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Language Outcomes Among ELBW Infants in Early Childhood

Ira Adams-Chapman, MD¹, Carla Bann, PhD², Sheena L. Carter, PhD¹, Barbara J. Stoll, MD¹, and for the NICHD Neonatal Research Network

Ira Adams-Chapman: iadamsc@emory.edu; Carla Bann: cmb@rti.org; Sheena L. Carter: scart01@emory.edu; Barbara J. Stoll: bstoll@emory.edu

¹Emory University School of Medicine, Atlanta, Georgia, Department of Pediatrics 2015
Uppergate Drive Atlanta, GA 30303.

²Research Triangle Institute, Research Triangle Park, North Carolina.

Abstract

Background—Limited data are available evaluating language outcomes of preterm infants in early childhood. Furthermore, the relationship between language outcomes, medical morbidities and developmental trajectory in early infancy is unclear.

Aims—The goal of this study was to evaluate language outcomes among extremely low birth weight (ELBW) infants at 30 months adjusted age (AA).

Study Design—The Bayley Scales of Infant Development IIR and the Peabody Picture Vocabulary Test or Expressive One Word Vocabulary Test/Receptive One Word Vocabulary Test were administered at 30 months AA to a prospective cohort of ELBW infants who participated in the NICHD Neonatal Network Glutamine Trial and Neurodevelopmental Follow-Up Study. A standardized history and physical examination and query regarding feeding behaviors were performed at 18 months AA and 30 months AA.

Results—Of the 467 infants evaluated, 55% had receptive language delay at 30 months with 23 % having severe delays. Fewer (26%) had expressive language delays, with 16% of those being severe delays. Non-English speaking infants had poorer performance on all language measures compared to English-speaking infants. Forty-seven percent of the cohort required assistance with feeds at 18 months. These children were more likely to have language delay at the 30 month assessment compared to infants who could feed themselves.

Conclusions—ELBW infants are at risk of language delay in early childhood. Additional research is needed to further explore the relationship between early predictors of language delay

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Corresponding Author: Ira Adams-Chapman, MD MPH, Assistant Professor of Pediatrics, Emory University School of Medicine, Department of Pediatrics, Division of Neonatology, 46 Jesse Hill Jr. Drive, Atlanta, GA 30303, 404-778-1450 (office), 404-778-1467 (fax), iadamsc@emory.edu.

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CONFLICT OF INTEREST STATEMENT

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and the use of monolingual language assessments in non-English speaking patients with a history of prematurity.

Introduction

Although improvements in neonatal care have resulted in increased survival among extremely low birth weight (ELBW) infants, there are growing concerns that surviving infants are at significantly increased risk for long term morbidity and abnormal neurocognitive functioning, often accompanied by delays in language (1–5). Data from the early 1990's suggested that differences in language outcome in the preterm population were primarily related to socioeconomic factors and higher neurologic risk. However, more recent reports suggest that these infants have an inherent increased risk for abnormal language development (5–8, 10–12), which may also be related to their increased risk for feeding difficulties.

Oral motor coordination is necessary for both expressive language skills and feeding skills (13, 14). The acquisition of language is often used as an important early indicator of cognitive function, therefore, exploring the relationship between early feeding behaviors and language development could potentially improve early prediction of cognitive function in early childhood.

Many questions remain regarding predictors of language outcomes in prematurely born children. This study offers a unique opportunity to evaluate language outcomes of a large cohort of ELBW infants at 30 months AA. Additionally, we evaluated the association between early abnormal feeding behaviors and language assessments at 30 months of age.

Methods

This study is a retrospective analysis of language assessments of infants enrolled in the NICHD Neonatal Research Network Glutamine Trial (15). The primary aim of this study was to evaluate the incidence of receptive and expressive language delays among this cohort of ELBW infants at 30 months adjusted age (AA). The secondary aim was to determine if ELBW infants with language delays at 30 months adjusted age had a higher incidence of feeding dysfunction at 18 months AA.

Infants weighing 401–1000 grams born between October 1999 and August 2001 at participating NICHD Neonatal Research Network sites who participated in both the Glutamine trial and the Neurodevelopmental (ND) follow-up study were eligible for inclusion in this study. Infants with congenital infection, major malformations or congenital syndromes were excluded from this analysis. Enrollment and study definitions for the Glutamine study have been described by Poindexter and colleagues (15).

The NICHD Neonatal Research Network maintains a registry which includes maternal and neonatal information from birth until patient death, hospital discharge or 120 days postnatal age. A standardized medical and neurological assessment was performed by certified examiners at 18 months and 30 months AA, including an assessment of feeding behaviors. Swallowing was considered abnormal if the child was unable to tolerate foods by mouth,

required nasogastric or G-tube feeds for > 50% of nutritional intake, or if the child choked, gagged, coughed or gasped with solids. Children who drooled continuously they were also coded as abnormal. A child with a documented history of dysphagia or aspiration on a fluoroscopic swallow study was coded as abnormal.

Certified examiners administered the Bayley Scales of Infant Development-II (BSID-II) at each study visit. BSID-II scores were recorded for the Mental Developmental Index (MDI) and the Psychomotor Developmental Index (PDI). The mean score is 100 ± 15 SD; a score less than 70 indicates significant delay. Children judged to be so severely developmentally delayed that they were untestable were assigned MDI and PDI scores of 49. Visual impairment was defined as the need for corrective lenses or blindness in one or both eyes. Hearing impairment was defined by hearing aid use in one or both ears. A composite outcome, neurodevelopmental impairment (NDI), was defined as one or more of the following: MDI<70, PDI<70, cerebral palsy, blind in both eyes, or hearing aids in both ears.

The Peabody Picture Vocabulary Test, 3rd Edition (PPVT-III) or both the Expressive One Word Picture Vocabulary Test (EOWPVT) /Receptive One Word Picture Vocabulary Test (ROWPVT) was administered at the 30 month visit to evaluate language skills. (16) The PPVT-III and the ROWPVT are both norm-referenced tests of receptive vocabulary. The EOWPVT is a test of expressive vocabulary which requires the child to name pictures presented on test plates. Raw scores for each test are converted to standard scores based on a mean of 100 ± 15 SD. Unlike the PPVT-III, the ROWPVT/EOWPVT is co-normed on a bilingual Spanish/English population and is designed to be administered in the patient's primary language. Children were classified as having a mild receptive language delay if scores on the ROWPVT or PPVT-III were between 70 and 84 and as a severe delay if scores were below 70. Similar classifications for expressive language delays were created for the EOWPVT.

To examine comparability of the groups of children receiving the PPVT-III versus the EOWPVT/ROWPVT, we conducted bivariate analyses of demographic characteristics of children according to language assessment received. Chi-square tests were used for categorical variables and analyses of variance for continuous variables. We explored possible differences in mean language scores by primary language spoken at home. Logistic regression models to identify significant predictors of receptive or expressive language delay at 30 months included gender, gestational age, birth weight, race/ethnicity, maternal education, income, feeding status, postnatal steroid exposure, BPD, and severe IVH or PVL. A series of linear regression models were conducted to explore the relationship between 30 month MDI controlling for demographics and 18 month feeding status. Outcomes were evaluated separately for the entire cohort and for the subset of children who identified English as the primary language.

Results

Of the 1433 children enrolled in the Glutamine study, 1024 (89%) were assessed at the 18 month follow-up visit and 740 (72%) were also assessed at the 30 month follow-up visit; 477 of these children had complete data for the language assessments with 467 of them

having English or Spanish as a primary language. Those who were lost to follow-up were more likely to be male ($p=.030$), white ($p=.037$), and have higher gestational age (GA) ($p < .001$). In our sample, 52% of infants were assigned to the Glutamine treatment group and 48% were controls, which is similar to the original study. Developmental and language outcomes were not affected by treatment group assignment to Glutamine. The sample had slightly more females (55%) with a large percentage of non-whites (40% black and 13% Hispanic or other) and the vast majority having English as their primary language (91%) (Table 1). There was a similar distribution across income levels and about half of mothers in each group had more than a high school education. Thirty percent received postnatal steroids, 43% had BPD, and 9% had IVH/PVL.

Although the language assessment was changed during the study period, a similar number of infants received each instrument (208 for PPVT-III and 249 for EOWPVT/ROWPVT). Ten children had both tools administered and all were classified consistently with respect to receptive language delay regardless of instrument was used.

Those receiving the PPVT-III were more likely to be of Hispanic or other race/ethnicity ($p < .001$), have Spanish as a primary language ($p = .004$), be born at higher weight ($p = .003$), and not have BPD ($p = .048$) (Table 1). There were no significant differences between the groups with respect to gender, gestational age, mother's education, income, postnatal steroids, or IVH/PVL.

Children receiving the PPVT-III were more likely to be classified as having a receptive language delay ($p < .001$) compared to those administered the ROWPVT. This difference remains significant even after controlling for demographic characteristics (OR (95% CI) = 2.44 (1.63, 3.64), $p < .001$). The difference in performance on these language outcome measures is not completely explained by our data analysis.

Fifty-five percent of the children in our cohort had some evidence of receptive language delay at 30 months with 23 percent having severe delays. Of the 259 children evaluated using the EOWPVT, (48%) had expressive language delays, with 30% of those being severe delays.

Overall, the group means for the ELBW infants are in the mildly delayed range on language assessment tools with mean scores ranging from 78 to 87 on the various tests administered (Table 2).

Children were evaluated in their primary language by a Spanish speaking examiner or with the assistance of an interpreter. Forty-one children were identified as having Spanish as their primary language; these children scored significantly lower than English speakers on all three language assessments: PPVT-III ($p=.002$), EOWPVT ($p < .001$), and ROWPVT ($p=.011$) (Table 2). About half (53%) of those with English as a primary language had delays in receptive language in contrast to delays among 85% of those with Spanish as a primary language ($p < .001$). Similar disparities were found for expressive delays. All Spanish speakers receiving the EOWPVT had delays compared to 53% among those with English as a primary language ($p = .002$). Although these differences were noted in unadjusted comparisons, in the regression analyses, primary language did not affect models to predict

receptive or expressive language delay at 30 months. Outcomes for only those children who identified English as the primary language are outlined in Table 3, 4 and 5.

A secondary goal of this analysis was to explore the association between a history of abnormal feeding behaviors at 18 months AA and language delay at 30 months. Forty-seven percent of the cohort required assistance with feeding at 18 months. After controlling for demographics, these children had twice the odds of receptive language delays (Table 3) and 2.5 times the odds of expressive delays (Table 4) at 30 months compared to those who were self fed. Other risk factors for receptive delays included being male, black or Hispanic, and having lower income. Non-whites were also at greater risk for expressive language delays.

The BSID-II was administered to study participants at 18 and 30 months. A significant correlation between the language assessment scores and the BSID-II MDI was anticipated as language items are included in the BSID-II cognitive scale. Linear regression models identified a strong positive relationship between MDI at each visit and receptive and expressive language delays, after controlling for feeding status and demographic characteristics (Table 5). A mild receptive language delay was associated with an 11-point decrease in MDI compared to children with no delay; this increases to a 21-point decrease among those with a severe delay (Model 1). Similarly, those with a mild expressive delay had scores of 12 points lower and those with severe delays had scores of 23 points lower compared to those with no delay (Model 4).

To ensure that the most severely disabled children were not influencing our interpretation of language and developmental performance at 30 months, we also ran the models after removing children with moderate/severe cerebral palsy. This adjustment in the model did not significantly alter the results (Table 5). The relationship between language delay and MDI at 30 months also persists even after controlling for MDI at 18 months.

Discussion

Although it has been challenging to develop predictive models for children at risk for long term language difficulties, early language development has been associated with concurrent and later cognitive functioning for various groups of at-risk children (9, 10, 18–20). Preterm infants have limited representation in most population based studies of language development which limits our current understanding of the natural history of language development in this population(21).

Our data suggest that ELBW infants are at significant risk for abnormal language development in early infancy. In fact, 64% of our cohort had evidence of language delay at 30 months AA, including 34% with severe delays. Affected infants were also more likely to have lower cognitive performance as measured on the BSID-II. Researchers have shown that many children with delayed language skills have recovery by school age(22); however, it is unclear if preterm infants with a higher risk of underlying brain injury follow the same trajectory.

Not surprisingly, infants in our cohort with evidence of neurodevelopmental impairment were at greatest risk for abnormal language development and they were significantly more

likely to have a history of dysfunctional feeding patterns in early infancy. These infants with central nervous system injury may be more likely to experience disruption in the maturation of critical neural pathways required for successful mastication (23) and their motor incoordination may affect both early feeding dysfunction and language delay.

We are intrigued by this relationship and further research is needed to determine if specific types of feeding dysfunction are more predictive than others. These data were obtained by parent report and review of the medical history; therefore, we were unable to further explore whether specific types of feeding abnormalities are more predictive. In an analysis of early feeding dysfunction and language performance measured using the BSID-III in a cohort of preterm infants, we previously reported a similar association between feeding dysfunction and language delay at 18 months AA.(24)

Structural and functional MRI technology has improved our understanding of the increased risk for abnormalities in brain structure and function in the preterm infant, including abnormalities in brain volumes, white matter injury and abnormal anisotropy.. (25, 26) Insults to the developing brain may disrupt these developing pathways. However, neural plasticity may result in recruitment of alternate pathways for various neural functions, including language processing skills making it difficult to identify clear relationships between insult and injury. In a comparison of patterns of connectivity between language centers in the brain at 8 years of age, Gozzo and colleagues found significantly different patterns of connectivity and increased cross-hemispheric connections to the right sided Broca's homologue and the supramarginal gyrus. These preterm subjects had significantly lower scores on all components of the Wechsler's Intelligence Scale for Children and the Peabody Picture Vocabulary Test-Revised(27).

In our cohort, infants with language delay had significantly lower MDI and PDI scores than infants with normal language skills. We anticipated correlation between BSID-II MDI scores and language performance because language items are embedded in the cognitive scale unlike the Bayley-III which separates the language and cognitive scores. The differences in motor performance were less dramatic yet statistically significant. Researchers continue to try to better understand how well the BSID-IIIR administered to preterm children in early childhood predicts school age outcome. There are concerns that the 3rd revision of this instrument overestimates performance in early childhood(28). Unlike the BSID-II which was used for our analysis, the BSID-III allows one to separate the language performance from cognitive performance. In a population based cohort analysis of preterm infants born in Sweden, preterm infants evaluated using the BSID-IIIR had lower scores in all areas assessed, including language (14.9% with receptive delays and 14.5% with receptive language delay) compared to term peers but these percentages are lower than what we have reported in our cohort(12). We are unable to speculate on how children in our cohort would have performed if evaluated with the BSID-IIIR.

The use of two different receptive language measures is a limitation of our study; however, one would expect similar outcomes on the PPVT and the ROWPVT since both evaluate receptive language using a similar format. Previous comparisons between these two language instruments have demonstrated that children may obtain significantly different

scores on the different tests. While receptive vocabulary scores are moderately correlated for groups of children (29, 30), an individual child's scores can vary widely from one test to the other (31, 32). We were limited in our ability to fully explore the relationship between MDI scores at 30 months and receptive language scores because only a subset of our cohort had both the PPVT and the ROWPVT administered.

In our analysis, infants had statistically significantly lower scores on the PPVT-III compared to the ROWPVT. This finding cannot be explained by differences in overall NDI since infants in the two groups had similar Bayley MDI and PDI scores and similar rates of NDI. The children in this study cohort were at the lower age limit of the normative sample for the PPVT-III, which suggests that obtaining a basal score may have been more difficult on the PPVT-III than the ROWPVT. Furthermore, these tests may be unequally sensitive to variations in visual-perceptual development involved in the interpretation of pictures as representation of objects, particularly for children at this young age (33). The PPVT-III uses black-and-white line drawings to reduce the impact of visual impairment or visual-perceptual factors; whereas, the ROWPVT/EOWPVT uses more detailed colored drawings. The importance of visual-perceptual skills in picture recognition may be of particular concern with this population as visual-perceptual delays are prevalent in children of extremely low birth weight (3, 33, 34). We have a limited ability to compare our findings to previously reported studies comparing language outcome measure on these two instruments because the children in our cohort were also younger than children in previously published studies (29–32).

The overall lower performance on both language assessment tools among the 9% of patients in our study cohort who identified Spanish as their primary language is concerning and requires further investigation. Our ability to perform additional analyses of this subgroup is limited by the small number of identified patients; however, the differences in outcomes are striking. A larger percentage of Spanish speaking patients were evaluated during the period that the PPVT-III was administered than when the ROWPVT was used ($p=0.001$) and it is unclear how this may be affecting our results. The PPVT-III is normalized based on a representative sample of the US population, unlike, the ROWPVT which is co-normalized on a bilingual US population. Nevertheless, Spanish speaking infants scored significantly lower than their English speaking peers regardless of the language instrument used, with performance scores an average of 12–22 points lower than English speaking peers. Forty-five percent of Spanish speaking infants scored in the severely delayed range for receptive language and 82% scored in the severely delayed range for expressive language. Bayley performance scores were similar to the rest of the cohort; however, even after adjustment for other sociodemographic variables known to impact ND outcome, Spanish as a primary language remained an independent predictor of abnormal language scores at 30 months. Other investigators have identified differences in patterns of language acquisition in various cultural groups (35, 36). These differences can represent testing bias due to the nature of tasks used to assess particular skills (37). Even simple tests of vocabulary development designed for monolingual language learners within a particular culture may not provide an accurate representation of the skills of children who are learning the same language within a different cultural context. Furthermore, word familiarity and difficulty level may differ between language groups. Duration of exposure to English was not measured in our cohort

but may have affected results as has been demonstrated by other investigators.(38) A similar association between ethnicity and language performance at 18 months on the BSID-III among a cohort of extremely preterm infants from the NICHD Neonatal Research Network by Lowe and colleagues(39). They reported significantly lower receptive and expressive language scores on the BSID III among preterm children who identified Spanish as the primary language even though the cognitive scores were similar to English speaking preterms.

We acknowledge the limitations associated with evaluating emerging language skills in a bilingual population. Children in our study were assigned to a single language group based on native language of their caregivers; however, many were learning language in a bilingual environment. Furthermore, neither group was homogeneous for sociocultural influences. There is some evidence to suggest that the lexical knowledge of bilingual children is not adequately reflected by monolingual tests in either language alone(40) (35) Due to these concerns regarding the validity of language assessment scores in this subgroup of Spanish speaking patients, we analyzed our data excluding non-English speaking patients to remove any confounding effect. Primary language did not affect the adjusted predictive models for expressive or receptive language delay at 30 months AA in this cohort. Additional research is needed to better understand acquisition of early language skills among preterm infant living in a bilingual environment.

Conclusion

Dysfunctional feeding behaviors in early infancy may help identify ELBW infants at risk for abnormal language development. Evaluation of longitudinal cohorts of ELBW infants are needed to better understand the relationship between feeding patterns, language impairment and cognitive dysfunction. Additional research is needed to explore the use monolingual language assessments in non-English speaking patients with a history of prematurity and correlations between Bayley-III language subscales administered in early infancy and school age performance.

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Data collected at participating sites of the NICHD Neonatal Research Network (NRN) were transmitted to RTI International, the data coordinating center (DCC) for the network, which stored, managed and analyzed the data for this study. On behalf of the NRN, Drs. Abhik Das (DCC Principal Investigator) and Carla Bann (DCC Statistician) had full access to all the data in the study and take responsibility for the integrity of the data and accuracy of the data analysis.

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NRN Chair: Alan H. Jobe, MD PhD, University of Cincinnati.

Alpert Medical School of Brown University and Women & Infants Hospital of Rhode Island (U10 HD27904) – William Oh, MD; Betty R. Vohr, MD; Angelita Hensman, BSN RNC; Lucy Noel, RN; Barbara Alksininis, PNP; Martha R. Leonard, BA; Rachel A. Vogt, MD; Teresa M. Leach, MEd CAES; Victoria E. Watson, MS CAS.

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Stanford University, Lucile Packard Children's Hospital (U10 HD27880, M01 RR70) – David K. Stevenson, MD; Barry E. Fleisher, MD; Susan R. Hintz, MD MS; M. Bethany Ball, BS CCRC; Joan M. Baran, PhD; Lori E. Bond, PhD; Carol G. Kuelper, PhD; Julie C. Lee, PhD; Renee P. Pyle, PhD; Nicholas St. John, PhD.

University of Alabama at Birmingham Health System and Children's Hospital of Alabama (U10 HD34216, M01 RR32) – Waldemar A. Carlo, MD; Myriam Peralta-Carcelen, MD; Kirstin J. Bailey, PhD; Fred J. Biasini, PhD; Stephanie A. Chopko, PhD; Monica V. Collins, RN BSN MaEd; Shirley S. Cosby, RN BSN; Vivien A. Phillips, RN BSN; Richard V. Rector, PhD.

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University of Miami Holtz Children's Hospital (U10 HD21397, M01 RR16587) – Shahnaz Duara, MD; Charles R. Bauer, MD; Ruth Everett-Thomas, RN MSN; Maria Calejo, MS; Alexis N. Diaz, BA; Silvia M. Frade, BA; Yamiley Gideon, BA; Kasey Hamlin-Smith, PhD; Silvia Hiriart-Fajardo, MD; Lisa Jean-Gilles, BA; Elaine O. Mathews, RN.

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University of Texas Southwestern Medical Center at Dallas, Parkland Health & Hospital System, and Children's Medical Center Dallas (U10 HD40689, M01 RR633) – Abbot R. Laptook, MD; Walid A. Salhab, MD; R. Sue Broyles, MD; Roy J. Heyne, MD; Susie Madison, RN; Jackie F. Hickman, RN; Alicia Guzman; Sally Adams, PNP; Linda Madden, PNP; Elizabeth Heyne, PA; Cristin Dooley, MS CIMI.

Wayne State University, Hutzel Women's Hospital, and Children's Hospital of Michigan (U10 HD21385) – Seetha Shankaran, MD; Yvette Johnson, MD; Rebecca Bara, RN BSN; Geraldine Muran, RN BSN; Deborah Kennedy, RN BSN; Laura Goldston, MA.

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Highlights

- Developmental outcomes at 18 and 30 months adjusted age in a cohort of extremely low birth weight children.
- Language performance was evaluated at 30 months.
- Children with a history of preterm birth are at risk for language delays in early childhood
- Feeding difficulties at 18 months is associated with expressive and receptive language delay at 30 months

Table 1

Selected Demographic Characteristics by Language Assessment

Variable	All N=467 N (Col %)	PPVT only N = 208 N (Col %)	EOW/ROWPVT only N = 249 N (Col %)
Gender			
Male	208 (45)	101 (49)	104 (42)
Female	258 (55)	106 (51)	145 (58)
Race/Ethnicity			
Black, not Hispanic	185 (40)	74 (36)	109 (44)
White, not Hispanic	223 (48)	92 (44)	124 (50)
Hispanic or Other	59 (13)	42 (20)	16 (6)
Primary language spoken to child			
English	426 (91)	181 (87)	236 (95)
Spanish	41 (9)	27 (13)	13 (5)
Gestational age...mean (SD)	26.2 (1.8)	26.4 (1.8)	26.1 (1.8)
Birth Weight (g) ...mean (SD)	798 (129)	819 (117)	783 (137)
Mother's Education			
Less than high school	103 (22)	49 (24)	53 (21)
High school graduate	130 (28)	61 (29)	66 (27)
Some college or more	224 (48)	93 (45)	126 (51)
Household Income			
< \$20,000	170 (36)	79 (38)	90 (36)
\$20,000–\$49,999	159 (34)	75 (36)	77 (31)
\$50,000	135 (29)	52 (25)	81 (33)
Postnatal steroids			
Yes	140 (30)	65 (31)	69 (28)
No	327 (70)	143 (69)	180 (72)
BPD			
Yes	200 (43)	77 (37)	115 (46)
No	267 (57)	131 (63)	134 (54)
Grade 3–4 IVH/PVL			
Yes	42 (9)	20 (10)	20 (8)
No	423 (91)	186 (89)	229 (92)
Feeding at 18 months			
Normal	248 (53)	107 (51)	114 (46)
Abnormal	218 (47)	100 (48)	135 (54)
Feeding at 30 months			
Normal	351 (75)	153 (74)	190 (76)
Abnormal	115 (25)	55 (26)	58 (23)
Neurodevelopmental impairment at 18 months			
Yes	111 (24)	51 (25)	60 (24)

Variable	All N=467 N (Col %)	PPVT only N = 208 N (Col %)	EOW/ROWPVT only N = 249 N (Col %)
No	331 (71)	151 (73)	171 (69)
Neurodevelopmental impairment at 30 months			
Yes	104 (22)	45 (22)	59 (57)
No	329 (70)	154 (74)	166 (52)
MDI at 18 months			
< 70	87 (19)	41 (20)	46 (18)
70–85	136 (29)	63 (30)	71 (29)
> 85	221 (47)	98 (47)	116 (47)
MDI at 30 months			
< 70	59 (13)	26 (13)	33 (13)
70–85	142 (30)	65 (31)	77 (31)
> 85	253 (54)	115 (55)	129 (52)
Receptive language delay			
None	203 (43)	71 (34)	123 (49)
Mild	148 (32)	67 (32)	80 (32)
Severe	106 (23)	70 (34)	36 (14)
Expressive language delay (Children receiving EOWPVT (N=224))			
None	100 (39)	--	93 (37)
Mild	47 (18)	--	44 (18)
Severe	77 (30)	--	77 (31)

Note: 10 children received both the PPVT and ROWPVT/EOWPVT. PPVT does not provide a score for expressive language. Numbers of children with missing values by variable are: gender (1), education (10), income (3), IVH/PVL (2), feeding at 18 and 30 mos (1), NDI at 18 mos (25), NDI at 30 mos (34), MDI at 18 mos (23), MDI at 30 mos (13), and receptive language delay (10).

Table 2

Mean Language and BSID-II Scores by Primary Language at 30 months

Measure	All		English		Spanish		p
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	
PPVT-III	218	78 (20)	190	80 (19)	28	67 (19)	0.002
EOWPVT	224	81 (19)	213	82 (19)	11	60 (10)	0.001
ROWPVT	249	87 (18)	236	88 (18)	13	75 (13)	0.011
Bayley MDI	454	87 (16)	413	88 (16)	41	80 (15)	0.003
Bayley PDI	433	90 (20)	393	90 (20)	40	92 (16)	0.574
<hr/>							
	N	N (%) with outcome	N	N (%) with outcome	N	N (%) with outcome	p
Bayley MDI < 70	454	59 (13)	413	51 (12)	41	8 (20)	0.193
Bayley PDI < 70	433	77 (18)	393	72 (18)	40	5 (13)	0.359
NDI	433	104 (24)	393	95 (24)	40	9 (23)	0.814

Note: Children were evaluated using their preferred primary language for all developmental evaluations.

Table 3

Logistic Regression Model of Receptive Language Delay at 30 Months: English Language Only

Variable	% with Receptive Delay	OR	95% CI	p
Feeding status at 18 months				
Eats with assistance/tube fed	60	1.96	1.22, 3.15	0.006
Feeds self	47	REF		
Treatment condition				
Glutamine	55	1.39	0.88, 2.20	0.156
Control	50	REF		
Gender				
Male	58	1.64	1.03, 2.60	0.035
Female	49	REF		
Birth weight (kg)	--	0.71	0.10, 5.30	0.741
Gestational age	--	1.18	1.01, 1.38	0.036
Race/Ethnicity				
White	35	0.31	0.19, 0.50	< 0.001
Non-White	71	REF		
Maternal Education Level				
Less than high school	73	1.94	0.95, 3.96	0.070
High school graduate	59	REF		
Some college or more	41	0.70	0.40, 1.21	0.200
Income				
\$50,000 or more	35	0.36	0.18, 0.69	0.002
\$20,000–\$49,999	47	0.45	0.26, 0.79	0.005
< \$20,000	73	REF		
Postnatal steroids				
Yes	56	1.21	0.68, 2.16	0.513
No	51	REF		
BPD				
Yes	55	1.82	1.08, 3.08	0.024
No	51	REF		
IVH/PVL				
Yes	57	1.40	0.61, 3.23	0.430
No	52	REF		

Note: N=400. REF=reference category. Percent represents the proportion of children with characteristic who have a receptive language delay.

Table 4

Logistic Regression Model of Expressive Language Delay at 30 Months: English Language Only

Variable	% with Expressive Delay	OR	95% CI	p
Feeding status at 18 months				
Eats with assistance/tube fed	67	2.52	1.26, 5.03	0.009
Feeds self	42	REF		
Treatment condition				
Glutamine	53	0.92	0.49, 1.74	0.803
Control	53	REF		
Gender				
Male	54	0.85	0.44, 1.64	0.633
Female	52	REF		
Birth weight (kg)	--	0.75	0.05, 12.11	0.836
Gestational age	--	1.06	0.86, 1.32	0.588
Race/Ethnicity				
White	34	0.23	0.12, 0.46	< 0.001
Non-White	75	REF		
Maternal Education Level				
Less than high school	70	1.67	0.59, 4.68	0.334
High school graduate	56	REF		
Some college or more	45	0.90	0.42, 1.92	0.784
Income				
\$50,000 or more	33	0.43	0.17, 1.07	0.070
\$20,000–\$49,999	55	0.73	0.31, 1.68	0.454
< \$20,000	74	REF		
Postnatal steroids				
Yes	55	0.90	0.40, 2.04	0.809
No	52	REF		
BPD				
Yes	50	1.12	0.55, 2.28	0.759
No	56	REF		
IVH/PVL				
Yes	60	1.19	0.32, 4.41	0.800
No	53	REF		

Note: N=208. REF=reference category. Percent represents the proportion of children with characteristic who have an expressive language delay.

Table 5

Linear Regression Models of MDI at 30 Months by Language Delays Controlling for Demographics and Feeding Status: English Language Only

Model/Variable	Reg coeff.	SE	p
Receptive			
Model 1: Receptive			
Severe Delay	-21.80	1.81	< 0.001
Mild Delay	-11.17	1.52	< 0.001
Model 2: Receptive + MDI			
Severe Delay	-15.36	1.83	< 0.001
Mild Delay	-7.33	1.46	< 0.001
MDI at 18 months	0.38	0.04	< 0.001
Model 3: Receptive + MDI (No CP)			
Severe Delay	-15.03	1.85	< 0.001
Mild Delay	-7.79	1.48	< 0.001
MDI at 18 months	0.35	0.04	< 0.001
Expressive			
Model 4: Expressive			
Severe Delay	-23.83	1.97	< 0.001
Mild Delay	-12.47	2.25	< 0.001
Model 5: Expressive + MDI			
Severe Delay	-16.78	2.01	< 0.001
Mild Delay	-9.30	2.06	< 0.001
MDI at 18 months	0.40	0.06	< 0.001
Model 6: Expressive + MDI (No CP)			
Severe Delay	-16.48	1.99	< 0.001
Mild Delay	-9.60	2.06	< 0.001
MDI at 18 months	0.39	0.06	< 0.001
Receptive and Expressive			
Model 7: Expressive + Receptive + MDI			
Severe Receptive Delay	-10.59	2.98	< 0.001
Mild Receptive Delay	-2.35	1.94	0.229
Severe Expressive Delay	-14.71	2.16	< 0.001
Mild Expressive Delay	-9.33	2.11	< 0.001
MDI at 18 months	0.35	0.06	< 0.001

Note: Reference category is no delay. Each model controls for feeding dysfunction at 18 months, treatment condition with Glutamine, gender, birth weight, gestational age, race/ethnicity, maternal education, household income, postnatal steroids, BPD, and IVH/PVL.