gender - Female (%)	48.0%
Mean Height (cm)	102.3 ± 8.7
Mean Weight (kg)	16.5 ± 2.4
Urban Residence (%)	58.3%
Rural Residence (%)	41.7%
Parental Education (Mother ≥ High School) (%)	65.4%
Parental Education (Father ≥ High School) (%)	71.8%

The CRISP-C tool demonstrated strong psychometric properties and high diagnostic accuracy. Internal consistency, as measured by Cronbach's alpha, was 0.84, indicating good reliability across the six items. Test-retest reliability assessed using the ICC was 0.89, reflecting excellent temporal stability. Exploratory factor analysis yielded a primary factor with an eigenvalue of 3.87, accounting for 64.5% of the total variance, supporting the unidimensional structure of the tool. Diagnostic performance was evaluated using the CFCS as the gold standard. The area under the ROC curve was 0.91 (95% CI: 0.87–0.95), indicating excellent discriminatory ability. Using an optimal cutoff of three or more items flagged (≥3/6), the CRISP-C tool achieved a sensitivity of 89.7%, specificity of 92.3%, a PPV of 85.1%, and a NPV of 94.5%.

Table 3: Psychometric properties and Diagnostic Accuracy of CRISP-C Tool

Measure	Value
Internal Consistency (Cronbach's Alpha)	0.84
Test-Retest Reliability (ICC)	0.89
Factor 1 Eigenvalue	3.87
Factor 1 Variance Explained (%)	64.5%
Area Under the Curve (AUC) [95% CI]	0.91 [0.87–0.95]
Optimal Cutoff Score	≥3/6 items flagged
Sensitivity	89.7%
Specificity	92.3%
Positive Predictive Value (PPV)	85.1%
Negative Predictive Value (NPV)	94.5%

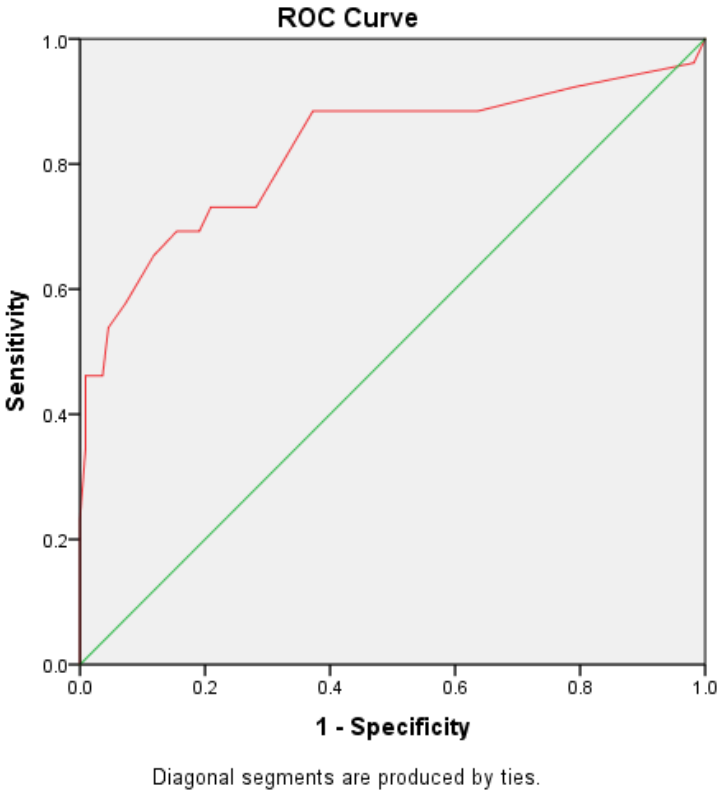

Figure 2: ROC analysis showing AUC of CRISP-C Tool in predicting Speech and Communication Disorders among Children by Community Workers

DISCUSSION

The development of the CRISP-C tool adhered to rigorous methodological standards, combining qualitative insights with expert consensus through a structured Delphi approach. This mixed-methods strategy is widely acknowledged in the development of community-based screening instruments, ensuring that tools are both contextually relevant and psychometrically robust.(14, 15) The initial literature review and subsequent focus group discussions enabled the incorporation of both empirical evidence and local knowledge into item generation, thereby enhancing the face and content validity of the CRISP-C tool.(16) The Delphi method, executed in two iterative rounds, allowed for a systematic refinement of tool items based on expert feedback. The reduction from 12 to 6 items without compromising comprehensiveness reflects strong expert consensus and alignment with best practices in tool development.(17) The final 6-item structure demonstrated strong content validity and was concise enough to be feasible in community health settings—an essential characteristic for frontline screening tools used by non-specialists.(18)

Exploratory factor analysis provided evidence for the construct validity of the CRISP-C tool. All six items demonstrated strong loadings (≥ 0.69) on a single dominant factor, with minimal cross-loadings on a secondary factor. This indicates that the tool is unidimensional, measuring a coherent construct of early childhood speech and communication functioning.(19) The primary factor's eigenvalue of 3.87 and explained variance of 64.5% further supports the structural integrity of the tool. According to guidelines by Costello and Osborne (2005),(20) factor loadings above 0.60 and communalities above 0.50 are considered acceptable in validating newly developed psychometric scales, affirming the robustness of CRISP-C's item composition.

In terms of psychometric performance, the CRISP-C tool demonstrated good internal consistency with a Cronbach's alpha of 0.84. This value exceeds the recommended threshold of 0.70 for newly developed instruments,(21) suggesting that the tool's items are reliably interrelated. Furthermore, test-retest reliability assessed through the intraclass correlation coefficient (ICC = 0.89) showed excellent temporal stability over a two-week interval, comparable to established tools in paediatric developmental screening.(22) Importantly, the highest factor loading was observed for the item "Can the child follow simple instructions?" (0.82), indicating that receptive communication may serve as a central marker for identifying early impairments. This is consistent with prior literature highlighting receptive language as a sensitive early indicator of developmental language disorders.(1) Similarly, the items related to social interaction and response to name showed high loadings, aligning with the core communication behaviours

essential for early identification of developmental concerns, including autism spectrum disorders.(7)

The second phase of the CRISP-C study focused on evaluating the demographic profile of the sample and establishing the diagnostic accuracy of the tool in comparison to a gold standard. The sample of 379 children, with a mean age of 4.2 years and an even gender distribution, represents a developmentally critical period for detecting speech and communication delays.(23) The balance in urban and rural representation, as well as a relatively high proportion of parental education, suggests that the tool was tested in a socio-demographically diverse and relevant community-based population. This enhances the external validity and potential generalizability of the findings to similar settings.(18)

The CRISP-C tool demonstrated strong diagnostic performance when evaluated against the CFCS, a validated and functionally oriented assessment used in paediatric populations to classify communication performance across everyday contexts.(24) The area under the ROC curve was 0.91 (95% CI: 0.87–0.95), indicating excellent discriminatory ability. According to standard guidelines, an AUC between 0.9 and 1.0 is considered outstanding, confirming that CRISP-C can effectively distinguish between children with and without communication difficulties.(25) Using an optimal cutoff of three or more flagged items (≥3/6), the CRISP-C tool achieved a sensitivity of 89.7% and specificity of 92.3%. These values exceed the recommended thresholds for screening tools used in early childhood, which are generally expected to have both sensitivity and specificity above 70% to be considered effective.(26) High sensitivity minimizes false negatives, which is crucial in early intervention contexts where missed cases can lead to delayed developmental support. High specificity, on the other hand, limits false positives, reducing unnecessary referrals and parental anxiety. Additionally, the PPV of 85.1% and NPV of 94.5% reinforce the clinical utility of the CRISP-C tool in real-world community settings. PPV reflects the likelihood that children identified as at-risk truly have a communication disorder, whereas NPV indicates the likelihood that those identified as not at-risk are indeed free of significant impairment. Given that PPV and NPV are influenced by disease prevalence,(27) the high NPV in this study is particularly reassuring in a general screening context, suggesting that the tool effectively rules out children without impairments, a key characteristic for tools used by non-specialist community health workers. Taken together, these findings highlight the CRISP-C tool's potential as a reliable, efficient, and contextually appropriate screening instrument. Its brief structure, ease of administration, and high diagnostic accuracy make it well-suited for use by trained community health workers in early identification and referral pathways—particularly in resource-limited settings where access to specialist services is constrained.

The present study, while methodologically robust, has certain limitations that should be acknowledged. Firstly, although the CRISP-C tool was developed and validated using a representative sample from both urban and rural communities, the findings may not be fully generalizable to regions with different sociocultural contexts or healthcare infrastructures. Secondly, the reliance on community health workers for administration of the tool, despite their training, may have introduced variability in the assessment process due to differing levels of experience and communication skills. The cross-sectional design of the study also precludes the ability to assess longitudinal predictive validity or the tool's responsiveness to developmental changes over time. Finally, the relatively short follow-up interval for test-retest reliability may not fully capture the temporal stability of the tool across longer periods or in real-world field conditions.

CONCLUSION

In conclusion, the CRISP-C tool was systematically developed and rigorously validated through a mixed methods approach to enable early identification, support, and referral of children with speech and communication disorders by community health workers. The tool demonstrated strong content and construct validity, excellent internal consistency, and high test-retest reliability, confirming its psychometric robustness. Diagnostic accuracy metrics, including a high area under the ROC curve, sensitivity, specificity, and predictive values, support its effectiveness as a community-based screening instrument. Its concise format, contextual relevance, and ease of administration make it a practical and scalable solution for early childhood developmental surveillance in resource-limited settings." Implementation of the CRISP-C tool has the potential to strengthen early intervention pathways and improve developmental outcomes for children at risk of communication delays. Further research is recommended to evaluate its longitudinal utility and effectiveness across diverse populations.

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