Section: Paediatrics

Original Research Article

COMPARISON OF TRIVANDRUM DEVELOPMENTAL SCREENING CHART AND LANGUAGE EVALUATION SCALE TRIVANDRUM AGAINST DENVER DEVELOPMENTAL SCREENING TEST TO ASSESS DEVELOPMENTAL DELAY IN PRETERM CHILDREN ≤ 34 WEEKS AT CORRECTED AGE OF 1 MONTH TO 3 YEARS

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Abstract

Background: Premature infants, particularly extreme and very preterm are at high risk for neurodevelopmental problems. Developmental screening facilitates early detection, promotes timely intervention, and potentially prevents childhood disabilities. This study compared TDSC and LEST with DDST II in children born ≤ 34 weeks of gestation, at a corrected age of 1 month to 3 years to screen for developmental delay. **Materials and Methods:** This descriptive cross-sectional study encompassed 186 preterm children born at ≤34 weeks who underwent screening at any point during the corrected age of 1 month to 3 years using TDSC, LEST, and DDST II. Children were classified as having "delay" if they failed any test item on the left side of the corrected age line in TDSC, LEST, and DDST while those who completed all left-side chart items were considered "normal." **Result:** TDSC demonstrated 68.97% sensitivity, 98.73% specificity, 90.91% positive predictive value, and 94.51% negative predictive value when compared to DDST. Combining TDSC and LEST showed a sensitivity of 86.21%, specificity of 97.45%, positive predictive value of 86.21%, and negative predictive value of 97.45%. The language domain of Denver showed 78.6% sensitivity,100% specificity,100% positive predictive value, and 96.3% negative predictive value when compared to LEST. The language delay prevalence was 15.05% using LEST and 11.83% using language domain of Denver. The prevalence of developmental delay in our study using TDSC, DDST II, and combined TDSC and LEST were 11.83%, 15.59%, and 15.59% respectively. **Conclusion:** The combination of TDSC and LEST resulted in enhanced sensitivity without significantly compromising specificity. Compared with DDST II, TDSC and LEST are quicker to administer, simpler to use, and require minimal training for community workers. TDSC and LEST can be effectively used in a busy high-risk newborn follow-up clinic for developmental screening without significantly increasing the workload.

INTRODUCTION

The initial three years of a child's life are critical for comprehensive development, encompassing physical capabilities, psychomotor skills, emotional and social maturation, cognitive functions, and language acquisition. A child is said to have a developmental delay when their development lags behind the expected norms for their age group. Global developmental delay involves a significant delay in reaching developmental milestones across at least two domains: gross and fine motor skills, speech and language, cognitive functions, social and personal interactions, and activities of daily living.[1] Research conducted in India has shown that 1.5% to 4.4% of children under the age of two years experience developmental delay.[2-4] Improvements in neonatal care have resulted in higher survival rates among preterm infants. Babies born prematurely, particularly extreme and very preterm, are at considerable risk for neurodevelopmental issues. These problems include cerebral palsy, mental retardation, and developmental delay.[5] Among the various forms of delay observed in very preterm infants, speech and language delays are frequently encountered.[6] Research conducted in India has revealed that approximately 25-26% of premature infants experience neurodevelopmental challenges.[7,8] These disabilities affect not only the child and their family but also the society, due to the costs associated with healthcare and educational support. Evidence suggests that early interventions for developmental disabilities lead to improved outcomes.[9]

Considerable importance has been given to the systematic implementation of developmental screening to enhance the detection of developmental delay in children, thus enabling timely early intervention. The Denver Developmental Screening Test (DDST) is a tool created for healthcare providers to assess the developmental progress of young children. The updated version, known as DDST II, has been validated and demonstrated a robust correlation between its classifications and scores obtained from both the Stanford-Binet Intelligence Scales and Bayley Infant Scales. The Denver 2 assessment categorizes a child's developmental progress into four distinct areas: personal-social (comprising 25 items), fine motor-adaptive (with 29 items), language (containing 39 items), and gross motor (consisting of 32 items).[10] The Child Development Centre in Trivandrum has created and validated two simple developmental screening instruments: the Trivandrum Developmental Screening Chart (TDSC) and the Language Evaluation Scale Trivandrum (LEST). Individuals with minimal training, including Anganwadi workers, can administer TDSC and LEST.[4,11] The objectives of this study were to compare TDSC and LEST with DDST II in preterm children born at ≤34 weeks gestation, assessed at a corrected age of 1 month to 3 years, and to evaluate developmental delay across different age groups using TDSC, LEST, and DDST II. Additionally, this study aimed to compare the language domain of DDST with that of LEST for screening language delay in preterm children.

MATERIALS AND METHODS

This is a descriptive cross-sectional study of preterm children who were born at or before 34 weeks gestation and assessed at any point between corrected ages of 1 month to 3 years, conducted in the Department of Paediatrics, Government Medical College Ernakulam, Kerala, from 19/11/2021 to 18/11/2022. The inclusion criteria encompassed all preterm babies ≤ 34 weeks gestation attending the high-risk newborn clinic and immunization clinic at any time between the corrected age of 1 month to 3 years during the study period. Children with major congenital malformations, syndromic children, and children of parents who did not give consent were excluded from the study.

The sample size was calculated using the equation given below:

$N = (Z\ 1\text{-}\alpha/2)^2\ Sp\ (1\text{-}Sp)\ /(1\text{-}p) \times d^2$,

Where the confidence level was 95%, $Z\ 1\text{-}\alpha = 1.96$, and a margin of error, d = +/- 5%

The specificity (Sp) was taken as 90.8%, from a validation study of TDSC[0-6years] conducted by the Child Developmental Centre in Trivandrum [4].

The prevalence (p) was determined to be 26% based on a study conducted by Nair et al. on developmental delay in preterm infants aged <34 weeks[7]. The calculated sample size was 186.

Our study used three assessment tools: TDSC, LEST, and DDST II. The Trivandrum development screening chart incorporates 27 meticulously chosen evaluation items. A vertical line is drawn on the child's corrected age in the chart. Typically, a child should achieve all milestones, with upper limits to the left of this line. If a child fails to meet any milestones on the left side of the line or shows any noticeable asymmetry, they are considered to have a developmental delay. This screening tool is simple and does not need a specialized kit; only a pen and a bunch of keys are needed[4]. The Denver Developmental Screening Test II (DDST II) employs a diverse array of items, including a large red yarn pom-pom, raisins, a rattle with a narrow handle, 10.1-inch square wooden blocks of various colours, a small glass bottle with a narrow neck, a small bell, a tennis ball, a red pencil, a small plastic doll with a feeding bottle, a plastic cup with a handle, and blank sheets of paper. The test form organizes these items into four domains: gross motor, fine motor-adaptive, language, and personal social. It graphically illustrates ages at which 25%, 50%, 75%, and 90% of children from birth to 6 years accomplished specific tasks. During the assessment, a perpendicular line was drawn or a pen was positioned vertically at the child's corrected age. If the child failed to accomplish tasks located to the left of this line, he was considered to have developmental delay[10]. The Language Evaluation Scale Trivandrum (LEST) consists of 33 items. During the evaluation, a perpendicular line was drawn or a pen was positioned vertically at the child's corrected age. If the child was unable to accomplish any item to the left of this line, it was deemed to have a delay. In our research, failing to achieve one item was categorized as a language delay according to LEST[11]. A comprehensive neurodevelopmental evaluation was conducted for all the children. This assessment encompassed a thorough medical history, with a special focus on antenatal history, newborn period, and development. Each child underwent a full physical and systemic examination, including anthropometric measurements. Developmental milestones were evaluated using TDSC, LEST, and DDST II. To eliminate observer bias, two separate examiners simultaneously screened all participants using both the TDSC and DDST II. Likewise, two observers independently assessed all subjects using LEST and the language domain of Denver. Statistical analysis was performed using Microsoft Excel and SPSS version 21.0. The analysis included sensitivity, specificity, positive and negative predictive values, as well as the prevalence rate.

RESULTS

186 children, ranging from 1 month to 3 years of corrected age, were sequentially enrolled from the high-risk newborn follow-up and immunization clinic. Observations were recorded and analysed.

[Table 1] illustrates the distribution of children across the four age groups, categorised by sex. Overall, females outnumbered males, slightly with a male-to-female ratio of 0.94:1. In the 1-6 month age group, comprising 45 children, 44.44% were male and 55.55% were female. Among the 51 children in the 7-12 month group, 49.01% were male and 50.98% were female. The 12-24 month age group, consisting of 46 children, and the 24-36 month age group, with 44 children showed an equal distribution of males and females.

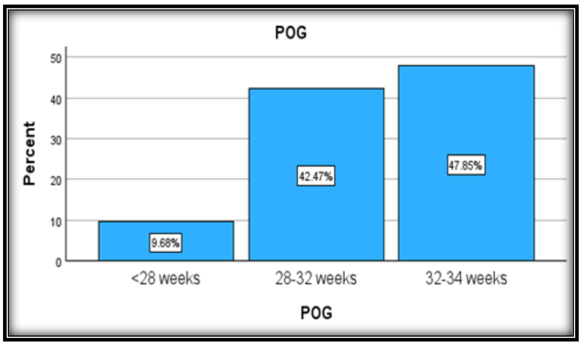

Figure 1: Distribution of cases according to period of gestation

The distribution of cases according to period of gestation is presented in [Figure 1]. There was a predominance of infants with gestational ages of 32-34 weeks (89 out of 186), followed by those at 28-31 weeks + 6 days (79 out of 186), with the least number representing infants of <28 weeks (18 out of 186).

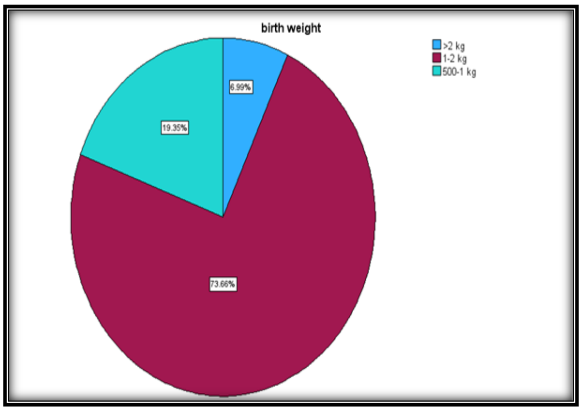

Figure 2: Distribution of cases according to birth weight

[Figure 2] shows the case distribution based on birth weight. The majority, 137 of 186 cases, were infants weighing 1-2 kg. Another 36 children weighed between 500 grams and 1 kg. Only 13 infants had a birth weight of >2 kg.

[Table 2] presents the classification of children as normal or abnormal across age groups using DDST II, TDSC, and combined TDSC and LEST assessments. The developmental delay detected by Denver II in this study was 15.55%, 19.61%, 10.87%, and 15.91% in the age groups 1-6 months, 7-12 months, 13-24 months, and 25-36 months, respectively. TDSC identified delay in 8.88%, 11.76%, 8.70%, and 18.88% in the age groups 1-6 months, 7-12 months, 13-24 months, and 25-36 months, respectively. Denver II classified more children as abnormal than TDSC in all age groups except 25-36 months. The combination of TDSC and LEST resulted in improved detection rates across all age groups. Specifically, the rates increased to 11.11% for infants aged 1-6 months, 17.65% for those 7-12 months old, 10.87% for children between 13-24 months, and 22.73% for the 25-36-month age group.

Out of 186 children, DDST identified developmental delay in 29 (15.59%) children, whereas TDSC identified a delay in 22 (11.83%) children. The combined TDSC and LEST identified developmental delay in 29 (15.59%) children. Among the 29 children identified as having developmental delay through DDST II and the combined TDSC and LEST, 25 were identified by both methods. However, there were four cases in which LEST identified language delay that DDST did not detect. Additionally, there were four cases of single-item delay in the gross motor domain of DDST II in which the combined TDSC and LEST failed to identify.

[Table 3] illustrates the distribution of children categorised as normal or abnormal across different age groups, based on assessments using the language domain of DDST II and LEST. The DDST II language domain results indicated that 88.17% (164 of 186) of the children were classified as normal and 11.83% (22 of 186) were classified as abnormal. In comparison, LEST evaluation demonstrated that 84.95% (158 of 186) of the children were categorized as normal and 15.05% (28 of 186) as abnormal.

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TDSC demonstrated a sensitivity of 68.97% and specificity of 98.73%. The positive predictive value of TDSC was determined to be 90.91%, while the negative predictive value was 94.51%. The prevalence rate of developmental delay was 15.59% according to DDST and 11.83% according to TDSC. As age increased, the sensitivity of TDSC exhibited an upward trend.

Upon combining TDSC and LEST, the sensitivity, specificity, positive predictive value, and negative predictive value were 86.21%,97.45%,86.21%, and 97.45% respectively. The prevalence rate of developmental delay was 15.59% for the combined TDSC and LEST. The sensitivity was found to increase with advancing age.

The prevalence rate of language delay was 15.05% using LEST and 11.8% using the language domain of Denver. The language domain of Denver had a sensitivity of 78.6% and specificity of 100% in screening for language delay in preterm children compared to LEST. The positive predictive value for the language domain of DDST II was 100%, while the negative predictive value was 96.3%.

Table 1: Distribution of children into four age groups according to sex.

Age group	**Sex**		
Corrected age(months)	**Female N (%)**	**Male N (%)**	**Grand Total**
1 month- 6 months	25 (55.55)	20(44.44)	45
7-12 months	26(50.98)	25(49.01)	51
12 -24 months	23(50.00)	23(50.00)	46
25-36 months	22(50.00)	22(50.00)	44
Grand Total	96(51.61)	90(48.38)	186

Table 2: Classification of children as normal and abnormal across four age groups, based on three developmental screening tests [DDST, TDSC, Combined TDSC, and LEST].

Age group months	**DDST II N(%)**		**TDSC N(%)**		**TDSC +LEST N(%)**		**Total**
	Normal	**Abnormal**	**Normal**	**Abnormal**	**Normal**	**Abnormal**	
1-6 months	38(84.44%)	7(15.55%)	41(91.11%)	4(8.88%)	40(88.89%)	5(11.11%)	45
7-12 months	41(80.39%)	10(19.61%)	45(88.24%)	6(11.76%)	42(82.35%)	9(17.65%)	51
13-24 months	41(89.13%)	5(10.87%)	42(91.30%)	4(8.70%)	41(89.13%)	5(10.87%)	46
25-36 months	37(84.09%)	7(15.91%)	36(81.82%)	8(18.18%)	34(77.27%)	10(22.73%)	44
Total	157(84.41%)	29(15.59%)	164(88.17%)	22(11.83%)	157(84.41%)	29(15.59%)	186

Table 3: Classification of children as normal or abnormal across four age groups, based on two screening tests DDST language domain and LEST.

Age group months	**Language domain DDST II N(%)**		**LEST N(%)**		**Total**
	Normal	**Abnormal**	**Normal**	**Abnormal**	
1-6 months	42(93.33%)	3(6.67%)	41(91.11%)	4(8.89%)	45
7-12 months	44(86.27%)	7(13.73%)	42(82.35%)	9(17.65%)	51
13-24 months	41(89.13%)	5(10.87%)	41(89.13%)	5(10.87%)	46
25-36 months	37(84.09%)	7(15.91%)	34(77.27%)	10(22.73%)	44
Total	164(88.17%)	22(11.83%)	158(84.95%)	28(15.05%)	186

Table 4: Comparison of TDSC (0-3 years) results with DDST II outcomes.

TDSC	**DDST Abnormal**	**Normal**	**Total TDSC**
Abnormal	20 (TP)	2 (FP)	22
Normal	9 (FN)	155 (TN)	164
Total DDST	29	157	186

Table 5: Cross-tabulation outcomes comparing TDSC (0-3 years) with DDST II

Test criteria	**Formula**	**Calculations**	**Results**
Sensitivity (%)	TP/(TP+FN)	(20/29) *100	68.97
Specificity (%)	TN/(TN+FP)	(155/157) *100	98.73
Positive predictive value (%)	TP/(TP+FP)	(20/22) *100	90.91
Negative predictive value (%)	TN/(TN+FN)	(155/164)*100	94.51%
Prevalence rate of developmental delay with DDST (%)	No. of children with delay using DDST/Total sample	(29/186) *100	15.59%
Prevalence rate of developmental delay with TDSC (%)	No. of children with delay using TDSC/Total sample	(22/186) *100	11.83%

Table 6: Cross-tabulation outcomes comparing TDSC and DDST II across four age categories

Criteria	**Age groups**			
	1-6 months	**7-12 months**	**13-24 months**	**25-36 months**
Sensitivity (%)	57.1	60	80.0	85.71
Specificity (%)	100	100	100	94.59
Positive predictive value (%)	100	100	100	75.0
Negative predictive value (%)	92.68	91.11	97.62	97.22

Prevalence rate (%) using DDST	15.6	19.6	10.9	15.9
Prevalence rate (%) using TDSC	8.9	11.8	8.7	18.2

Table 7: Cross-tabulation of Combined TDSC (0-3 years) and LEST (0-3 years) against DDST II

TDSC+LEST	DDST Abnormal	Normal	Total TDSC+LEST
Abnormal	25 (TP)	4 (FP)	29
Normal	4 (FN)	153(TN)	157
Total DDST	29	157	186

Table 8: Results of Cross tabulation of Combined TDSC (0-3 years) and LEST (0-3 years) against DDST II

Test criteria	Formula	Calculations	Results
Sensitivity (%)	TP/(TP+FN)	(25/29) *100	86.21
Specificity (%)	TN/(TN+FP)	(153/157) *100	97.45
Positive predictive value (%)	TP/(TP+FP)	(25/29) *100	86.21
Negative predictive value (%)	TN/(TN+FN)	(153/157) *100	97.45
Prevalence rate of developmental delay with combined TDSC and LEST (%)	No. of children with delay using combined TDSC and LEST/Total sample	(29/186) *100	15.59%

Table 9: Results of Cross tabulation of Combined TDSC (0-3 years) and LEST (0-3 years) against DDST II according to 4 age groups

Criteria	Age groups			
	1-6 months	7-12 months	13-24 months	25-36 months
Sensitivity (%)	71.4	80	100	100
Specificity (%)	100	97.6	100	91.9
Positive predictive value (%)	100	88.9	100	70.0
Negative predictive value (%)	95.0	95.2	100	100
Prevalence rate (%) using combined TDSC and LEST	11.1	17.6	10.9	22.7

Table 10: Cross-tabulation of the language domain of Denver against LEST

Language domain of Denver	LEST Abnormal	Normal	Total Language domain of Denver
Abnormal	22 (TP)	0(FP)	22
Normal	6(FN)	158(TN)	164
Total LEST	28	158	186

Table 11: Results of Cross tabulation of language domain of Denver against LEST

Test criteria	Formula	Calculations	Results
Sensitivity (%)	TP/(TP+FN)	(22/28) *100	78.6
Specificity (%)	TN/(TN+FP)	(158/158) *100	100
Positive predictive value (%)	TP/(TP+FP)	(22/22) *100	100
Negative predictive value (%)	TN/(TN+FN)	(158/164) *100	96.3
Prevalence rate of Language delay using LEST (%)	No. of cases with language delay using LEST/Total sample	(28/186) *100	15.05
Prevalence rate of Language delay using language domain of DDST (%)	No. of cases with language delay using language domain of DDST/Total sample	(22/186) *100	11.83

Table 12: Results of Cross tabulation of Language domain of Denver against LEST according to four age groups.

Criteria	Age groups			
	1-6 months	7-12 months	13-24 months	25-36 months
Sensitivity (%)	75	77.8	100	70
Specificity (%)	100	100	100	100
Positive predictive value (%)	100	100	100	100
Negative predictive value (%)	97.6	95.5	100	91.9
Prevalence rate of Language delay using LEST (%)	8.9	17.6	10.9	22.7
Prevalence rate of Language delay using language domain of DDST (%)	6.7	13.7	10.9	15.9

DISCUSSION

The current study demonstrated a sensitivity of 68.97% and specificity of 98.73%, with a positive predictive value of 90.91% and a negative predictive value of 94.51% when comparing TDSC with DDST. However, by combining TDSC and LEST, the sensitivity increased to 86.21%, specificity remained high at 97.45%, positive predictive value was 86.21%, and negative predictive value was 97.45%. This combination enhanced both sensitivity and negative predictive value, without a substantial reduction in specificity, although it resulted in a decrease in the positive predictive value. This observation can be attributed to the four cases in which LEST identified language delay that the DDST did not detect. In addition, there were four instances of single-item delay in the gross motor domain of DDST II that the combined TDSC and LEST approach failed to identify. The prevalence rates of developmental delay in preterm children in our study

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were 15.59%,11.83%, and 15.59% for DDST II, TDSC, and combined TDSC and LEST respectively.

Research by Dewangan et al. revealed that TDSC, when compared with DDST, exhibited a sensitivity of 77.77% and a specificity of 100%. Additionally, TDSC showed a positive predictive value of 100% and a negative predictive value of 97.26%.[12] A study evaluating TDSC [0-6 years] against DDST was conducted with participants from a village in southern Kerala and infants attending a well-baby clinic at SAT Hospital Trivandrum. The results demonstrated 84.62% sensitivity and 90.8% specificity, with a positive predictive value of 30% and a negative predictive value of 99.23%.[4] The low positive predictive value was attributed to the high proportion of normal cases [93.6%] and low prevalence of developmental delay [4.4%] in the examined sample.

Kannur et al. found that TDSC had 83.33% sensitivity and 91.4% specificity compared to Denver, with a positive predictive value of 38.4% and a negative predictive value of 98.8%.[13] Kishore et al. found that the TDSC had a sensitivity of 57.4% and specificity of 100% compared with the DDST for detecting developmental delays in children aged 0-3 years.[14] Elenjickal et al's study, "Development of High-Risk Newborns – A Follow-up Study from Birth to One Year," which compared TDSC and DDST showed a sensitivity of 57.4% and specificity of 100%.[15]

The LEST 0-3 years screening tool, validated by Nair et al. against the Receptive Expressive Emergent Language Scale (REELS) for children 0-3 years, showed 84.4% sensitivity, and 80.3% specificity. It also had a Positive Predictive Value (PPV) of 91.5% and a Negative Predictive Value (NPV) of 67.1%.[11] In our study LEST detected language delay in 8.89%, 17.65%, 10.87%, and 22.73% in the age groups 1-6 months, 7-12 months, 13-24 months, and 25-36 months respectively. The language domain of Denver detected 6.67%, 13.73%, 10.87%, and 15.91% in the age groups 1-6 months, 7-12 months, 13-24 months, and 25-36 months respectively. Thus, LEST identified a higher number of children with language delay. Considering the higher prevalence of language delay in preterm children, it is crucial to employ a screening tool with high sensitivity. Previous studies have demonstrated that the prevalence of language delay ranges from 16% to 27% in very low birth weight preterm children.[8,16,17]

Research conducted by Bharaswadkar et al on the developmental evaluation of infants with neonatal hypoglycaemia found that, in comparison to DDST II, TDSC exhibited a sensitivity of 93.18% and a specificity of 100%. In contrast, when compared to the language domain of DDST II, LEST showed a sensitivity of 88.64% and specificity of 97.3%.[18]

Our research revealed a developmental delay of 11.83%, 15.59%, and 15.59% in preterm children ≤ 34 weeks of gestation when assessed at corrected ages of 1 month to 3 years, using TDSC, DDST II, and a combination of TDSC and LEST, respectively. Previous studies have shown that developmental delay manifests in 15.6% - 26% of infants born prematurely.[5,7,8]

The limitation of combining TDSC and LEST is the inability to detect mild motor delays; however, enhanced language evaluation can be incorporated. Conversely, Denver can detect minor motor delays, although there is a potential for overlooking mild language delays. But these three screening tests could not be utilised to determine developmental quotient or developmental age. A screening tool should demonstrate both high sensitivity and specificity, although achieving this balance is frequently challenging. Typically, a screening test with high sensitivity and gold standard with high specificity is accepted. TDSC and LEST are easier to administer, less time-consuming, and require minimal training than DDST. A higher prevalence of developmental delay was observed in preterm than in term children. Furthermore, preterm children exhibit a higher prevalence of language delay. This emphasizes the need for a highly sensitive developmental screening tool, particularly for preterm children.

CONCLUSION

TDSC demonstrated higher specificity (98.73%) but exhibited lower sensitivity (68.97%) compared to DDST. DDST tends to over-screen, whereas TDSC tends to under-screen. Combining TDSC with LEST can enhance the sensitivity (86.21%) without substantially reducing the specificity (97.45%). Considering the high prevalence of language delay in preterm children, the use of LEST increases the sensitivity of the detection of language delay. All these screening tests necessitate further comprehensive evaluation after identifying a child as abnormal. TDSC and LEST offer advantages over DDST II in terms of faster administration, greater ease of use, and reduced training requirements for community-based workers. These screening tools facilitate the identification of early indicators of developmental and speech delay by community-based healthcare practitioners, thus enabling timely intervention. TDSC and LEST can be effectively utilised in a busy high-risk newborn follow-up clinic to screen for developmental delay, without significantly adding to the workload or requiring excessive time.

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