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Speech and language outcomes of children with bronchopulmonary dysplasia

Barbara A. Lewis[a,*], Lynn T. Singer[a], Sarah Fulton[a], Ann Salvator[a], Elizabeth J. Short[b], Nancy Klein[c], Jill Baley[a]

[a]*Department of Pediatrics, School of Medicine, Behavioral Pediatrics and Psychology 6038, Rainbow Babies and Childrens Hospital, Case Western Reserve University, 11100 Euclid Ave., Cleveland, OH 44106, USA*
[b]*Department of Psychology, Case Western Reserve University, Cleveland, OH 44106, USA*
[c]*Department of Education, Cleveland State University, Cleveland, OH 44115, USA*

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Abstract

A prospective follow-up of very low birth weight infants (VLBW) with ($n = 89$) and without ($n = 71$) bronchopulmonary dysplasia (BPD) and Term control children ($n = 93$) was conducted at 8 years of age. Groups were compared on measures of articulation, receptive and expressive language, verbal and performance IQ, oral motor skills and gross and fine motor skills. The BPD group demonstrated reduced articulation, receptive language skills, performance IQ, and overall gross and fine motor skills when compared to VLBW and Term groups. The BPD and VLBW groups did not differ on expressive language, oral motor skills, or verbal IQ. The groups also differed in enrolment in special classes and speech–language therapy, with almost half (48%) of the BPD group enrolled in speech–language therapy compared to 21% of the VLBW group, and 9% of the Term group. These results suggest that BPD may have adverse effects on speech development as well as on performance IQ, motor skills, and receptive language over and above the effects of VLBW.

Learning outcomes: (1) As a result of this activity the reader will be able to describe what BPD is and how it impacts speech and language. (2) As a result of this activity the reader will be able to discuss how children with VLBW with BPD differ from children with VLBW without BPD in their developmental outcomes.

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Keywords: Very low birth weight; Bronchopulmonary dysplasia; Prematurity; Language; Articulation

* Corresponding author. Tel.: +1-216-844-6204; fax: +1-216-844-6276.
E-mail address: bxl@po.cwru.edu (B.A. Lewis).

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1. Introduction

Prematurity has long been identified as a risk factor for speech and language disorders (Aram, Hack, Hawkins, Weissman, & Borawski-Clark, 1991; Briscoe, Gathercole, & Marlow, 1998; Tomblin, Smith, & Zhang, 1997). This association of prematurity to speech and language disorders may be due to multiple correlates of prematurity including socio-demographic factors such as socio-economic status, race, and maternal education, and perinatal and postnatal neurological and medical complications such as seizures, intraventricular hemorrhage (IVH), septicemia, neurological malformations, meningitis, and patent ductus arteriosis (PDA). Premature infants comprise a heterogeneous group of children who differ in the medical complications that they experience. The types and severity of the medical conditions may impact speech and language differentially.

The most common chronic medical complication of prematurity that may be associated with speech and language disorders is bronchopulmonary dysplasia (BPD), a chronic lung disease first described in 1967 by Northway, Rosan, and Porter. Preterm neonates with immature lungs who are treated with artificial ventilation and supplemental oxygen for severe respiratory distress syndrome (RDS) are at risk for BPD. BPD is one of the most common chronic lung diseases in infants in the United States with approximately 5000–10,000 new cases of BPD each year (National Heart, Lung, and Blood Institute, 1998). As more infants of very low birth weight (VLBW), i.e., less than 1500 g, survive due to advances in medical technology and neonatal intensive care, the incidence of BPD also increases (McAleese, Knapp, & Rhodes, 1993; McCormick, 1993; Paneth, 1995). The risk of BPD rises with decreasing birth weight such that 22% of infants weighing 1000–1500 g and 71% of all infants weighing <1000 g present with BPD (Northway, 1990).

BPD typically develops during the first 4 weeks after birth. The lungs are one of the last organs to develop in the fetus. The lungs of a premature infant have fewer alveoli and produce less surfactant (a lubricant) making the lungs abnormally stiff and unable to absorb sufficient amounts of oxygen to meet the baby's needs, resulting in RDS. Infants with RDS require oxygen and mechanical ventilation, which can leave the alveoli scarred or over inflated resulting in BPD (National Heart, Lung, and Blood Institute, 1998). BPD may be characterized by tachypnea (rapid shallow breathing), retraction of the ribs and chest, paradoxical respiration, and wheezing. Treatment for BPD is symptomatic including surfactant administration, supplemental oxygen and mechanical ventilation for RDS, and medications including bronchodialators, corticosteroids, diuretics, and antibiotics. Intravenous feeding and physical therapy is also required.

Very little is known about the long-term effects of BPD on development. Children with BPD are often smaller in size and more susceptible to illness than their peers (Singer, Yamashita, Lilien, Collin, & Baley, 1997). Abnormalities in coordination, muscle tone, vision and hearing (Sauve & Singhal, 1985), as well as learning disabilities, have been associated with BPD. Recent prospective longitudinal studies of outcomes of infants with BPD and VLBW have reported equivocal findings with

regards to language development. Hughes et al. (1999) found that 8–10 year-old children with VLBW and BPD performed more poorly than VLBW children without BPD on measures of verbal IQ and visual-motor integration, while another research team (O'Shea et al., 1996) found lower scores at 4–5 years of age for VLBW children with BPD and in comparison to VLBW children without BPD on performance IQ but not verbal IQ. However, these studies did not investigate language abilities apart from verbal IQ. A recent study by Singer et al. (2001) investigated receptive and expressive language skills in 3-year-old children with BPD while controlling for IQ. When IQ was controlled, children with BPD demonstrated impairment in receptive language skills compared to VLBW children without BPD.

In addition to language abilities, children with BPD may present with delayed speech sound development. Studies of children with low birth weight and prematurity have reported delays in phonological and articulatory development (Byers-Brown, Bendersky, & Chapman, 1986; Ross, Lipper, & Auld, 1985). Byers-Brown et al. (1986) examined 33 children with birth weights less than 1500 g (9–22 months old) on a speech sound rating scale and the Sequenced Inventory of Communication Development. They found that children with intraventricular hemorrhage (IVH) performed more poorly than children without IVH, although both groups showed delayed speech sound development. Ross et al. (1985) examined 94 children (3–4 years of age) with birth weights less than 1501 g on the articulation subtest of the Preschool Language Scale. Thirty-seven children (39%) were classified as demonstrating articulation deficits. To date, no study has reported on the articulation skills of children with BPD.

Several studies have described motor delays in children with BPD (O'Shea et al., 1996; Perlman & Volpe, 1989; Sauve & Singhal, 1985). Gross and fine motor delays as well as visual-motor integration difficulties have been associated with children with low birth weight (Hack, Klein, & Taylor, 1995). Motor outcomes in premature infants may depend on varying degrees of medical risk as well as environmental factors (McGrath & Sullivan, 1999). Fine motor, gross motor, and visual-motor integration skills, but not oral motor skills, at 4 years of age were directly correlated to the degree of perinatal medical risk experienced (McGrath & Sullivan, 1999).

In a prospective, longitudinal cohort study, children with history of BPD were compared to children who had been VLBW without BPD and to healthy Term controls at 8 years of age. By 8 years of age children generally have mastered the speech sound system of their language. Receptive and expressive language abilities and speech sound development, as well as gross, fine, and oral motor skills, and cognitive abilities were examined.

2. Methods

2.1. Participants

All infants with VLBW and BPD admitted to the neonatal intensive care units (NICUs) of hospitals in the Cleveland region were eligible for the study, and were

prospectively, consecutively recruited. For the approximately four county regions, all infants with BPD were cared for in the NICUs of the three participating hospitals that had the only Level 3 NICUs in the region, providing an exhaustive regional sample. BPD infants were preterm, <1500 g at birth, requiring supplementary oxygen for more than 28 days with radiographic evidence of chronic lung disease (Northway, Rosan, & Porter, 1967). A partial stratification sampling strategy was adopted to enrol adequate numbers of subjects without socio-economic disadvantage or severe neurologic risk so that these factors could be investigated in data analyses. Infants diagnosed with BPD who were free of neurologic problems other than grades I–II IVH, and who were not socially disadvantaged (i.e., Hollingshead classifications IV and V; Hollingshead, 1975), were exhaustively recruited. The remainder were randomly recruited by approaching the family of the next available BPD infant diagnosed who could be accommodated in the follow-up schedule. A research assistant in the NICU approached parents of infants with BPD as soon as possible after the diagnosis of BPD was made by the attending physician.

For each infant with BPD, the next born VLBW comparison infant without BPD of the same race and socio-economic status, born during the same time period, was recruited. Term infants were recruited from the newborn nurseries. Information about the study and return addressed postcards were left to all mothers in the nurseries. For each BPD infant enrolled, the next term infant equivalent in race and socio-economic status with a returned postcard indicating parental willingness to participate was recruited, if eligibility criteria were met. Infants with major congenital malformations or drug exposure, or whose mothers had major psychiatric or physical illness, human immunodeficiency virus or mental retardation, or who lived more than 2 hours driving distance, were excluded. VLBW infants without BPD were preterm, <1500 g birth weight, and required oxygen supplementation for less than 14 days. Term infants had no diagnosed medical illnesses or abnormalities at birth, were >36 weeks gestational age and >2500 g birth weight for singleton infants.

During the recruitment period, 250 infants with BPD were identified, of whom 89 were excluded (35 for drug/alcohol exposure, 21 for all other exclusions, 33 who could not be accommodated into the testing schedule and who were, by definition, all of lower socio-economic status, on public assistance), leaving 161 eligible VLBW infants with BPD. Twenty (12%) refused the study, 14 (9%) died before enrolment, 7 (5%) died after enrolment, and 5 (3%) were unable to be contacted leaving 115 enrolled infants of whom 103 (90%) were seen at 8 years.

Of 214 VLBW infants, 24 were excluded for drug/alcohol exposure, 34 for oxygen supplementation for 21–28 days, and 46 for all other exclusions, leaving 110 eligible VLBW infants without BPD, 8 (7%) of whom were unable to be contacted and 18 (16%) who refused the study. Of 84 recruited, 2 withdrew, and 1 was lost. One infant died at 2 years, leaving 75 (90%) at 8 years. Of 123 term infants, 6 withdrew, 5 were lost, 16 did not come for the visit and 95 (77%) were seen at 8 years. Groups did not differ by gender, race, socio-economic status,

maternal education, or marital status of parents. At follow-up at 8 years, group demographic and medical characteristics did not differ significantly from the sample recruited at birth.

The following neonatal medical and demographic information was obtained from the hospital chart: infant gestational age (based on both the date of the last menstrual period and the Ballard examination (Ballard, Novak, & Driver, 1979)), birth weight (g), length (cm), head circumference (cm), and Apgar scores at 1 and 5 min. The presence or absence of RDS, BPD, PDA, necrotizing enterocolitis (demonstrated, with or without surgery), septicemia, retinopathy of prematurity, and failed hearing screening was recorded, as well as the number of days of ventilator support and of supplemental oxygen, and peak bilirubin levels. Also noted was the presence or absence of the following neurologic abnormalities: minor neurologic malformations, seizures, echodense lesions, porencephaly, hydrocephaly, ventriculoperitoneal shunt, meningitis, and periventricular leukomalacia.

Cranial ultrasound studies were performed and reviewed by board certified radiologists, typically at 3, 10, and 28 days, as well as prior to discharge. A system for rating the severity of IVH was devised based on the extent of the lesion. A score of zero was used to indicate no hemorrhage. Identifiable lesions were graded on a scale from one to four, based on the criteria of Papile (Papile, Burnstein, Burnstein, & Koffler, 1978). At least one ultrasound study was available for all infants; ratings were based on the most severe lesion diagnosed. A total neurologic risk score was calculated for the above neurologic risk factors, wherein zero was used to indicate absence and one was used to indicate presence of neurologic risk.

2.2. Procedures

All children recruited at birth were invited to participate in the follow-up and scheduled for the 8-year follow-up visit. Assessments were completed in the behavioral laboratory of the Department of Pediatrics and administered by a masters level, licensed and certified speech–language pathologist. Families were reimbursed for transportation to the assessment and given a stipend of $100. The Institutional Review Boards of participating hospitals approved this study, and informed consent was obtained for all subjects.

The following measures were selected to assess the domains of articulation, language, cognitive ability, oral motor skills, and fine and gross motor skills. The Goldman–Fristoe Test of Articulation-Sounds in Words Subtest (GFTA; Goldman & Fristoe, 1986) was employed to assess articulation skills. This test elicits all consonant sounds of English in the initial, medial, and final position of words, as well as consonant blends in the initial position. A percentile score was employed in data analysis.

The Clinical Evaluation of Language Fundamentals-3 (CELF-3; Semel, Wiig, & Secord, 1995) assessed expressive and receptive language skills. Subtests included Sentence Structure, Concepts and Directions, Word Classes, Word Structure, Formulated Sentences, and Recalling Sentences. A total standard

score, expressive language score, receptive language score, and individual subtest scores were compared and utilized in data analysis.

The Test of Oral Structures and Functions (TOSF; Vitali, 1986) was employed to evaluate oral motor skills. The TOSF is comprised of five subtests: Speech Survey, Verbal Oral Functioning, Nonverbal Oral Functioning, Orofacial Structures, and a History Behavioral Survey. Standardized scaled scores are provided for each subtest. Scaled scores between 0.70 and 0.79 indicate borderline performance. Scaled scores between 0.80 and 0.89 indicate impaired functioning, and scaled scores between 0.90 and 0.99 indicate marked impairment.

The Bruininks–Oseretsky Test of Motor Proficiency-Short Form (BOMT; Bruininks, 1978) was used to assess fine and gross motor skills. The short form consists of 14 items drawn from the eight subtests that were found to correlate highly with both the subtest score and the total score. A percentile score was calculated for data analysis.

Cognitive abilities were determined by the Weschler Intelligence Scale for Children-III (WISC-III; Weschsler, 1991). Verbal, performance, and full-scale IQ scores were analyzed.

In addition, all children received a pure-tone audiometric screening the day of testing to ensure normal hearing acuity. Children with sensory neural hearing loss were eliminated from the study ($n = 7$). Only children completing the speech and language measures were included. Parent questionnaires and interviews were utilized to obtain information concerning school placements and enrolment in speech–language therapy.

3. Results

ANOVAs and chi-square (χ^2; for categorical data) were employed to compare groups on demographic and medical birth characteristics, and to compare the VLBW groups in the incidence of medical complications associated with preterm birth. To control for Type I errors, alpha levels were determined by Bonferroni corrections. As shown in Table 1, children with a history of BPD were smaller and more immature at birth than VLBW and Term control children. The BPD group had a higher incidence of neonatal seizures, PDA and IVH in the perinatal period. The groups did not differ in race, gender, socio-economic status, maternal education, and marital status.

To assess the effects of BPD and VLBW birth on speech, language, cognitive, and motor outcomes, ANOVAs were used to compare the three groups. Post hoc tests were employed to assess which groups differed from each other. Table 2 presents articulation, language, intelligence, and motor outcomes at 8 years of age for children with BPD, VLBW and Term controls. Children with a history of BPD achieved articulation scores (GFTA) that were significantly lower than the other two groups. VLBW children did not differ significantly from matched Term control children in articulation skills.

Table 1
Medical and socio-demographic characteristics at birth ($n = 253$)

Characteristic	Mean (S.D.)			χ^2	F	P
	BPD ($n = 89$)	VLBW ($n = 71$)	Term ($n = 93$)			
Birth weight (g)	970 (254)	1251 (179)	3467 (556)	–	1148	<0.0001
Gestational age (week)	27 (2.1)	30 (2.2)	40 (1.2)	–	1122	<0.0001
Total oxygen (days)	102 (165)	5.2 (5.1)	0 (0)	–	27	<0.0001
PDA	53%	18%	0	67.6	–	<0.0001
Neonatal seizures	10%	1%	3%	7.3	–	0.02
IVH						
1	19%	14%	0	59.6	–	<0.0001
2	10%	0	0			
3	12%	1%	0			
4	2%	1%	0			
None	56%	83%	100%			
Race (White)	56%	45%	54%	2.1	–	0.35
Gender (male)	53%	41%	48%	2.3	–	0.32
SES (Hollingshead)						
1	5%	4%	6%	5.6	–	0.70
2	12%	4%	9%			
3	30%	31%	26%			
4	34%	44%	43%			
5	19%	17%	16%			
Maternal education						
<High school	26%	29%	30%	3.5	–	0.47
High school	30%	22%	17%			
>High school	44%	49%	53%			
Marital status (married)	52%	49%	59%	1.6	–	0.44

Both the BPD group and the VLBW group differed from the Term controls on the receptive, expressive, and total language scores. The BPD group differed from the VLBW group on the receptive language measure, but not the expressive language score. Examination of the subtests of the CELF-3 revealed that the BPD group and the VLBW group differed from the Term controls on all subtests. However, the BPD group and the VLBW group showed significant differences only on the Concepts and Directions subtest (see Table 3).

Similarly, the BPD and VLBW group differed from the Term group but not from each other on verbal IQ. All three groups differed from each other on the performance and full-scale IQ, with the BPD group performing the poorest, followed by the VLBW group and the Term group achieving the best scores.

An examination of motor skills revealed that the BPD group differed from the Term control group but not the VLBW group on the oral motor measures. All three groups differed from each other in gross and fine motor skills as measured by

Table 2
Language, articulation, mental, and motor outcomes at 8 years ($n = 253$)

Measure	Mean (S.D.)			F	P
	BPD ($n = 89$)	VLBW ($n = 71$)	Term ($n = 93$)		
Articulation					
Goldman–Fristoe percentile[a,b]	56 (38)	78 (30)	79 (31)	13.1	<0.0001
Language					
Receptive[a,b,c]	90 (18)	97 (17)	105 (15)	17.9	<0.0001
Expressive[b,c]	92 (18)	95 (16)	103 (15)	10.6	<0.0001
Total[b,c]	90 (18)	95 (16)	104 (15)	15.4	<0.0001
Intelligence					
Verbal IQ[b,c]	89 (17)	95 (15)	102 (15)	15.5	<0.0001
Performance IQ[a,b,c]	83 (17)	90 (16)	102 (15)	30.7	<0.0001
Full IQ[a,b,c]	85 (17)	92 (15)	102 (15)	26.6	<0.0001
Oral motor skills					
Speech Survey[a,b]	78 (18)	72 (18)	70 (18)	5.9	0.003
Verbal oral[b,c]	60 (15)	59 (12)	54 (10)	6.7	0.002
Nonverbal[b]	74 (19)	68 (21)	63 (21)	6.1	0.003
Oral facial[b]	82 (13)	78 (16)	76 (15)	3.6	0.029
Gross and fine motor skills					
BOMT percentile[a,b,c]	42 (33)	58 (31)	70 (31)	17.7	<0.0001

[a] BPD group differed from VLBW group.
[b] BPD group differed from Term group.
[c] VLBW group differed from Term group.

the Bruininks Oseretsky Test of Motor Proficiency-Short Form. Again, the BPD group scored more poorly than the VLBW group, which scored more poorly than the Term control group.

Enrolment in special classes and speech–language therapy was examined for each group, as was the percentage of children meeting criteria for speech and language disorders. The percentage of children scoring 1 and 2 S.D. below the mean on the CELF-3 and the GFTA was calculated for each group. The number of children scoring in the impaired and marked impairment range on the Verbal Oral Functioning and the Nonverbal Oral Functioning subtests of the TOSF were tallied. Chi-squares were used to compare the percentages of children with speech and language impairments in each group. Enrolment in special classes and speech and language therapy at 8 years of age are reported in Table 4. The BPD group differed from the Term control group in the percentage of children enrolled in special classes. The groups did differ significantly in enrolment for speech therapy, with the BPD group reporting the largest percentage of children receiving therapy (48%), followed by the VLBW group (21%), and the Term controls with the fewest children in therapy (9%). To further examine the proportion of children falling within the disordered range for each group, the number of children scoring

Table 3
CELF-3 subtest outcomes at 8 years ($n = 253$)

Measure	Mean (S.D.)			F	P
	BPD ($n = 89$)	VLBW ($n = 71$)	Term ($n = 93$)		
Receptive subtests					
Sentence Structure standard score (SS)[b,c]	9.7 (3)	10.4 (3)	11.8 (3)	8.4	<0.0003
Concepts and Directions (SS)[a,b,c]	8.1 (3)	9.3 (3)	10.9 (3)	19.3	<0.0001
Word Classes (SS)[b]	8.0 (3)	9.0 (3)	10.0 (3)	10.1	<0.0001
Expressive subtests					
Word Structure (SS)[b,c]	9.6 (3)	10.0 (3)	11 (3)	8.0	<0.0004
Formulated Sentences (SS)[b,c]	7.6 (3)	8.3 (3)	9.7 (3)	12.8	<0.0001
Recalling Sentences (SS)	9.6 (3)	9.6 (3)	10.7 (3)	3.6	<0.03

[a] BPD group differed from VLBW group.
[b] BPD group differed from Term group.
[c] VLBW group differed from Term group.

between 70 and 85 and below 70 on the CELF-3, the number of children scoring between the 20th and 16th percentile and below the 16th percentile on the GFTA, and the number of children scoring in the impaired or marked impairment range on the Verbal Oral Functioning and Nonverbal Oral Functioning of the TOSF were compared. Significant differences were found in the number of children falling within the disordered ranges for the CELF Total, receptive and expressive language scores, the GFTA, and oral motor skills on the TOSF.

4. Discussion

Children with BPD showed reduced articulation skills, receptive language, PIQ and overall gross and fine motor skills when compared to VLBW and Term groups. These findings are in agreement with previous studies that reported differences between BPD and VLBW groups in motor skills and performance IQ (deRegnier, Roberts, Ramsey, Weaver, & O'Shea, 1997; Hughes et al., 1999; O'Shea et al., 1996; Singer et al., 2001). Although previous studies did not specifically examine articulatory or oral motor skills, reduced articulatory skills may be suggestive of an overall motor impairment. BPD may have a localized effect on brain development that encompasses fine and gross motor skills as well as visual-motor integration and visual-spatial skills (O'Shea et al., 1996).

The language deficits observed, however, may be related to more global problems of prematurity and not specifically to BPD. The BPD and VLBW groups differed from the Term group on both receptive and expressive language measures. However, the BPD group differed significantly from the VLBW group on receptive language only. This is in agreement with our earlier findings of receptive language deficits at preschool (Singer et al., 2001). An examination of

Table 4
Therapy and educational outcomes at 8 years ($n = 253$)

Measure	BPD ($n = 89$)	VLBW ($n = 71$)	Term ($n = 93$)	χ^2	P
Special classes[b]	21	17	9	5.1	0.08
Speech therapy[a,b]	48	21	9	37.8	<0.0001
Language disorders					
Total standard score[b,c]					
<70	10	4	2	28.1	0.0004
>70 <85	21	15	9		
Receptive standard score[b,c]					
<70	15	7	1	31.8	0.0001
>70 <85	17	21	10		
Expressive standard score[b]					
<70	9	8	4	25.8	0.001
<85	24	14	6		
Speech disorders					
Goldman–Fristoe percentile[a,b]					
<16	18	6	3	27.3	0.0001
>16 <20	12	3	4		
Verbal Oral Functioning[b]					
WNL	76	76	88	17.08	0.009
Borderline	8	13	9		
Impaired	8	11	3		
Marked impairment	7	0	0		
Nonverbal Oral Functioning[b,c]					
WNL	31	41	49	30.31	0.0001
Borderline	15	15	25		
Impaired	33	37	25		
Marked impairment	21	7	0		

[a] BPD group differed from VLBW group.
[b] BPD group differed from Term group.
[c] VLBW group differed from Term group.

the subtests of the CELF-3 revealed significant differences between the BPD and the VLBW groups only for the Concepts and Directions subtest. Children with BPD may have difficulty interpreting, recalling, and executing spoken directions of various length and linguistic complexity. However, other language impairments may be related to prematurity in general. Briscoe, Gathercole and Marlow (1998) suggest that premature children may have language impairment due to subtle disturbances of the brain arising from the complications of prematurity. The neurological underpinnings of language are complex and interface with other cognitive skills such as working memory (Grodzinsky, Shapiro, & Swinney, 2000). Thus, the functional neuroanatomy of language may extend beyond the traditional language centers, Wernicke's and Broca's areas in the brain, including

some bilateral representation of specific language functions (Hickok, 2000). Factors associated with VLBW such as IVH, minor neurological malformations, seizures, echodense lesions, meningitis, patent ductus arteriosus, and others may have global neurological effects that impact language development.

Differences among the groups in the rates of children enrolled in speech therapy were also noted with almost half of the BPD group (48%) enrolled in therapy compared to 21% of VLBW group and 9% of the Term group. It is difficult to interpret the role of speech therapy on speech, language and cognitive outcomes at 8 years of age as this study was not designed to assess the efficacy of therapy in this population of children. However, it may be assumed that speech therapy would serve to bolster a child's speech and language skills. Since a greater proportion of children with BPD received speech/language therapy, the differences between groups in speech and language abilities may actually have been reduced. Thus, our findings of group differences are robust.

Significant differences among groups were also observed for the percent of children in each group scoring greater than 1 S.D. below the mean on the language and articulation measures. The BPD group had more children scoring within the disordered range for both receptive and expressive language than the Term group. The BPD group did not differ from the VLBW group in the number of children scoring within the disordered range on the CELF-3.

Children with BPD were also more likely to score in the impaired range on the TOSF than children in the Term group. Examination of subtests showed that the greatest differences were observed on the Nonverbal Oral Functioning subtest which examines imitation of oral motor movements outside the context of speech. This finding provides additional evidence of a motor impairment in children with BPD.

These findings suggest that clinically significant neurodevelopmental effects of BPD may persist to 8 years of age and beyond. Researchers have disagreed as to whether or not the developmental effects of BPD persist past infancy and few studies have followed children to school age (O'Shea et al., 1996). A study by Vohr et al. (1991) found that full-scale IQ scores of 10–12 year-old children who had recovered from BPD did not differ from control children. However, another study of school-age children found that the mean performance IQ scores of children with BPD were significantly lower than those of Term controls. No differences were found between children with BPD and preterm children without BPD (Giacoia, Venkataraman, West-Wilson, & Faulkner, 1997). Yet another study of children with BPD at 8 years of age, found differences between VLBW children with and without BPD for verbal IQ and on a test of visual-motor integration (Hughes et al., 1999).

These apparent contradictory findings suggest that an IQ test may not be a sensitive measure of specific cognitive abilities including language and motor integration. Residual effects of BPD at school age may be specific to higher linguistic functions that may not be detected by verbal IQ scores. Subtle motor deficits that impact articulation will not be observed in performance IQ scores.

Further studies are needed to document specific linguistic, speech, verbal working memory, visual-motor, and cognitive deficits that may be associated with BPD in school-age children.

This study differs from previous school-age reports of children who experienced BPD during infancy as it reports on a large cohort of children followed prospectively from birth. No other study to date has reported articulation data, and most studies have assessed language outcomes by means of verbal IQ scores. Results demonstrated that BPD may be a risk factor for poor articulation and motor development at school-age. Children with BPD are more likely to be enrolled in speech and language therapy than children with VLBW without BPD. While language outcomes appear to be a function of prematurity itself rather than a specific risk condition, speech outcomes may be related to specific conditions such as BPD.

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Appendix A. Continuing education

1. Prematurity may be associated with speech and language disorders due to:
   a. Socio-demographic factors
   b. Perinatal neurological complications
   c. Postnatal neurological complications
   d. Septicimia
   e. All of the above
2. BPD is associated with all of the following EXCEPT:
   a. RDS
   b. Mechanical ventilation
   c. Birth weight greater than 1500 g
   d. Scarred and over inflated aveoli
   e. Surfactant administration
3. Developmental sequelae that have been reported for children with BPD include:
   a. Difficulties with visual-motor integration
   b. Learning disabilities

c. Poor verbal skills
d. None of the above
e. All of the above

4. The findings of the present study suggest that children with BPD and VLBW differ from children with VLBW without BPD in:
   a. Articulation skills
   b. Receptive language
   c. Performance IQ
   d. Motor skills
   e. All of the above

5. The BPD group differed significantly from the VLBW without BPD in:
   a. Number of children enrolled in special classes
   b. Number of children with language disorders
   c. Number of children enrolled in speech therapy
   d. Number of children with impaired verbal oral functioning
   e. All of the above

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