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Psychosocial Sequelae of BPD and VLBW – Phase 2

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Abstract:

There is a rapidly expanding population of very low birth weight (VLBW) children with bronchopulmonary dysplasia (BPD), yet there is scant literature documenting the long-term outcomes of these children, or the adaptation of their families. This study sample included 3 groups of subjects, with the first consisting of VLBW children with BPD, the second consisting of VLBW children without BPD, and a third matched control group of children born healthy full-term. Data had been previously collected at 5 time points from birth through child corrected age three years, and were collected again at 8 years of age for the current study. The sample has been well characterized with respect to sociodemographic, behavioral, neurologic, medical, and family characteristics.

Standardized instruments were used to assess school achievement and sensory-motor, cognitive, behavioral, and emotional function, and specific neuropsychological tests were used to measure visual-motor, executive, attentional, and phonological language functions related to specific learning disabilities. Qualified physicians performed medical examinations and pulmonary function studies. Self-report inventories were administered to mothers to assess psychological symptoms, parenting stress, family strains, perceptions of social support, and coping mechanisms.

Significant differences were found between groups in neuropsychological, motor, speech and language, pulmonary, and school program placement. Some differences in parental stress and family stress were found as well. Findings and implications are discussed.

Key Words:

Bronchopulmonary dysplasia
Very low birth weight
Development

Statement of the Problem:

Although medical advances over the past 3 decades have led to dramatic reductions in mortality rates for infants born at very low birth weight (VLBW; <1500 g), there has not been a concomitant reduction in morbidity, and the growing population of VLBW survivors is at substantial risk of chronic health problems and adverse developmental outcomes. Moreover, the incidence of bronchopulmonary dysplasia (BPD), a serious lung condition associated with VLBW, is rising, having grown from 7,000 cases annually in 1989 to > 11,000 cases per year in 2000. Despite the rapidly expanding population of VLBW children with BPD and the consequent growing impact on societal resources, there is scant literature documenting the long-term health, cognitive, academic, language, and psychosocial outcomes of these children, or the adaptation of their families. Investigation of the specific biological and environmental pathways that contribute to differential outcomes is vital to formulating policies and designing medical, social, and educational services that will effectively meet the on-going needs of these children and their families.

We have studied a cohort of VLBW children with and without BPD from birth, which has been well characterized with respect to sociodemographic, behavioral, neurologic, medical, and family characteristics. Our research has investigated the differential effects of bronchopulmonary dysplasia (BPD), VLBW, and associated medical, neurologic and sociodemographic risk factors on the pulmonary, cognitive, language, neuropsychological, and behavioral outcomes of these children through 3 years of age. Family strains, parenting stress, social supports, maternal psychological distress, maternal coping, and maternal-child interactions have been investigated as predictors and correlates of child outcomes, as well.

Research Objectives:

The 3-fold purpose of the study was to investigate a) the differential impact of VLBW and BPD, relative to other medical, neurologic, sociodemographic, psychosocial, and sociodemographic risk factors, on school-age children's health and pulmonary outcomes, school achievement, cognitive abilities, behavior, motor skills, and specific neuropsychological abilities; b) the complex, multidirectional relations among VLBW, BPD, child developmental outcomes, sociodemographic variables, family factors, parenting stress, maternal psychological status, maternal coping, social supports, and parent-child interaction; and c) change over time in VLBW and BPD-related child outcomes and maternal and family adaptation.
Hypotheses of the study were as follows:

Hypothesis 1: At 8 years of age, children with history of BPD and very low birthweight will continue to exhibit impaired functioning in comparison to cohorts of very low birthweight children without BPD and term, healthy children of similar age, race, sex, and socioeconomic status, when assessed on standard measures of physical health and growth, lung function, cognition, school achievement, language, behavior and specific neuropsychological abilities. These impairments will still be apparent when children with mental/motor retardation or frank neurosensory deficits are excluded.

Hypothesis 2: Parents of children with BPD will experience more symptoms of psychological distress, more parenting stress, and more overall life stress than parents of non-BPD, very low birthweight and term children at 8-year follow-up, controlling for race, sex, SES, and multiple birth. Interactions will be less optimal in BPD maternal-child dyads in comparison to VLBW or term dyads. More adaptive coping mechanisms and positive social supports will moderate distress symptoms for mothers of BPD and non-BPD, VLBW children.

Hypothesis 3: BPD, after consideration of other neurologic, medical, and socioeconomic risk factors, will account for independent variance in overall cognitive, motor and neuropsychological outcomes at 8 years, within the combined BPD and non-BPD very low birthweight groups.

Hypothesis 4: BPD and VLBW will have direct effects on child school achievement and indirect effects through their impact on both earlier and concurrent maternal distress and maternal child interactions.

Components of the model presented for the study will be tested through latent variable structural equation analyses, particularly to assess maternal psychological distress and mother-child interactions as mediators of the effects of infant risk status on various outcome domains.

Study Design and Methods:

This study employed a prospective, longitudinal quasiexperimental design. The sample included 3 groups of subjects, with the first consisting of VLBW children with BPD, the second consisting of VLBW children without BPD, and a third matched control group of children born healthy at Term. A randomized partial stratification sampling strategy was used to ensure enrollment of adequate numbers of subjects across socioeconomic groups. Dependent variables of interest included children's health, cognitive, school achievement, neuropsychological, language, and behavioral outcomes; and maternal psychological distress, parenting strain, perceived social support, coping, and evaluations of the impact of the child on the family. Independent and/or control variables used in various analyses included child neonatal risk status, i.e. the presence of BPD and/or VLBW (group), time (repeated measures), race, social class, multiple birth status, child age, length of hospitalization, severity of BPD (total days of oxygen supplementation), presence of medical problems, neurologic risk score, severity of IVH, and maternal IQ, marital status, and education.

Data had been previously collected at 5 time points from birth through child corrected age three years, and were collected again at 8 years of age for the current study. Standardized instruments were used to assess school achievement and sensory-motor, cognitive, behavioral, and emotional function, and specific neuropsychological tests were used to measure visual-motor, executive, attentional, and phonological language functions related to specific learning disabilities. Qualified physicians performed medical examinations and pulmonary function studies. Self-report inventories were administered to mothers to assess psychological symptoms, parenting stress, family strains, perceptions of social support, and coping mechanisms.

Subjects were recruited from a cohort of 302 8-year old children and their parents of BPD and VLBW infants. Subjects were followed at five previous points in time from birth, i.e. 1, 8, 12, 24 and 36 mos. (corrected ages), and were initially recruited from three Cleveland hospitals whose NICUs treated all infants with BPD in the greater Cleveland, Ohio region. The eligibility criteria for recruitment for BPD infants included birthweight < 1,500 grams, oxygen dependence > 28 days, and radiologic evidence of chronic lung disease. The comparison group of very low birthweight infants without BPD were born preterm, weighed < 1,500 grams birthweight, and required oxygen supplementation < 14 days. Term infants had no diagnosed medical illnesses or abnormalities at birth, were > 36 weeks gestational age, and > 2,500 grams birthweight for singleton infants. Infants whose mothers had known psychiatric illness, mental retardation or severe medical illnesses, were excluded. Infants were excluded if they had major congenital malformations, were cocaine exposed, or positive for HIV. For both comparison groups, exclusion criteria were the same as for the BPD group.

At 8 years, 278 subjects (104 (90%) subjects with BPD, 75 (90%) VLBW, and 99 (80%) term controls) were seen.

Findings:

<u>Neuropsychological and Motor Outcomes</u>: Results in the cognitive, neuropsychological and motor areas, the BPD group demonstrated deficits compared to VLBW and term children in intelligence; reading, mathematics, and gross motor skills; and special education services. VLBW children differed from term children in all of the above areas, except reading recognition, comprehension and occupational therapy. Attentional differences were obtained between BPD and term children only. The BPD group (54%) was more likely to be enrolled in special education classes than VLBW (37%) or term children (25%). In

addition, more BPD children (20%) achieved full scale IQ scores less than 70, in the mental retardation range, compared to either VLBW (11%) or term (3%) children, with all VLBW children significantly more likely than term children to achieve IQs in the subaverage category. After controlling for birth weight and neurological problems, BPD and/or duration on oxygen predicted lower performance IQ, perceptual organization, full scale IQ, motor and attentional skills, as well as special education placement. The qualitative classification of BPD (Present or Absent) was a significant predictor for lower scores on measures of applied problems, motor skills, and incidence of speech-language, occupational, and physical therapies.

Speech and Language Outcomes: In the area of speech and language, 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. 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.

Pulmonary Outcomes at School Age: We performed pulmonary function tests (PFTs) and administered standardized, normative cognitive, motor, attentional and language tests. Groups did not differ in Thoracic Gas Volume (TGV) or % predicted FVC, but children with history of BPD had lower FEV1, and % predicted FEF 25/75 than Term (p's $< .002$), and lower FEV1/FVC than VLBW and Term groups. Independent of race and SES, % predicted FEF 25/75 and FEV1/FVC were related to total days on oxygen (-.44 and -.38, $p < .0001$), child 8 year IQ (r's = .30 and .36, p's $< .002$), language (r's = .34 and .35, p 's $<$ .001), and motor scores (r's = .23 and .19, p's $< .05$).

BPD predicted subnormal pulmonary function at 8 years, even after asthma, gestational age, medical risk and other covariates were controlled for. More severe pulmonary abnormalities were also associated with poorer cognitive, language, and motor functioning. Moreover, pulmonary outcomes were not related to neurologic risk or SES, but were related to male gender.

Maternal/Family Outcomes: Analyses revealed significant group differences in maternal education, with mothers of VLBW children reporting fewer total years of education than mothers of Term children at 8-year follow-up. There were also group differences in intrafamily strains during the past year, including conflict among children, difficulty managing school-age children, and number of activities in which children were involved outside the home. Accordingly, maternal education and intrafamily strains were controlled in subsequent analyses if found to be significantly correlated with any of the outcome variables.

There were over all effects for group on Total Parenting Stress, Child Domain Parenting Stress, and maternal ratings of child Acceptability and Hyperactivity/Distractibility, controlling for maternal education and intrafamily strains during the past year. Post hoc analyses indicated that mothers of BPD children reported significantly greater total parenting stress and child domain parenting stress than mothers of VLBW children, and that BPD children were regarded as less acceptable than VLBW children and as more hyperactive and distractible than both VLBW and Term children.

Analyses showed significant effects for group on several subscales of the Impact on Family, including financial, personal, and family/social strains. Mothers of BPD children reported greater financial strains than mothers of Term children, greater personal strains than mothers of VLBW children, and greater family/social strains than mothers of both VLBW and Term children. Group differences also were found for the Denial and Mental Disengagement subscales of the COPE. BPD mothers used less Denial coping than VLBW mothers, and less Mental Disengagement coping than both VLBW and Term mothers. No group differences were found for maternal symptoms of psychological distress at child age 8 years.

Intrafamily strains during the past year were positively correlated with all BSI subscales and summary scores; Financial, Family/Social, Personal, and Total Impact on the Impact on Family; and all PSI scales except Attachment in the Parent Domain. Greater intrafamily strains also were correlated with more social support, as indicated by higher scores on all MSPSS scales, and with greater use of Focus on Emotions and Alcohol-Drug coping. Multiple birth was positively correlated with the Sibling subscale of the Impact on Family, and there was a trend (p=.06) toward a positive correlation between multiple birth and Humor coping. Maternal education was negatively correlated with the Phobic Anxiety, Paranoid Ideation, and Psychoticism subscales of the BSI; the Family, Friend, and Total Support subscales of the MSPSS; the Reinforces Parent, Acceptability, Sense of Competence, Role Restriction, Social Isolation, Parent Health, Distractibility-hyperactivity, Life Stress, Child Domain Stress, Parent Domain Stress, and Total Parenting Stress of the PSI; and the Planning, Seek Social Support for both Informational and Emotional Reasons, Positive Reinterpretation, Religion, Denial, and Behavioral Disengagement subscales of the COPE. Maternal education was positively correlated with Active, Suppression of Competing Activities, and Focus on Emotions coping. There was a trend (p=.06) for a positive correlation between maternal education and the Personal Strains subscale of the Impact on Family.

Recommendations:

The impact of VLBW and related conditions, such as BPD, has become a serious public health issue, as well as a compelling social problem, in the US. Policymakers should allocate funds to study the outcomes of VLBW children into adulthood, as well as the efficacy of various medical treatments and psychosocial and educational interventions, so that data can inform solutions.[1] Scientific evaluation is essential to assessing potential risk, creating innovative strategies, improving quality of services, enhancing outcomes, and conserving health care resources.[1-3] Federal laws should mandate that funds be made available for early intervention and continuing medical, educational, and psychosocial services for VLBW children with serious developmental disabilities, [1] and a commitment must be made to provide additional support to families.[2] Regionalized health-care services afford easy access, but policymakers must insure that such local facilities are staffed with medical and developmental specialists trained to assist with the particular needs and problems of VLBW children.[1]

Further studies are needed to document specific linguistic, speech, verbal working memory, visual-motor, and cognitive deficits that may be associated with BPD in adolescence and early adulthood. In addition, MRI and fMRI research could be instructive in helping to understand any underlying brain differences that could be correlated with the behavioral findings. Findings from these types of studies could help further instruct how early therapies might impact brain and behavioral development and how they are related to developmental risk.

References

1. Shiono, P.H. & Behrman *The problem of low birth weight, ch 1, Low birth weight*. The Future of Children (The David and Lucille Packard Foundation), 1995. **5**(1): p. 418.
2. Hauser-Cram, P., Warfield, M.E., Shonkoff, J.P., Krauss, M.W., Sayer, A., & Upshur, C.C. *Children with Disabilities: A longitudinal studyof child development and parent well being*. Monographs of the Society for Research in Child Development, 2001. **66**(3:i-viii): p. 1-114; Discussion 115-126.
3. Berlin, L.J., Brooks-Gunn, J., McCarton, C., & McCormick, M.C. *The effectiveness of early intervention: Examining risk factos and pathways to enhanced development*. Preventive Medicine, 1998. **27**(2): p. 238-245.

For List of Products, please see section VI, pages 22-25 of the Final Report.

I. Introduction

A. Nature of the Research Problem

Although medical advances over the past 3 decades have led to dramatic reductions in mortality rates for infants born at very low birth weight (VLBW; <1500 g), there has not been a concomitant reduction in morbidity, and the growing population of VLBW survivors is at substantial risk of chronic health problems and adverse developmental outcomes. Moreover, the incidence of bronchopulmonary dysplasia (BPD), a serious lung condition associated with VLBW, is rising, having grown from 7,000 cases annually in 1989 to > 11,000 cases per year in 2000. Ninety percent of infants who develop BPD are born at VLBW, and VLBW children with BPD, compared to VLBW children without BPD, are more vulnerable to cognitive, language, and motor delays; neurosensory deficits; behavioral problems; and chronic pulmonary disease. Mothers of VLBW infants with BPD are at increased risk of experiencing higher levels of parenting stress and more clinically significant symptoms of psychological distress [1] and interacting with their children in less congruent ways [2]. Despite the rapidly expanding population of VLBW children with BPD and the consequent growing impact on societal resources, there is scant literature documenting the long-term health, cognitive, academic, language, and psychosocial outcomes of these children, or the adaptation of their families. Investigation of the specific biological and environmental pathways that contribute to differential outcomes is vital to formulating policies and designing medical, social, and educational services that will effectively meet the on-going needs of these children and their families.

We have studied a cohort of VLBW children with and without BPD from birth, which has been well characterized with respect to sociodemographic, behavioral, neurologic, medical, and family characteristics. Our research has investigated the differential effects of bronchopulmonary dysplasia (BPD), VLBW, and associated medical, neurologic and sociodemographic risk factors on the pulmonary, cognitive, language, neuropsychological, and behavioral outcomes of these children through 3 years of age. Family strains, parenting stress, social supports, maternal psychological distress, maternal coping, and maternal-child interactions have been investigated as predictors and correlates of child outcomes, as well. This cohort has offered a unique opportunity to extend our investigation by assessing the differential effects of VLBW, BPD, and associated risk factors, such as lower social class and minority race, on child and family outcomes when the children reach school age.

B. Purpose, scope and methods of the investigation

The 3-fold purpose of the study was to investigate a) the differential impact of VLBW and BPD, relative to other medical, neurologic, sociodemographic, psychosocial, and sociodemographic risk factors, on school-age children's health and pulmonary outcomes, school achievement, cognitive abilities, behavior, motor skills, and specific neuropsychological abilities; b) the complex, multidirectional relations among VLBW, BPD, child developmental outcomes, sociodemographic variables, family factors, parenting stress, maternal psychological status, maternal coping, social supports, and parent-child interaction; and c) change over time in VLBW and BPD-related child outcomes and maternal and family adaptation. The study sample comprised a cohort of 302 children (110 VLBW with BPD, 80 VLBW without BPD, and 112 healthy, Term) and their mothers, initially recruited from the neonatal intensive care units (NICUs) of 3 different hospitals in a 4-county region in the Midwest. All infants were born after the routine use of surfactant and steroid therapies in neonatal care, and all were prospectively, longitudinally followed from birth through child age 3 years. Studies were funded through two separate grants from the NIH and the Maternal and Child Health Bureau (NIH HL38193 and MCJ390592). Data were collected previously at 1, 8, 12, 24, and 36 months, and at 8 years for the current study. Standardized assessments of school achievement, sensory-motor function, cognitive, behavioral, emotional, and functional abilities were conducted. Specific neuropsychological tests documented visual-motor, executive, attentional, and phonological language functions hypothesized to be related to specific learning disabilities. Medical examinations and pulmonary function studies were

performed by expert physicians. For mothers, self-report instruments were used to describe psychological symptoms, parenting stress, family strains, perceptions of social support, and coping mechanisms.

Although VLBW occurs three times more frequently in children born to mothers of minority race and lower social class [3], white, middle class mothers have been over-represented in most other studies. Our cohort is unique in that it is sociodemographically representative of the VLBW population, and the sample is large enough to allow assessment of the effects of racial and socioeconomic factors on outcomes. In addition, most other research has not included a control group, whereas our cohort includes a matched group of healthy, Term children and their mothers to afford the opportunity for normative comparisons.

C. Nature of the findings

Findings indicated that BPD has an independent effect on certain developmental outcomes of children over and above the effects of VLBW, even after controlling for other variables, such as gestational age, neurologic risk, and sociodemographic factors. Results also showed that BPD differentially affects maternal adaptation and functioning, as well as maternal-child interactions. Specific findings are explored below, in section **IV**.

II. Review of the Literature

Very Low Birth Weight Birth: Over 57,000 very low birth weight (VLBW; < 1500g) infants are born annually in the U.S.,[4] and increasing numbers survive due to recent advances in neonatology and biomedical technology.[3, 5, 6] Substantial research indicates that VLBW cohorts have more neurosensory abnormalities,[7-9] and perform more poorly than full-Term cohorts in growth, general cognitive abilities, specific neuropsychological functions, and behavioral competence. [10-15] Differences in IQ increase with decreasing birth weight,[10, 13, 14, 16, 17] and persist even when children with frank neurological abnormalities are excluded. Some specific neuropsychological outcomes, such as attention, memory, visual-motor skills,[13, 14, 18, 19] memory and processing speed,[20, 21] may be more compromised than others. Epidemiological studies have also linked VLBW birth to increased incidence of cerebral palsy [22, 23] and to higher risk for severe mental retardation in childhood. One recent prospective, population-based study of infants born at 20–25 weeks of gestation revealed that >50% had significant neurologic and developmental disabilities when assessed at 30 months corrected age.[24-27] At preschool-age, VLBW children lag behind full-Term preschoolers in speech and language development, even when IQ, sociodemographic factors, and medical risk factors are controlled.[25-27] Rivkin[28] suggested that neurodevelopmental deficits associated with VLBW become more apparent with increasing age of the child. Follow-up studies indicate that, by school-age, preterm children encounter greater cognitive, psychological, and motor impairments, including attention disorders, behavior problems, learning disabilities, poor motor coordination, and deficits in language and social skills,[10, 17, 29-31] and are at significantly greater risk for grade repetition, special education placement, and use of school-based services than full-term matched controls.[17, 31-37]

Because of an increasing demand for health care, social, and educational services for the growing population of VLBW survivors and their families, and the great variation in the developmental sequelae of VLBW, delineation of specific medical and environmental factors that contribute to poorer outcomes has become an important focus of concern. Factors implicated in developmental studies have included neurologic complications such as IVH and PVL;[38-40] lower birth weight or gestational age;[13] necrotizing enterocolitis, steroid use to reduce inflammation, and infant gender;[41] postnatal transport to NICU, maternal race and marital status;[33] lower socioeconomic status;[15, 33] maternal-child interactions,[42-45] and maternal psychological distress.[42, 46] In addition, severe chronic lung disease, i.e., BPD, has been noted to be a prominent factor leading to increased morbidity among VLBW cohorts.[26],[46-53]

Bronchopulmonary Dysplasia: BPD is a serious, chronic pulmonary condition that has emerged in the past 15 years as the leading cause of chronic lung disease (CLD) in infancy in the U.S.[54] Medical and technological advances have reduced mortality for VLBW infants but have resulted in a corollary increase in survivors with BPD.[55] The incidence of BPD climbs with decreasing birth weight and approximates 22 percent of infants weighing 1,000 – 1,500 grams and 71 percent of all infants weighing <1,000 grams.[56, 57]

BPD was first described in 1967 by Northway, whose diagnostic criteria for this condition included the neonate's sustained need for oxygen supplementation >28 days and radiologic evidence of lung abnormalities related to premature birth, respiratory failure, oxygen toxicity, and barotrauma associated with prolonged mechanical ventilation[56] . Recent research has implicated a variety of risk factors for development of BPD, including patent ductus arteriosus (PDA), prenatal intrauterine infection or postnatal nosocomial respiratory infection, sepsis, fluid overload, and deficiencies in antioxidant vitamins.[58-64] In addition to exerting harmful effects on pulmonary outcomes, BPD is linked to processes shown to be deleterious to neural development, such as hypoxia, alterations in neurotransmittors, and nutritional deficiencies, which may result in specific functional deficits, dependent on the nature, degree, and timing of the insult.

Pulmonary Outcomes: Characteristic pulmonary changes seen in BPD lung specimens include decreased alveoli, interstitial edema, fibrosis, bronchial and bronchiolar mucosal hyperplasia, smooth muscle hypertrophy, and reduced vascular branching.[60, 61, 65] VLBW infants with BPD suffer prolonged oxygen dependence, hypoxemia, hypercarbia, and congestive heart failure, and experience persistent respiratory symptoms such as bronchospasm, tachypnea, rales, and intercostal retractions.[54] BPD has been related to small airway injury and a higher incidence of lower respiratory tract infections, including respiratory syncytial virus (RSV), pneumonia and bronchitis early in life, as well as to chronic lung structure abnormalities, increased airway resistance and reactivity, reduced pulmonary function, and decreased exercise tolerance in children from preschool age through early adolescence and even into adulthood.[50, 58, 66-70] [26]Northway et al.[70] found that 22 former BPD preterm survivors seen at 14 – 23 years had significant pulmonary dysfunction compared to controls, suggesting that preterm infants with BPD may be at increased risk for obstructive airway diseases later in life. Pulmonary dysfunction and decreased exercise tolerance may limit BPD children's opportunities to develop gross motor skills, contributing to deficits in motor outcomes found in our study cohort now and at three years of age.

Burgeoning research documents the long-term deleterious effects of BPD on respiratory function. A prospective follow-up study[71] of 103 VLBW children at age 5 years found oxygen dependence at age 28 days to be the only independent positive predictor of subsequent adverse respiratory outcomes. Children with lung function abnormalities, such as raised airway resistance and low functional capacity/thoracic gas volume ratio, were distinguished from children without respiratory morbidity by having required respiratory support neonatally >28 days. Sadeghi et al.[69] found more pulmonary abnormalities in 11 children with BPD between the ages of 5–8 years old compared to 32 age and height-matched children with asthma. Gross et al.'s[67] prospective, longitudinal study of 43 preterm children with BPD, 53 preterm children without BPD, and 108 sociodemographically matched full-Term healthy controls found that, at age 7 years, preterm children with BPD demonstrated abnormal pulmonary function, while preterm children without BPD were comparable to the control group. Jacob et al.[68] reported similar findings. At 11 - 12 years old, children with history of BPD had distorted pulmonary architecture on radiographic examination, as well as persistent obstructive airflow and gas-trapping. Longer duration of oxygen dependence neonatally, rather than birth weight or prematurity, predicted long-term abnormalities in lung function. Similarly, Giacoia et al.[50] found evidence of obstructive lung disease in 12 BPD children at 11-14 years of age compared with full-term controls, but no significant differences between the preterm without BPD and full-term groups.

In the largest study to date,[72] 11 years, VLBW children were shorter and lighter than controls, with significantly reduced lung function, while children with a neonatal diagnosis of BPD had the lowest pulmonary expiratory flows. Other data, however, indicate that VLBW, rather than BPD, predicts long-term respiratory problems,[73] indicating the need for further studies to resolve inconsistencies in the long-term effects of BPD on pulmonary function.

Long-term Developmental Outcomes: Long-term neurodevelopmental outcomes of VLBW infants with BPD has become a growing concern, because the rapidly developing fetal and postnatal brain may be particularly vulnerable to the harmful effects of both primary lung disease and its associated treatment-related insults and side-effects. The pathophysiology that leads to infants with BPD having greater developmental delay is probably multifactorial and may include chronic, intermittent hypoxia, growth deficiencies, and altered environmental stimulation.[74, 75]

Inadequate nutrition also contributes significantly to adverse developmental outcomes in VLBW infants with BPD.[54, 61] Preterm infants are typically deficient in essential micronutrients, including those which promote lung tissue growth and repair, normally transported from mother to developing fetus during the third trimester of pregnancy.[61, 76, 77] The metabolic expenditure and nutritional demands of BPD infants are greatly increased due to the arduous work of breathing and the physiological processes of fighting infection and repairing damaged lung tissue,[76, 78] yet caloric intake is markedly limited due to the neonate's oral feeding problems,[42, 79] and the fluid restrictions required to treat the pulmonary edema frequently associated with BPD.[78] Singer et al.[42] found that VLBW infants with BPD spent less time sucking and ingested less formula at each feeding than VLBW infants without BPD, and depressed mothers tended to prompt their infants to eat less often during feeding [2]. Nutritional deficiencies compromise lung defenses and healing capacities [54, 76, 77], impede normal growth and development [61, 78, 80, 81], and have a detrimental effect on brain development.[81-84]

Central Nervous System: BPD usually occurs initially in the third intrauterine trimester, when cerebellar growth is particularly rapid and neural development is vulnerable to the alterations in blood gases and undernutrition characteristic of BPD. Central nervous system pathology in infants with BPD shows brain atrophy and gliosis compatible with chronic hypoxia. Prolonged ventilator and oxygen dependence may result in repeated episodes of hypoxia and acidosis, leading to hypoxic-ischemic cerebral injury[78, 84, 85] that preferentially damages primary sensory and forebrain motor systems,[54] and leads to cognitive, motor, and attentional deficits. Clinically unsuspected hypoxia during sleep, sleep apnea and hypoxic airway constriction have been reported in infants with moderate to severe BPD.[86, 87] Recurrent oxygen desaturations have been observed during and immediately after oral feedings in patients with BPD who have been previously discharged from the hospital after weaning from supplemental oxygen.[86, 88] Northway[56] originally perceived that BPD might have significant neurological ramifications. More recently, Volpe[80] suggested that the spectrum of long-term neurological correlates in infants with BPD includes selective neuronal injury, and noted that there are abnormalities in dendritic development and structure in the medulla oblongata of ventilator-dependent premature infants.

The fetal and postnatal neurologic alterations described above, in conjunction with other risk factors, may contribute to poorer outcomes in VLBW infants with BPD [65, 67]. A number of investigations of the sequelae of BPD in the preschool years have found significant developmental delays relative to other VLBW and full-term children.[26, 89] Several of these studies attempted to assess the effects of BPD relative to neurological complications and other social or demographic factors which correlate with poor outcome. Bozynski et al.[90] found that prolonged mechanical ventilation consistent with BPD was the best independent predictor of mental and motor outcomes at 18 months of age. Although not focused specifically on BPD, a recent study [91]found number of days on a ventilator neonatally and oxygen dependence at 36 weeks to be

significant correlates of cerebral palsy and other neurological impairment in a large cohort of 20 month-old children who had been born at VLBW.

DeRegnier et al.[48] studied outcomes of 174 VLBW infants born in the post-surfactant era who had no ultrasonographic evidence of IVH neonatally. The infants were categorized into 3 groups based on duration of oxygen supplementation they had required neonatally, with VLBW infants who had received supplemental oxygen at 28 days classified as having mild BPD, infants who had required oxygen at 36 weeks classified as having severe BPD, and infants breathing room air at 28 days classified as having no lung disease. At 1 year, infants with severe BPD were shorter and lighter, and rehospitalized more often than infants with mild or no BPD. Adjusting for medical and sociodemographic confounds, 89% of adverse outcomes were independently predicted by mild or severe BPD.

In our current prospective, longitudinal investigation, 122 infants with BPD were followed from birth and seen at 1, 8, 12, 24, and 36 months (corrected ages) and now 8 years, and compared to cohorts of VLBW infants without BPD and Term healthy controls.[46,52] BPD was defined on an accepted standard,[56] all infants had at least one cranial ultrasound, and medical and neurologic conditions associated with BPD were characterized. Study groups were equivalent on racial, demographic, and socioeconomic factors known to relate to outcome, and infants with other medical risk factors, including drug exposure, were excluded. Infants were born after recent innovations in neonatal care, such as surfactant and steroid management, became common practice. In this study, infants with BPD had more neurologic problems and were smaller in birth weight and gestational age than the VLBW control group, but the large sample allowed for statistical control of these factors in multivariate analyses. At all ages, BPD infants performed more poorly than the other two groups in mental and motor outcomes. After controlling for confounding risk conditions, including prematurity and neurologic risk, BPD predicted significant independent variance in motor outcome, accounting for a 10 - 12 point decrement in the psychomotor development index (PDI) of the Bayley Scales of Infant Development. Mental Scale scores were predicted by SES, racial and neurologic factors, suggesting that BPD has specific effects on the motor domain and that the postnatal environment is an important contributor to cognitive outcomes. Differences between BPD and non-BPD VLBW children persisted even when those with severe sensory handicaps and neurologic or SES risks were excluded.

Increasing research suggests that BPD may have long-term effects on children's development and specific neuropsychological functions at school age, and may be implicated in the high rate of learning disabilities in VLBW cohorts at school age. Although their focus of inquiry was not BPD, per se, Robertson et al.[34] found lower IQs associated with longer duration of supplemental oxygen in an 8 year follow-up. Likewise, Hack et al.,[13] found mental retardation at school age to be associated with prolonged oxygen dependence from BPD, even after birth weight and other neonatal complications were controlled. Vohr and colleagues[53] followed a cohort of 15 BPD survivors to 10- 12 years. Children with BPD neonatally had more neurologic abnormalities, poorer motor scores, and lower visual motor scores than full-Term but not preterm controls. Children who had BPD had smaller head circumferences, but their learning disabilities and special education needs were similar to VLBW controls. However, this study had no information from cranial ultrasounds to assess early neurologic complications and was too small for multivariate analyses.

O'Shea[92] compared 31 VLBW children who had recovered from CLD with 31 VLBW controls at 4 – 5 years and found significant differences in cognitive development that remained even when children with IVH neonatally or neurological abnormality at age 1 year were excluded and other sociodemographic and physical/medical variables were controlled. Children who had been VLBW with CLD had significantly lower IQ scores and a higher proportion of IQ scores <70. Majnemer et al.[47] sought to determine whether children with a history of prematurity and BPD and who had required home oxygen therapy were at greater risk for neurological and motor deficits at school age than preterm, non-BPD peers. Twenty-seven BPD children and 27 matched preterm controls were assessed at about 10 years of age, and the incidence of

neurological abnormalities, such as cerebral palsy, microcephaly, and behavior problems, was found to be 71% versus 19%, respectively. Greater than 50% of the BPD children had gross and fine motor skills deficits. Duration of initial hospitalization and home oxygen use, and decreased lung function were correlated with motor outcomes.

Hughes et al.[49] examined 3 groups of 8 – 10 year-old children to determine whether a history of BPD adversely affected cognitive performance at school age. Children who had been VLBW infants with BPD had the poorest performance on 8 year outcome measures, with significantly poorer full scale and performance IQ, visual-motor integration, reading, and math scores, than children who had been VLBW without BPD or children who had been full-term. The effects of BPD persisted even when potentially confounding medical and sociodemographic variables were controlled. One important limitation to this study was that neonatal diagnoses of intracranial hemorrhage (ICH) were made based on clinical findings rather than on cranial ultrasonography, and presence of ICH was recorded with a yes/no response, with no distinction for differing grades of ICH. In addition, as infants with clinical manifestations of ICH likely had more severe pathology, infants with lower grades of ICH may have been missed.[49] Hughes et al.[49] noted that this may have influenced findings concerning visual-motor outcomes. Another limitation to the study was lack of data on maternal substance abuse and prenatal drug exposure.

Another follow-up study[50] of matched cohorts (n = 12), of 11 –14 year olds who were born preterm with BPD, preterm without BPD, and full-term found that children in the BPD group scored significantly lower than children in the Term group on performance and full-scale IQ tests. Significantly higher proportions of preterm children with and without BPD had borderline or intellectually deficient verbal and full scale IQ scores compared to the Term children. A higher proportion of BPD children had borderline or intellectually deficient performance scores compared to the Term children, whereas preterm children without BPD did not differ from full-term children. BPD children were shorter and had less lean body mass, lower bone mineral content, more frequent rehospitalizations for respiratory problems, and poorer pulmonary function than either the preterm or full-term children. Shortcomings of the study include small sample size, cross-sectional design, and maternal report of respiratory illness.

Environmental and Family Factors as Mediators/Moderators of Outcome: Emerging research underscores the importance of assessing the behavioral and psychological functioning of preterm infants, in conjunction with their cognitive and motor performance, and considering the sociodemographic and family factors that may moderate or mediate long-term developmental outcomes. Resnick et al.[33] examined approximately 10,000 children in kindergarten - third grade who were graduates of 9 level III NICU's in Florida, and found that placement in standardized, statewide special education disability categories was influenced differentially by perinatal and sociodemographic factors. Perinatal factors, including VLBW, transport to a NICU, ventilation, and medical conditions such as IVH, seizures, and congenital anomalies, were associated with placement in sensory impaired, physically impaired, and mentally handicapped categories, whereas sociodemographic factors, including child's sex, family income, and mother's race, marital status, and education, were associated with placement in emotionally handicapped and speech/language impaired classes.

Klebanov, Brooks-Gunn, and McCormick[30] investigated the effect of birth weight on classroom behavior among 326 NBW children and 674 low birth weigh (LBW) children, including 137 extremely low birth weight (ELBW), 223 VLBW, and 434 heavier low birth weight (HLBW), from a stratified random sample of births in multi-site geographically defined areas. Children's teachers provided assessments of language and attention in the classroom, behavior problems, and social competence. All LBW children had lower attention, language and social competence and higher daydreaming and hyperactivity scores than NBW children, and the classroom behavior of all LBW children was rated as poor, even if children were at grade level academically. Maternal depression, home environment, race, and maternal education were

significantly associated with social competence. Race, gender, and maternal education were associated with behavior problems, language and attention scores. White children with more educated mothers had higher competency scores, and girls had fewer behavior problems. In the present cohort, we (Singer et al.[26]) found that low social class and minority race, in addition to BPD, PDA, and neurological complications, were significant predictors of language delays for VLBW children at 3 years of age.

Studies have suggested that VLBW children may have increased rates of behavioral and emotional problems even when only neurologically intact children are considered. For example, Breslau, Klein, and Allen[11] found 9 year old boys with history of VLBW to have more emotional distress and conduct disorders and less social competence than matched controls. Hoy et al.[93] reported similar findings in 183 6 - 9 year olds in Ireland. The only study of BPD children compared 15 BPD children from ages 10-12 years to VLBW and Term children and found the BPD children to have more externalizing (i.e., aggression, conduct disorders) behavior problems.[94] However, neurologic status was confounded with BPD and groups were not equivalent on social class, perhaps accounting for these findings. While neurologic and social class factors predicted cognitive outcome, family factors, such as cohesion, predicted behavioral outcomes. Levy-Shiff, Einat, Mogilner, Lerman, and Krikler[95] compared 90 VLBW and 90 NBW Israeli adolescents and found that VLBW children scored lower on all measures. Child IQ, visual-motor coordination, and hyperactivity were predicted by both psychosocial and biological factors; visual memory by biological factors; and reading comprehension by psychosocial factors. Biological factors included birth weight and perinatal medical complications. Psychosocial factors included SES, marital and family relations, paternal involvement, maternal attitudes, and maternal emotional state.

Maternal Psychological Distress: Several conceptual models have implicated child risk/illness status as a stressor affecting maternal psychological distress, family functioning, maternal-child interactions, and child developmental outcomes.[43, 96, 97] Maternal-child interactions are particularly relevant to the development of child language, attentional and behavioral capacities, and a number of studies have documented poorer functioning in these areas in children of depressed mothers.[98, 99] VLBW populations may be more vulnerable to the negative impact of early maternal depressive symptoms from several perspectives. First, the birth and parenting of a VLBW child has been related to a higher incidence of maternal psychological distress postpartum.[1, 100] Second, dependent on medical risk, VLBW infants may be differentially affected by differences in maternal caregiving[42, 45] associated with VLBW birth and/or maternal depression. Third, transactional models of development also suggest that infant characteristics and behaviors, which may be negatively affected by preterm birth and medical complications, also affect caregiver psychological distress and interactions, with each reciprocally modifying the other over time.[101]

The relationships among infant VLBW birth, medical risk, maternal psychological distress, and child outcomes are particularly complex, and also are dependent on a host of other factors, including the number of other life stressors, social class, racial characteristics, coping strategies, and social supports. Social supports have been found to have significant impact, either as mediating or independent variables, on maternal distress, maternal-child interactions, and child outcomes[102, 103] in healthy samples, as well as in preterm populations. Maternal positive perception of intimate supports postpartum was associated with better mother-child interactions in preterm dyads at 1 and 4 months,[44] while more general social supports moderated psychological distress postpartum for mothers of VLBW infants.

Our own studies of BPD infants through the first 3 years of life suggest that both sociodemographic and family factors are related to child risk status and outcomes, especially maternal psychological distress, coping mechanisms and social supports. In the neonatal period, mothers of BPD and VLBW infants self-reported increased distress, reflecting depression and anxiety, compared to mothers of Term infants.[1] However, mothers of BPD and VLBW infants who experienced higher levels of social support did not differ from Term mothers. Mothers of BPD and VLBW infants who were more depressed were less likely to

respond actively to their infants during neonatal feedings.[42] While mothers of BPD and VLBW infants were initially more stimulating than Term mothers neonatally, they were significantly less stimulating by 12 months and both BPD and VLBW preterm infants were less responsive than Term infants. By child age of 2 and 3 years, the initially high psychological distress of VLBW infants had decreased while that of mothers of BPD infants did not, and less positive interactions were apparent in feeding and play through 2 years. Severity of maternal depressive symptoms postpartum was related to poorer child outcomes at 3 years in both the preterm and Term groups. [46]

The increased risk of health problems and adverse developmental outcomes associated with BPD adds to the pile-up of stressors associated with VLBW birth. Compared to families of Term controls, families of VLBW infants with BPD more often reported that their child's health had constituted a significant burden, impacting their work, education, and pastimes, far beyond the neonatal period.[46, 104, 105]

III. Study Design and Methods

A. Study design

This study employed a prospective, longitudinal quasiexperimental design. The sample included 3 groups of subjects, with the first consisting of VLBW children with BPD, the second consisting of VLBW children without BPD, and a third matched control group of children born healthy at Term. A randomized partial stratification sampling strategy was used to ensure enrollment of adequate numbers of subjects across socioeconomic groups. Dependent variables of interest included children's health, cognitive, school achievement, neuropsychological, language, and behavioral outcomes; and maternal psychological distress, parenting strain, perceived social support, coping, and evaluations of the impact of the child on the family. Independent and/or control variables used in various analyses included child neonatal risk status, i.e. the presence of BPD and/or VLBW (group), time (repeated measures), race, social class, multiple birth status, child age, length of hospitalization, severity of BPD (total days of oxygen supplementation), presence of medical problems, neurologic risk score, severity of IVH, and maternal IQ, marital status, and education.

Data had been previously collected at 5 time points from birth through child corrected age three years, and were collected again at 8 years of age for the current study. Standardized instruments were used to assess school achievement and sensory-motor, cognitive, behavioral, and emotional function, and specific neuropsychological tests were used to measure visual-motor, executive, attentional, and phonological language functions related to specific learning disabilities. Qualified physicians performed medical examinations and pulmonary function studies. Self-report inventories were administered to mothers to assess psychological symptoms, parenting stress, family strains, perceptions of social support, and coping mechanisms.

Hypotheses of the study were as follows:

Hypothesis 1: At 8 years of age, children with a history of BPD and VLBW will continue to exhibit impaired functioning in comparison to cohorts of VLBW without BPD and Term, healthy children of similar age, race, sex, and socioeconomic status, when assessed on standard measures of physical health and growth, lung function, cognition, school achievement, language, behavior and specific neuropsychological abilities. These impairments will persist when children with mental/motor retardation or frank neurosensory deficits are excluded.

Hypothesis 2: Parents of VLBW children with BPD will experience more symptoms of psychological distress, more parenting stress, and more overall life stress than parents of VLBW children without BPD, and Term children at 8-year follow-up, controlling for race, sex, social class, and multiple birth. Maternal-child interactions will be less optimal in BPD mother-child dyads in comparison to VLBW or Term mother-child

dyads. More adaptive coping mechanisms and positive social supports will moderate distress symptoms for mothers of VLBW children both with and without BPD.

Hypothesis 3: BPD, after consideration of other neurologic, medical, and socioeconomic risk factors, will account for independent variance in overall cognitive, motor and neuropsychological outcomes at 8 years, within the combined BPD and non-BPD VLBW groups.

Hypothesis 4: BPD and VLBW will have direct effects on child school achievement and indirect effects through their impact on both earlier and concurrent maternal distress and maternal child interactions. Components of the model presented for the study will be tested through latent variable structural equation analyses, particularly to assess maternal psychological distress and mother-child interactions as mediators of the effects of infant risk status on various outcome domains.

B. Population studied/Sample Selection

Subjects included 302 8-year old children and their mothers (110 BPD; 80 very low birth weight; and 112 Term) who were prospectively recruited and followed to 3 years of age by the P.I. in two prior longitudinal studies (NIH HLB38193 and MCJ390592) of BPD and VLBW infants. Subjects were followed at five previous points in time from birth, i.e. 1, 8, 12, 24 and 36 mos. (corrected ages), and were initially recruited from NICUs at three hospitals serving all infants with BPD in a 4 county region in northeast Ohio. Eligibility criteria for recruitment for BPD infants included birth weight < 1,500 grams, oxygen dependence > 28 days, and radiologic evidence of chronic lung disease. The comparison group of VLBW infants without BPD were born preterm, weighed < 1,500 grams birth weight, and required oxygen supplementation < 14 days. Term infants had no diagnosed medical illnesses or abnormalities at birth, were > 36 weeks gestational age, and > 2,500 grams birth weight for singleton infants. Exclusionary criteria included major congenital malformations, prenatal cocaine exposure, HIV, or maternal psychiatric illness, mental retardation, severe medical illnesses, or substance use. Because the focus of the original study was to assess the effects of BPD, relative to other neurologic, medical and social class factors known to be associated with child developmental outcome, all infants diagnosed with BPD who were free of neurologic problems other than Grades I-II intraventricular hemorrhage, and who were not socially disadvantaged, [i.e. Hollingshead[106] classification IV and V, were exhaustively recruited. The remainder of the cohort were randomly recruited, by identifying the next consecutively born study child who met enrollment criteria. This recruitment strategy maximized the number of neurologically intact, non-socially disadvantaged subjects, thus allowing better representation of all social classes. Comparison groups of VLBW infants without BPD and of full-term infants born during the same time period and matched for sex, race, social class, and child age also were recruited. BPD subjects were recruited as soon as possible after diagnosis. For each BPD infant enrolled, the next born VLBW infant who met matching criteria was approached for study. Term control infants were recruited based on the matching criteria from the pool of volunteers who responded to letters left in the newborn nurseries.

Attrition rates were very low. At 8 years, 104 (90%) subjects with BPD, 75 (90%) of VLBW cohort, and 99 (80%) of the Term control subjects participated in the follow up study.

C. Instruments Used and Statistical techniques employed

CHILD MEASURES: Measurements used to investigate child development in the three subjects groups included:

Physical Assessment: A standardized medical history, vision exam and physical assessment was performed under the supervision of Jill Baley, M.D. Medical history assessed lung, cardiac, kidney and neurologic problems. Weight, height and head circumference were measured according to standard criteria. Parental head circumference was available from prior studies. Logarithmic Visual Acuity Chart criteria was used for vision assessment. As part of the physical evaluation, Dr. Baley administered the Tanner Scale of Pubertal Changes and Their Rates of Progression. [107]

Pulmonary Measures: Lung function was measured at the Rainbow Babies & Childrens Hospital Pulmonary Function lab through spirometry and peak flow measures using the same methodology as the standard operating procedures for the clinical laboratory. Carolyn Kercsmar, M.D., a national expert in pediatric pulmonary research, supervised the all pulmonary function tests and interpreted data, which included baseline spirometry, lung volumes, and airway resistance.

For each maneuver, the FEV_1, FVC, FEV_{25-75}, forced expiratory volume over 25-75% of forced vital capacity, and FEV_1/FVC was computed. Lung volumes were measured by body plethysmography. All measures were converted to body temperature and atmospheric pressure saturated with water vapor at body temperatures. The predicted values of Dockery et al.[108] were used as normal standards.

Hearing: Pure Tone Audiometric Screening Test: Hearing was assessed using a pure tone audiometry at 25 dB HL bilaterally at 500, 1000, 2000, and 4000 Hz and a middle ear screening test utilizing tympanometry.

Cognition: The Wechsler Intelligence Scale for Children III, (WISC III)[109]was used to assess cognitive development.

School Achievement: The Woodcock Johnson Tests of Achievement-Revised (WJR)[110](20-25 min.) was used to assess basic reading and math skills and reading comprehension. Subtests administered were: Word Identification, Passage Comprehension, Calculation, and Applied Problems.

Attentional Outcomes: The Continuous Performance Test (CPT) [111]was used to assess children's attentional skills via a computerized presentation of letter stimuli. In addition, the parent and teacher 28-item versions of the Connors Rating Scale[112](CPRS-28, CTRS-28) were used to assess attentional, hyperactive, and impulsive symptomotology.

Motor Outcomes: Motor development was assessed using the short form of the Bruininks-Oseretsky Test of Motor Proficiency.[113]

Emotional, Behavioral, and Educational Outcomes: The Child Behavior Checklist (CBCL)[114, 115] were employed to assess behavior problems and social competence. The Children's Depression Inventory (CDI),[114, 115] as self-report form, was used to measure levels of depression.

The Academic Performance Rating Scale (APRS),[116]a nineteen-item questionnaire that requires teachers to evaluate school performance using a 5-point likert scale (1=never to 5=very often), was used to help assess school performance.

Speech Measures: The Goldman Fristoe Test of Articulation [117]was used to assess articulation errors. The Test of Structures and Functions (TOSF) [118] was used to assess oral-motor function and oral structures.

Language Measures: The Clinical Evaluaton of Language Fundamentals –3 (CELF-3) [119]was used to assess receptive and expressive language. In addition, a conversational sample and narrative retelling task were collected to further explore language skills.

PARENT MEASURES: The following parent measures were used:

The Parenting Stress Index (PSI),[120] a 120-item self-report questionnaire, was administered to assess parent-child systems under stress.

The **COPE**,[121] a multidimensional self-report inventory, was used to assess the different ways in which subjects respond to stress.

The **Brief Symptom Inventory** (BSI),[122] a 53 item self-report questionnaire tapping a range of psychiatric symptom patterns, was used to assess presence and severity of psychiatric symptoms.

The **Impact on Family Scale**[123] was used to assess parental perception of the impact of the child on the family.

The **Multidimensional Scale of Perceived Social Support** (MSPSS),[124] was used to assess perceptions of social support from family, friends, and significant other, as well as total perceived social support.

The Family Inventory of Life Events and Changes (FILE)[125] was used to assess the family's experience of a variety of life changes during the previous year.

Table 1 describes the domains tested in this study, together with the measures used and the statistical methods used to evaluate outcomes.

TABLE 1: SUMMARY OF DOMAINS, MEASURES AND MAJOR STATISTICAL ANALYSES

HYPOTHESIS 1			
DOMAIN: Child Outcomes	**MEASURES**	**SCORE**	**ANALYSES**
Medical	Physical		MANOVAS/ MANCOVAS
Pulmonary	Spirometry	FEV_1, FEV_{75}, FEV_{25-75}, FVC, FEV 75/FVC	
Growth	Wt/Ht/hc	Percentile for Age	
Vision	Logarithmic Visual Acuity Chart "2000"	% Abnormal	
Hearing	Pure Tone Audiometric Screen	% Abnormal at 25 dB	
General Cognitive	WISC-III	Verbal IQ	
Motor Skills	Bruininks-Oseretsky Test of Motor Proficiency (BOT)	Standard Score	
Speech - Language	CELF-3	Standard Scores	
	Conversational Sample	SALT Outcomes	
	Goldman-Fristoe Test	Percentiles, number of errors	
	Test of Oral Structures and Functions	Standard Scores	
	Narrative Retelling Task	Coded scores	
Neuropsychological			
IQ	WISC - III	Verbal and Full Scale IQ	MANOVAS/ MANCOVAS
Visual-Motor	WISC-III Performance	Subscale Standard Scores	
Attention	Continuous Performance Test	#, % Target Hits, #, % Omission & Commission Errors in Reaction Time	
	Conner's Rating Scale, Parent and Teacher versions	T-scores	
Achievement	Woodcock Johnson-R	Standard Scores	
	Grade Level/Learning Disability	% at Grade Level, % LD	
Socioemotional	CBCL	T Scores	
	Child Depression Inventory	Total Score	
Interaction	Interaction Rating Scale	Child Summary Score	
Teacher Rating	CBCL, Adaptive Language Inventory, Academic Performance Rating	Standard Scores, Total Score	
	HYPOTHESIS 2		
DOMAIN: Parental Outcomes	**MEASURE**	**SCORE**	**ANALYSES**
Psychological Status	BSI	GSI, PST, Depression Score	MANOVAS/ MANCOVAS
Parenting Stress	PSI	Child/Parent Domain Scores	
Coping Style	COPE	Subscale Scores; Adaptive/Maladaptive Totals	
Social Support	MSPSS	Subscale Totals	
Interaction	Interaction Rating Scale adapted from Greenberg & Crnic, Harnish	Parent Summary Score/Warmth Factor	
Life Stressors	FILE	Subscale Scores	
	HYPOTHESES 3 & 4		
Prediction of Child and Parent Outcomes from Neonatal Medical and Sociodemographic Risk, and from prior longitudinal data	Independent Variables	Race, SES, Multiple Birth, Medical Risk Variables, BPD, Maternal marital status, Maternal Education	Hierarchical Multiple Regression
	Dependent Variables	Child and Parent Outcomes noted above	HLM, Structural Equation Models

IV. Presentation of Findings

CHILD OUTCOMES: Findings at 8 years supported our hypotheses in many areas:

Neuropsychological and Motor Outcomes: [126]The BPD group demonstrated deficits compared to VLBW and Term children in intelligence, reading, mathematics, and gross motor skills. VLBW children differed from Term children in all of the above areas, except reading recognition, comprehension and occupational therapy. Attentional differences were found between BPD and Term children only. The BPD group (54%) was more likely to be enrolled in special education classes than the VLBW (37%) or Term children (25%). In addition, more BPD children (20%) achieved full scale IQ scores less than 70, in the mental retardation range, compared to VLBW (11%) and Term (3%) children, with all VLBW children significantly more likely than Term children to achieve IQs in the subaverage category. After controlling for birth weight and neurological problems, BPD and/or duration on oxygen predicted lower performance IQ, perceptual organization, full scale IQ, motor and attentional skills, as well as special education placement. The presence or absence of BPD was a significant predictor of scores on measures of applied problems, motor skills, and incidence of speech-language, occupational, and physical therapies.

Individual difference analyses were performed to ascertain whether differences between the risk groups were due primarily to neurological complications. Even when only neurologically intact BPD and VLBW children were studied, differences in many outcome measures persisted between the Term comparison group and both the BPD and VLBW groups. When birth weight and neurological complications were controlled, BPD and severity of BPD were associated with lower performance and full scale IQ, poorer perceptual organization, attention, and motor skills, lower school achievement, and greater participation in special education services, including occupational, physical, and speech-language therapies.

Postnatal medical treatment protocols may be responsible in part for differences observed in our BPD sample. Steroid and non-steroid groups of BPD children differed significantly in performance IQ (72.8 vs. 84.8) and full scale IQ (77.0 vs. 85.2), perceptual organization (74.0 vs. 85.2), BOT score (36.6 vs. 44.7), and participation in special education (78% vs. 48%), occupational therapy (71% vs. 44%) and physical therapy (71% vs. 41%). In every instance, BPD children who received steroids fared more poorly than those BPD children not receiving steroids.

Speech and Language Outcomes: [127] In the area of speech and language, 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. 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.

The groups differed significantly in enrollment 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 (9%). To further examine the proportion of children falling within the disordered range for each group, the number of children scoring 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-3 Total, Receptive, and Expressive language scores, the GFTA, and oral motor skills on the TOSF.

Stability of IQ among BPD, VLBW, and Term children:[128] BPD in conjunction with VLBW places children at high risk for cognitive and language delays which may affect school readiness and academic performance. Longitudinal data on 170 children were available on the following measures: Bayley MDI & PDI at age three; WISC-III, Woodcock Johnson, CELF at age eight. Three IQ groups were formed: Below average (SS < 85), Average (SS = 85-115), and Above Average (SS > 115). Group differences were examined using MANOVAs followed up with ANOVAs when indicated. In the BPD group, 55% of children fell in the Average and 45% fell in the Below Average Range. Chi-square analyses were used to examine the stability of IQ. BPD children performed significantly less well than their VLBW or Term counterparts on all cognitive, linguistic, and achievement measures ($p < .01$). In addition, VLBW children performed more poorly than Term infants in mathematical and spatial tasks, but not in verbal domains. Stability of IQ was 78% from 3 to 8 years. All Below Average BPD children were low in language, with only 25% of the average BPD children experiencing language problems. In the VLBW group, 66% were Average, 32% were Below Average, and 2% were Above Average. Stability of IQ was 70%. Below Average VLBW children tended to be low in language (80%), whereas only 20% of the Average and none of the Above Average children were low in language. In the Term group, 66% were Average, 8% were Below Average, and 26% were Above Average. Stability of IQ was 66%.

We concluded that BPD together with VLBW poses additional cognitive and linguistic challenges for elementary school children. Academic problems are not limited to linguistic processing difficulties, but also include perceptual organizational skills.

Pulmonary Outcomes at School Age:[129] There are few studies of long-term pulmonary and neuropsychological outcomes of VLBW infants with BPD who were born after the use of surfactant became standard practice. At 8 years of age, we performed pulmonary function tests (PFTs) and administered standardized, normative cognitive, motor, attentional and language tests. Of 227 children scheduled, 31 were not tested [24 (28%) BPD, 4 (6%) VLBW, and 3 (4%) Term, $p < .001$] for medical or developmental (low IQs) reasons. Only PFTs which met standard ATS criteria were used. Groups did not differ in age, race, or SES, but children with history of BPD had lower birth weights and gestational age and more neurologic complications. Of 196 children tested, 32 (52%) BPD, 18 (48%) VLBW< and 46 (62%) Term children met ATS criteria. Groups did not differ in Thoracic Gas Volume (TGV) or % predicted FVC, but children with history of BPD had lower FEV1, and % predicted FEF 25/75 than Term ($p's < .002$), and lower FEV1/FVC than VLBW and Term groups. Independent of race and SES, % predicted FEF 25/75 and FEV1/FVC were related to total days on oxygen (-.44 and -.38, $p < .0001$), child 8 year IQ ($r's = .30$ and .36, $p's < .002$), language ($r's = .34$ and .35, $p's < .001$), and motor scores ($r's = .23$ and .19, $p's < .05$).

BPD predicted subnormal pulmonary function at 8 years, even after asthma, gestational age, medical risk and other related factors were controlled. Moreover, more severe pulmonary abnormalities were associated with poorer cognitive, language, and motor functioning. Pulmonary outcomes were not related to neurologic risk or SES, but were related to male gender.

Maternal And Family Outcomes: Analyses revealed significant group differences in maternal education, with mothers of VLBW children reporting fewer total years of education than mothers of Term children at 8-year follow-up. There were also group differences in intrafamily strains during the past year, including conflict among children, difficulty managing school-age children, and number of activities in which children were involved outside the home. Accordingly, maternal education and intrafamily strains were controlled in subsequent analyses if found to be significantly correlated with any of the outcome variables.

There were over all effects for group on Total Parenting Stress, Child Domain Parenting Stress, and maternal ratings of child Acceptability and Hyperactivity/Distractibility, controlling for maternal education and intrafamily strains during the past year. Post hoc analyses indicated that mothers of BPD children reported significantly greater total parenting stress and child domain parenting stress than mothers of VLBW children, and that BPD children were regarded as less acceptable than VLBW children and as more hyperactive and distractible than both VLBW and Term children.

Analyses showed significant effects for group on several subscales of the Impact on Family, including financial, personal, and family/social strains. Mothers of BPD children reported greater financial strains than mothers of Term children, greater personal strains than mothers of VLBW children, and greater family/social strains than mothers of both VLBW and Term children. Group differences also were found for the Denial and Mental Disengagement subscales of the COPE. BPD mothers used less Denial coping than VLBW mothers, and less Mental Disengagement coping than both VLBW and Term mothers. No group differences were found for maternal symptoms of psychological distress at child age 8 years.

Intrafamily strains during the past year were positively correlated with all BSI subscales and summary scores; Financial, Family/Social, Personal, and Total Impact on the Impact on Family; and all PSI scales except Attachment in the Parent Domain. Greater intrafamily strains also were correlated with more social support, as indicated by higher scores on all MSPSS scales, and with greater use of Focus on Emotions and Alcohol-Drug coping. Multiple birth was positively correlated with the Sibling subscale of the Impact on Family, and there was a trend (p=.06) toward a positive correlation between multiple birth and Humor coping. Maternal education was negatively correlated with the Phobic Anxiety, Paranoid Ideation, and Psychoticism subscales of the BSI; the Family, Friend, and Total Support subscales of the MSPSS; the Reinforces Parent, Acceptability, Sense of Competence, Role Restriction, Social Isolation, Parent Health, Distractibility-hyperactivity, Life Stress, Child Domain Stress, Parent Domain Stress, and Total Parenting Stress of the PSI; and the Planning, Seek Social Support for both Informational and Emotional Reasons, Positive Reinterpretation, Religion, Denial, and Behavioral Disengagement subscales of the COPE. Maternal education was positively correlated with Active, Suppression of Competing Activities, and Focus on Emotions coping. There was a trend (p=.06) for a positive correlation between maternal education and the Personal Strains subscale of the Impact on Family.

Ongoing analyses will continue to explore group differences in child and maternal measures, and will further explore the longitudinal effects on growth, health, stability of child and maternal outcomes, and changes in the relationships among child and maternal outcomes.

V. Discussion of Findings

A. Conclusions to be drawn from findings

These findings suggest that BPD and, more specifically, duration on oxygen, have long term deleterious effects on children's perceptual abilities, motor skills, and cognitive processing speed, beyond the effects of VLBW.[49, 50] BPD children performed more poorly than VLBW and Term children on tests of reading and math abilities. The BPD group had significantly lower scores than both comparison groups, and were nearly one standard deviation below the mean, on the calculations subtest. Thus, difficulties with mathematics appear to be even more pronounced for VLBW children with BPD than for children with VLBW only. [130]

The finding that more BPD children were enrolled in lower grades may be explained by several factors. Many parents of children with a history of BPD and even VLBW without BPD have indicated that they chose to delay school entry for a variety of reasons, including small stature, history of repeated illness and hospitalizations, and perceptions of "increased vulnerability." In addition, given the multiplicity of

difficulties experienced by both the child and the family during the early years of life, educational and clinical specialists may have advocated delayed entry into formal education.

Over 50% of BPD children were receiving some type of special educational services at 8 year follow-up. Even when neurologically compromised BPD children were excluded, over 40% children with a history of BPD were receiving special education services. The prolonged hospitalizations experienced by children with BPD and the frequent interactions of families with medical personnel may result in increased access and opportunities for services for parents of children with BPD. Our finding that approximately one third of the VLBW children were receiving special education is consistent with those reported in earlier studies.[60, 130] In addition, our findings suggest that more VLBW and BPD children could benefit from special services, particularly occupational and physical therapy.

One striking finding regarding diagnosis and placement in special education pertained to the incidence of attention deficit hyperactivity disorder (ADHD) in this sample. More BPD children received the diagnosis of ADHD than Term or VLBW children. While their teachers did not rate BPD children as having more attention problems in school than the VLBW or Term children, BPD children had more attention problems as measured by the laboratory Continuous Performance Task. This measure of attention at 8 years may be an early indication of attention deficits that may increase over time. Because several of the BPD children were unable to complete the task and it was not administered to children with IQ scores under 70, this average score may underestimate of the severity of attention difficulties for children with a history of BPD.

Taken together, these results suggest that BPD has adverse effects on academic achievement above and beyond the effects of VLBW. The medical complications experienced by this sample of BPD children, in conjunction with socioeconomic risk that often coexists with VLBW and prematurity, [26, 127] place these children at high risk for learning problems and related behavioral and psychosocial difficulties.[52, 127] Results demonstrated that BPD may be a risk factor for poor articulation and delayed motor development at school-age. Children with BPD were more likely than children with VLBW without BPD to be enrolled in speech and language therapy. While language outcomes appear to be a function of prematurity itself, speech outcomes may be related to specific risk conditions, such as BPD. School difficulties have the potential to become more severe over time as academic demands increase. The problems that have been identified at eight years of age underscore the need for continued monitoring of the learning, behavior, and development of BPD children in order to identify, refer and intervene with children most at risk for school difficulties.

Findings showed that BPD continued to have significant effects on mothers when children reached school-age. Although no group differences were found for maternal symptoms of psychological distress at child age 8 years, mothers of BPD children reported greater parenting stress and personal strains than mothers of VLBW children, greater financial strains than mothers of Term children, and greater family/social strains than mothers of both VLBW and Term children. In addition, mothers rated their BPD children as less acceptable than VLBW children and as more hyperactive and distractible than both VLBW and Term children. Whereas these ratings may reflect accurate maternal assessments of child behavior and developmental outcomes, they also could be influenced by the increased levels of parenting stress and other strains reported by the mothers of BPD children. Interestingly, at child age 8 years, group differences in maternal coping emerged. At previous data collection times, mothers in all 3 groups had used the same types and amounts of coping. At school age, however, data indicated that mothers of BPD children used less Denial coping than VLBW mothers, and less Mental Disengagement coping than both VLBW and Term mothers. One possible explanation for these coping differences may be that the BPD children's developmental delays are more marked and/or more visible than the problems of the VLBW children, and thus the mothers may not be able to rely on Denial to cope. Further, the problems of the BPD children may

demand more maternal time and direct attention, and consequently mothers must use less Mental Disengagement than mothers of VLBW and Term children.

B. Explanations of limitations or possible distortion of findings

Findings of significant group differences may have been minimized because no descriptive data were collected on educational and psychosocial services received by the BPD group, although we documented that BPD children received more therapies and were enrolled for a longer time than the VLBW and control groups. Thus, interventions may have improved BPD outcomes, and had these special services been included as control variables, findings of group differences might have been even more robust. A limitation of this study is that it did not investigate types of interventions received by subjects, or their effects on child outcomes.

C. Comparison with findings of other studies

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. 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. [92] A study by Vohr et al.[53] found that Full scale IQ scores of 10 to 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.[50] However, these studies had very small sample sizes and may have lacked adequate statistical power.[50, 53]

The findings are also consistent with two previous studies which found impairment in IQ at school age in children with BPD.[49, 60] However in these prior studies, neither cranial ultrasound findings nor screening for drug exposure was available. Thus obtained differences may have resulted from confounding variables. Two other studies assessed the outcome of children with BPD to school age and found no differences between them and other VLBW children Although BPD was not a focus of inquiry, Robertson et al. [34] found lower IQs associated with longer duration of supplemental oxygen in an 8-year follow-up. The findings are also consistent with outcomes found in this cohort at 3 years of age, which indicated that history of BPD predicted poor motor skills beyond the effects of other medical and demographic factors.[26]

No other study to date has reported articulation data, and most studies have assessed language outcomes by means of verbal IQ scores.

Gross and fine motor problems have been described in several studies of VLBW children.[10, 12] In this study, the BPD children scored more poorly than both VLBW and Term comparison children on a measure of gross motor skills. Furthermore, VLBW children scored more poorly than Term children. The gross motor difficulties experienced by the BPD children have been noted in previous smaller studies.[47, 53] Majnemer and colleagues[47] found that, at 10 years of age, 50% of BPD children who had required home oxygen therapy had gross and fine motor skill deficits.

D. Possible application of findings to actual MCH health care delivery situations

Findings indicate that BPD children are at risk for cognitive and motor delays, neurosensory deficits, and learning and speech problems that may persist into the school years and potentially may increase over time. In addition, the mothers of these children are at risk for increased strains and parenting stress that could adversely affect maternal-child interactions and thereby negatively influence child developmental outcomes. Health care delivery situations should include routine screening and/or testing for these children and their mothers, and should offer comprehensive on-site services or appropriate referrals to accessible educational

and/or psychosocial resources. Primary care providers, as well as health care specialists who have regular contact with these children and their families, should strive to insure the provision of complete preventative and remedial services to BPD children and families. Families should be targeted for intervention immediately after birth and followed throughout the child's school years.

E. Policy implications

The impact of VLBW and related conditions, such as BPD, has become a serious public health issue, as well as a compelling social problem, in the US. Policymakers should allocate funds to study the outcomes of VLBW children into adulthood, as well as the efficacy of various medical treatments and psychosocial and educational interventions, so that data can inform solutions.[131] Scientific evaluation is essential to assessing potential risk, creating innovative strategies, improving quality of services, enhancing outcomes, and conserving health care resources.[131-133] Federal laws should mandate that funds be made available for early intervention and continuing medical, educational, and psychosocial services for VLBW children with serious developmental disabilities, [131] and a commitment must be made to provide additional support to families.[132] Regionalized health-care services afford easy access, but policymakers must insure that such local facilities are staffed with medical and developmental specialists trained to assist with the particular needs and problems of VLBW children.[131]

F. Suggestions for further research

Further studies are needed to document specific linguistic, speech, verbal working memory, visual-motor, and cognitive deficits that may be associated with BPD in adolescence and early adulthood. In addition, magnetic resonance imaging (MRI) and functional MRI (fMRI) research could be instructive in helping to understand any underlying brain differences that could be correlated with the behavioral findings. Findings from these types of studies could help further instruct how early therapies might impact brain and behavioral development and how they are related to developmental risk.

VI. List of Products

Below is a list of products of this phase (2) as well as phase 1 products, all produced since phase two began:

Peer Reviewed Articles:

Singer, L.T., Bruening, P., Davillier, M., Hawkins, S., & Yamashita, T. Social support, psychological distress and parenting strains in mothers of very low birth weight infants, Family Relations, 1996, 45, 343-350.

Singer, L.T., Yamashita, T.S., Lilien, L., Collin, M. & Baley, J. A longitudinal study of infants with bronchopulmonary dysplasia and very low birth weight, Pediatrics, 1997, 100, 987-993.

Singer, L.T., Davillier, M., Hawkins, S., Salvator, A., Manuel, M., Klaus, L., & Fulton S. The relationship of maternal post partum depression to child outcomes in preterm and Term infants. Infant Behavior and Development, 1998, 21.

Singer, L.T., Salvator, A., Guo, S., Collin, M., Lilien, L., and Baley, J. Maternal psychological distress and parenting stress after the birth of a very low birth weight infant, JAMA: The Journal of the American Medical Association, 1999, 281, 9:1-7; Also abstracted in The Journal of Pediatrics, 1999, 135(3).

Singer, L.T., Siegel, A.C., Lewis, B., Hawkins, S., and Yamashita, T. Preschool language outcomes of children with history of bronchopulmonary dysplasia and very low birth weight. Journal of Developmental and Behavioral Pediatrics, 2001, 22:19-25.

Singer, L.T., Hawkins, S., Huang, J., Davillier, M., and Baley, J. Developmental outcomes and environmental correlates of very low birth weight, cocaine-exposed infants, Early Human Development, 2001, 64, 91-103.

Lewis, B.A., Singer, L.T., Fulton, S., Salvator, A., Short, E.J., Klein, N., Baley, J. Eight year speech and language outcomes of children with a history of bronchopulmonary dysplasia and very low birth weight, Journal of Communication Disorders, 2002, 35, 393-406.

Eisengart, S.P., Singer, L.T., Fulton, S., & Baley, J. Coping and psychological distress in mothers of very low birth weight young children. Parenting: Science and Practice, 2002, 3(1), 49-72.

Short, E.J., Klein, N.K., Lewis, B.A., Fulton, S., Eisengart, S. Kercsmar, C. Baley, J. Singer, L.T. Cognitive and academic consequences of bronchopulmonary dysplasia and very low birth weight: 8-year-old outcomes, Pediatrics, 2003, 112(5), 359-366.

Under Review:

Eisengart, S.P., Singer, L.T., Fulton, S. A factor analytic reassessment of the COPE: Mothers of very low birth weight infants, Submitted.

Abstracts:

Singer, L.T., Yamashita, T.S., Lilien, L., Collin, M., and Baley, J. Three year outcomes of infants with BPD and VLBW. Pediatric Research, 1996, 39, 280A.

Singer, L.T., Yamashita T.S., Hawkins, S., Davillier, M., Kuc, A., Klaus, L., and Manuel, M. Maternal-child feeding interactions in very low birth weight birth dyads. Abstracts of the Society for Research in Child Development, 1997, 11.

Singer, L.T., Baley, J., Collin, M., Lilien, L., & Salvator, A. Maternal mental health and parenting stress after the birth of a VLBW infant. Pediatric Research, 1998, 42, 229A.

Singer, L.T., Davillier, M., Hawkins, S., Salvator, A., Manuel, M., Klaus, L., & Fulton S. The relationship of maternal post partum depression to child outcomes in preterm and Term infants. Infant Behavior and Development, 1998, 21, 688.

Short, E.J., Klein, N., Lewis, B., Fulton, S., Guo, S., Carlisle, M., Baley, J., & Singer, L.T. The stability of intelligence in BPD, VLBW, & Term children: Follow-up at eight years of age. Pediatric Research, 2000, 45, 323A.

Singer, L.T., Salvator, A.E., Guo, S., & Baley, J. Growth outcomes of infants with bronchopulmonary dysplasia (BPD) and very low birth weight (VLBW). Pediatric Research, 2000, 45, 324A.

Lewis, B.A., Fulton, S.E., Short, E., Klein, N., Davillier, M.R., & Singer, L.T. School age outcomes of children with VLBW and BPD. Pediatric Research, 2000, 45, 317A.

Kercsmar, C., Baley, J., Short, E., Lewis, B., Klein, N., Salvator, A., Khosla, A., & Singer, L.T. 8 Year pulmonary function, cognitive, and motor outcomes of bronchopulmonary dysplasia (BPD) and very low birth weight (VLBW) infants. Pediatric Research, 2001, 46, pp. 316A.

Eisengart, Sheri P., Singer, Lynn T., Fulton, S., Baley, J. The buffering effects of coping of psychological distress in mothers of high-risk and low-risk very low birth weight infants. Presented at the International Conference on Infant Studies, 2002, Toronto, Canada.

Singer, L.T., Minnes, S., Arendt, R.E., Klein, N., Short, E., Lewis, B., Farkas, K. Preschool behavioral outcomes of cocaine, polydrug-exposed children. Pediatric Research, 2002, 51, pp. 358A.

Singer, L.T., Short, E., Klein, N., Lewis, B., Fulton, S., Kerscmar, C., Baley, J. School age behavioral outcomes of children with history of very low birth weight and bronchopulmonary dysplasia. Pediatric Research, 2002, 51, pp. 289A.

Weigand, K., Singer, L.T., Fulton, S., Short, E., Klein, N. The relationship between nonclinical language delay and behavior in 8-year-old sample. Poster presented at Society for Research in Child Development (SRCD) Biennial Meeting, April 25, 2003, Tampa, Florida.

Presentations:

Singer, L.T., Yamashita, T., Huang, J., and Davillier, M. A longitudinal study of parenting stress after the birth of a very low birth weight infant. Presented at the International Conference on Infant Studies, Providence, Rhode Island, April 18, 1996.

Singer, L.T., Yamashita, T., Hawkins, S., Davillier, M., Kuc, A., Klaus, L., & Manuel, M. Maternal-child feeding and play interaction in very low birth weight birth dyads. Presented at the Society for Research in Child Development Meetings, Washington, D.C., April 5, 1997.

Fulton, S.E., Lewis, B.A., Salvator, M.S., Short, E., Klein, N., Davillier, M.R., and Singer, L.T. School-age outcomes of children with VLBW and BPD: Speech and language sequelae. Presented at the Symposium on Research in Child Language Disorders. Madison, Wisconsin, June 5, 1999.

Short, E.J., Klein, N., Lewis, B., Fulton, S., Guo, S., Carlisle, M., Baley, J., & Singer, L.T. The stability of intelligence in BPD, VLBW, & Term children: Follow-up at eight years of age. Presented at Society for Pediatric Research, Boston, Massachusetts., May 16, 2000.

Lewis, B.A., Fulton, S.E., Short, E., Klein, N., Davillier, M.R., & Singer, L.T. School age outcomes of children with VLBW and BPD. Presented at the ASHA Annual Convention, San Francisco, California, November, 2000.

Kercsmar, C., Baley, J., Short, E., Lewis, B., Klein, N., Salvator, A., Khosla, A., & Singer, L.T. 8 Year pulmonary function, cognitive, and motor outcomes of bronchopulmonary dysplasia (BPD) and very low

birth weight (VLBW) infants. Presented Society for Pediatric Research Annual Meeting, Baltimore, Maryland, April 30, 2001.

Weigand, K., Singer, L. T. & Melamed, L. Language Delay and Behavior in a Non-Clinical Preschool Sample. Presented at The American Psychological Association 2001 Annual Convention, San Francisco, California, August 24, 2001.

Eisengart, Sheri P., Singer, Lynn T., Fulton, S., Baley, J. The buffering effects of coping on psychological distress in mothers of high-risk and low-risk very low birth weight infants. Presented at International Conference on Infant Studies, Toronto, Canada, April, 2002.

Singer, L.T., Short, E., Klein, N., Lewis, B., Fulton, S., Kerscmar, C., Baley, J. School age behavioral outcomes of children with history of very low birth weight and bronchopulmonary dysplasia. Presented at Pediatric Academic Society Meeting, May 4-7, 2002, Baltimore, Maryland.

Lewis, B., Minnes, S., Fulton, S., Singer, L., Short, E. Four-year language outcomes of children with prenatal cocaine exposure: The influence of foster/adoptive care. Poster presented at the International Association of Child Language Meeting, July 16-21, 2002, Madison, Wisconsin.

Lewis, B., Minnes, S., Fulton, S., Arendt, R.E., Klein, N., Singer, L., Short, E. Six-year language outcomes of children with prenatal cocaine exposure. Poster accepted, ASHA Convention, November 23, 2002, Atlanta, Georgia.

Weigand, K., Singer, L.T., Fulton, S., Short, E., Klein, N. The relationship between nonclinical language delay and behavior in 8-year-old sample. Poster presented at Society for Research in Child Development (SRCD) Biennial Meeting, April 25, 2003, Tampa, Florida.

References

1. Singer, L.T., P., B., Davillier, M., Hawkins, S., & T., Y. *Social support, psychological distress, and parenting strains in mothers of very low birthweight infants*. Family Relations, 1996. **45**: p. 343-350.
2. Singer, L.T., Davillier, M., Preuss, L., Szekely, L., Hawkins, S., Yamashita, T., & Baley, J. *Feeding interactions in infants with very low birth weight and bronchopulmonary dysplasia*. Journal of Developmental and Behavioral Pediatrics, 1996. **17**(2): p. 69-76.
3. Paneth, N.S. *the problem of low birth weight*. The future of children, 1995. **5**(1): p. 19-34.
4. Ventura, S.J., Martin, J.A., Curtin, S.C., Mathews, T.J., & Park, M.M. *Births: Final data for 1998*. National vital statistics reports, 2000. **48**(3).
5. McAleese, K.A., Knapp, M.A., & Rhodes, T.T. *Financial and emotional costs of bronchopulmonary dysplasia*. Clinical Pediatrics, 1993. **8**: p. 393-400.
6. McCormick, M.C. *has the prevalance of handicapped infants increased with improved survival of the very low birthweight infant?* Clinical Perinatology, 1993. **20**(1): p. 263-277.
7. Gallo, J.E., Holmstrom, G., Kugelberg, U., Hedquist, B., & Lennerstrand *Regressed retinopathy of prematurity and its sequelae in children aged 5-10 years*. Journal of Ophthalmology, 1991. **75**(9): p. 527-531.

8. Harvey, E., Dobson, V., & Luna, B. *Long-term grating acuity and visual field and development in preterm children who experienced bronchopulmonary dysplasia*. Developmental Medicine and Child Neurology, 1997. **39**: p. 167-173.
9. Torrioli, M.G., Frisone, M.F., Bonvini, L., Luciano, R., Pasca, M.G., Lepori, R., Tortotolo, G., & Guzzetta, F. *Perceptual motor, visual, and cognitive ability in very low birthweight preschool children without neonatal ultrasound abnormalities*. Brain and Development, 2000. **22**: p. 163-168.
10. McCormick, M.C. & Brooks-Gunn, J. *The health and developmental status of very low birth weight children at school age*. Journal of the American Medical Association., 1992. **267**(16): p. 2204-2208.
11. Breslau, N., Klein, N., & Allen, L. *Very low Birthweight: Behavioral sequelae at nine years of age*. Journal of the American Academy of Chld and Adolescent psychiatry, 1988. **27**(5): p. 602-612.
12. Klein, N., Hack, M., & Breslau, N. *Children who were very low birthwieght; Developmental and academic achievement at 9 years of age*. Journal of Developmental and Behavioral Pediatrics, 1989. **10**: p. 32-37.
13. Hack, M., Taylor, G., Klein, N., & Eiben, R. *Outcome of <750 gm birthweight children at school age*. New England Journal of Medicine, 1994. **331**: p. 753-759.
14. Saigal, S., Szatmari, P., & Roenbaum, P. *Cognitive abilities and school performance of extremely low birthweight children and matched term controls at age 8 years: A regional study*. Journal of Pediatrics, 1991. **118**: p. 751-760.
15. Ross, G., Lipper, E.G., & Auld, P.A.M. *Social competence and behavior problems in premature children at school age*. Pediatrics, 1990. **86**: p. 391-397.
16. Breslau, N., DelDotto, J.E., & Brown, G.G. *A gradient relationship between low birth weight and I IQ at age 6 years*. Archives of Pediatric and Adolescent Medicine, 1994. **148**: p. 377-383.
17. Saigal, S. *Long-term outcomes of very low birth weight infants:*. Developmental Brain Dysfunction, 1995. **8**(2-3): p. 109-118.
18. Hack, M., Breslau, N., & Aram, D. *The effect of very low birth weight and social risk on neirocognitive abilities at school age*. Journal of Developmental and Behavioral Pediatrics, 1992. **13**: p. 412-420.
19. Teplin, S.W., Burchinal, M., & Johnson-Martin, N. *Neurodevelopmental, health, and growth status at age 6 years of children with birth weigth less than 1001 grams*. Journal of Pediatrics, 1991. **118**: p. 768-777.
20. Luciana, M., Lindeke, L.G., Georgieff, M., Mills, M., & Nelson, C.A. *neurobehavioral eveidence for working-memory deficits in school-aged children with histories of prematurity*. Developmental Medicine and Child Neurology, 1999. **41**(521-233).
21. Rose, S.A. & Feldman, J.F. *Memory and processing speed in preterm children at 11 years: A comparison with full terms*. Child Development, 1996. **67**: p. 2001-2021.
22. Bhushan, V., Paneth, N.S., & Kiely, J.L. *Impact of improved survival of very low birth weight infants on recent secular trends in the prevalnace of cerebral palsy*. Pediatrics, 1993. **91**: p. 1094-1100.
23. Hack, M., Klein, N., & Taylor, G. *Long term developmental outcomes of low birth weight infants*. The future of children, 1995. **5**(1): p. 176-196.
24. Wood, N.S., Marlow, D.W., Costeloe, K., & Gisbson, A.T. *neuroogic and developmental disability after extremely preterm birth*. New England Journal of Medicine, 2000. **343**(6): p. 378-384.
25. Briscoe, J., Gathercole, S.E., & Marlow, N. *Short term memory and language outcomes after extreme prematurity at birth*. Journal of Speech, Langauge, and Hearing Research, 1998. **41**: p. 654-666.
26. Singer, L.T., Yamashita, T.S., Lilien, L., Collin, M., & Baley, J. *A longitudinal study of infants with bronchopulmonary dysplasia and very low birthweight,*. Pediatrics, 1997. **100**(987-993).

27. Weisglas-Kuperus, N., baerts, W., DeGaff, M.A., van Zabten, G.A., & Sauer, P.J. *Hearing and language in preschool very low birthweight children*. International Journal of Pediatric Otorhinolaryngology, 1993. **26**: p. 129-140.
28. Rivkin, M.J. *Developmental neuroimaging of children using magnetic resonance techniques*. Mental Retardation and Developmental Disabilities Research reviews, 2000. **6**: p. 68-80.
29. Keller, H., Aub, B.V., Saigal, S., & Bar-Or, O. *Neuromotor ability in 5 to 7 year old children with very low birthweight*. Developmental Medicine and Child Neurology, 1998. **40**(10): p. 661-666.
30. Klebanov, P.K., Brooks-Gunn, J., & McCormick, M.C. *School achievment and failure in very low birth weight children*. Journal of Developmental and Behavioral Pediatrics, 1994. **15**(4): p. 248-256.
31. Stjernqvist, K. & Svenningsen, N.W. *Ten year follow up of children born before 29 gestational weeks*. Acta Paediatrica, 1998. **88**(12): p. 557-562.
32. Buck, G.M., Msall, M.E., Schisterman, E.F., Lyon, N.R., & Rogers, B.T. *Extreme and prematurity and school outcomes*. Paediatric and perinatal Epidemiology., 2000. **14**: p. 324-331.
33. Resnick, M.B., Gomatam, S.V., Carter, R.L., & Ariet, M. *Educational disabilities of neonatal intensive care graduates*. Pediatrics, 1998. **102**: p. 308-314.
34. Robertson, C.T., Ethes, P.C., Goldson, E., & Kyle, J.M. *Eight-year school performance, neurodevelopmental and growth outcome of neonates with broncopulmonary dysplasia: A comparative study*. Pediatrics, 1992. **89**: p. 365-372.
35. Schrader, B.D., heverly, M.A., O'Brien, C., & Goodman, R. *Academic and educational resource use of very low birth weight survivors*. Pediatric Research, 1997. **23**(1): p. 21-25.
36. Peterson, B.S., Vohr, B., & Staib, L.H. *Regional brain abnormalities and long-term cognitive outcome in preterm infants*. JAMA, 2000. **284**(15): p. 1939-1947.
37. Stewart, A.L., Rifkin, L., & Amess, P.N. *Brain structure and neurocognitive and behavioural function in adolescents who were born very preterm*. The lancet, 1999. **353**: p. 1653-1657.
38. Frisk, V. & Whyte, H. *The long term consequences of periventricular brain damage on langauge and verbal memory*. Developmental Neuropsychology, 1994. **10**: p. 313-333.
39. Aziz, K., Wickar, D., & Suave, R. *Population based study of neurologic disability of children weighing 500-1249 grams at birth in relation to neonatal cerebral ultrasound findings*. Pediatrics, 1995. **95**: p. 837-844.
40. Bendersky, M. & Lewis, M. *Early language ability as a function of ventricular dilation with IVh*. Journal of Developmental and Behavioral Pediatrics, 1990. **11**: p. 17-21.
41. Vohr, B., Wright, L.L., Dusick, A.M., & al, e. *Neurodevelopmental and functional outcomes of extremely low birth weight infants in the national institute of child health and human development neonatal research Network*. Pediatric, 1993-1994. **105**(76): p. 1216-1226.
42. Singer, L.T., Davillier, M., & Preuss, L. *Feeding interactions in infants with VLBW and BPD*. Journal of Developmental and Behavioral Pediatrics, 1996. **17**: p. 69-76.
43. Crnic, K.A., Ragonzin, A.S., & Greenberg, M.T. *Social interaction and developmental competence of preterm and full term infants during the first year of life*. Child Development, 1983. **43**: p. 1199-1210.
44. Greenberg, M.T. & Crnic, K.A. *Longitudinal predictors of developmental status and social interaction in premature and full-term infants at age two*. Child Development, 1988. **59**: p. 544-570.
45. Landry, S.H., Chapieski, M.L., Richardson, M.A., Palmer, J., & Hall, S. *The social competence of children born prematurely: effects of medical complications and parent behaviors*. Child Development, 1990. **61**(5): p. 1605-1616.

46. Singer, L.T., Salvator, A., Guo, S., Collin, M., Lilien, L., & Baley, J. *Maternal psychological distress and parenting stress after the birth of a very low birthweight infant*. Journal of the American Medical Association., 1999. **281**((9)): p. 799-805.
47. Majnemer, A., Riley, P., Shevell, M., Birnbaum, R., Greenstone, H., & Coates, A.L. *Severe bronchopulmonary dysplasia increases risk for later neurological and motor sequelae in preterm survivors*. Developmental Medicine and Child Neurology, 2000. **42**(1): p. 53-60.
48. DeRegnier, R.A., Roberts, D., Ramsey, D., Weaver, R.G., & O'Shea, T.M. *Association between the severity of chronic lung disease and first-year outcomes of very low birth weight infants*. Journal of Perinataology,, 1997. **17**((5)): p. 375-382.
49. Hughes, C.A., O'Gorman, L.A., Shyr, Y., Schork, M.A., Bozynski, M.E.A., & McCormick, M.C. *Cognitive performance at school age of very low birth weight infants with bronchopulmonary dysplasia*. Developmental and Behavioral Pediatrics, 1999. **20**((1)): p. 1-8.
50. Giacoia, G.P., Venkataraman, P.S., West-Wilson, K.I., & Faulkner, M.J. *Follow-up of school-age children with bronchopulmonary dysplasia*. The Journal of Pediatrics, 1997. **130**((3)): p. 400-408.
51. Gregoire, M.C., Lefebvre, F., & Glorieux, J. *Health and developmental outcomes at 18 months in very preterm infants with bronchopulmonary dysplasia*. Pediatrics, 1998. **101**((5)): p. 856-860.
52. Singer, L.T., Siegel, A.C., Lewis, B., Hawkins, S., & Yamashita, T. *Preschool language outcomes of children with history of bronchopulmonary dysplasia and very low birthweight*. Journal of Developmental and Behavioral Pediatrics, 2001. **22**: p. 19-25.
53. Vohr, B.R., Coll, C.G., Lobato, D., Yunis, K.A., O'Dea, C., & Oh, W. *Neurodevelopmental and medical status of low-birthweight survivors of bronchopulmonary dysplasia at 10 to 12 years of age*. Developmental Medicine and Child Neurology, 1991. **33**: p. 690-697.
54. Martin, R.J. & Walsh-Sukys, M.C. *Bronchopulmonary dysplasia - No simple solution*. New England Journal of Medicine, 1999. **276**: p. 3557-3560.
55. Mercier, C. & Soll, R. *Clinical trials of natural surfactant in respiratory distress syndrome*. Clinical Perinatology, 1993. **20**: p. 723-725.
56. Northway, W., R, R., & D., P. *Pulmonary disease following respiratory therapy of hyaline membrane disease*. New England Journal of Medicine, 1967. **276**: p. 3557-3560.
57. Horbar, J. & Lucey, J. *Evaluation of NICU technologies*. In: The Future of Children, 1996. **5**: p. 147.
58. Rojas, M.A., Gonzales, A., Bancalari, E., Claure, N., Poole, C., & Silva-Neto, G. *Changing trends in the epidemiology and pathogenesis of neonatal chronic lung disease*. Changing trends in the epidemiology and pathogenesis of neonatal chronic lung disease., 1995. **82**: p. 527-532.
59. Bancalari, E. *Changes in the pathogenesis and prevention of chronic lung disease of prematurity*. American Journal of Perinatalogy, 2001. **18**(1): p. 1-9.
60. Farrell, P.A. & Fiascone, J.M. *Bronchopulmonary dysplasia in the 1990's: A review for the pediatrician*. Current Problems in Pediatrics, 1997: p. 133-163.
61. Marshall, D.D., Kotelchuck, M., Young, T.E., Bose, C.L., Kruyer, L., & O'Shea, T.M. *Risk factors for chronic lung disease in the surfactant era: A North Carolina population-based study of very low birth weight infants*. Pediatrics, 1999. **104**(6): p. 1345-1350.
62. Pierce, M.R. & Bancalari, E. *role of inflammation in the pathogenesis of bronchopulmonary dysplasia*. Pediatric Pulmonology, 1995. **19**: p. 371-378.
63. Shenai, J.P. *Vitamin A supplementation in very low birth weight infants: Rationale and evidence*. Pediatrics, 1999. **104**: p. 1369-1374.
64. Bancalari, E. & Gerhardt, T. *Bronchopulmonary Dysplasia*. Pediatric Clinics of North America, 1986. **33**: p. 1-23.

65. Groothius, J., Gutierrez, K., & Lauer, B. *Respiratory synctial virus infection in children with bronchopulmonary dysplasia*. Pediatrics, 1988. **82**: p. 199-203.
66. Bader, D., Ramos, A., Lew, C., Platzker, A.C., Stabile, M.W., & Keens, T.G. *Childhood sequelae of infant lung disease*. Journal of Pediatrics, 1987. **110**: p. 693-699.
67. Gross, S.J., Iannuzzi, D.M., Kveselis, D.A., & Anbar, R.D. *Effect of preterm birth on pulmonary function at school age: A prospective controlled study*. The Journal of Pediatrics, 1998. **133**(2): p. 188-192.
68. Jacob, S.V., Coates, A.L., Lands, L.C., MacNeish, C.F., Riley, S.P., Hornby, L., Outerbridge, E.W., Davis, G.M., & Williams, R.L. *Long-term pulmonary sequelae of severe bronchopulmonary dysplasia*. Pediatrics, 1998. **133**(2): p. 193-200.
69. Saghedi, H., Lowenthal, D.B., & Dozor, A.J. *Inspiratory flow limitation in children with bronchopulmonary dyspasia*. Pediatric Pulmonology, 1998. **26**: p. 1167-1172.
70. Northway, W.H., Jr., Moss, R.B., Carlisle, K.B., Parker, B.R., Popp, R.L., Pitlick, P.T., Eichler, I., Lamm, R.L., & Brown, B.W., Jr. *Late pulmonary sequelae of bronchopulmonary dysplasia*. New England Journal of Medicine, 1990. **323**: p. 1793-1799.
71. Kinali, M., Greenough, A., Dimitrou, G., Yuksel, B., & Hooper, R. *Chronic respiratory morbidity following premature delivery -- prediction by prolonged respiratory support requirement?* European Journal of Pediatrics, 1999. **158**(6): p. 193-496.
72. Kennedy, J.D., Edward, L.J., Bates, D.J., Martin, A.J., Dip, S.N., Haslam, R.R., McPhee, A.J., Staugas, R.E., & Baghurst, P. *Effects of birthweight and oxygen supplementation on lung function in late childhood in children of very low birth weight*. Pediatric Pulmonology, 2000. **30**: p. 32-40.
73. Hakulin, A.L., Jarvenpaa, A.L., Turpeinen, M., & Sovijarvi, A. *capacity of the lung in school-aged children born very preterm, with and without bronchopulmonary dysplasia*. Pediatric Pulmonology, 1996. **21**: p. 353-360.
74. Meisels, S.J., Plunkett, J.W., Roloff, D.W., Pasick, P.L., & Stiefel, G.S. *Growth and development of preterm infants with repiratory distress syndrome and bronchopulmonary dysplasia*. Pediatrics, 1987. **77**: p. 725-729.
75. Frank, L. & Sosenko, I.R.S. *Undernutrition as a major contributing factor in the pathogenesis of bronchopulmonary dysplasia*. American Review of Respiratory Disease, 1988. **138**: p. 725-729.
76. Welty, S.E. *Is there a role for antioxidant therapy in bronchopulmonary dysplasia?* Symposium: Pediatric Pulmonary Insufficiency: Nutritional Strategies for Prevention and Treatment., 2001(Paper presented at the Experimental Biology 2000 meeting in San Diego, California,): p. April 15 -18, 2000. U.S. Department of Agriculture.
77. Barrington, K.J. & Finer, N.N. *Treatment of bronchopulmonary dysplasia: A review*. Clinical Perinatology, 1998. **25**(1): p. 177-202.
78. Singer, L.T., Martin, R.J., Hawkins, S.W., Benson-Szekely, L.J., Yamashita, T.S., & Carlo, W.A. *Oxygen desaturation complicates feeding in infants with bronchopulmonary dysplasia after discharge*. Pediatrics, 1992. **90**(3): p. 380-384.
79. Abrams, S.A. *Chronic pulmonary insufficiency in children and its effects on growth and development*. Symposium: Pediatric Pulmonary Insufficiency: Nutritional Strategies for Prevention and Treatment., 2001. **Paper presented at the Experimental Biology 2000 meeting in San Diego, California,**(April 15 -18, 2000.): p. U.S. Department of Agriculture.
80. Volpe, J.J. *Neurology of the newborn (3rd ed.)*. IN, (eds.). 1995, Philadelphia: W.B. Saunders.
81. Cooke, R.W.I. & Abernathy, L.J. *Cranial magnetic resonance imaging and school performance in very low birth weight infants in adolescence*. Archives of Disease in Fetal Neonatal Ed,, 1999. **81**: p. F116-F121.

82. Scrimshaw, N.S. *Malnutrition, brain development, learning, and behavior*. Nutrition Research, 1998. **18**: p. 35-379.
83. Volpe, J.J. *Overview: Normal and abnormal human brain development*. Mental Retardation and Developmental Disabilities Research Reviews, 2000. **6**: p. 1-5.
84. Perlman, J. *Neurologic manifestations in infants with severe brochopulmonary dysplasia*. International Pediatrics, 1990. **5**: p. 108-111.
85. Groothius, J.R. & Rosenberg, A.A. *Home oxygen promotes weight gain in infants with BPD*. American Journal of Diseases of Children, 1987. **145**: p. 813-817.
86. Garg, M., Kurzner, S.I., Bautista, D.B., & Keens, T.G. *Clinically unsuspected hypoxia during sleep and feeding in infants with bronchopulmonary dysplasia*. Pediatrics, 1988. **81**: p. 635-642.
87. Overstreet, W., Jackson, J.H., van Belle, G., & Truog, W.E. *Estimation of mortality risk in chronically ventilated infants with bronchopulmonary dysplasia*. Pediatrics, 1991. **88**: p. 1153-1160.
88. Garner, A. *The role of hyperoxia in the etiology of ROP*. Doc Ophthalmology, 1990. **74**: p. 193-197.
89. Skidmore, M., Rivers, A., & Hack, M. *Increased risk of cerebral palsy among very low birthweight infants with chronic lung disease*. Developmental Medicine and Child Neurology, 1990. **32**: p. 325-332.
90. Bozynski, M.E., Nelson, M.N., Matalon, T.A., O'Donnell, K.J., Naughton, P.M., Vasan, U., Meier, W.A., & Ploughman, L. *Prolonged mechanical ventilation and intracranial hemorrhage: Impact on developmental progress through 18 months in infants weighing 1,200 grams or less at birth*. Pediatrics, 1987. **79**: p. 670-676.
91. Wilson-Costello, D., Borawski, E., Friedman, H., Redline, R., Faranoff, A.A., & Hack, M. *Perinatal correlates of cerebral palsy and other neurologic impairment among very low birth weight children*. 102, 1998(315-322).
92. O'Shea, T.M., Goldstein, D.J., deRegnier, R., Sheaffer, C.I., Roberts, D.D., & Dillard, R.G. *Outcome at 4 to 5 years of age in children recovered from neonatal chronic lung disease*. Developmental Medicine and Child Neurology, 1996. **38**: p. 830-839.
93. Hoy, E.A., Sykes, D.H., Bill, J.M., Halliday, H.L., McClure, G., & Reid, M.M. *The social competence of very-low-birthweight children: Teacher, peer, and self-perceptions*. Journal of Abnormal Child Psychology, 1992. **20**(2): p. 123-150.
94. Lobato, D.J., Watson, J.E., Coll, C.G., & Vohr, B.R. *Behavioral and family characteristics of low-birthweight survivors of bronchopulmonary dysplasia at 10 to 12 years of age*. Children's Health Care, 1995. **24**(3): p. 193-204.
95. Levy-Schiff, R., Einat, G., \Mogilner, M.B., Lerman, M., & Krikler, R. *Biological and environmental correlates of developmental outcome of prematurely born infants in early adolescence*. Journal of Pediatric Psychology, 1994. **19**(1): p. 63-78.
96. Belsky, J. *The determinants of parenting: A process model*. Child Development, 1984. **55**: p. 83-96.
97. McCubbin, H.L. & Patterson, J.M. *The double ABCX model of adjustment and adaptation*, in *Advances and developments in family stress theory and research*, In H. McCubbin, M.S., and J. Patterson (Eds.), Editor. 1981, Haworth Press: New York. p. 95-106.
98. Cogill, S.R., Caplan, H.L., Alexandra, H., Robson, K.M., & Kumar, R. *Impact of maternal postnatal depression on cognitive development of young children*. British Medical Journal (Clinical Research Edition), 1986. **292**(6529): p. 1165-1167.
99. Wrate, R.M., Rooney, A.C., Thomas, P.F., & Cox, J. *Postnatal depression and child development: A 3 year follow-up study*. British Journal of Psychology, 1985. **146**: p. 662-667.

100. Radke-Yarrow, M., Cummings, E., Kuczynski, L., & Chapman, M. *Patterns of attachments in 2-3 year olds in normal families and families with prenatal depression*. Child Development, 1984. **56**: p. 884-893.
101. Brooten, D., Gennaro, S., Brown, L., Britts, P., Gibbons, A., Babenwill-Sachs, S., & Kumar, S. *Anxiety, depression and hostility in mothers of preterm infants*. Nursing Research, 1988. **37**: p. 213-216.
102. Blumberg, N.L. *Effects of neonatal risk, maternal attitude, and cognitive style on early post-partum adjustment*. Journal of Abnormal Psychology, 1980. **89**: p. 139-150.
103. Sameroff, A. & Chandler, M.J. *Reproductive risk and continuum of caretaking casualty*. In F.D. Horowitz, E.M. Hetherington. Review of Child Dev Research, 1997. **4**(Chicago: University of Chicago Press): p. 187-243.
104. Korhohen, P., Koivisto, A.M., Ikonen, S., Laippala, P., & Tammela, O. *Very low birthweight, bronchopulmonary dysplasia, and health in early childhood.* Acta Paediatrica, 1999. **88**(12): p. 1385-1391.
105. Cronin, C.M.G., Shapiro, C.R., Casiro, O.G., Cheang, M.S., & Math, M. *The impact of very low-birth-weight infants on the family is long lasting*. Archives of Pediatrics and Adolescent Medicine, 1995. **149**: p. 151-158.
106. Hollingshead, A.B. *Two Factor Index of Social Position.* 1957, Yale University: New Haven, Connecticut.
107. Marshall, W.A. & Tanner, J.M. *Variations in pattern of pubertal changes in girls*. Archives of Disease in Childhood, 1969. **44**(235): p. 291-303.
108. Dockery, D.W., Berkey, C.S., Ware, J.H., Speizer, F.E., & Ferris, B.G. *Distribution of FEV1 and FVC in children 6-11 years of age*. American Review of Respiratory Disease, 1983. **127**: p. 725-734.
109. Wechsler, D. *Wechsler Intelligence Scale for Children - Third Edition.* IN, (eds.). 1991, San Antonio, TX: Psychological Corporation.
110. Woodcock, R.W. & Mather, N. *Woodcock-Johnson Test of Achievement Revised: Standard and Supplemental Battery*. IN, (eds.). 1987, Allen, TX: DLM Teaching Resources.
111. Connors, C.K. *Connors Continuous Performance Test.* IN, (eds.). 1995, North Tonawanda, NY: Multi-Health Systems, Inc.
112. Connors, C.K. *Conners Rating Scales*. IN, (eds.). 1989, Toronto, Ontario, Canada: Multi-Health Systems, Inc.
113. Bruininks, R.H. *Bruininks-Oseretsky Test of Motor Proficiency.* IN, (eds.). 1978, Circle Pines, MN: American Guidance Service, Inc.
114. Achenbach, T.M. *Child Behavior Checklist for Ages 4-18.* IN, (eds.). 1991, Burlington, VT: University of Vermont.
115. Achenbach, T.M. *Teacher's Report Form For Ages 5-18.* IN, (eds.). 1991, Burlington, VT: University of Vermont.
116. DePaul, G.J., Rapport, M., & Perriello, L.M. *Teacher Ratings of Academic Peformance: The Development of the Academic Performance Rating Scale*. 1990: Unpublished Manuscript, University of Massachusetts Medical Center,Worcester, MA.
117. Goldman, R. & Fristoe, M. *The Goldman-Fristoe Test of Articulation.* IN, (eds.). 1986, Circle Pines, MN: American Guidance Service.
118. Vitali, G.J. *Test of Oral Structures and Functions.* IN, (eds.). 1986, East Aurora, NY: Slossan Educational Publications, Inc.
119. Semel, E., Wiig, E., Secord, W., & Sabers, D. *Clinical Evaluation of Language Fundamentals- 3rd Edition*. IN, (eds.). 1995, New York, NY: Psychological Corp.

120. Abidin, R.R. *Parenting Stress Index. 2nd ed.* IN, (eds.). 1986, Charlottesville, VA: Pediatric Psychology Press.
121. Carver, C., Scheier, M., & Weintraub, J.K. *Assessing coping strategies: A theoretically based approach*. Journal of Personality and Social Psychology, 1989. **56**: p. 267-283.
122. DeRogatis, L. & Nelisaratos, N. *The Brief Symptom Inventory: An introductory report*. Psychological Medicine, 1983. **13**: p. 595-605.
123. Stein, R.E.K. & Riessman, C.K. *The development of an impact-on-family scale: Preliminary findings*. Medical Care, 1980. **4**: p. 465-472.
124. Zimet, G.D., Powell, S.S., Farley, G.K., S., W., & Berkoff, K.A. *Psychometric characteristics of the multidimensional scale of perceived social support*. Journal of Personal Assessment, 1990. **55**(3-4): p. 610-617.
125. McCubbin, H.I., Patterson, J.M., & Wilson, L.R. *FILE: Family Inventory of Life Events and Changes*. IN Family Inventories: Inventories used in a national survey of families across the family life cycle, Olson, D., McCubbin, H., Barnes, H., Larsen, A., Muxen, M., & Wilson, M., (eds.). 1983, St. Paul, MN: Family Social Science, Univ. of Minnesota.
126. Short, E.J., Klein, N.K., Lewis, B.A., Fulton, S., Eisengart, S., Kercsmar, C., Baley, J., & Singer, L.T. *Cognitive and academic consequences of bronchopulmonary dysplasia and very low birth weight: 8-year-old outcomes*. Pediatrics, 2003. **in press**.
127. Lewis, B.A., Singer, L.T., Fulton, S., Salvator, A., Short, E.J., Klein, N., & Baley, J. *Eight year speech and language outcomes of children with a history of bronchopulmonary dysplasia and very low birth weight*. Journal of Communication Disorders, 2002. **35**: p. 393-406.
128. Short, E.J., Klein, N., Lewis, B., Fulton, S., Guo, S., Carlisle, M., Baley, J., & Singer, L.T. *The stability of intelligence in BPD, VLBW, & Term children: Follow-up at eight years of age*. in *Pediatric Academic Societies & American Academy of Pediatrics Joint Meeting*. 2000. Boston, MA.
129. Kercsmar, C., Baley, J., Short, E., Lewis, B., Klein, N., Salvator, A., Khosla, A., & Singer, L.T. *8 Year pulmonary function, cognitive and motor outcomes of bronchopulmonary dysplasia (BPD) and very low birthweight (VLBW) infants*. in *Society for Pediatric Research Meeting*. 2001. Baltimore, MD.
130. Saigal, S., Rosenbaum, P.L., Szatmari, P., & Campbell, D. *Learning disabilities and school problems in a regional cohort of extremely low birthweight children (1000g): A comparison with term controls*. Joural of Developmental and Behavioral Pediatrics, 1991. **12**(5): p. 294-3000.
131. Shiono, P.H. & Behrman *The problem of low birth weight, ch 1, Low birth weight*. The Future of Children (The David and Lucille Packard Foundation), 1995. **5**(1): p. 418.
132. Hauser-Cram, P., Warfield, M.E., Shonkoff, J.P., Krauss, M.W., Sayer, A., & Upshur, C.C. *Children with Disabilities: A longitudinal studyof child development and parent well being*. Monographs of the Society for Research in Child Development, 2001. **66**(3:i-viii): p. 1-114; Discussion 115-126.
133. Berlin, L.J., Brooks-Gunn, J., McCarton, C., & McCormick, M.C. *The effectiveness of early intervention: Examining risk factos and pathways to enhanced development*. Preventive Medicine, 1998. **27**(2): p. 238-245.