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Construction, Standardization and Validation of a Multi-Domain Indian Developmental Inventory (IDI) for Children

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The primary aim of the study was to construct, standardize and validate a multi-domain, culturally sensitive, development inventory for children aged 0 to 8 years. The study was conducted in two parts: construction of the battery and validation. The development of the battery was carried out in three stages: planning, pilot, and standardization. Four hundred and twelve items were included in the battery and were administered to 626 children (across 18 age categories) to standardize the test. The final constructed battery comprised of 378 items. The norms constructed provided standard scores (M=100, SD=15) reported as development quotients (DQs) at two levels: domain (domain specific DQ) and overall level (Total DQ). The standard scores ranged from 20 to 160. Three types of reliability estimates were calculated: internal consistency, test-retest and inter-rater. The standard errors of measurement (SEM) were computed for five domains. Three types of validity were established including content, construct, and criterion related. The newly constructed Indian Developmental Inventory (IDI) provides child health professionals a culturally sensitive, standardized, multi-domain instrument with excellent psychometric properties and it is hoped that its availability would provide an impetus to the field of developmental assessment in India..

Keywords: Developmental assessment, Test construction, Culturally sensitive, Multi-domain battery

In recent years, screening children who are at risk for developmental delay and intellectual disability has emerged as an important public health challenge for policy makers as early identification is related to better prognosis (Aly, Taj, & Ibrahim, 2010; Bellman, Byrne, & Sege, 2013; Guevara, Gerdes, Localio, Huang, Pinto-Martin, Minkovitz et al. 2013; Poon, La Rosa, & Pai, 2010). Since the early developmental period of the child is highly variable and marked by rapid developmental changes, there are considerable difficulties inherent in assessment of young children. Despite these challenges, detection of developmental delays before five years and timely intervention, particularly during sensitive developmental periods when the brain is most malleable, is imperative for optimal, long-term outcomes (Kolb, 2011; Nair, Mini, Leena, Harikumaran Nair, Bhaskaran, & Russell, 2014; Wallander, Bann, Biasini, Goudar, Pasha, Chomba, E., et al., 2014; Walker, Chang, Powell, & Grantham-McGregor, 2005).

A large proportion of children from low income countries, like India, are exposed to multiple risk factors including poverty, malnutrition, neglect and psychosocial deprivation and these factors negatively impact child development and increase the risk for developmental delays (Malhi, Bharti, & Sidhu, 2013; Shonkoff, 2011; Walker, Wachs, Grantham-McGregor, Black, Nelson, Huffman, et al, 2011). Global developmental delay is defined in the DSM-5 as the inability of the child to meet expected developmental milestones in multiple developmental domains including physical, adaptive, social-emotional, cognitive, and communication (American Psychiatric Association, 2013). Despite the urgent need for early detection of these developmental problems, only a handful of indigenously constructed developmental tests are available for use in clinical practice (Bhave, Bhargava, & Kumar, 2010; Nair, George, Philip, Lekshmi, Haran, & Sathy, 1991; Nair, Nair, Mini, Indulekha, Letha, & Russel, 2013; Phatak & Khurana 1991).

However, most of these developmental tests are screening instruments, that typically focus on a limited age range, do not yield standard scores, and have low sensitivity on detecting developmental problems (Mondal, Bhat, Plakkal, Thulasingham, Ajayan, & Poorna, 2016). For example, the Language Evaluation Scale Trivandrum (LEST) assesses screening delay in only the language sector for children up to three years and has poor concurrent validity (Nair et al., 2013). Since developmental screening tools are first-line measures to identify children who require more detailed assessment, they typically have little diagnostic utility, particularly for identifying subtle impairments. The limited availability of locally constructed assessment tools leaves clinicians' little choice but, to use tests constructed and standardized in developed countries. There are several pitfalls in using developmental tests from other socio-cultural settings including use of culturally irrelevant test items and using scores and cut offs which are not standardized on the target population (Chaudhari, 2006; Gladstone, Lancaster, Umar, Nyirenda, Kayira, van den Broek, et al. 2010).

Clearly, there is a need to construct assessment instruments that are standardized on representative populations using culturally appropriate test items and tasks. Standardized developed tests would add to the repertoire of the child health professionals and provide an impetus to the program of early detection and intervention of children with developmental disabilities. Keeping this in mind, the present study aimed at constructing a standardized, multi-domain, Indian Developmental Inventory (IDI) for children aged 0 to 8 years. Secondly, the study also attempted to establish norms, provide percentile scores, classification categories, reliability, and validity for the newly constructed battery.

Method

The development of the battery was carried out in three stages: planning, pilot, and standardization. In the planning phase, based on the review of literature, five development domains and 10 sub domains were identified: motor (fine and gross motor), adaptive (self-care and personal responsibility), social-emotional, (interpersonal interaction and social role), cognitive (attention and perception), and communication (receptive and expressive language) (Newborg, 2005). An item bank of 425 items selected from the existing screening tests and batteries and books on child development for initial testing. Each item was written in English and Hindi and a standard procedure for assessing each item was defined. These items were given to experts from the field of child development to evaluate them. Based on the inputs of the experts the items were modified. The items from the assembled item bank were pilot tested on 236 children (2 months to 8 years, Boys = 54.7%), recruited from immunization clinics, play way schools, and public and government schools of an urban center in North India. On testing, some of the items were found to be problematic in terms of their difficulty level, age appropriateness, and ease of administration. These items were reviewed and were either replaced or rewritten. In cases where the difficulty level of the item was misaligned, the item was repositioned. Of the 425 items that were pilot tested, 13 items were deleted after the pilot study, and a total of 412 items were retained for the next phase of the study.

In the standardization phase, the 412-item battery was administered to 626 children (Boys= 58.4%) categorized into 18 age groups from birth through 7 years and 11 months. Children in the first two years (0 to 23 months) were divided into four-month groupings as the most rapid change in development are observed for children in this age range. For children aged 2 to 8 years, the age groups selected spanned a six-month period of development. The demographic distribution of the sample is presented in Table 1.

Table 1: Demographic Distribution of the Standardization Sample

Age in Months	N	Boys		Urban	
		n	%	n	%
0-3	39	25	64.1	30	76.9
4-7	45	25	55.6	38	84.4
8-11	39	18	46.2	33	84.6
12-15	28	18	64.3	23	82.1
16-19	33	20	60.6	24	72.7

20-23	20	12	60.0	16	80.0
24-29	21	8	38.1	16	76.2
30-35	29	15	51.7	20	69.0
36-41	12	8	66.7	6	50.0
42-47	30	22	73.3	21	70.0
48-53	46	22	47.8	37	80.4
54-59	36	21	58.3	27	75.0
60-65	39	22	56.4	29	74.4
66-71	61	35	57.4	44	72.1
72-77	38	30	78.9	29	76.3
78-83	39	22	56.4	34	87.2
84-89	48	28	58.3	35	72.9
90-95	23	15	65.2	19	82.6
Total	626	366	58.5	481	76.8

The data were collected over 18 months from an urban center, and this formed the basis of the development of normative scores. Children studying in the Playway, Pre-Nursery, Nursery, Lower Kindergarten, Upper Kindergarten, and Classes 1 and 2 were enrolled from two private and two government schools. The preschool, toddler and infant children were recruited from one private and one government hospital. An attempt was made to identify schools and paediatric clinics that had a balance of children from high, middle and lower socioeconomic status. Half the sample (51.8% of children) was from the upper socio-economic status and a little less than one-third (28.3%) belonged to the upper-middle socio-economic status. Only 20% of the children were from a low socio-economic background; as identified by the revised Kuppuswamy socio-economic status scale (Kumar, Shekhar, Kumar, & Kundu, 2007).

The sample was predominantly urban (76.8%), Hindu (76.7%) and non-scheduled caste (77.2%). Almost 60% of the children belonged to joint families while only 40.6% lived in nuclear homes. Children with a history of any chronic illness, motor or sensory impairments were excluded. The study was approved by the Ethics board of the institute and a written, informed parental consent was obtained before enrolling the child in the study.

Scoring and placement of items followed standard procedures delineated by previous authors (e.g., Alpern, Boll, & Shearer, 1986; Newborg, 2005). An objective three-point scoring system was devised. A score of "2" was assigned for consistent performance on the task (90% of the time), score of "1" was assigned if the skill was still emerging, and any skill which the child demonstrated inconsistently was scored as "0" (< 20%). Rules for starting point, basal and ceiling levels were also established. Each item was placed at the age where 75% of the children passed that item within a particular age group. The performance of children on each item was also compared as a function of sex, residence, and socioeconomic status. This was done to ensure that the items were not discriminatory to any group. Items with highly discrepant passing rates (a difference of 40% between groups) were eliminated. Items with slight discrepancies were "balanced" within age levels. In the final battery, only 378 items were retained.

Angoff and Robertson (1983) procedure was used to develop normalized standard scores (M =100, SD=15) at the domain level and the total test composite level to yeild domain specific DQs and a total DQ. Percentile ranks and descriptive categories defining the scores at the domain and the total test score level were also determined. The standard scores were banded with confidence intervals that take into acount errors of measurement. Bands of error were calculated for five levels of confidence: 68%, 85%, 90%, 95%, and 99% at the domain and the total DQ level.

Three types of reliability estimates were calculated. Internal consistency was determined by calculating the split-half reliability coefficients obtained for the five domains and for the total score separately for all the 18 age groups using the Spearman-Brown formula (Spearman 1910). Test-retest reliability was calculated by administering the battery twice after a median of 12 days gap to 36 children (9 to 87 months). The inter-rater reliability was calculated by having two trained examiners administering and rescoring the battery to children. In addition, the standard errors of measurement (SEM) were computed for the five domains, 10 sub-domains, and the total test composite score using the standard deviation of 15 along with the split half reliability coefficients for each of the 18 age groups.

Three types of validity were established for the IDI mainly content, construct, and criterion. The content validity of the battery was assessed by examining three dimensions: professional judgment of content, coverage of important constructs, and empirical item analysis conducted at the time of the pilot phase. Construct valdity was established by examining the developmental progression of scores; intercorrelations of domain and total test scores; and factor analyses. Criterion validity was determined by examining the correlations of the IDI with several existing developmental batteries, intelligence tests, and tests which measure specific domains.

Results

The final constructed battery comprised of 378 items and sample items for every sub-domain are presented in Table 2. The norms constructed provided standard scores reported as development quotients (DQs) at two levels: domain level (Domain specific DQ) and overall level (Total DQ). The standard scores ranged from 20 to 160. For the total DQ, the values of the total sample approximated the desired mean of 100 and standard deviation of 15 (M =100.10, SD= 14.90). The Social-Emotional DQ mean was 102.25 (SD= 14.14); Adaptive Behavior DQ mean was 102.47 (SD =11.22); Motor mean DQ was 105.04 (SD =10.49); mean Communication DQ was 98.69 (SD= 10.76); and mean Cognitive DQ was 103.71 (SD=10.44). The entire battery takes about 60 to 75 minutes to administer and this is similar to the time taken by other comprehensive development batteries (e.g., Newborg, 2005).

The reliability coefficients are presented in Table 3. The internal consistency reliability coefficients for the total score ranged from 0.90 to 0.97 across the 18 age groups with a median of 0.94. However, the domain coefficients were lower. The test-retest reliability coefficients were very high and ranged from 0.93 for the Communication domain to 0.99 for the Social-Emotional domain. The test-retest reliability coefficient for the total DQ was high (0.95). The inter-rater reliability was also high and ranged from 0.94 (Communication domain) to 0.97 (Cognitive domain). The SEM values ranged from 2.10 to 4.65 standard score units (Median =3.60) for the total DQ, with most of the SEMs ranging from 3 to 4 standard score points.

To examine the domain specific development progression, the mean raw scores on each of the development domains by age were plotted (Figures 1 to 5). Principal component analysis was conducted with the domain standard scores to confirm the underlying structure of the test and to determine the percentage of variance accounted for by the first principal component to establish construct validity of the battery. For each age group, the analysis produced one significant factor, using the “eigenvalue equal to or greater than 1.0” criterion, which for the eight age groups accounted for 47.3 to 64.7% of the variance in domain standard scores. Further, the principal factor analysis was conducted for the sub-domain raw scores for each of the eight age groups. Intercorrelation matrices of the sub-domain raw scores, with the effects of chronological age removed, were analysed with the resulting factors rotated orthogonally. It is noteworthy that at the higher age groups, the factor structure became clearer, i.e., the sub-domains fell more clearly in the five domains and a more defined structure emerged.

Criterion validity of the battery was established by correlating the total DQ and domain DQ scores to existing development batteries and intelligence tests currently being used in India. The inter-correlations between various tests and the domain and total DQ on IDI are presented in Table 4. The correlations between the domain scores on IDI and the Developmental Profile II (DP II, Alpern et al. 1986) were moderate to high (0.43 to 0.74) across all domains. Correlations between the IDI and the Developmental Profile 3 (DP 3, Alpern 2007) were found to be moderate to high across all domains (0.39 to 0.73). Interestingly, the correlations were the highest between the domains assessing similar content. The correlations between the domain standard scores of the IDI and the three IQ scores

Table 2: Sample items from each domain and subdomain with age placements (in months)

Domain	Subdomain	Sample Item	Age Placement 75%	3%	97%
Social-Emotional	Social Role	The child smiles or vocalizes in response to adult attention.	3.8	1.3	11.4
		The child describes his/ her feelings.	76.0	30.5	92.0
	Interpersonal Interaction	The child plays very simple interaction games with others e.g. – peek-a-boo.	9.0	4.5	13.0
		The child separates easily from the parent.	51.0	26.5	65.0
Adaptive	Self Care	The child can remove front opening coat/sweater/shirt/frock if unbuttoned.	31.0	16.0	46.8
		The child cares for his own toileting needs without help.	76.7	40.0	93.0
	Personal Responsibility	The child demonstrates understanding that it is unsafe to accept rides, food or money from strangers.	79.0	36.5	93.0
		The child uses a telephone to place a call.	83.0	52.0	92.9
Motor	Gross Motor	The child stands up by holding on to furniture or solid object.	10.0	8.8	15.0
		The child walks upstairs one foot per step and downstairs two feet per step.	48.0	22.0	82.0
	Fine Motor	The child displays pincer grasp.	15.0	9.0	22.0
		The child fastens laces into a bow.	86.0	55.4	94.0
Communi-cation	Receptive Communication	The child follows 2 unrelated commands.	32.2	20.0	70.0
		The child recalls events from a story	84.5	46.3	94.0
	Expressive Communication	The child uses one object word with meaning.	19.0	9.0	22.0
		The child uses 3-word phrases meaningfully.	45.0	18.8	70.0
Cognitive	Attention and Perception	The child inserts round block in the form-board.	17.0	11.0	20.0
		Numerical memory – The child repeats 5 digits forward.	77.0	45.4	89.0
	Concepts and Academics	The child has a concept of 1.	31.0	20.0	44.0
		The child draws a person with a head, trunk and arms or legs.	67.5	42.8	91.1

Table 3: Reliability Coefficients and Standard Errors of Measurement for Domains DQs and Total DQ

Domain DQ	Internal Consistency Reliability (N=626)	Test Retest Reliability (N=36)	Inter-rater Reliability (N=30)	Standard Error of Measurement (N=626)
Social-Emotional	.63	.99	.96	9.08
Adaptive	.78	.97	.95	7.13
Motor	.79	.96	.95	6.98
Communication	.79	.93	.94	6.90
Cognitive	.87	.96	.97	5.48
Total DQ	.94	.95	-	3.60

Table 4: Validity Coefficients for the Domain and total test Composite score with the criterion measures

Criterion Measure	N	Mean age in years (SD)	IDI (Domain and Total Test DQ)					
			Social-Emotional	Adaptive	Motor	Communi-cation	Cognitive	Total
Developmental Profile II (IQE)	50	5.67 (1.04)	.67	.68	.62	.66	.78	.73
Developmental Profile 3 (GDS)	50	5.67 (1.04)	.59	.56	.52	.70	.75	.82
MISIC-FSIQ	25	6.95(0.59)	.16	.44	.61	.67	.79	.83
Draw-A-Man Test	50	5.97(1.07)	.42	.46	.61	.32	.60	.58
Bender Visual Motor Gestalt Test	30	6.55(0.71)	.27	.35	.52	.47	.63	.68
Raven's Coloured Progressive Matrices (CPM)	30	6.55(0.71)	.37	.41	.46	.43	.64	.67
Clinical Linguistic Auditory Milestone Scale (CLAMS)	40	1.03(0.61)	.33	.38	.26	.61	.59	.55
Vineland Social Maturity Scale (VSMS)	50	5.67 (1.04)	.78	.73	.68	.79	.80	.81

generated by the Malin's Intelligence Scale for Indian Children (MISIC, Malin 1969) ranged from a low of 0.10 (between Social-Emotional DQ and Performance IQ) to a high of 0.75 (between Cognitive DQ and Full-Scale IQ). Since, the MISIC is a measure of the child's intelligence one would expect that it would be most closely related to the Cognitive DQ of the battery and in this context, it is noteworthy, the Cognitive DQ was highly correlated with the FSIQ (0.83). In fact, the Cognitive DQ of the current battery had the highest correlation with the IQs of the criterion tests.

Majority of the correlations found between the IDI and Draw-a-Man test (Phatak, 1993) were found to be in the moderate range (0.32 to 0.61). The highest correlation was with the Motor DQ (r = 0.61) and the Cognitive DQ (r = 0.60) and the lowest with the Communication DQ (r=0.32). The inter-correlations between the domain standard scores and the Bender Visual Motor Gestalt test(Bender, 1946) ranged from low to moderate with the lowest being 0.27 (Social-Emotional DQ) to a high of 0.63 (Cognitive DQ). The highest correlation was with the total DQ (0.68). The large range in the correlations was to be expected because the IDI assesses development in five different domains, whereas the Bender Gestalt test assesses only perceptual motor skills. The highest correlation of the Coloured Progressive Matrices (CPM, Raven 1965) was with the total DQ (0.67).

In addition to comparing the IDI with other tests of intelligence and general development tests, the scores generated by the battery were also correlated to other tests that examine areas which are specific to only one developmental domain. The results indicated that the inter-correlations between the domain standard scores and the Vineland Social Maturity Scale (VSMS, Malin 1971) ranged from 0.68 (Motor DQ and SQ) to a high of 0.81 (Total DQ and SQ). The correlations between the IDI and the Clinical Linguistic Auditory Milestone Scale (CLAMS, Capute, Shapiro, Wachtel, Gunther, & Palmer, 1986) ranged from a low to moderate range (0.26 to 0.61).

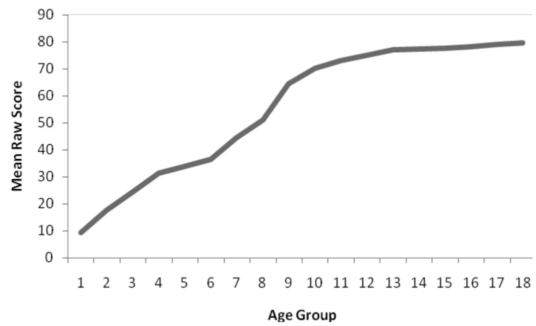

Figure 1. Growth curve for the Social-Emotional Domain

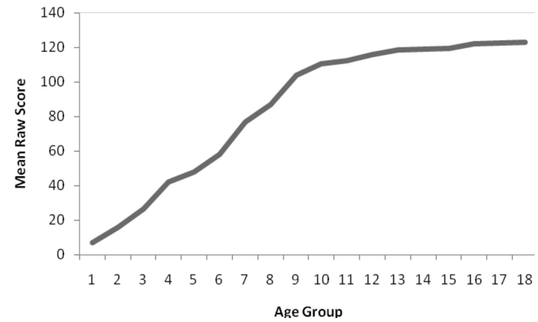

Figure 4. Growth Curve for the Communication Domain

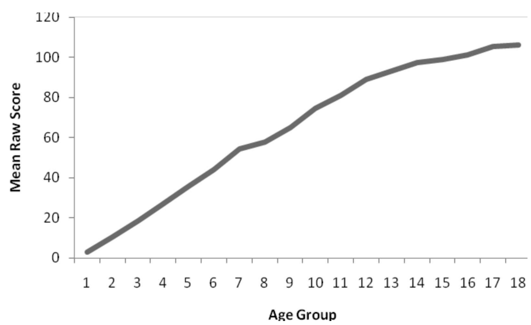

Figure 2. Growth curve for the Adaptive Domain

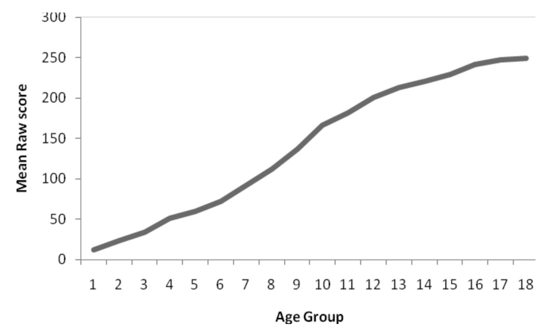

Figure 5. Growth Curve for the Cognitive Domain

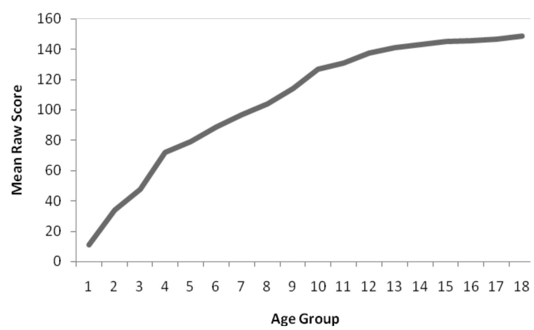

Figure 3. Growth curve for the Motor Domain

Discussion

The present study reports on the construction of a culturally sensitive, multi-domain developmental battery for use with Indian children which provides not only standardized scores but also provides percentile ranks for each of the standard scores across domains and total score level, errors of measurement, and classification categories. Standard scores have many advantages as they consist of equal-interval units, are easy to interpret and have exceptional psychometric properties. In addition, standard scores are statistically the most valid measurement to use when assessing child's development over a period of time. None of the developmental assessment instruments constructed in India provide standard scores at the domain or at the total composite level across the entire development range (e.g., Bhave et al., 2010; Nair et al., 2013; Phatak & Khurana, 1991).

The only development assessment tool which provides standard scores is the Developmental Assessment Scales for Indian Infants (DASII) (Misra & Phatak, 1996). However, the DASII only assesses two developmental domains (motor and mental) and that too for a limited age range (0 to 30 months). Since there are very few standardized developmental tests available in India, child health professionals are constrained to use instruments standardized in western countries and there is a need to use indigenously developed reliable and valid tests (Aly et al., 2010; Chaudhari, 2006; Malhi & Singhi, 1999).

An examination of the reliability coefficients revealed that the internal consistency reliability estimates for the total DQ, test-retest reliability, and the inter-rater reliability coefficients for the total DQ were high, 0.90 and above, across all the age groups and therefore acceptable. The battery was found to have excellent content validity and was adjudged by experts to have good coverage of important constructs. The growth trends for all the developmental domains, with more rapid development at younger ages, provided excellent evidence for construct validity. For example, the development in the motor, adaptive, and social-emotional domains was the most rapid in the earlier years while the development in the cognitive and communication domains coincided with the age when the child began attending play school and continued developing till 8 years. The inter-correlations between the IDI and other tests provided strong evidence for both convergent validity; illustrated by the high correlation between the Total DQ generated by the IDI and the total scores of various tests; and divergent validity by the relatively low correlations between domains, which were unrelated. Since the Cognitive DQ of the IDI correlated highly with the IQs assessed by other criterion measures, it is recommended that the Cognitive DQ be used as an IQ equivalent score of the child.

The IDI can be used effectively in a variety of settings and utilized for various purposes. Firstly, it can serve both as an assessment tool for assessing global developmental delay in young children and intellectual disability in older children. Secondly, it can identify child's areas of strengths and weaknesses and this can aid in designing an individualized remediation plan. Thirdly, the wide age range of the battery can facilitate its use in longitudinal studies. Many authors have argued that the emphasis of testing should not merely be on disability classification but, also provide an appropriate intervention plan to remediate early delays (Marks, Page Glascoe, & Macias, 2011; Poon et al., 2010). In this context, the IDI can be used as a plan for intervention by sensitizing parents and school teachers to the domain specific developmental tasks, which need to be taught to the child.

The study is however limited by what it does not measure. The present norms were constructed on a predominantly urban, cross–sectional sample. Therefore, future research should test the battery with different populations, including clinical presentations of children who are developmentally delayed to establish discriminant validity. Longitudinal research needs to be conducted with the battery to establish the predictive validity of the battery.

Conclusion

The newly constructed IDI meets the felt need among the child development professionals for a culturally appropriate, multi-domain, and standardized test battery, which provides a comprehensive assessment of the child across the entire developmental period. The excellent psychometric properties of the IDI add to its value as a reliable and valid tool for use with young children. It is hoped that the IDI will help the clinicians to identify children with developmental delays and developmental disabilities at the earliest, serve as an intervention instrument, and assist in the longitudinal follow up of children with developmental impairments. It is hoped that the availability of a standardized battery would provide an impetus to the program of early detection and intervention of children with developmental disabilities in India.

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