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The outcome of growth and development assessment of under-fives using a new tool, the SMAT Score

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Abstract *Background:* The death of growth and development screening tools in developing countries has grave implications for child health outcomes. The aim of the study was to determine the effectiveness of a novel screening tool in a rural Nigerian community.

Method: Speech and language, Motor, Appearance and Temperament (SMAT) parameters of under-fives were queried using a novel tool, the SMAT Score. The effectiveness of the tool was assessed in three phases. In the first two phases the tool was administered to 210 under- fives (Subjects) independently. Those screened as having anomalies are classified as NOT SMAT while those screened otherwise as SMAT. In the third phase all NOT SMAT subjects and a number of randomly selected SMAT subjects were clinically evaluated. Outcomes of SMAT Score administration and clinical evaluation were subjected to psychometric assessments.

Results: There were 210 subjects with age range of 0.5 to 4.9 years (mean 2.3 ± 1.3 years) studied. Out of these 34 (16.2%) were screened as NOT SMAT. All the 90 (51.1%) randomly selected SMAT subjects as against 1 (2.9%) of the NOT SMAT subjects were clinically evaluated as normal. Inter rater and test – retest agreement rate in SMAT Score administrators was 100%. SMAT Score sensitivity and negative predictive value was 100% respectively in all age groups. The specificity was 98.9% overall and 96.3% among infants. Higher SMAT Score positive predictive value (97.1%) was observed with the entire study population as against 87.5% among infants.

Conclusion: SMAT Score effectively identified subjects with growth and developmental disorders. Its use has potential for improving health systems and consequently child health outcomes in developing countries.

Keywords: Growth, Development, Assessment, Tool, Under-fives

Introduction

Growth and developmental disorders are significant contributors to childhood, particularly under-five, morbidity and mortality in developing countries.[1–3] Early identification of childhood disorders has been reported to improve child health outcomes.[4,5] The regular assessment or monitoring of childhood growth and development, particularly of those at risk such as the under-fives, would facilitate improvement in the outcome of growth and developmental disorders.

While there is a plethora of growth and developmental screening tools in the developed countries, [6,7] there is a dearth of such tools in their under developed counterparts.[8–10] Even where these tools are available their use is limited by cost of accessing the tools, social-cultural diversity that affect validity, and poor knowledge of tool administration. The measures taken in the past to obviate these limitations, such as tools validation for local use and creation of culturally sensitive development assessment tools, have met with functional limitations.[8–13]

The SMAT Score is a screening tool, designed by the author, which assesses multiple growth and development domains using conventional methods. The aim of the study was to determine the effectiveness of this tool in identifying under-fives with growth and developmental disorders in a rural Nigerian community.

Method

Study area

The study was conducted in the Katari North District of Kachia Local Government Area (L.G.A.) and the 44 Nigeria Army Reference Hospital in Kaduna South L.G.A. both in Kaduna State, Northwestern Nigeria.

Kachia L.G.A. was selected through a simple random selection from the 23 LGAs that make up Kaduna State, one of the 36 states and the Federal Capital Territory that constitute Nigeria. The Katari North district was also selected through a simple random selection from the 24 districts in Kachia Local Government Area. It has an estimated population of 3,500 persons who are mainly subsistence farmers and petty traders. [14] Administratively the district is headed by a District Head who is assisted by the Village Heads of the 20 villages that make up the district. Health care delivery is made available through a Primary Health Care Centre, a private hospital owned by a faith based organization and a government owned General Hospital 30km away. Main languages spoken are Hausa, Adara and Pidgin English.

The 44 Nigerian Army Reference Hospital Kaduna (44 NARHK) is a tertiary health institution located in the state capital and approximately 100 kilometers from Katari. It renders specialist health services to military personnel and the civilian population in Kaduna and its environs. The hospital is an accredited centre for post graduate medical training by the National Postgraduate Medical College of Nigeria and the West African Postgraduate Medical College. The department of Paediatrics offers both out and in patient clinical services. It has a total of 16 beds and its medical staff comprises of two Consultant Paediatricians, one medical officer and, residents and interns rendering service and undergoing various stages of training. SMAT Score (Table 1)

Table 1. SMAT Score

1. Identification Number……..…….
2. Name…….…..3. Informant.....
4. Address…...…….
5. Age (Years)…… 6.Sex…… 7. Height/length (H/L)….cm
8. Weight (W)……..…… kg 9.Occipito–Frontal–Circumference (OFC)…….....cm

10. PARAMETER		RESPONSE (CIRCLE)	
A. SPEECH – LANGUAGE		YES	NO
I.	Is it present	1	0
II.	Is it normal	1	0
III.	Is current status appropriate for age	1	0
IV.	SUB TOTAL SCORE……..		
B.	MOTOR		
I.	Is it present	1	0
II.	Is it normal	1	0
III.	Is current status appropriate for age	1	0
IV.	SUB TOTAL SCORE……..		
C.	APPEARANCE		
I.	No absence in form	1	0
II.	No abnormality in form	1	0
III.	Is current physical status (H/L, W, OFC) appropriate for age	1	0
IV.	SUB TOTAL SCORE……..		

D. TEMPERAMENT AT ACTIVITY* MOST TIMES

	HIGH	ODERATE	LOW
I. Level of motor involvement in activity	1	1	0
II. Mood level during activity	1	1	0
III. Energy level during activity	1	1	0
IV. Level of change in activity needed for response	0	1	1
V. Adaptability to new activity	1	1	0
VI. Role completion in activity	1	1	0
VII. Role completion despite interference	1	1	0
VIII. Response to new activity	1	1	0
IX. Regularity at activity	1	1	1

X. SUB TOTAL SCORE…….

11. TOTAL SCORE= A.IV + B.IV + C.IV + D.X

ACTIVITY*(FEEDING for those≤ one year of age or PLAY for those> one year of age)

12. ASSESSMENT OUTCOME: ……..….. (SMAT if total score=18 and NOT SMAT if total score <18)

13. Assessed by ……. 14. Date ……

The SMAT Score, conceived and developed by the author, assesses three developmental domains and physical growth. The assessed parameters, from which the acronym SMAT is derived from, are Speech and language, Motor, Appearance (representing physical growth) and Temperament. Administration of the tool involves both caregiver's and tool administrator's assessment of a child's growth and development.

SMAT Score parameters:

a. Speech and language

This parameter is assessed through queries in three sections. These include:

i. The first query, directed at the caregiver, asks about the presence or absence of speech and/or language. The expected response is 'Yes' or 'No'.
ii. The second query, also directed at the caregiver, asks whether the development of speech and/or language has been normal. The expected response is also a 'Yes' or 'No'.
iii. The third query, directed at the tool administrator, determines the relationship between the child's state of speech and language development and that of its peers. To achieve this, the child state of development is compared with that of its peers using a conventional standard. [15] the expectations in this standard is similar to that expected of Nigerian children.[16] The expected response to the query, after assessment, is a 'Yes' or 'No'.

b. Motor (Motor function development)

The queries are similar to those in the speech and language parameter and they include:

i. Query about the presence of motor function in the child and directed at the caregiver with an expected response of 'Yes' or 'No'.
ii. Query about the presence of any observed abnormality in motor function of the child directed at the caregiver with an expected response of

'Yes' or 'No'.

iii. The third query is directed at the tool administrator and questions the relationship between the child's state of motor function development and that of its peers. The child's state of development is compared with that of its peers using a summary of the World Health Organization motor milestones development standards and a more comprehensive conventional standard.[17,18] The WHO standard is universal but limited to six major milestones and children less than two years of age. The milestones in the conventional standard are more encompassing and similar to those expected of Nigerian children.[16,18] The expected response to the query, after assessment, is a 'Yes' or 'No'.

c. Appearance (Physical growth)

In this parameter growth is assessed through queries about the physical attributes of the child.

i. The first query, directed at the caregiver, questions the presence of any deficit in the physical attributes specifically the absence or lack of formation of any physical structure of the body. The expected response is 'Yes' or 'No'.

ii. The second query, also directed at the caregiver, questions the presence of any abnormality in the form of the child's physical structure specifically the presence of dysmorphic features in the child. The expected response is 'Yes' or 'No'.

iii. The third query, directed at the tool administrator, questions the current state of development of the child's physical attributes by comparing the child's current anthropometric measurements of Height, Weight and Occipito-Frontal-Circumference with that of its peers. The comparative conventional standard is the 2006 World Health Organization growth standards. [19,20]All measurements less than -2 z scores or greater than 2 z scores for age and sex are regarded as abnormal. The expected response after assessment is a 'Yes' or 'No'.

d. Temperament

This parameter assesses the behavioral responses of a child to a common childhood activity. The two childhood activities queried in SMAT Score are Feeding and Play. The behavioral queries were developed, by the author, along the temperamental characteristics of Thomas and Chess.[18,21] The queries are directed at the caregiver and concern the child's behavioral responses most of the times and during feeding or play to the characteristics of activity level, adaptability, approach and withdrawal, attention span and persistence, distractibility, intensity of reaction, quality of mood, rhythmicity and threshold of responsiveness. The responses are graded as High, Moderate or Low reflecting both the intensity and/ or frequency of the behavioral characteristics most of the times with emphasis on 'most of the times' presentation.

During the SMAT Score pre test, three common childhood activities namely feeding, play and sleep were considered for assessment in the temperament parameter of SMAT Score. In the course of the pre test it was observed that in children between the ages of six months and one year of age caregivers provided comparatively more information, relevant to the temperament parameter, about feeding than during play or sleep. Also, for children between the ages of one and five years more relevant information was available concerning play than feeding or sleep. Consequently feeding and play were the assessed activities for children aged less than one year and those between one and five years respectively.

SMAT Score scoring

For the parameters of Speech and language, Motor function and Appearance a 'Yes' response scores one point while a 'No' response scores zero. Consequently for each of these parameters the maximum score is three points and the minimum is zero. For the parameter of Temperament, every 'High' grade scores one point except in the characteristic 'Level of change in activity needed for response' which scores zero. Thus the maximum score in the 'High' grade is eight. The 'Moderate' grade scores one point for all characteristics giving a maximum score of nine. The 'Low' grade scores zero for all characteristics except for the characteristics of 'Regularity at activity' and 'Level of change in activity need for response' making two points the maximum recordable score for this grade. In total Temperament has maximum and minimum recordable scores of nine and two respectively. Overall a normal SMAT Score is the outcome when a child scores maximum scores in all four parameters assessed. A child that scores the maximum score of 18 is referred to as SMAT Score positive or SMAT. Conversely any child who scores less than 18 is referred to as SMAT Score negative or NOT SMAT. A child who is SMAT Score negative or NOT SMAT would require a further clinical evaluation.

SMAT Score administration

To administer SMAT Score in the study, two English and Hausa Languages speaking Community Health Extension Workers (CHEWS) were recruited and trained by the author on the content and how to administer SMAT Score as a screening tool. Prior to commencement of the study a pretest was conducted in a community with characteristics similar to Katari. The community, the Rido community, is located approximately 85km from Katari. Also a translation and back translation of SMAT Score from English to Hausa Language, the commonly spoken language in the pretest and study communities, was carried out during the pretest. It takes 15 to 20 minutes to administer SMAT Score.

Sample size determination

The estimated prevalence of the under-five population in Nigeria is 16.8%.[22] This prevalence was used in calculating the under-five population size for this study. Consequently with a prevalence of 17%, a confidence level

of 95% and allowing for a 5% margin of error a sample population sample size of 211 was calculated. However considering that the study population is less than 10,000 persons, the sample population was readjusted to 210 under-fives.

Inclusion criteria

Included in the study were all under-fives, referred to as Subjects, residing in Katari Community and who have a verifiable birth date made available through birth records or corroborative oral evidence.

Exclusion criteria

Excluded were Subjects who did not fulfill the inclusion criteria and those who had a current illness requiring immediate medical attention. The need for intervention in such cases could influence participation and outcome of the study.

Conduct of study

The study was conducted between September and December 2012. Ethical approval was obtained from the Research Ethics Committee of 44 NARHK and consent obtained from the district head, respective village heads and heads of every participating household before commencement of the study.

The study was conducted in three phases. The first and second phases were conducted in Katari Community. The 20 villages were enumerated and a village selected for study through a simple random selection. From the house of the village head an axis is randomly selected and all eligible Subjects in households along a selected axis are studied. If the households along a selected axis are exhausted and the sample size not met, there is a return to the house of the village head and a new axis to be studied along randomly selected. If a village is studied and the study sample size is yet to be attained another village is randomly selected and the study process repeated until the sample size was attained.

In the first phase SMAT Score was administered by the trained administrators, to the same caregivers and their respective Subjects, independently and simultaneously. The administrators took all anthropometric measurements and assessed all comparative responses with the derived conventional standards. Height was measured using a stadiometer for those who could stand erect and to the nearest 0.1cm while recumbent length, using an adjustable calibrated flat board, was measured in those who could not stand or were yet to achieve the milestone. Weight was measured to the nearest 0.1kg and using a standing weighing scale for those who could stand and a bassinet weighing scale for those who could not or had not achieved the milestone. The OFC was measured using a non stretchable but flexible tape measure. The tape measure is applied across the frontal bone anteriorly and the occipital bone posteriorly along the widest possible diameter and measurement taken to the nearest 0.1cm. Each growth parameter was measured twice by the tool administrator, at the beginning and end of the tool application, and the average measurement recorded as the measurement for that parameter.

SMAT Score was re administered, three weeks later, by the same administrators to the same caregivers and Subjects in the second phase of the study. The third phase was conducted at 44 NARHK. In this phase all NOT SMAT Subjects and at least half of the SMAT Subjects, randomly selected, were evaluated clinically in the paediatric outpatient clinic of 44 NARHK by a consultant paediatrician. All those diagnosed as having a medical disorder were treated and managed accordingly in the department of paediatrics.

Data analysis

SMAT Score was analyzed for inter rater, test retest and validity outcomes. Chi-square test, with Yates' correction were appropriate, was used for assessing the significance of validity differences in the age groups. A *p* value less than 0.05 was regarded as significant.

Results

A total of 210 Subjects were assessed using SMAT Score. They had an age range of 0.5 to 4.9 years (mean 2.3±1.3years) and a male preponderance 123(58.6%). Out of the total number assessed, 34(16.2%) were identified as NOT SMAT. Their age range was 0.5 to 4.3 years (mean 2.1±1.3years) and had a male preponderance (18, 52.9%) as well. Table 2 shows the age and sex distribution of the 210 Subjects and the 34 NOT SMAT Subjects.

Table 2: Age and sex distribution of the 210 assessed and 34 NOT SMAT Subjects

Age (years)	All assessed Subjects (%) Sex			NOT SMAT Subjects (%) Sex			%of Total
	M	F	Total	M	F	Total	
≤1	21 (17.1)	13 (14.9)	34(16.2)	4(22.2)	4(25)	8(23.5)	13.1
1.1–2	35 (28.4)	26 (29.9)	61(29)	7(38.9)	6(37.5)	13(38.2)	38.1
2.1–3	31 (25.2)	19 (21.8)	50(23.8)	1(5.5)	3(18.8)	4(11.8)	28.6
3.1–4	14 (11.4)	17 (19.5)	31(14.8)	3(16.7)	1(6.2)	4(11.8)	20.2
4.1–5	22 (17.9)	12(13.8)	34(16.2)	3(16.7)	2(12.5)	5(14.7)	
Total	123	87	210	18	16	34	100

Inter rater reliability

There was no difference in the outcome of the assessment by the two SMAT Score assessors in the first phase of the study. Both identified the same Subjects and number that were NOT SMAT.

Test retest reliability

The repeat assessment of the study population in the second phase of the study by the same assessors yielded

the same outcomes. The same Subjects and number (34, 16.2%) were identified as NOT SMAT.

Validity

All the 90 randomly selected SMAT Subjects were assessed as normal after clinical evaluation in the department of paediatrics, 44 NARHK. Out of the 34 NOT SMAT Subjects, only 1(2.9%) was clinically evaluated as normal. The Subject that was evaluated as clinically normal is a seven month old male whose SMAT Score was 16. The SMAT Score abnormality was observed in the Temperament parameter in which LOW MOST TIMES (score of 0) response to the queries about response and adaptation to a new activity (feeding) was indicated respectively. This singular finding among the infants compared to none in the older children was not significant (χ^2=0.40, df=1, p=0.526). Table 3 shows the validity estimates of SMAT Score.

Table 3: Estimates of SMAT Score validity in clinically evaluated 90 SMAT and 34 NOT SMAT Subjects

Variable	All Subjects	Subjects ≤ 1 year	Subjects >1 year
Sensitivity(a/a+c x 100)	100	100	100
Specificity(d/b+d x100)	98.9	96.3	100
Positive Predictive Value (a/a+b x100)	97.1	87.5	100
Negative Predictive Value (d/c+d x100)	100	100	100
a=true positives b=false positives c=false negatives d=true negatives			

Under nutrition seen in 13(39.4%) of the 33 Subjects with a clinical diagnosis was the commonest childhood disorder (Table 4). The least common disorder was physiologic stereotypy diagnosed in a 10 month old male who presented with a two month history of repeated head nodding without any other co-morbidity.

Table 4: Outcome of the clinical evaluation of 33 NOT SMAT Subjects

Childhood disorder	No of Subjects	Percent of Total
Under nutrition	13	39.4
Rickets	6	18.2
Sickle Cell Anemia	4	12.1
Cerebral palsy	4	12.1
Stuttering	3	9.1
Expressive Language Disorder	2	6.1
Physiologic Stereotypy	1	3
Total	33	100

Discussion

SMAT Score recorded absolute inter rater and test-retest agreement outcomes in this study. Its high sensitivity and specificity outcomes are comparable to that of contemporary growth and development screening tools. Even though SMAT Score specificity was lower in infants, all psychometric outcomes met requirements for standard screening test accuracy.[7] The tool also demonstrated remarkable ability to screen out children with mild to severe disorders of growth and development.

Modalities for assessing or monitoring growth and development in developing countries are variable. They include use of assessment tools from the developed countries, [23] locally developed tools, the Road To Health Card (RTHC), [24–26] and routine clinical evaluation during hospital visits. Generally there is a dearth of assessment tools, particularly those concerning development, in developing countries. While high cost of procurement, lack of knowledge about the existence and application of these tools contribute to the scarcity of tools from the developed countries, paucity of research into child development as reported by Ertem and colleagues[9] is a constraint to tool development in the in developing countries.

Where tools from the developed countries are available, socio cultural differences between the two worlds and very robust construct content throw up validity issues. Gladstone and colleagues[23] observed several items on social development in assessment tools from developed countries performing poorly in a typical developing country setting. The content of the construct of some assessment tools are so extensive such that the benefit of shortening them have been explored even in the developed countries. The Very Short Form of the Children's Behavior Questionnaire (CBQ-VSF) was recently psychometrically evaluated and limited validity was found for the extracted factors and the external constructs.[27] Validity could have been more limited in an under developed setting. Consequently limited validation is observed with most of these tools. Limited validation and application of the tools make it difficult to appreciate the impact of these tools on child development in developing countries.

Assessment tools such as the Guide for Monitoring Child Development (GMCD),[9] the Malawi Development Assessment Tool (MDAT),[10] the Ten Questions Questionnaire (TQQ),[11,12] and the Disability Screening Schedule (DSS)[13] are some recent tools that have been designed in developing countries. However there are reported limitations of these tools which restrict their application or impact. The validity of the GMCD though remarkable was obtained in a clinical research setting questioning the possibility of similar outcomes in population based samples,[9] the MDAT was developed using a select group of Malawian children as standard with limited applicability,[10] the TQQ and DSS have been reported to having a tendency of identifying only children with severe disabilities and not having a frame work for monitoring the development of young children.[11-13]

The RTHC is widely available in developing countries.[24,25] It documents information about a child's socio-demographic characteristics, immunization history,

feeding practices as well as growth and developmental advances in charts. The focus, in this card, being on documentation rather than assessment can be implied from the RTHC's under utilization as a growth and development assessment tool.[25] This short coming is likely enhanced by the restricted number of growth and developmental domains indicated for assessment in these cards. The restriction limits caregiver participation in assessment and obscures the training needs of the health worker filling these cards. These increase the risk of not identifying early a significant population of children with growth and developmental anomalies. The use of clinical evaluation as a screening tool, in developing countries, is impracticable considering the scarcity of human and health care resources.[28]

SMAT Score recorded high sensitivity and specificity outcomes for a growth and development assessment tool.[7] The outcomes were as remarkable as findings from other environmentally sensitive assessment tools, such as the GMCD and MDAT, proposed for use in LMICs.[9,10] Consequently SMAT Score has immense prospect as a tool for effective identification of those who have or are at risk of having growth and development anomalies in early childhood. This could have a significant impact on child health services in the country and other LMICs that do not have a model for promotion and monitoring of child development.[29] SMAT Score equally recorded a high concurrent validity outcome. This attribute of SMAT Score and its ease of application underscore its potential in augmenting child health services particularly in settings where skilled manpower and equipment for identifying growth and development anomalies are either scarce or not available. SMAT Score also displayed the capacity of detecting growth and developmental anomalies in a wide range of disorders with varying prevalence, severity and etiology. It was able to identify these anomalies in a potentially serious condition like under nutrition, a severe condition like cerebral palsy and a genetic disorder like sickle cell anemia. The capacity for facilitating early detection of these conditions and other potentially grave childhood disorders signify great potential for SMAT Score in strengthening child health services particularly with its incorporation into well child health visits and school health services. Furthermore, the age range for which SMAT Score is applicable makes it a valuable tool for the monitoring of early childhood growth and development.[29]

The characteristics of an effective growth and development screening tool, in developing countries, were aptly described by Ertem and colleagues.[9] They highlighted that such a tool must be based on and supported by standard theories of child development, be reliable and valid, have capacity for supporting and managing developmental frame works, should be easily applicable and at a minimal cost.[9] The SMAT Score is based on standard theories and universal standards. This reduces the need to standardize and validate across countries. Moreover the tool adds to contemporary growth assessment by appraising the presence or otherwise of physical deficits. It also provides another platform of exploring behavioral responses to common childhood activities. SMAT Score has shown remarkable reliability and validity in a population based sample. Its potential in developing caregiver perception and participation in screening assessments in addition to developing the assessment capacity of the health worker strengthens the health care system. Application of SMAT Score required administrators with basic qualification in health care delivery, simple administrative materials and was easily administered in a rural population. These attributes suggests a minimal cost and a cost effective benefit to the health care system. The characteristics exhibited by SMAT Score in this study underscore its relevance and that of tools like it in child health care delivery particularly in developing countries.

A limitation in the use of SMAT Score was highlighted in the discrepancy between clinical evaluation and temperamental assessment in the respective infant. Caregiver understanding or expectation rather than the actual temperamental status could be the response to queries in a parameter. This can be reduced by providing adequate caregiver enlightenment and emphasizing the need to giving appropriate responses to queries. Also there are complexities associated with growth and development in very young children which could limit the outcome of SMAT Score. These complexities include the challenge associated with quantifying all inherent variations, in growth indices and motor functions of very young children, in a normal population and being able to account for all of them in an established standard. This was highlighted by Gorter and colleagues in a study concerning classification of motor function in very young children with cerebral palsy.[30] Also complex is the extrication of the impact of a variable in a developmental domain from the assessment of another related variable. For instance observation of a low most times response to a new activity (feeding) in this study could be the product of a normal positive psychological influence such as attachment on development.

SMAT Score, the limitations notwithstanding, has shown relevance and standard psychometric properties in a population based sample of under-fives. Its incorporation into health care delivery through affiliation with maternal and newborn health initiatives, school health programs and community based health initiatives would broaden the scope of health services coverage. The training of all health workers and health allied workers, such as school health teachers, on the SMAT Score and its application would help develop service delivery capacity in the health sector. Also establishment of a SMAT Score data bank, in the health monitoring units at all levels of health care delivery, to document and communicate the outcomes of periodic evaluation of children would facilitate dissemination of health information within health systems. Consequently SMAT Score has the potential of strengthening health care systems and as a result would improve child health outcomes in developing countries. However, further insight into the effectiveness of this tool would be served by more studies in

larger and more diverse under- five populations.

Authors' contribution
The study was conceived and designed by the author. The author also supervised data collection, analyzed and interpreted the data, and wrote the final draft of the manuscript.

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