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RESEARCH ARTICLE

Validity of the Best Beginnings Developmental Screen in Former Preterm Infants

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Abstract

Background: Premature infants remain at significant risk for future developmental disabilities; as such, periodic developmental evaluation and early identification of developmental delays are especially important aspects of ongoing care for preterm infants after discharge. However, in-depth assessment can be costly and time consuming. The Best Beginnings Developmental Screen (BBDS) was created to screen former preterm infants for developmental delays, in an inexpensive and rapid manner.

Aims: The purpose of this study was to determine the sensitivity and specificity of the Best Beginnings Developmental Screen (BBDS) to identify infants who are >25% delayed on the Bayley Scales of Infant Development, Second Edition (BSID-II).

Study design: A prospective validation study was conducted to examine 8 different definitions of fail on the BBDS.

Subjects: 81 infants and toddlers born prematurely, and whose chronological ages ranged between 3 and 38 months, participated in the study.

Outcome measures: Children were evaluated using the BBDS and the BSID-II.

Results: Two of the 8 BBDS fail definitions (Definitions 4 and 6) resulted in adequate sensitivity (.95 and .90 respectively) and specificity (.77 and .83 respectively) for identifying children with at least a 25% delay on the BSID-II.

Conclusions: This validation study demonstrates that the BBDS may be a valid screening tool when used with children born prematurely. The following scoring and referral protocol is recommended: refer children who fail Definition 6 for further testing, rescreen children who fail Definition 4 at a closer interval, and rescreen children who pass both at the regular interval.

Keywords: Developmental Screening, Premature Infants, NICU follow-up, Best Beginnings Developmental Screen

Abbreviations: AAP: American Academy of Pediatrics, BBDS: Best Beginnings Developmental Screen, BSID-II: Bayley Scales of Infant Development, Second Edition, BW: Birth weight, EI: Early Intervention, GA:Gestational Age, NICU: Neonatal Intensive Care Unit, MDI: Mental Developmental Index, PDI: Physical Developmental Index, UMMC: University of Maryland Medical Center

Introduction

A progressive decline in perinatal mortality has occurred during the past three decades. However, despite advances in neonatal intensive care, premature infants remain at significant risk for future developmental disabilities. The incidence of neurodevelopmental impairment in these infants is inversely correlated with birth weight (BW) and gestational age (GA) [1-7].

Periodic developmental evaluation and early identification of developmental delays are especially important aspects of ongoing care for preterm infants after discharge. Once developmental delays are identified, participation in early intervention (EI) programs has been shown to have a positive impact on neurodevelopment [8-10]. As such, the American Academy of Pediatrics (AAP) emphasizes the importance of neurodevelopmental follow-up for preterm infants, and recommends referral to EI programs as soon as deficits are identified [11]. In 2006, the AAP Section on Developmental Behavioral Pediatrics issued a policy statement addressing developmental surveillance. In this statement, they categorized the sensitivity and specificity of various pass/fail developmental screening tools as follows: low sensitivity or specificity as ≤69%, moderate sensitivity or specificity as 70-89% and high sensitivity or specificity as ≥90% [12].

The Best Beginnings Developmental Screen (BBDS) was created to screen preterm infants and toddlers from 36

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weeks gestational age (GA) through 39 months of age for developmental delays, in an inexpensive and rapid manner. The BBDS allows both providers and parents to longitudinally observe developmental milestone attainment and quality, and to identify domains of development that may require additional focus and referral for EI services.

Development of the BBDS was a 4-step process. First, an extensive review of the literature on infant and toddler development was conducted and 1-2 key milestones per age (36 weeks post-conceptual age, newborn, 1-9, 12, 15, 18, 21, 24, 27, 30, 33, 36 and 39 months) were identified in each of 6 developmental domains (adaptive, social-emotional, fine motor, cognitive, language, gross motor). This process yielded 174 key milestones for potential inclusion. Second, 17 developmental screening tools, developmental assessments, and infant/toddler curriculums were reviewed in detail to identify the age at which most children should possess these key milestones. Third, once items were placed in the appropriate domain and age, content validity was assessed by a group of 12 professionals to verify that items were placed in the correct domain at the appropriate age, and that the items represented key milestones for that age. Items were modified until consensus was obtained regarding appropriate domain placement, age placement, and importance. Fourth, neonatologists staffing the University of Maryland Children's Hospital (UMCH) Neonatal Intensive Care Unit (NICU) Follow-Up Program used the BBDS to screen >800 patients during a one year pilot. Pilot data was utilized to evaluate clarity of item administration and scoring; thus resulting in 170 items in 6 domains. Finally, time to administer the BBDS was determined across 100 examinations; the BBDS took an average of 8 minutes to administer (range = 2 to 15 minutes).

The purpose of this study was to determine a BBDS pass/fail definition with the greatest sensitivity and reasonable specificity to identify infants who are delayed on the Bayley Scales of Infant Development, Second Edition (BSID-II) [13]. We predicted that the BBDS had high sensitivity and specificity to identify infants and toddlers who are delayed >25% on the BSID-II.

Material and Methods

Participants

After receiving approval by the Institutional Review Board, 81 infants and toddlers born prematurely (GA<37 weeks), and whose chronological ages ranged between 3 and 38 months (adjusted age range = 18 days to 38 months) were recruited from the UMMC NICU Follow-Up Program in Baltimore, Maryland. To have a sample representative of all age groups, the recruitment was stratified to ensure that approximately 10 children were represented for each visit level (i.e., 3, 6, 9, 12, 18, 24, 30, and 36 months chronologic age). Exclusion criteria included children whose caregivers did not speak English and any child born at ≥37 weeks GA. Children whose adjusted age was ≤16 days were also excluded, because the BSID-II is not capable of assessing children this young. Study subject demographics are shown in Table 1.

VARIABLE	N	Percent
CHILD		
Gender		
Male	45	55.6
Female	36	44.4
Race/Ethnicity		
African-American	54	66.7
Caucasian	23	28.4
Other	4	4.9
Birth Weight		
(Range = 542-2,634 grams, Mean = 1,197.52 grams, SD = 390.36 grams)		
<1,000 grams	24	29.6
1,000 to 1,500 grams	39	48.2
>1,500 grams	18	22.2
Gestational Age at Birth		
(Range = 23-35 weeks, Mean = 28.91 weeks, SD = 2.63 weeks)		
23 to 28 weeks	23	28.4
28 to 32 weeks	43	53.1
32 to 36 weeks	15	18.5
Age at Testing		
(Range = 18 days – 37 months, Mean = 15.42 months, SD = 11.99 Months)		
<12 months (adjusted)	23	28.4
6-12 months (adjusted)	17	21
12-18 months (chronologic)	9	11.1
18-24 months (chronologic)	5	6.2
24-30 months (chronologic)	11	13.6
30-36 months (chronologic)	16	19.8
MOTHER		
Marital Status		
Single	41	50.6
Married	34	42
Together but Not Married	1	1.2
Separated or Divorced	4	4.9
Not Provided	1	1.2
Level of Education		
<High School	10	12.3
High School/GED	27	33.3
Some College or Vocational School	29	35.8
>Bachelor's Degree	13	16
Not Provided	2	2.5

Table 1: Demographic characteristics of study subjects (N=81).

Data collection

The BBDS and BSID-II were conducted in a pediatric examination room. After informed consent, parents completed a brief demographic questionnaire. Independent examiners, blinded to the test results, administered the BBDS and BSID-II consecutively within the same program visit. In alignment with the Code of Maryland Regulations Applicable to the Provision of Early Intervention Services to Infants and Toddlers and Their Families [14], which uses adjusted age until a child's adjusted age is 12 months to calculate developmental delay for eligibility determination, the BBDS and the BSID-II were scored at adjusted age for children whose adjusted age <12

months; children with an adjusted age ≥12 months were scored at their chronologic age. Neonatologists administered the BBDS as part of routine NICU follow-up care. A psychologist administered the BSID-II when administration was part of routine care (e.g., child was 24 months of age, cognitive concerns were present); otherwise a single research staff member administered the BSID-II.

Instrumentation

BSID-II

The BSID-II [13] is a standardized test used to assess the mental and physical development of children 1 to 42 months of age. Standard scores are derived from the results with a mean of 100 and a standard deviation of 15. The psychometric properties of the instrument are high for both scales. Reliability coefficients for the mental developmental index (MDI) range from 0.78 to 0.93 and the physical developmental index (PDI) ranges from 0.81 to 0.91. Results of the BSID-II were collapsed into binary categories to indicate a developmental delay was present or absent using a 25% delay criteria. Age equivalents associated with raw scores provided by the BSID-II manual were used to categorize the child. For example, a 24-month chronologically old child who scored at an age equivalent of 17 months as determined by the MDI or PDI was categorized as developmentally delayed [(24 month age-17 months age tested)/24 months age)*100=29%]. The 25% delay cutoff was chosen because it is the most frequently used definition of developmental delay for EI eligibility in the United States [15].

BBDS

To obtain a pass/fail on the BBDS, all items in the corresponding age row on the BBDS were completed, for each of the 6 domains. When possible, the examiner administered the item so that the child's response could be observed. For items not possible to observe or those the child did not display, the examiner asked the parent an open-ended (versus yes/no) question about the item.

When a child's ability to perform an item was observed or the parent informed the examiner, *O* (observed) or *I* (informed) was circled on the BBDS. If the child completed the item in an atypical manner, by observation or parent report, the *A* (atypical) was circled (e.g., child is walking, but only on toes). Finally, the examiner circled the *X if* an item was not observed and/or the parent did not provide confirmation that the child was able to demonstrate the item successfully. If any item was scored as *X*, the examiner administered the previous age range item within the same domain. For example, if the child was screened at 8 months and received an *X* for the gross motor item creeps on all fours, the examiner also administered the gross motor items at 7 months; *belly crawls* and *sits no support*. The examiner continued to administer items, within the same domain, at earlier age ranges until the child was able to perform the item(s) by observation or parent information. If there were two items in an age row for a domain, the child had to successfully demonstrate both items (Figure 1).

Inter-rater reliability was established prior to data collection on 12 subjects (15% of proposed sample). Reliability of both BBDS

Screen Age	Date	Adaptive		Social-Emotional		Fine Motor		Cognitive		Language		Gross Motor		Results
6 5m16d-6m15d		Swallows strained or pureed foods	OIAX	Responds to mirror image	OIAX	Rakes	OIAX	Looks for dropped spoon	OIAX	Single syllables	OIAX	Sits tripod	OIAX	PSCTA
										Holds arms out to be picked up	OIAX	Supports weight standing	OIAX	
7 6m16d–7m15d		Takes baby food well	OIAX	Separation anxiety	OIAX	Transfers	OIAX	Pulls out peg	OIAX	Orients to bell upward/indirect	OIAX	Belly crawl	OIAX	PSCTA
						Holds cube takes another	OIAX					Sits no support	OIAX	
8 7m16d-8m15d		Bites food voluntarily	OIAX	Distinguishes own name	OIAX	Grasp cube thumb-fingers	OIAX	Rings bell	OIAX	Combines syllables	OIAX	Creeps on all fours	OIAX	PSCTA
9 8m16d-9m15d		Holds, bites, chews cracker	OIAX	Enjoys peek-a-boo	OIAX	Inferior pincer grasp	OIAX	Lifts cup to reveal car	OIAX	Imitates playful sounds	OIAX	Comes to sit	OIAX	PSCTA

Best Beginnings Developmental Screen:

Name: _____ DOB: _____/_____/_____ Gestational Age at Birth: _____weeks; Birth Weight: _____

[1]The BBDS form includes 170 items from 36 weeks gestational age through 39 months of age. This is a sample of the form inclusive of items from 6 through 9 months of age.

[2]**Key:** O=Observed, I=Informed, A=Atypical, X=Not Present, P=Pass, S=Suspect, C=Concern, T=Typical.

Figure 1: Sample of BBDS Form[1,2]

and BSID-II administration was 1.0 agreement using Cohen's Kappa. Scores gathered on the BBDS and BSID-II for reliability was not included in the final data set. Inter-rater reliability was stable throughout monthly periodic checks during data collection.

Statistical analysis

The BBDS was scored for each child as pass or fail using 8 different definitions of fail (Table 2). The BSID-II was scored as pass or fail for each child by using the cutoff of greater than 25% delay on either the MDI or PDI for adjusted or chronologic age as applicable. The ability of each definition of the BBDS to correctly identify pass/fail on the BSID-II was calculated as number of false positives, false negatives, true positives, true negatives, sensitivity, specificity, positive and negative predictive values (Table 2).

Once the pass/fail definitions (Table 2) of the BBDS that had the greatest sensitivity and specificity were identified, these definitions were used in subgroup analysis to determine the effect of child (i.e., gender, race, gestational age, birth weight, age at testing) and maternal (i.e., age, education, income) variables. All analyses were performed with SPSS software version 24 (2016).

Results

Pass/fail definitions

Results are shown in Table 2 for all study subjects. Sensitivities ranged from 52% to 95% and specificities ranges from 57% to 97% for the 8 definitions. Definition 4 resulted in the highest sensitivity (95%), Definition 7 resulted in the highest specificity (97%), and Definition 6 resulted in the highest overall combined sensitivity (90%) and specificity (83%). As Definition 7 demonstrated the lowest sensitivity (52%) and it did not meet the AAP recommendation of sensitivity ≥70%, further analyses were not conducted on this definition. All remaining analyses were performed using Definitions 4 and 6.

False positives and false negatives

The false positive rate (children who failed the BBDS but demonstrated <25% delay on the BSID-II) for Definitions 4 and 6 were 17% (N=14) and 12% (N=10), respectively (Table 2). Under Definition 4, 9 children failed the BBDS due to milestone delays, 2 due to atypical development and 3 additional children due to a combination of milestone delay and atypical development. Under Definition 6, 5 children failed the BBDS due to milestone delays, 4 due to atypical development and 1 additional child failed for a combination of milestone delay and atypical development. The same 5 children scored atypical under both definitions: 4 children scored atypical for increased tone (3 noted in prone and 1 in supported stand) and 1 scored atypical for articulation concerns.

The false negative rate (children who passed the BBDS but demonstrated a ≥25% delay on the BSID-II) was low and similar for Definitions 4 and 6, 1.2% (N=1) and 2.5% (N=2), respectively for a total of 2 children in the cohort. Both children were identified as false negatives at their evaluations at an adjusted age of 4 months. On the BSID-II, one child had an MDI equivalent of 3 months and both children had a PDI of 3 months, representing a 29% delay.

Further analyses by child and maternal variables

BBDS results were evaluated according to 5 child (Table 3) and 3 maternal (Table 4) characteristics to determine whether

Definition	False Positives	False Negatives	True Positives	True Negatives	Sensitivity (95% CI)	Specificity (95% CI)	Positive Predictive Value (95% CI)	Negative Predictive Value (95% CI)
Child receives score of X on >1 item at current age range in >1 domain.	25	2	19	35	90 (68-98)	58* (45-71)	44 (29-59%)	95 (80-99)
Fail for Definition 1 OR >1 item scored A.	26	1	20	34	95 (74-100)	57*(43-69)	43(29-59)	(83-100)
Child receives score of X on >1 item in >1 domain at current age OR child receives score of X on >1 item in 1 domain at current age range and preceding age range.	12	2	19	48	90(68-98)	80(67-89)	61(42-78)	96(85-99)
Fail for Definition 3 OR >1 item scored A.	14	1	20	46	95(74-100)	77(64-86)	59(41-75)	98(87-100)
Child receives score of X on >1 item at current age range AND first proceeding age range in >1 domain.	6	4	17	54	81(57-94)	90(79-96)	74(51-89)	93(82-98)
Fail for Definition 5 OR >1 item scored A.	10	2	19	50	90(68-98)	83(71-91)	66(46-81)	96(86-100)
Child receives score of X on >1 item at current, first, and second preceding age range in >1 domain.	2	10	11	58	52* (30-74)	97(87-99)	86(54-97)	85(74-92)
Fail for Definition 7 OR >1 item scored A.	7	7	14	53	67*(43-85)	88(77-95)	67(43-85)	88(77-95)
*Does not meet AAP recommendation of >70% sensitivity and specificity for developmental screening tools [14].								

Table 2: Sensitivity and specificity of the BBDS by definition (N=81).

Status	N	Definition 4				Definition 6			
		Sensitivity % (95% CI)	Specificity % (95% CI)	Positive Predictive Value % (95% CI)	Negative Predictive Value % (95% CI)	Sensitivity % (95% CI)	Specificity % (95% CI)	Positive Predictive Value % (95% CI)	Negative Predictive Value % (95% CI)
Gender									
Male	45	100 (66-100)	74 (56-87)	53 (29-75)	100 (84-100)	100 (66-100)	80 (63-91)	59 (33-81)	100 (85-100)
Female	36	90 (54-99)	77(56-90)	60 (33-83)	95 (74-100)	82 (48-97)	88 (68-97)	75 (43-93)	92 (72-99)
Race									
African American	54	100 (73-100)	80 (64-90)	64 (41-82)	100 (87-100)	93 (66-100)	87(72-95)	74 (49-90)	97 (83-100)
Caucasian	23	83 (36-99)	76 (50-92)	56(23-85)	93(64-100)	83(36-99)	82(56-95)	63(26-90)	93(66-100)
Other	4	NaN1	25*(1-78)	0 (0-69)	100(5-100)	NaN1	50*(9-91)	0(0-80)	100(20-100)
Gestational Age									
<28 Weeks	23	100	64*	64	100	100	79	75	100
		(63-100)	(36-86)	(36-86)	(63-100)	(63-100)	(49-94)	(43-94)	(68-100)
28-32 Weeks	43	90	76	53	96	82	84	64	93
		(54-99)	(57-88)	(29-76)	(78-100)	(48-97)	(66-94)	(36-86)	(76-99)
>32 Weeks	15	100 (5-100)	86(56-97)	33 (2-87)	100(70-100)	100(5-100)	86(56-97)	33(2-87)	100(70-100)
Birth Weight									
<1,000g	24	100(66-100)	64*(36-86)	67(39-87)	100(63-100)	100(66-100)	79(49-94)	77(46-94)	100(68-100)
1,000g-1,500g	39	80(30-99)	74(55-86)	31(10-61)	96(78-100)	67*(24-94)	79(61-90)	36(12-68)	93(75-99)
>1,500g	18	100(46-100)	92(62-100)	83(36-99)	100(70-100)	100(46-100)	100(72-100)	100(46-100)	100(72-100)
Age at Testing									
<12 Months	40	86(42-99)	82(64-92)	50(22-78)	96(80-100)	75(36-96)	91(74-98)	67(31-91)	94(77-99)
12-24 Months	14	100(60-100)	67*(24-94)	80(44-96)	100(40-100)	100(60-100)	83(36-99)	89(51-99)	100(46-100)
>24 Months	27	100(46-100)	68*(45-85)	42(16-71)	100(75-100)	100(46-100)	73(50-88)	45(18-75)	100(76-100)
* Does not meet AAP recommendation of >70% sensitivity and specificity for developmental screening tools [14].									

Table 3: Sensitivity and specificity by child variables using definitions 4 and 6.

Status	N	Definition 4				Definition 6			
		Sensitivity % (95% CI)	Specificity % (95% CI)	Positive Predictive Value %	Negative Predictive Value %	Sensitivity % (95% CI)	Specificity % (95% CI)	Positive Predictive Value %	Negative Predictive Value %
Age (N=80, 1 not provided)									
<20 Years	5	100 (20-100)	100 (31-100)	100 (20-100)	100 (31-100)	100 (20-100)	100 (31-100)	100 (20-100)	100 (31-100)
20-30 Years	38	88 (47-99)	70 (50-85)	44 (21-69)	95 (75-100)	78 (40-96)	79 (60-91)	54 (26-80)	92 (72-99)
>30 Years	37	100 (63-100)	79 (59-91)	60 (33-83)	100 (82-100)	100 (63-100)	86 (66-95)	69 (39-90)	100 (83-100)
Education (N=79, 2 not provided)									
<High School	10	67* (13-98)	86 (42-99)	67 (13-98)	86 (42-99)	67* (13-98)	86 (42-99)	67 (13-98)	86 (42-99)
High School/ GED	27	100 (56-100)	75 (51-90)	58 (29-84)	100 (75-100)	88 (47-99)	79 (54-93)	64 (32-88)	94 (68-100)
Some Post High School	29	100 (56-100)	73 (50-88)	54 (26-80)	100 (76-100)	100 (56-100)	86 (64-96)	70 (35-92)	100 (79-100)
>Bachelor's Degree	13	100 (20-100)	73 (39-93)	40 (7-83)	100 (60-100)	100 (20-100)	82 (48-97)	50 (9-91)	100 (63-100)
Annual Household Income (N=72, 9 not provided)									
<$25,000	27	100 (63-100)	72 (46-89)	64 (36-86)	100 (72-100)	90 (54-99)	82 (56-95)	75 (43-93)	93 (66-100)
$25,000-$50,000	19	75 (22-99)	80 (51-95)	50 (14-86)	92 (62-100)	75 (22-99)	87 (58-98)	60 (17-93)	93 (64-100)
>$50,000	26	100 (46-100)	76 (52-91)	50 (20-80)	100 (76-100)	100 (46-100)	86 (63-96)	63 (26-90)	100 (78-100)
* Does not meet AAP recommendation of ≥70% sensitivity and specificity for developmental screening tools [14].									

Table 4: Sensitivity and specificity by maternal characteristics using definitions 4 and 6.

sensitivity and specificity remained stable across subgroups for Definitions 4 and 6. For child characteristics, Definition 4 resulted in adequate sensitivity for all variables while specificity was impacted by 4 variables: gestational age <28 weeks (64%), birth weight <1,000 grams (64%) and age at testing of 12-24 months (67%) and ≥24 months (68%). In comparison, Definition 6 maintained sufficient specificity for all variables while sensitivity was impacted by one variable: birth weight 1000-1500 grams (67%). For maternal characteristics, Definitions 4 and 6 maintained sufficient specificity for all variables while sensitivity was impacted by one variable: maternal education <high school (67%).

Discussion

Preterm infants represent a high-risk population in need of close observation for neurodevelopmental sequelae [7]. The BBDS was designed as an inexpensive and rapid screening tool to identify infants and toddlers born prematurely, who are at high risk of delayed or atypical development, and need further in-depth testing. The BBDS kit used in this study cost $100 to self-assemble and took an average of 8 minutes to administer; in comparison, the BSID-II kit cost $1,000 to purchase and took 30 to 60 minutes to administer. The validity of any screening instrument, when incorporated into clinical practice, is important. A screening tool that is highly sensitive, but not specific, will detect a greater number of children as potentially having developmental delays, resulting in over-referrals for further assessment. Such referrals may be costly and create staffing issues. Alternatively, a screening instrument that is highly specific, but not sensitive, yields a smaller number of children being referred for in-depth evaluation but may fail to identify children who are delayed and in need of diagnosis and referral for EI services. The purpose of this study was to identify a BBDS pass/fail definition with the greatest sensitivity and reasonable specificity. Of the 8 definitions evaluated, we found that Definitions 4 and 6 best met these criteria.

Using Definition 4, we found that 95% of children failing the BBDS had a 25% or greater delay on the BSID-II and 77% of the children passing the BBDS had a 25% or less delay on the BSID-II. Using Definition 6, we found that 90% of children failing the BBDS had at least a 25% delay on the BSID-II and 83% of the children passing the BBDS had less than a 25% delay on the BSID-II. For Definition 4, children who received an X at their current age for >1 domain were included in the fail criteria, thus leading to a more sensitive yet less specific definition. Definition 6, in contrast, was slightly less sensitive but more specific, as these children met the pass criteria. Thus, while Definition 4 created a greater number of false positives, the false negatives that resulted from utilizing Definition 6 represent children whose developmental needs could have been neglected. The 2 children who passed the BBDS but demonstrated >25% delay on the BSID-II were born at 30-31 weeks GA, weighed 1040-1075 grams and were tested at 4 months adjusted age; both children were delayed on the PDI of the BSID-II, demonstrating difficulty with sitting items.

To prevent false negatives from slipping through the system, it is imperative that children born prematurely receive longitudinal developmental monitoring, at routine intervals, so that multiple opportunities exist to identify potential delays and refer for EI services. As utilizing a specific screening test while capturing false negatives in a timely fashion is important in this high-risk population, a practice that combines Definitions 4 and 6 may be optimal. Thus, we suggest a scoring and referral protocol that classifies children who fail Definition 4 but pass Definition 6 as suspect (Table 5).

The percentage of children born prematurely who were identified as delayed on the BSID-II, was 26%; greater than rates of developmental delay reported in the term population (10-16%) [16-19]. Available data describing neurodevelopmental outcomes in the preterm population are highly variable, based on study design. The literature indicates that the rate of developmental delay is greater in children born prematurely, and is inversely proportional to BW and GA. Cognitive, behavioral and social-emotional impairment occur in approximately 25 - 50%, and often persist at school age. In addition, approximately 5-15% of very preterm infants are diagnosed with cerebral palsy, severe neurosensory impairment, or both [6, 20, 21]. We speculate that our findings on the BSID-II may represent the lower end of prevalence of neurodevelopmental delay (26%), due to the higher mean and range of GA represented in our cohort. Alternatively, the classification method used in this study, greater than or equals to a_25% delay on both or either the MDI or PDI subscales of the BSID-II, varied from a classification based on standard deviation from the mean used in other studies. Finally, the prevalence rate in this study could be attributed to the fact that some developmental problems are not identifiable until pre-academic and academic skills emerge.

This study has several limitations. This study does not examine the validity of the BBDS with other populations of children nor does it examine the validity with preterm infants less than 16 days adjusted age (i.e., 42 2/7 weeks post conceptual age).

Score	Definition	Action
Pass	Child scores O/I for all items at current age.	Rescreen at regular interval (e.g., 6 months).
Suspect	Child scores X on >1 item in >1 domain at current age.	Rescreen at closer interval (e.g., 3 months). If suspect on two consecutive visits, refer for further testing.
Refer	Child scores X on >1 item at current age range AND first preceding age range in >1 domain and/or >1 item scores A.	Refer for further testing.
[1]Key: O=Observed, I=Informed, X=Not Present, A=Atypical		

Table 5: Final scoring recommendation with suspect.[1]

Therefore, future studies utilizing various samples of children and those less than 16 days adjusted age are needed. Test-retest is also important to determine the extent to which BBDS scores of the same children remain stable over time. While administration time for the BBDS is approximately 10 minutes (approximately 30-60 minutes for the BSID-II), BBDS timing has not been empirically measured. Further research is also needed regarding the predictive validity of the BBDS. This, however, may be difficult to ascertain, as children identified with potential delays will be referred for further assessment and those with confirmed delays or atypical development will receive EI services.

Although true random selection of the sample was not accomplished due to the clinical environment of the NICU Follow-up Program, a sequential and stratified recruitment of available participants was conducted to ensure that the sample was representative of the program's population. A pitfall of concurrent validity research is the threat to internal validity resulting from testing history. In this study, the measure administered first (either the BBDS or the BSID-II) may have impacted subject performance. For example, a child may not have been able to build a tower of cubes during the administration of the first measure but exposure through testing may have resulted in learning and succeeding during the next measure. Data was not collected on the order in which the measures were administered; this should be considered in future studies.

Conclusions

This validation study demonstrates that the BBDS has both strong sensitivity and specificity, and provides evidence that the BBDS, when used with children born prematurely, may be a valid screening method. The validity of the BBDS should continue to be examined with and beyond a population of children born prematurely.

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