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The relationship of birth weight and maternal education to developmental outcomes of low birth weight infants

Shehan-Bakewell, Colleen, M.S.

The University of Arizona, 1994

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THE RELATIONSHIP OF BIRTH WEIGHT
AND MATERNAL EDUCATION TO
DEVELOPMENTAL OUTCOMES OF
LOW BIRTH WEIGHT INFANTS

by
Colleen Shehan-Bakewell

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A Thesis Submitted to the Faculty of the
COLLEGE OF NURSING
In Partial Fulfillment of the Requirements
for the Degree of
MASTER OF SCIENCE
In the Graduate College
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1994
STATEMENT BY AUTHOR

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ABSTRACT

The purpose of this research was to investigate the relationship between specific infant and maternal characteristics with the developmental outcome of low birth weight infants.

Birth weight was statistically significant in relation to the Mental Developmental Index (p = .001) and the Psychomotor Developmental Index for chronologic age (p = .023). Birth weight predicted 25% of the variance in infant cognitive development and 24% in infant motor development. There was no statistically significant positive correlation between maternal education and infant cognitive and motor developmental outcome.

There was a statistically significant correlation between: number of hospital days (MDI, p = .006; PDI, p = .010); number of days on oxygen (MDI, p = .006; PDI p = .037); gestational age (MDI, p = .006); and infants with bronchopulmonary dysplasia (MDI, p = .020; PDI, p = .020) in relation to developmental outcome. These findings support the premise that co-morbidity of infants appears to increase the risk of developmental delay.
CHAPTER ONE: INTRODUCTION

Survival among low birth weight (LBW) infants is higher in the United States than other industrialized nations (Wegman, 1989). The survival of pre-term and sick neonates has increased with technological advances in perinatal medicine and concurrent concerns about the developmental outcomes for these tiny infants. There is considerable evidence that many NICU graduates suffer moderate to severe developmental delays (Hack & Fanoroff, 1989; Hack, Weissman, Aram, Klein & Borawski, 1991; Orgill, Astbury, Bajuk, & Yu, 1982; Stanley & Blair, 1991; Jarvenpaa, Virtanen & Pohjakuori, 1991; Smith & Knight-Jones, 1990; Veen, Ens-Ookhum, Schreuder, Verloove-Vanhorick, Brand & Ruys, 1991). The literature confirms that careful follow-up and early intervention can greatly improve the long-term developmental outcomes of these infants (Barrera, Doucet & Kitching, 1992; Richmond, 1990; Ramey, Bryant, Wasik, Sparling, Fendt & La Vange, 1992; Brooks-Gunn, Gross, Kramer, Spiker & Shapiro, 1992). However, the interventions are costly and there remains uncertainty about which NICU graduates may be at greater risk for poor developmental outcomes.

The long-term goal of this study was to provide a research foundation for identifying infants at greatest risk for developmental problems, specifically in the cognitive and neuro-motor areas of development. In addition, this
study investigated the relationship between maternal education and developmental status of neonatal intensive care graduates.

**Incidence of Low Birth Weight**

More than 270,000 low birth weight (LBW) neonates are born annually in the United States, and about 48,000 of these infants weigh less than 1500 grams (National Center for Health Statistics, 1988). In the past 30 years, the proportion of low birth weight infants has declined moderately, and infant mortality rates have dropped sharply. In the United States, 7 percent of all neonates weigh 2500g or less at birth. In addition, the proportion of live births with very low birth weight (VLBW) (<1500 grams) has changed little over time, and constitutes 1.15 percent of all births (McCormick, 1985; Orgill et al., 1982). The extremely low birth weight infant (ELBW) (<750g) represents 0.5% to 0.2% of the total number of newborns and 37% of the perinatal mortality (Jarvenpaa et al., 1991; Hack & Fanaroff, 1989). A study by Hack and Fanaroff (1989) from 1982 to 1988 revealed survival rates specific to birth weight ranging from: 5 to 20 percent for infants weighing 500 to 599 grams; 23 to 41 percent at 600 to 699 grams; and 33 to 61 percent at 700 to 799 grams. These extremely low birth weight (ELBW) infants will have a tremendous impact on the workload and economy of the neonatal intensive care unit and society.
It is important to note that minority women have a higher probability of giving birth to low birth weight infants than Caucasian women. Black infants are twice as likely to weigh under 2500 grams than white infants (13 vs 5.6 percent). This is also true for VLBW infants (2.4 vs 0.9 percent) (McCormick, 1985; National Center for Health Statistics, 1988). Other minority groups with an increased risk for delivery of low birth weight infants include Hispanic and American Indian women (6.2 percent) (National Center for Health Statistics, 1988). Women with more education are less likely to have low birth weight babies in every group (Wegman, 1989).

Developmental Sequelae

The survival of pre-term and sick newborns has increased with advanced technology in perinatal care, such as in the treatment of respiratory distress syndrome with surfactant, and collaboration between obstetric and perinatal care providers (Ferrara, Hoekstra, Couser, Jackson, Andersen, Myers & Raye, 1991; Resnick, Roth, Ariet, Carter, Emerson, Hendrickson, Packer, Larsen, Wolking, Lucas, Schenck, Fearnside & Burciarelli, 1992). The NICU graduates are surviving at a younger age, but may have problems from the visual, auditory, and tactile onslaught of the environment (Lawhon & Melzar, 1988). The combined effect of prematurity and environmental stress following birth increases the chance of permanent developmental delays
and problems. There is grave concern about the long-term development of these tiny NICU graduates.

Approximately 30 percent of low birth weight babies who weigh less than 1500 grams at birth can now expect to have moderate to major developmental delays. Of those who weigh less than 800 grams at birth, half will have moderate to major developmental delays (Lawhon & Melzar, 1988; Stjernquist & Svenningsen, 1990).

A number of studies have reported low rates of severe handicaps (5-20%) which have remained stable over the years (Smith & Knight-Jones, 1990; Stewart, Reynolds & Lipscomb, 1981; Orgill et al., 1982). However, more recent studies have shown higher levels of severe disabilities, learning and behavior problems, lower intelligence, and health problems among children who were NICU graduates than among the general population (Ramey et al., 1992; Sternquist & Svenningsen, 1990; Hack & Fanaroff, 1989). The disability rates have been highest for those with lowest birth weight (Robertson, Hrynychshyn, Etches & Pain, 1992). The ELBW infants show a significant trend of increased cerebral palsy (Orgill, et al., 1982). In addition to learning and behavioral problems, the infants are at increased risk for complications such as cerebral palsy, bronchopulmonary dysplasia, retinopathy, seizures, and intracranial hemorrhage (Gorga, Stern, Ross & Nagler, 1991; Parker, Lindstrom & Cotton, 1992; Jarvenpaa et al., 1991). A higher
incidence of neurologic abnormalities has been found in infants with the above complications, especially those with intracranial hemorrhage and bronchopulmonary dysplasia (Robertson, Etches, Goldson & Kyle, 1992; Medoff-Cooper, Delivoria-Papadopoulous & Brooten, 1991).

**Parent-Infant Interaction Issues**

Neurologically impaired infants are more likely to display hyperactive behavior with difficult temperaments as compared to neurologically intact infants (Hack et al., 1991; McCormick, Brooks-Gunn, Workman-Daniels, Turner & Peckman, 1992; Medoff-Cooper et al., 1991). These difficult temperaments and behavior problems may be related to increased interactional problems with parents (Medoff-Cooper et al., 1991). It is important for infants to be able to respond to each family member in a joint regulation of interactions. Maladaptive behavior results when one member of the dyad is unable to respond appropriately and elicits or demonstrates unexpected cues. Mothers and pre-term infants have less eye contact, less optimal patterns of holding, and mothers give lower levels of positive messages during teaching and have lower levels of reported involvement in daily care of the child compared to mothers of term babies (Barnard, Bee & Hammond, 1989; Hanzlick, 1989). The social experience and the environment influence whether the deviations become a disability (Fritz, 1987).
The quality of early interaction between parents and infants is predictive of many long-term developmental outcomes (Fraley, 1990; Barnard et al., 1984).

**Interventions**

Many interventions have focused on improving parent-infant interactions among pre-term infants and their parents. These interventions have resulted in greater emotional security of infants and better cognitive outcome for LBW infants (Barrera et al., 1990; Ramey et al., 1990).

The potential developmental delays and disabilities among NICU graduates are of great concern for nurses, physicians, educators, and economists. The challenge will be to optimize the outcome of the pre-term neonates (Lawhon & Melzar, 1988). This concern is reflected in the recent attention that the federal government has given to this high risk population through the legislation PL 99-457. This plan was developed to provide early intervention, and the goals for early intervention were: (a) to provide support for families that may need multiple, complex services for their handicapped child; (b) to provide family training and counseling in the following areas: physical, cognitive, language and speech, psycho-social and self-help; and (c) to enhance child development by minimizing delay in beginning and thereby increasing the scores or educational gain (Hanft, 1988; Knowles, 1991). There is growing evidence that early intervention with infants and their parents will
minimize future costs in education, decrease institutionalization, avert the need for special education, and have positive effects on children's development (Blackman, Healy & Ruppert, 1992). A large, multi-center study reported by Ramey et al. (1992) revealed higher IQ scores at 36 months of age and fewer behavior problems for the low birth weight group enrolled in the intervention program, with multi-intervention modalities, education, family support, and pediatric follow-up than the infants without intervention.

This study investigated a sample population of low birth weight infants at the Newborn Follow-up Clinic. The Bayley Scales of Infant Development was used to assess their developmental outcome. All the children at the Newborn Clinic received developmental intervention and appropriate referrals such as physical therapy when needed. The sample is considered to be an intervention group.

Effective early interventions are expensive. There is no quick cure for developmental delay (Ramey et al., 1990). However, there are many examples of long-term cost savings as a result of early intervention. If intervention for handicapped infants is delayed until age 6, education costs to age 18 are estimated to be $53,350.00. In contrast, if the infant is provided with early intervention at birth, education costs $37,272.00, a net savings of $16,078.00 (report number Y4(.43/2:op/5). For every $1.00 invested in
preschool programming there is a $3.00 savings or reduction in public special education costs (Report number Y4.C.43/2: op/5). The earlier the intervention, the greater the cost savings and the higher the rate of educational attainment.

Significance to Nursing

Low birth weight infants are not routinely followed after discharge from neonatal intensive care, unless they are categorized as "at risk." The Federal Government, under PL-457, has established a program to follow-up the "at risk" population, and each state was given the responsibility to establish their own criteria for the follow-up care of high risk pre-term infants. No clear definition has been established of the "at risk" population, and that is a problem. Not only is research necessary to establish exactly what groups are most likely to have developmental problems, but research about follow-up care in the home and/or clinic by a nurse specialist is needed.

Preventive health care is an important concept, and is an integral part of a nurse's role in the health care system. The early intervention program is an excellent example of preventive care. Nurses and other health professionals are working together and have an opportunity to increase their role in prevention. The early childhood intervention PL-457 will provide nurses with different roles, increased Federal funds, and an increase in early intervention programs for the handicapped (Velsor-Friedrich & Frager, 1990).
Efforts to reduce premature births is important in reducing the population burden of morbidity, especially in the case of ELBW infants. However, the prevalence is unlikely to be reduced to zero. McCormick et al. (1992) concluded that "those with birth weights of 1500g or less were more likely to experience multiple health problems with increased morbidity at an early school age" (p.688). Robertson and coworkers (1992) found that VLBW babies showed academic delay at the eight year level of school performance when compared with their peer group. Robertson et al. (1992) concluded that the duration of pulmonary disease affected the outcome of premature infants. However, prematurity with and without chronic lung disease, along with other variables (poverty and other social factors), compromised the neuro-developmental outcome of the LBW infants. The above results provide important prognostic information for the children and their families, and, in addition, support early and prompt initiation of post-discharge interventions to improve developmental outcome (McCormick et al., 1992).

The increased survival rate of LBW neonates accompanied by a decrease in neurologic status and other complications has put a considerable strain on the health care system. Supportive nursing care with close follow-up supervision of the families of LBW infants can enhance the child's development and save money. Nurses must be committed to
optimizing long-term developmental outcome. Nursing influence can start right after birth and continue to influence the infants' development in the community by positively influencing the environment and by providing teaching for appropriate family interactions (Lott, 1989).

Intensive intervention increases cognitive performance, which is supported by an increase in IQ scores and decreased behavior problem scores in the intervention group relative to the pediatric follow-up group. Intensive intervention does not eliminate correlative relationships between individual differences in biological, social, and psychological risk factors (Ramey et al., 1992). It is necessary for prevention programs and nurses to consider potentially alterable factors in biology (birth weight and neonatal health status) and behavior (maternal education and intervention participation) when developing an individualized care plan for early intervention (Ramey et al., 1992). Brooten, Kumar, Brown, Butts, Finkler, Bakewell-Sachs, Gibbons and Delivoria-Papadopoulos (1986) concluded "that early discharge of VLBW infants, with follow-up care in the home by a nurse specialist is safe and cost effective" (p.934). Prolonged hospitalization increases parental stress, possible child abuse, and is associated with infant failure to thrive (Crnic, Greenburg, Robinson & Ragozin, 1984). Nurses will become a bridge between the hospital and the community and provide
continuity of care with specialized knowledge and skills for these families and infants, with backup care available by the physicians (Brooten et al., 1986).

**Statement of Purpose**

The purpose of this study was to investigate the relationship of birth weight and maternal education on infant development among Neonatal Intensive Care Unit graduates. The specific objectives were to investigate the research questions as follows: (a) What is the relationship between birth weight and infant developmental outcome at 12-36 months of age?; (b) What is the relationship between maternal education (measured in number of years) and infant development?; and (c) Do maternal education and birth weight account for a significant amount of variance in infant development?

**Statement of Problem**

There is insufficient data available to identify low birth weight infants at highest risk for developmental problems in the first year. Therefore, it is difficult to direct the resources effectively. The low birth weight infants are in great need of nursing intervention and support services. Many studies suggest that educational outcome and cognitive ability improve with intervention, especially with positive parent-infant interactions and quality environmental influences (Barnard et al., 1984; Brooks-Gunn et al., 1992). In addition to the environment
influencing the developmental outcome, the infant's own physical difficulties also impact the developmental course. It is important to take a comprehensive approach to development and all its related variables, which could predict developmental outcome. Research is needed to explore the degree to which neonatal illness and prematurity impact mental, physical, behavioral, and educational morbidity (Resnick et al., 1992). This research will help to increase knowledge and increase the understanding of developmental outcome for LBW and VLBW infants by studying individual characteristics and exploring the influence of birth weight and maternal education on development in the first year. This information can be used to identify infants with increased risk, establish family-focused intervention programs, enhance parent-infant interactions, and improve cognitive and neuro-motor developmental outcomes. Information about the health status and disabilities associated with prematurity is critical to perinatal and obstetric assessment and to the management of the high risk survivors (McCormick et al., 1992).

**Research Questions**

This research was designed to answer the following questions regarding high risk NICU graduates:

1. What is the relationship between birth weight and infant developmental outcomes? Specifically:
a. Is there a significant positive correlation between birth weight and infant cognitive development (Mental Developmental Index [MDI])?
b. Is there a significant positive correlation between birth weight and infant motor development (Psychomotor Index [PDI])?

2. What is the relationship between maternal education and infant developmental outcomes?
   a. Is there a significant positive correlation between maternal education and infant cognitive development (MDI)?
   b. Is there a significant positive correlation between maternal education and infant motor development (PDI)?

3. Do maternal education and birth weight account for a significant amount of variance in infant development?
   a. Do birth weight and maternal education account for a significant amount of variance in infant motor development (PDI)?
   b. Do birth weight and maternal education account for a significant amount of variance in infant cognitive development (MDI)?

Definitions

LBW refers to low birth weight, which is defined as birth weight <2500 grams. The LBW infants were all premature infants appropriate for gestational age.
VLBW refers to very low birth weight, which is defined as birth weight <1500 grams.

ELBW refers to extremely low birth weight (<600 grams).

Birth-weight refers to the weight recorded on the discharge hospital summary in the chart at the newborn follow-up clinic.

Prematurity refers to the gestational age (<37 weeks) determined by Dubowitz at birth, as recorded in the chart.

Bayley Scales of Infant Development (Bayley, 1969). The Bayley Scales measure infant mental and motor development and provides standard scores (M=100, SD=15). This is a carefully developed measure of infant development for children from 2 months to 2.5 years of age. The Bayley Scales contain three parts: (a) mental scale; (b) motor scale; and (c) infant behavior record. The two standard scores provided are a Mental Developmental Index (obtained from the Mental Scale), and a Psychomotor Developmental Index (obtained from the Motor Scale). An Infant Behavior Record rating scale can also be completed.

1. Mental Scale (Bayley, 1969) This scale contains 163 items arranged by tenths of months. Items involve shape discrimination, sustained attention, purposeful manipulation of objects, imitation and comprehension, vocalization, memory, problem solving, and naming objects. The results of the Mental Scale are expressed as a standard score, the MDI, or the Mental Developmental Index.
2. **Motor Scale (Bayley, 1969)** This scale contains 81 items which provide a measure of the degree of control of the body, coordination of the large muscles, and use of the fine motor manipulation of the hands and fingers. These gross motor and fine motor movements include sitting, standing, walking, and grasping. The results of the administration of the Motor Scale are expressed as a standard score, the PDI, or Psychomotor Developmental Index.

3. **Infant Behavior Record (Bayley, 1969)** This scale provides a systematic way of assessing and recording observations of a child's behavior during the examination. The Infant Behavior Record (IBR) helps the clinician assess the nature of the child's social and objective orientations toward his environment as expressed by the following areas: social orientation, cooperativeness, fearfulness, tension, general emotional tone, objective orientation, goal directedness, attention span, endurance, activity, and reactivity.

**Cognitive development.** The term "cognitive" refers to the individual and how that person develops in relation to the objects and environment around that person. Children are born with inherited potential but adapt to the world around them and develop through interaction with the environment (Als, Lawhon, Brown, Gibes, Duffy, McAnulty & Blickman, 1986; Whaley and Wong, 1991). By assimilating information
through the senses and interacting with the environment, the infant comes to understand the world in relation to her/himself. Developmentally appropriate input from the environment may be associated with improved cortical development and therefore have better mental and motor development (Als, 1986). Cognitive development allows individuals to reason abstractly, to think in a logical manner, and to organize intellectual functioning in higher order structures (Whaley and Wong, 1991).
CHAPTER TWO: REVIEW OF LITERATURE

Developmental outcome of NICU survivors is affected by multiple factors, including both biological and environmental. This study will concentrate on birth weight and maternal education and their relationship to the infant's developmental outcome, specifically in the cognitive and motor areas. A description of the association of birth weight and maternal education to development may assist health professionals in prioritizing which high risk survivors are most in need of early intervention.

Theoretical Framework

The creation and implementation of this research was guided by a model called the "Influence of Maternal and Infant Characteristics on Infant Development," adapted from the theoretical framework of Bronfenbrenner (1969) and Barnard et al. (1984) by the primary investigator, Colleen Shehan-Bakewell.

The major concepts of the model were based on Bronfenbrenner's ecological theory and are as follows: Infant characteristics, Maternal Characteristics, and Infant Development, all of which are in a process of continuous change and interaction with the environment. This model utilizes and adapts the definition of environment from Bronfenbrenner's theory (Bronfenbrenner, 1969). The ecology of human development is based on a systems
perspective and has been defined by Bronfenbrenner as:

The ecology of human development involves the scientific study of the progressive, mutual accommodation between an active, growing human being and the changing properties of the immediate settings in which the developing person lives, as this process is affected by relations between these settings, and by the larger contexts in which the settings are embedded (Bronfenbrenner, 1969, p.21).

Through the process of growing, the person continues to change and acquires a more extended, differentiated and valid concept of the ecologic environment. Development is expressed through behavior in a particular environmental context. Behavior evolves as a function of interplay between person and environment.

Environment defined by Bronfenbrenner (1969) consists of the developing person and the immediate surroundings that contain this developing person. Environment is how the person perceives the setting and the interconnections between the environment and the developing person. Bronfenbrenner (1969) states that these interconnections can be decisive for the development of the child as events take place in the setting.

Barnard's (1989) framework emphasizes the parent-child interaction and the environment in which it occurs. The infant is seen as a growing dynamic organism that
continuously interacts with the environment. The individual infant integrates sensory, cognitive, motor, and social capacities and negotiates his/her unique and specific development by bringing these capacities to bear on the environment (Als, 1982). The study of human development is characterized by the intra-organism, subsystem interaction, and the reciprocity between the organism and the environment (Als, 1982; Linton, 1986). Measuring the behavior of the infant will assist in the assessment of the developmental progress of the neonate. Behavior in one subsystem will affect the expression and the development of other subsystems (Linton, 1986).

Although heredity sets some limits on a child's potential, it is the environment that permits that potential to be actualized. The environment may promote or restrict intelligence, so heredity estimates do not set final limits on human intelligence (Sattler, 1992).

Multiple variables effect the developmental outcome of low birth weight infants, and birth weight and maternal education are two factors that are important in the developmental profile. The two sub-concepts, maternal education and infant birth weight, will be evaluated for relationship on several dimensions of development: social, cognitive, and motor development (See Figure 2).

The model "Influence of Maternal and Infant Characteristics on Infant Development" was based on
information extracted from both Barnard and Bronfenbrenner's theories, and the investigator's concepts. This model's unique feature is its focus on the concepts of motor and cognitive infant development.

The main concepts of the model are Infant Characteristics, Maternal Characteristics, and Infant Development (See Figure 1). This model illustrates that infant characteristics and maternal education have a significant relationship to infant development, independently and in interaction. The model also shows an interactive effect between maternal education and infant characteristics, and that they have an overall impact on infant development.

The operational definitions were developed to measure the sub-concepts and include (a) infant weight measured in grams, (b) maternal education measured in years, and (c) the two dimensions of development measured by the Bayley Scales of Infant Development (Cognitive = MDI, Motor = PDI).

**Maternal Characteristics Influencing Development**

Low birth weight infants whose parents have both lower socio-economic (SES) and a minority status are at a great risk for developmental delay. Unfortunately, it is difficult to locate and follow families of low SES due to high attrition rates.

For example Laskey, Tyson, Rosenfeld, Krasinski, Dowling and Gant (1987) reported that, despite the efforts
Figure 1, Conceptual Framework

Influence of Maternal and Infant Characteristics on Infant Development.

Adapted from the theoretical framework of Bronfenbrenner (1969) and Barnard (1989).
Infant Characteristics

Birth Weight

grams

Maternal Characteristics

Maternal Education

Years

Infant Development

Cognitive

Motor

MDI

PDI

Environment

Figure 2, Conceptual Framework

MDI = Mental Developmental Index

PDI = Psychomotor Developmental Index
to minimize attrition, only 56% of the indigent high risk children participating in the study came for follow-up at one year of age. Follow-up care was compromised by problems of communication, transportation, and frequent address changes, along with a variety of other factors. Laskey et al. (1987) stated that infants who failed to return for follow-up, but who were later located, had a two fold greater incidence of neurologic deficits.

Therefore, minimal literature is available regarding the low SES population with high risk, LBW infants. A large number of studies involved white middle class populations because they have a much lower attrition rate than the lower socio-economic subjects (Laskey et al., 1987).

Laskey's study population of indigent high risk very low birth weight (VLBW) infants was assessed at one year of age with the Bayley Scales of infant development and by two neurologic examiners. The percentage of these high risk infants with gross motor abnormality and developmental delay varied in all groups, but was disturbingly high in the high risk subgroups. The ventilator-treated infants were significantly more delayed in the mental and motor areas than non-ventilated infants regardless of the weight status of the babies, but was highest in VLBW infants (39%). The Mental Developmental Index (MDI) was less than 70, and the gross motor abnormalities was increased in 27% of all VLBW infants and 33% of ventilator treated infants.
Feingold (1991) studied a sample population of LBW infants from low income families. The Bayley Mental Scale was used to assess this group of infants between one and two years of age. Feingold concluded that the incidence of gross motor and mental delay was 19.8% in LBW infants. Feingold's study had a lower incidence of developmental deficits (19.8%) than the 29-39% reported by Laskey et al. (1987). One reason Feingold's study reported a lower incidence of developmental deficits could be that the majority of infants were low birth weight (with mean birth weight 1700 grams) rather than very low birth weight, and were largely a group of relatively well infants, while Laskey's study included mostly very low birth weight infants.

There was no significant correlation between maternal education level (range 8-17 years; mean 12.4 years) and infant development in the sample of LBW infants from low income families, as reported by Feingold (1991). This finding conflicts with results reported by Brooks-Gunn et al. (1992) and Resnick et al. (1992) that maternal education was correlated to cognitive outcome in high risk infants. Feingold suggested that the reason for the conflicting results may be related to the difference in the age of the infants at the time of testing and the different tools used to measure developmental status.
Brooks-Gunn, Liaw and Klebanov (1992) state that early intervention, especially center based programs, had positive results for low birth weight, socio-economically disadvantaged children. The Bayley Scale of Infant Development, including both Mental and Motor Scales, was used to assess cognitive outcome in this multi-center study. Children whose mothers were black or Hispanic and who had less education scored lower in all cognitive domains than the children whose mothers were white and more educated (Brooks-Gunn et al., 1992, p. 356). The black families in the study were at a greater environmental risk than the white families. The results of the Infant Health and Development Program (IHDP) study indicated that genetic and socio-cultural factors (e.g., gender, ethnicity, and geographic area) exert additive influences on cognitive development beyond the effects of participating in early intervention (Ramey et al., 1992). Continued investigation and research is needed to help identify important variables from infant characteristics, maternal characteristics, and environment to help determine their impact on developmental outcome (Ramey et al., 1992).

Shapiro, Palmer, Antell, Bilker, Ross and Capute (1990) studied the relationship between current reading ability and the achievement of early language and motor developmental milestones for 240 normal newborn children aged 7.5 years. The Wechsler Intelligence Scale was used in this study to
evaluate cognitive and language ability. A high attrition rate was associated with lower socio-economic status. Approximately one third of the cohort from the lower SES were present for the final test evaluation. A significantly higher proportion of black children and children in lower SES were found to have a reading delay and performed less well on the Wechsler Intelligence Scale (Full Scale IQ 94.3 vs 115.6).

Resnick and others (1992) studied neonatal intensive care (NICU) graduates in the public school system from 1975 through 1983. Outcomes of the NICU graduates compared to other newborn graduates were evaluated by placement in four academic categories: regular classroom, academic problems, speech/language impairment and major impairment. The outcome for these groups was essentially the same. Their placement into different groups was effected by poverty status, sex, and race. Seventy percent of the poverty-level children were in one of the three problem categories as opposed to 40% of children above the poverty level. Seventy percent of black children vs 44% of white children were in the problem categories; 65% of the boys vs 54% of the girls, and; 63% of the NICU vs 57% normal nursery.

Resnick et al. (1992) concluded, "poverty status and race have a major impact on educational outcome" (p.377). The main predictors of mental development are race, maternal education, and birth weight for infants less than 1000
grams. In addition, Resnick states that intervention programs are needed to reduce poor educational outcome and should be targeted primarily to children with diagnosable handicaps and children from minority low income families.

Mother-infant interactions may be influenced by the mother's socio-economic status, maternal education, and the use of social supports (Ramey et al., 1992). Feingold (1991) reported the level of both maternal and paternal education were significantly correlated with the home environment. Parents with more education provide a better quality of home environment, and may impact the knowledge base of the parents, employment opportunities, and available resources (Feingold, 1991). The quality of the home environment was strongly correlated to infant development in Feingold's study.

Mothers with less education may not understand proper developmental stimulation for their LBW infants. Better educated mothers provide more positive messages, are more responsive to their infant, are less restrictive, and provide more facilitation for the learning experiences (Barnard et al., 1984). The use of encouragement and education about the LBW infant's developmental milestones and the infant's stress cues may be related to improved developmental outcome. An early intervention program may be able to alter these characteristics, directly and/or indirectly (Ramey et al., 1992).
Developmental Outcomes: Cognitive

Although morbidity rates have improved for premature infants, these infants are at great risk for neurologic, cognitive, and behavioral problems (Becker, Grunwald, Moorman & Stuhr, 1991). Even the infants with "normal" cognitive and neurologic outcome have a high incidence of attention-related disorders and information processing problems in school. The premature infants with the largest risk for learning difficulties in school are the very low birth weight infants (Volpe, 1991).

Each year approximately 45,000 VLBW infants are born in the United States, and about 80 to 85 percent survive the neonatal period (Volpe, 1991). Twenty to 25% of very low birth weight infants have appreciable school difficulties as a result of cognitive and related difficulties (i.e. deficits in attentional skills and specific learning skills) (Volpe, 1991). A study by Hack et al. (1991) concluded that VLBW infants with subnormal head circumference at eight months of age were more prone to poor cognitive function, poor academic achievement, and behavioral problems at eight years of age. Perinatal growth failure is common among VLBW infants (Casey, Kraemer, Bernbaum, Tyson, Sells, Yogman & Bauer, 1990; Hack et al., 1991). Hack et al. (1991) showed that head size at eight months is a predictor for cognitive function at three years of age and this was independent of environmental and biologic risk factors. In this study, the
IQ was less than 85 in 50 percent of the VLBW survivors, and the index of academic skills was less than 80 in 34 percent. Although there are fewer severe neurologically disabled LBW, NICU survivors, there is a lower incidence of intelligence and a higher incidence of learning difficulties found in this group. These disabilities will remain hidden if the criteria for "normality" is the absence of major neurologic impairment (Smith & Knight-Jones, 1990; Robertson et al., 1992).

Forslund and Bjerre (1990) concluded that growth and mental development at four years of age was within normal range for the pre-terms (<2035 ±441g; range 900-3200g) when compared to full-term infants. Psychometric evaluation with Griffith's Mental Developmental Scale showed that pre-terms did perform less well than the full-term babies, especially in the areas of language development, sub-scales of eye hand coordination, practice, and practical reasoning. There was no correlation in this study within the pre-term group and birth weight, gestational age, prenatal score, or parental social status or education.

Feingold (1991) agreed with Forslund and Bjerre (1990) that birth weight was not significantly correlated with infant development in the sample of LBW infants from low income families. It was suggested by Feingold (1991) that these results indicate that perinatal risk factors are not good predictors of developmental outcome, but further research is needed in this area.
In contrast, Hack et al. (1991) demonstrated that birth weight <1000 grams has an impact on mental development. Several studies agree that infants with VLBW and ELBW have a higher incidence of poor cognitive and developmental outcome (Jarvenpaa et al., 1991; Brooks-Gunn et al., 1992). The mean IQ declines with decreasing birth weight in the first four years of life, according to Brooks-Gunn and coworkers (1992).

Most studies have found that VLBW infants are less likely to achieve developmental milestones on time, have more difficulties in school, and are less able than their peer group who were born at term. A study by Smith and Knight-Jones (1990) showed VLBW children performed poorly when compared to term babies. The study population consisted of infants born in 1981 in the Nottingham Health District who weighed less than 1500 grams. The VLBW survivors' mean score on the McCarthy Scales was significantly lower (12 points) than their control group (the differences were most evident in verbal and the memory subtests). No children in the control group scored below 74, but eight of the study children scored below 70, which places the study group in need of special education. The results of the present studies suggest that learning difficulties among the study group will become increasingly apparent at higher educational levels (Smith & Knight-Jones, 1990).
The results of Smith and Knight-Jones (1990) are similar to the results of Casiro, Moddermann, Stanwick, Pannikkar-Thiessen, Cowan & Cheang, (1990). Casiro and coworkers found that the language scores in VLBW infants were significantly lower than in full-term babies, and 39% had significant language delays at one year of age. The VLBW infants exhibited a shorter attention span, and were less likely to understand simple commands, to recognize body parts when named, to initiate speech gesture games, or to use words consistently. Language delays were more prevalent but not limited to infants with mild to moderate neurologic problems.

Williamson, Wilson, Lifschitz and Thurber (1990) also agree with the results of Smith and Knight-Jones (1990) and Casiro et al. (1990). The VLBW infants were more likely than term infants to have significant discrepancies between their fine motor or their language abilities and problem solving skills as measured by the revised Gesell. These infants scored significantly below term infants across all fields of behavior (gross motor, fine motor, language, adaptive, and personal-social). The "normal" pre-term infant with adequate global developmental scores in this study showed significant deficits in several areas which could effect school performance in the future. The quality of survival is a cause of anxiety, and the above studies give rise to the concern that extreme pre-term birth may itself be a factor perpetuating social disadvantage.
The Infant Health and Development Program was a national collaborative study that investigated the efficacy of combining pediatric follow-up, child developmental and family support services in order to reduce the problems of development and health status of the low birth weight premature infants (Ramey et al., 1992; Brooks-Gunn et al., 1992). The intervention of the IHDP began at discharge and continued until the age of three, and emphasized the importance of early and consistent experience for the LBW infant.

Low birth weight infants have an increased risk for problems in visual-motor, spatial skills, and receptive language skills. The NICU survivors not only have neurosensory problems, but they are at increased risk for neurodevelopmental problems. The primary outcome of this project was that early intervention did have a positive impact on the child's cognitive and behavioral competence at three years of age. The Bayley Scales of Infant Development were used to assess the children's cognitive ability at ages 12 and 24 months. The Peabody Picture Vocabulary Test, the Stanford-Binet, and Beery Test of Visual Motor were utilized at 36 months.

The early intervention service resulted in cognitive gains across the domains. The effects were not specific to any one domain as analyzed by factor analysis. Birth weight and ethnic group were associated with treatment efficacy.
Larger treatment effects on the level of IQ scores were seen for heavier birth weight infants (2001g to 2500g) than for the lighter birth weight infants (< 2000g) \( (p=.014) \). These results suggest that biological factors may play a role in limiting some interventions. Intervention is questionable for the infants weighing less than 1500 grams and with IQ scores less than 70. The results were strongest in the areas of visual-motor, spatial and language skills for the LBW infants. Developmental and biologically vulnerable infants can improve their developmental profile by early intervention services.

**Developmental Outcomes: Motor**

A goal for neonatal medicine and nursing is to improve the accuracy of predictors for the long term developmental outcome of NICU survivors (Bennet, Silver, Leung & Mack, 1990). Motor milestones are not directly related to cognition, but delayed motor development may serve as a marker for other neuro-developmental dysfunctions (Shapiro, et al., 1990). Major motor deficits in VLBW infants occur in 5 to 15% of this group (Volpe, 1991). Cognitive development of pre-term infants is more difficult to use as a marker of outcome because there is a great deal more variability seen in cognitive developmental outcome than motor development.

Epidemiologic studies in many developed countries report that cerebral palsy among pre-term infants has
increased over the last decade with increasing survival of LBW babies (Stanley & Blair, 1991). The risk of cerebral palsy rises as birth weight falls, and as more of these children survive the number will also rise. It has been suggested that birth asphyxia, intraventricular hemorrhage, and other complications of immaturity are the main causes for brain damage and consequential neurologic problems (Stanley & Blair, 1991).

Stanley and Blair (1991) show that 55 of 725 (or 76 per 1000) neonatal survivors (<1500g) born from 1982 through 1985 developed cerebral palsy; an increase from 43 per 1000 of LBW survivors born in the late 1960's. There was no relationship between sub-optimal care and the occurrence of cerebral palsy. This study stated that perinatal mortality declined because of the increased survival of VLBW infants, and with this increase in morbidity there is no further significant improvement in the outcome of VLBW infants.

Hack and Fanaroff (1989) report that infants below 24 weeks gestation or with a birth weight below 600 grams have extremely poor outcomes. Ninety-eight infants weighing less than 750 grams born between 1982 and 1985 (period 1) were compared with 129 infants born between 1985 and 1988 (period 2). The Bayley Scale of Infant Development was used to measure development at 20 months of age; 4 of 18 (22%) surviving children born in period 1 had moderate to severe neuro-developmental impairment. Seven of the 14 children
(50%) born in period 2 who reached the corrected age of 20 months had moderate to severe impairment. The mean (± SD) Bayley Motor and Mental scores were 90 ± 17 and 88 ± 14 for period 1, and 77 ± 25 and 81 ± 30 for period 2. The trend toward an increase in the incidence of neuro-developmental handicap during period 2 is a serious concern. Infants in period 2 were of smaller birth weight than infants in period 1. The increased survival of extremely low birth weight infants with an increase incidence of neuro-developmental handicap is indeed a concern.

Hack and Fanoroff suggest good judgment needs to be exercised on the use of maximal care in the delivery room for infants with birth weights of less than 600 grams. A fetus of 25 weeks or more, with an expected birth weight of 700 grams, has a 50% survival rate, and should receive every assistance to survive beyond the critical period.

In contrast to the above literature, the study by Robertson et al. (1992) demonstrated there was no significant increase in cerebral palsy in neonates of 500 through 1250 gram birth weight in the Northern and Central Regional Perinatal Program. A one-year population-based survival of newborns 500 to 1250g increased from 36 to 67% (p<.01) between 1979 and 1988-89. Cohort 1 survivors (1978-79) were heavier and more mature than cohort 2 survivors (1988-89) (1047g vs 930g, or 29.6 vs 27.3 weeks).

The overall number of disabled children (17 [21%] vs 30[15%]); complexity of disability (11 [13%] vs 10 [5%]);
and severity of disability (6 [7%] vs 10 [5%]) did not differ between cohorts. Cerebral palsy prevalence based on neonatal survival decreased from 157 per 1000 to 93 per 1000. In contrast to other reports, this study showed no increase in incidence, complexity, or severity of disability in NICU survivors with the birth weight of 500 to 1250g. However, this study agrees that disability rates were highest for those with lowest weight, which is consistent with the literature. The investigator suggested that the change in prevalence of cerebral palsy was related to improved perinatal and neonatal practices.

The following two studies concluded that there is no significant increase in cerebral palsy. The chance of survival for VLBW (<1500g) infants at Queens Victoria Medical Center in Melbourne from January 1979 to July 1980 has increased, whereas their handicap-rate remains stable or relatively low. Ninety-two percent (108 = n) of survivors were able to function within normal range according to the Bayley Scales of Infant Development at 12 months of age. Eleven (9%) of the survivors had physical handicaps and 4 (3%) had developmental delays. Nine of the 14 children were considered to have a significant functional handicap (Orgill et al., 1982).

During the years 1978 to 1989, all extremely low birth-weight survivors (<1000g) in Southern Finland at Children's Hospital, University of Helsinki, were followed up for six years. The results indicated that an increased survival
rate of ELBW infants was not associated with an increase in the number of infants with handicaps (Jarvenpaa et al., 1991). Jarvenpaa and others (1991) assessed the neuro-developmental status according to Griffith's Scale from 1988 onward, and earlier with a modified system of the Denver developmental Scale. This study reported that the neurologic status by two years of age was normal in 40 to 70% of the NICU survivors born during the years 1978 to 1981, and that of the babies born 1986 to 1989, 63 to 84% were normal. The infants with major abnormalities decreased from 28 to 8% along with better survival. Eighty percent (n=73) of the children who were developmentally normal at two years of age remained so at ages four and six; 2 out of 73 infants became slightly abnormal; and 7 were abnormal. The factors associated with poor neuro-development were sepsis, IVH, and birth weight. The neurologic status at one year was a valid predictor (94%) at four years.

The follow-up group of children born in the 1970's - 1980's was at an increased risk for motor difficulties and behavior problems. These children scored lower on motor and verbal scores than the full-term infants, and 50% of the ELBW babies showed vaso-motor impairments. School problems were reported in one third of the ELBW survivors and poor school performance in 20%, which is two times the number of the full-term controls. The results indicate that special education, vaso-motor coordination and improved psychosocial support for families is needed for the "normal" ELBW child
in order to help decrease developmental complications and school difficulties (Jarvenpaa et al., 1991).

Despite the reported increase or decrease of major handicaps, the LBW survivors are reported to develop deviations from the norm and have atypical movement patterns (Gorga et al., 1991). Allen and Capute report two patterns of "normal" development before term: tone and reflexes all emerge in a caudocephalad and centripetal manner. These examinations revealed individual variability. Research is needed to obtain knowledge of the signs of normal neuro-motor development in pre-term infants; to detect abnormality; to gain knowledge of individual variability and factors that effect variability; and to allow one to define more precisely abnormal delay (Allen & Capute, 1990).

Gorga et al. (1991) concluded that the quality of movement of the child can help further identify children with subtle movement problems and that sick pre-term children were at highest risk for these problems. Prematurity, perinatal illness, and unfavorable outcomes within the first year should be carefully monitored through the preschool years.

Astbury, Orgill, Bajuk and Yu (1990) report the number of children diagnosed as having major impairments fluctuated according to age assessment. Confining assessment to one year of age can result in an underestimation of impairment. The diagnosis of cerebral palsy changed over the first few years of life, including one child who "outgrew" the
cerebral palsy by age 5. The pattern of mental development also changed over the first year. Five children were diagnosed as having developmental delay at two years of age and only one continued to have a delay at five years. These findings agree with Gorga et al. (1991) that low birth-weight children experience changing developmental status, erratic maturation patterns, and developmental lags.

Different patient populations, a variety of evaluation methods, follow-up intervals, and different definitions of developmental delay make comparison of follow up studies difficult (Laskey et al., 1987). It is important to continue to document early neurologic and developmental outcomes of LBW and VLBW infants to understand the patterns of development, and to investigate and document trends of survival and handicap rates (Orgill et al., 1982; Allen & Capute, 1990).

Summary

Newborns who are VLBW and ELBW have a high risk of developmental delays and problems. Ongoing study is needed to investigate the characteristics of this population to determine if this group can be considered "high risk" and therefore qualify for developmental, educational, and physical interventions by birth-weight alone. The follow-up of the tiny NICU survivors will help to determine both the proportion of children who develop impairments and exactly when intervention can best assist this group of LBW infants (Astbury et al., 1990).
CHAPTER THREE: METHODOLOGY

The purpose of this research was to investigate the relationship between birth weight and maternal education with infant development among Neonatal Intensive Care Unit (NICU) graduates. The specific research questions were as follows: (a) What is the relationship between birth weight and infant developmental outcome at 12-36 months of age?; (b) What is the relationship between maternal education (measured in number of years) and infant development?; and (c) Do birth weight and maternal education account for a significant amount of variance in infant development?

Research Design

An ex-post-facto design was used to examine the relationships of birth weight and maternal education with selected developmental outcome of NICU graduates. The variables were selected based on an extensive literature review. A secondary analysis was conducted, using data available from the records of babies at a Newborn Follow-up High Risk Clinic.

Research Questions

The developmental outcome of the low birth weight infants is influenced not only by perinatal and physical variables, but by environmental factors as well.

The specific questions addressed by this study were for low birth weight (LBW) and very low birth weight (VLBW) infants and are:
1. What is the relationship between birth weight and infant developmental outcomes? Specifically:
   a. Is there a significant positive correlation between birth weight and infant cognitive development (Mental Developmental Index [MDI])?
   b. Is there significant positive correlation between birth weight and infant motor development (PDI)?

2. What is the relationship between maternal education and infant developmental outcomes?:
   a. Is there a significant positive correlation between maternal education (measured in number of years) and infant cognitive development (MDI)?
   b. Is there a significant positive correlation between maternal education (measured in number of years) and infant motor development (PDI)?

3. Do maternal education and birth weight account for a significant amount of variance in infant development?:
   a. Do birth weight and maternal education account for a significant amount of variance in infant motor development (PDI)
   b. Do birth weight and maternal education account for a significant amount of variance in infant cognitive development (MDI)?
Setting and Sample

The study population was comprised of 31 babies, ages 12 months to 36 months, chronological age. A convenience sample was chosen from the Newborn Follow-up Clinic charts based on the following inclusion criteria for participation:

1. The infant was average for gestational age according to Dubowitz scores.
3. The infant's chronological age was between 12 and 36 months of age at the time the Bayley test was administered.
4. The infant did not have a severe neurological problem, persistent neonatal seizures, or congenital neurological abnormality.
5. The infant was less than 2500 grams at birth.

Infants who weighed less than 1000 grams at birth, or who were 23 to 26 weeks gestation at birth, have a high incidence of complications such as intraventricular hemorrhage (IVH), Bronchopulmonary Dysplasia (BPD) and seizures. This study included the children with IVH, BPD, and seizures, but identified them as a separate subgroup for purposes of data analysis.

The sample population was enrolled in a Newborn Follow Up Program after discharge from NICU. Each infant received developmental interventions and family focused teaching at
the clinic. In addition to the developmental interventions, the infants were provided with physical therapy, occupational therapy, feeding and speech evaluations and psychologic evaluations if needed as deemed appropriate by the physician, nurse, or the psychologist.

The program was funded by the University of Arizona and the State of Arizona. Consent was obtained from the mothers of these infants enrolled in the program to use chart data for research purposes (See Appendix A).

Procedure

The data were collected from the infants' charts at the Newborn Follow Up Clinic, and permission to use the data was given by the director of the Newborn Follow-up Clinic, Dr D. Raval. The charts were reviewed and infants who did not meet the inclusion criteria were excluded. Each chart contained written permission to utilize the information from the chart for research (see NICU Follow-Up Program consent form in Appendix A). Data from the chart remained strictly confidential and the child's name was not used.

The protocol for eligibility for clinic follow-up is based on the Newborn Follow-Up Clinic Medical Risk Criteria established by the State of Arizona. The medical risk criteria divides the children into two groups: (a) high risk conditions and treatment modalities; and (b) moderate risk conditions (see Appendix B for the details of the medical risk criteria). The children who are high risk and
the children who are moderate risk each have to follow a protocol of scheduled visits. The periodicity of visits also varies depending on abnormal or normal results of the examination (see Appendix C).

Demographic data were obtained from newborn follow-up charts, birth information and medical details were obtained from the discharge summary. Information on maternal education, income, and ethnicity were obtained from nurses' interviews with parents and/or demographic data sheets completed by parents.

**Instrument**

The Bayley Scales Infant Development (Bayley, 1969) evaluated the children from 2 months to 2 years of age. Bayley recommends that correcting the age for prematurity may be necessary until 24 months of age. The results of the Bayley Scales in this study are listed for both the chronologic and adjusted age. The Bayley Scales require considerable practice and experience. The child psychologist at the Newborn Follow-Up Clinic is trained to use the Bayley Motor Scales. Typically, this exam is administered to children at the Newborn Follow-Up Clinic between 18 to 24 months of age. However, this schedule may vary according to the evaluation results of the child.

Bayley and her coworkers (1969) generated this tool to evaluate the development of the child. The Scale contains three parts: (a) The Mental Scale was designed to assess
the cognitive or mental skills; (b) the Motor Scale evaluates the motor or physical skills; and (c) the Infant Behavior Record evaluates the social emotional maturity.

With this comprehensive evaluation of the infant's development, the Bayley Scale was used to establish the current status of the infant at the time of the exam, and provides a means of comparing him/her to his/her peers. Bayley (1969) states "The primary value of the developmental indexes is that they provide the basis for establishing the child's current status, and also a basis for instituting early corrective measures."

The Mental Scale was used to assess: (a) sensory-perceptual acuities (the differences and the ability to respond to these); (b) functions of perception, memory, learning, and problem solving; (c) vocalizations; and (d) rudimentary abstract thinking. Results of the Mental Scale are expressed as a standard score on the Mental Developmental Index (MDI). The Motor Scale measured the gross and the fine motor abilities, which reflects motor coordination and skills. The Psychomotor Index (PSI) expresses the results of the Motor Scale.

The PDI and the MDI are both normalized standard scores (M=100, SD=16). The standard scores range from 50 to 150, and cover three standard deviations on either side of the average MDI and PDI for each age. These standard scores allow for quick comparisons of individual performance with
the performance of his/her peer group. The Infant Behavior Record provides a systematic way of assessing and recording the child's observed behavior during the exam. Behaviors oriented to cognitive tasks such as attention span, goal directedness, object orientation, and reactivity have been related to mental ability whereas behaviors related to extroversion (emotional tone, cooperativeness, social orientation to examiner) have little predictive power (Sattler, J.M., 1992).

The Bayley was standardized on a sample of 1,262 normal infants and children from 14 age groups 2 months to 30 months of age. The stratification variables are: gender, ethnicity, education of the head of household, geographic area, and urban-rural residence. The reliability of the Motor Scales and the Mental Scales was determined separately for each age group in the standardization sample by computing coefficients of correlation of the scores on the two half tests of each scale. The split half reliability coefficients for the 14 age groups range from .81 to .93, with a median value of .88 on the Mental Scale, and from .68 to .92, with a median value of .84, on the Motor Scale (Sattler, 1992, p. 320). The Bayley Scales were administered by an experienced child psychologist. The Bayley PDI and MDI results were reported on all infants using both the corrected gestational and the chronological age.

The manual for the Bayley Scales (1969) reports a correlation of .57 between the Mental Scale and the
Stanford-Binet Intelligence Scale. Both scales were administered to a sample of 120 children (ages 24 to 30 months) in the standardization group. Validity coefficients for the younger children are not reported.

A factor analysis of the Infant Behavior Record shows that the items cluster into three categories: (a) Task Orientation (e.g. goal directedness and attention span); (b) Test Affect-Extraversion (e.g. cooperativeness and fearfulness); and (c) Activity (body motion and energy). Factor scores obtained from 300 to 400 children indicate that these aspects of infant behavior are not stable between 6 to 24 months of age (Sattler, 1992).

Data Analysis

The SPSS statistical program was used to analyze the data. Descriptive statistics were computed to help organize all the variables and determine the normal distribution. Frequency distribution and measures of central tendency and variability were computed to help describe and analyze characteristics of the sample population.

Pearson's product-moment correlation coefficients were used to address the relationship of birth weight and maternal education to MDI and PDI scores. Level of significance for all the data analysis was set for $p = .05$. Pearson's product-moment correlation coefficients were used to help identify any relationship between the variables of birth weight and maternal education on infant development.
Hierarchical multiple regression analysis was used to determine if the independent variables of maternal education, infant birth weight, and the interactive effect of maternal education and infant birth weight predicted a significant amount of variance for the dependent variable, infant development. The multiple regression analysis was done to see if the independent variables had a simultaneous additive effect on developmental outcome. Multiple regression analysis is a method used to study the effects and the magnitudes of the effects of more than one independent variable on one dependent variable using principles of correlation and regression (Kerlinger, 1974).

An exploratory analysis of the research data was done to investigate if any other possible relationships existed and if the relationships had a significant impact on developmental outcome. Pearson's product-moment correlations were used to identify any relationship between gestational age, bronchopulmonary dysplasia, intraventricular hemorrhage, oxygen use, and hospital days in relation to MDI and PDI scores.
CHAPTER FOUR: RESULTS OF STUDY

The sample characteristics of the study group will be included in this chapter and will encompass both demographic and perinatal information. Chapter four will contain the results of the Pearson product-moment correlations and/or the multiple linear regression analysis for each research question.

Sample Characteristics

This study included a convenience sample of 31 infants between the ages of 12 to 29 months chronological age, or 9 to 18 months when adjusted for prematurity. No children older than 29 months of age were available at this time for data collection. The infants' gestational age according to Dubowitz ranged from 23 weeks to 34 weeks with the mean of 27 weeks of age. Birth weight ranged from 580 grams to 2450, with the mean of 1050 grams. The infants were born between the years 1989 to 1991. Infants between the ages of 12 to 29 months chronologic, or 9 to 18 months adjusted for prematurity were administered the Bayley Scales of infant development in 1992. Each test was done by a trained psychologist at the Newborn Follow-up Clinic.

Overviews of the demographic and perinatal characteristics of the sample population are provided in Tables 1 and 2. Approximately fifty-eight percent of the infants had mild to severe bronchopulmonary dysplasia, and
39% had moderate to severe Respiratory Distress Syndrome. The average stay in the hospital was 13 to 147 days with a mean of 83 days. Apnea was found in 77.4% of the infants with apnea occurring at a range of 1-36 days and a mean of 10 days.

Each infant received developmental intervention and their families received training in providing developmental care, which include the physical, cognitive, language and speech, and psycho-social areas. Twenty-five (79.3%) of the infants were receiving services from the Department of Developmentally Delayed (DDD) for gross motor and developmental delays. Seventy-four percent of the infants received physical therapy, 51.6% occupational therapy, 29% speech and language services, and 22.6% received feeding evaluations.

The following discussion of the findings will be organized by research question.

**Birthweight and Infant Cognitive Development**

1a. Is there a significant positive correlation between birth weight and infant cognitive development?

The Bayley Scales of Infant Development were used to assess the infants' cognitive development between the ages of 12 to 29 months chronologic (no data was available for children greater than 29 months of age) and 9 to 18 months adjusted for prematurity. The Mental Developmental Index (MDI) was calculated for both chronological and adjusted age. The age of the infant was adjusted for prematurity up
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<td>Maternal Education</td>
<td>12.5</td>
</tr>
<tr>
<td>Ethnicity Mother:</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>9</td>
</tr>
<tr>
<td>Caucasian</td>
<td>18</td>
</tr>
<tr>
<td>Black</td>
<td>2</td>
</tr>
<tr>
<td>Maternal Marital Status</td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>20</td>
</tr>
<tr>
<td>Single</td>
<td>1</td>
</tr>
<tr>
<td>Boyfriend</td>
<td>6</td>
</tr>
<tr>
<td>Hollingshead Social Class</td>
<td></td>
</tr>
<tr>
<td>Class One or Two</td>
<td>8</td>
</tr>
<tr>
<td>Class Three</td>
<td>5</td>
</tr>
<tr>
<td>Class Four or Five</td>
<td>5</td>
</tr>
<tr>
<td>Unable to Classify</td>
<td>12</td>
</tr>
</tbody>
</table>

NA = Information Not Available
until two years of age. The child's raw test score and age were used to calculate the MDI, which has a standard score with a mean of 100 and a standard deviation of 16 (Bayley, 1969). When the score was less than or equal to fifty the child was considered to have had a major abnormality or severe developmental delay. When the child scored less than or equal to 50 a score of 49 was assigned to the child.

The mean MDI score for this sample using the chronological age of the infant was 73.4 (SD = 20.27, SE = 3.64). The mode for this group was <50 and the MDI scores ranged from <50 to 118. The distribution MDI of the Bayley Scores is shown in Figure 3. The mean MDI for this sample when corrected for gestational age was 96.19 (SD = 29.68, SE = 5.82). The mode was still <50 and the MDI scores ranged from <50 to 148.

MDI and PDI scores of less than 70 or <85 have been defined in the literature as developmental delay in low birth weight infants (Astbury et al., 1990; Laskey et al., 1987; Hack et al., 1989; Feingold, 1991). An infant with MDI of less than 70 is considered to have a moderate to severe developmental delay (Astbury et al., 1990; Feingold, 1990). Sixteen infants (chronological age) of 31 (52%) fell into this category and had scores of 70 or less. When corrected for prematurity six of the 26 infants (19.3%) had scores of less than or equal to 70. Five of the infants were beyond the age for adjustments to the score for prematurity.
In this study a score of one standard deviation below the mean (MDI < 84) was considered evidence of developmental delay. Twenty infants (of chronological age) (N = 31 months) (64.5%) had scores of 84 or less. The scores increased when prematurity was adjusted for, and 29% (9 of 26 infants) showed developmental delay.

Pearson's product-moment correlation coefficient for infants measured at the chronological age indicated birth weight was significant in relation to the MDI (r value = .5604, p = .001 [MDI]). The babies' adjusted age showed no significant correlation for the MDI (r value = .3256, p = .112).

A multiple linear regression indicated that 25% of the variance in MDI was explained by birth weight (R square = .25066). Birth weight was significant in the equation (Signif. F = .0078) (see Table 3). Mental developmental index increased as birth weight increased. There was a significant positive correlation between birth weight and cognitive development (MDI) for chronologic age.

Less than one percent of the variance of MDI was explained by birth weight in premature infants when their age was adjusted for prematurity. Birth weight was not significant in the equation for infants whose age was adjusted for prematurity (R Square = .06614, Signif F = .2251).
### Table 2

**Statistics of Infant Sample Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Range</th>
<th>SD</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infant:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gestational Age</td>
<td>27.37</td>
<td>23.7 - 34</td>
<td>2.80</td>
<td>31</td>
<td>100.</td>
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<tr>
<td>Birth Weight (Grams)</td>
<td>1049.5</td>
<td>580 - 2450</td>
<td>444.7</td>
<td>30</td>
<td></td>
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<tr>
<td>Birth Head Circumf. (cm)</td>
<td>25.3</td>
<td>21 - 34</td>
<td>3.06</td>
<td>30</td>
<td>96.8</td>
</tr>
<tr>
<td>Birth Length (cm)</td>
<td>35.56</td>
<td>29.5 - 49</td>
<td>3.99</td>
<td>30</td>
<td>96.8</td>
</tr>
<tr>
<td>Male</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td>41.9</td>
</tr>
<tr>
<td>Female</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td>48.4</td>
</tr>
<tr>
<td>Apgar One Min</td>
<td>3.8</td>
<td>1 - 8</td>
<td>2.25</td>
<td>30</td>
<td>96.8</td>
</tr>
<tr>
<td>Apgar Five Min.</td>
<td>6.5</td>
<td>4 - 9</td>
<td>1.33</td>
<td>30</td>
<td>96.8</td>
</tr>
<tr>
<td>Total Days in Hospital</td>
<td>83.03</td>
<td>13 - 147</td>
<td>34.7</td>
<td>28</td>
<td>82.4</td>
</tr>
<tr>
<td>Total Days on Ventilation</td>
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<td>1 - 83</td>
<td>20.5</td>
<td>30</td>
<td>96.8</td>
</tr>
<tr>
<td>Total Days on F&lt;sub&gt;O&lt;/sub&gt;&lt;sub&gt;2&lt;/sub&gt;</td>
<td>71.7</td>
<td>1 - 237</td>
<td>52.4</td>
<td>29</td>
<td>93.5</td>
</tr>
<tr>
<td>Surfactant Given</td>
<td>14</td>
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<tr>
<td>Bronchopulmonary Dysplasia</td>
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<td>Stage I and II</td>
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<td></td>
<td>19.4</td>
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<td></td>
<td></td>
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<td>Mild</td>
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<td></td>
<td>19.4</td>
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<td>Apnea</td>
<td>24</td>
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<td></td>
<td></td>
<td>77.4</td>
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<td>Intraventricular Hemorrhage</td>
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<td></td>
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<td>13</td>
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<td>Grade III</td>
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<td></td>
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</tr>
<tr>
<td>Grade IV</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>3.2</td>
</tr>
<tr>
<td>Age at Time of Testing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronological</td>
<td>17.06</td>
<td>12 - 29</td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Adjusted</td>
<td>10.8</td>
<td>9 - 18</td>
<td></td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Diagnosed Gross Motor Delay</td>
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<tr>
<td>Services Received</td>
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<td></td>
</tr>
<tr>
<td>Physical Therapy</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td>74.2</td>
</tr>
<tr>
<td>Occupational Therapy</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td>51.6</td>
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<tr>
<td>DDD</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td>74.2</td>
</tr>
<tr>
<td>Speech and Language</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td>29.0</td>
</tr>
<tr>
<td>Feeding</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td>22.6</td>
</tr>
</tbody>
</table>
Birth Weight and Infant Motor Development

1b. Is there a significant positive correlation between birth weight and infant motor development (PDI)?

The mean PDI for this sample when corrected for gestational age was 86.26 (SD = 26.69, SE = 5.23). The mode was <50 and the scores ranged from <50 to 122. The distribution of PDI Bayley Scales is shown in Figure 4. The PDI equal to or greater than one standard deviation from the mean of 100 (SD = 16) is considered to be a developmental delay (Sattler, 1992). Eleven of twenty-six infants (42%) were greater than one standard deviation away from the mean score (<84). Five of the infants were older than two years of age and the scores were no longer adjusted for prematurity.

In contrast, the PDI scores based on the chronological age ranged from <50 to 115. The mean score was 70.52 (SD = 18.1, SE = 3.2), and the mode was <50. Twenty-three infants of 31 months (74.2%) had a score of less than or equal to 84, and of those 23, sixteen (51.6%) of the infants were moderately to severely delayed with scores of 70 or less.

The results of the Pearson product-moment correlation analysis indicated a statistically significant positive relationship between birth weight and psychomotor index for chronological age (r value = .4135, p = .023), but not significant for adjusted age (r value = .2173, p = .297).

Multiple regression was used to help estimate the influence of birth weight in relation to PDI. Birth weight
accounted for twenty-four percent of the variance in the psychomotor index, and birth weight was significant in the equation (see Table 4). However, birth weight was not significant in the equation when the age of the infant was adjusted for prematurity (R Square = .03641, Signif F = .3718).

**Maternal Education and Infant Cognitive Development**

2a. Is there a significant positive correlation between maternal education and infant cognitive development (MDI)?

The results of the Pearson product-moment correlation analysis indicated no significant positive correlation between maternal education and cognitive development for either chronological (r value = .2592, p = .183) or adjusted age (r value = .0936, p = .656). The relationship between the variables as evidenced by the r value indicated a very weak negative relationship between the two variables.

The multiple regression analysis did not change the r square significantly, therefore education did not add to the equation, it only increased the variance slightly. The value Signif. F = .0312 was significant, most likely due to birth weight, and education alone was not significant ([birth weight] Sig T = .0235, [education] Sig T = .9207) (see Table 3). There is no significant positive correlation between maternal education and cognitive development (MDI).
Figure 3a: Distribution of Bayley MDI Scores
Figure 3b: Distribution of Bayley MDI Scores

Adjusted Age
Figure 4a: Distribution of Bayley PDI Scores

Chronological Age
Figure 4b: Distribution of Bayley PDI Scores

Adjusted Age
Maternal Education and Infant Motor Development

2b. Is there a significant positive correlation between maternal education and infant motor development (PDI)?

No statistically significant positive correlation between maternal education and motor development (PDI) was determined through the data analysis using the Pearson's product-moment correlation statistics. The analysis for the chronological age showed an $r = -0.0158$ and $p = 0.937$. The adjusted age had a $r = -0.0582$, and $p = 0.782$. The $r$ value indicated the degree of relationship between the two variables and showed a nonexistent relationship.

Birth Weight and Maternal Education: Variance in Motor Development

3a. Do birth weight and maternal education account for a significant amount of variance in infant motor development? The multiple regression analysis showed no significance or interactive effect between maternal education and birth weight in relation to the psychomotor index. The $R$ Square = .2724 and the $R$ Square change = .1202 (see Table 4). The interactive effect of education and birth weight does not add to the equation and only increases the variance slightly. The interactive effect between maternal education and birth weight as measured by PDI is not supported by the data analysis.
Table 3

**Multiple Regression Analysis (Mental Development Index)**

<table>
<thead>
<tr>
<th></th>
<th>Birth Weight (BW)</th>
<th>Education (Ed)</th>
<th>Variance (BW X Ed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R square</td>
<td>.2507</td>
<td>.2591 (.00032)</td>
<td>.3265 (.07522)</td>
</tr>
<tr>
<td>Sign. F</td>
<td>.0078</td>
<td>.0312</td>
<td>.0258</td>
</tr>
<tr>
<td>Beta</td>
<td>.5007</td>
<td>.0204</td>
<td>-2.4937</td>
</tr>
<tr>
<td>T</td>
<td>2.8920</td>
<td>.1010</td>
<td>-1.6060</td>
</tr>
<tr>
<td>Sig. T</td>
<td>.0078</td>
<td>.9207</td>
<td>.1219</td>
</tr>
</tbody>
</table>
Table 4

Multiple Regression Analysis (Psychomotor Index)

<table>
<thead>
<tr>
<th>Birth Weight (BW)</th>
<th>Education (Ed)</th>
<th>Variance (BW X Ed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R square</td>
<td>.2424</td>
<td>.1522 (.03924)</td>
</tr>
<tr>
<td>Sign. F</td>
<td>.0091</td>
<td>.1379</td>
</tr>
<tr>
<td>Beta</td>
<td>.4923</td>
<td>-.2275</td>
</tr>
<tr>
<td>T</td>
<td>2.8280</td>
<td>-1.0540</td>
</tr>
<tr>
<td>Sig T</td>
<td>.0091</td>
<td>.3024</td>
</tr>
</tbody>
</table>
Birthweight and Maternal Education:
Variance in Cognitive Development

3b. Do birth weight and maternal education account for a significant amount of variance in infant cognitive development (MDI)?

The multiple regression analysis showed no interactive effect between birth weight and maternal education in relation to the MDI. The R Square = .27248 and includes the birth weight. The R Square Change = .05484 which indicates little variance is added to the equation by including maternal education (see table 3). Maternal education and birth weight indicate no variance in relation to MDI, and is not supported by the data analysis.

Exploratory Data Analysis

Other important findings that were established in relation to the framework were the significant Pearson product-moment correlations between number of hospital days, number of days on oxygen, gestational age, and bronchopulmonary dysplasia, in relation to infant development. The babies' length of stay in hospital (number of days) in relation to MDI was significant for adjusted age (p = .006, r = -.5431), and PDI was also significant (p = .010, r = -.5132). The number of days infants were on oxygen in relation to the MDI was significant for both chronologic (p = .022, r = -.4240) and adjusted (p = .001, r = -.6451). Number of days of oxygen therapy in relation to
the PDI was also significant for chronologic (p = .021, r = -.4263) and adjusted (p = .006, r = -.5462). The infants who developed BPD were more likely to have lower Bayley Mental scores than pre-term infants without BPD; chronologic (p = .002, r = -.5808), adjusted (p = .002, r = -.5908). The BPD infants had lower scores for motor development than premature infants without BPD (chronologic, p = .036, r = -.4206; adjusted, p = .020, r = -.4719). Gestational age was statistically significant (MDI except for the adjusted age: chronologic age p = .000, r = .6739; adjusted p = .037, r = .4105) (PDI chronologic age: p = .003, r = .5185; adjusted age p = .088, r = .3413). These important findings will be discussed further in chapter five. The findings of this study were based on a relatively small sample size of 31 babies. Twenty-nine percent (n = 9) of the 31 infants had a mild IVH (grade I and II). One infant (3.2%) had grade III IVH, and one infant had grade IV bleed (3.2%). It became difficult to interpret the results of the infants with IVH because there were too few babies with Grade III and grade IV bleed.

Summary

The incidence of motor and cognitive delay in this sample of low birth weight and very low birth weight infants was approximately 65%-74% for chronological age and 29%-42% for the adjusted age. There were statistically significant correlations between birth weight and infant cognitive
development and PDI for chronologic age. There was no significant correlation between maternal education and infant motor or mental development. The interactive effect between birth weight and maternal education in relation to infant development was not significant.
CHAPTER FIVE: DISCUSSION OF FINDINGS

This chapter will include a discussion of findings as follows: Birth weight and infant developmental outcome, maternal education and infant developmental outcome, and the additive effect of birth weight and maternal education on infant development.

Lastly, exploratory analysis of the relationships between gestational age, bronchopulmonary dysplasia, intraventricular hemorrhage, oxygen use, and hospital days in relation to MDI and PDI scores was investigated. This chapter will discuss the results of the data analysis.

**Birth Weight and Developmental Outcome**

Findings demonstrated that in this sample of low birth weight and very low birth weight infants, birth weight was significant in relation to predicting infant cognitive development ($p = .001$) and infant motor development ($p = .023$), for chronologic age. Birth weight accounted for a significant amount of variance in the equation for infant development in cognitive area (25%) and some variance in motor developmental area (11%).

The scores from the Bayley Mental Scale, when corrected for gestation, revealed that 34.6% percent demonstrated mental delays. The infants' motor development as measured by Bayley Motor Scales was delayed in 42% of the sample.
These findings agree with McCormick et al. (1992) that almost half of the extremely low birth weight infants (<1000 grams) had an IQ of less than 85. A score of less or equal to 85 is considered to be low average, and a score of less than or equal to 70 is indicative of mental retardation. The mean IQ and the proportion with IQs less than 85 or 70 among low birth weight and very low birth weight children are comparable in other studies (Laskey et al., 1987; Hack et al., 1989; Volpe, 1991; McCormick et al., 1990).

In contrast to this study, Feingold reported 19.8% of her sample demonstrated mental and/or gross motor delay. However, the majority of infants in Feingold's sample were low birth weight (mean 1703, range 735-2500), and most were relatively well preterm infants. The sample for the current study included infants with histories of intraventricular hemorrhage, bronchopulmonary dysplasia, and septicemia. The infants' birth weights ranged from 580 to 2450 grams (mean = 1049). This sample population was chosen from a high risk group of mothers, and the infants' overall health status may have been more fragile than the "well" infants in previous studies of preterm infants.

**Maternal Education**

There was no significant correlation between the education level of the mother and the infant's mental or motor development in this study. These findings concur with
Feingold's (1991) results, and are in conflict with findings from Brooks-Gunn et al. (1992), Resnick et al. (1992), and Robetson et al., (1992). Feingold suggested the reason for conflicting results may be related to the difference in the age of the infants tested, and the different tools used for developmental assessment.

Maternal education in this study may not have been significantly related to infants' developmental status because of inadequate variance in the number of years of maternal education and the small sample size. The majority of these mothers had less than or equal to twelve years of education (60.7%). Twenty-five percent (8 mothers) had some college, and three mothers (9.7%) had a college education or more. Maternal education may no have been significantly related to infant developmental status because the infants were from an intervention group.

There is substantial agreement in the literature that intervention has positive results for low birth weight infants and for families of low socioeconomic status. Brooks-Gunn's et al. (1992) results indicated that intervention had a positive result on the low birth weight, low SES group. The children with intervention whose mothers were black or Hispanic and who had less education scored lower in all cognitive domains than the children whose mothers were white and more educated. Resnick et al. concluded that poverty status and race have a major impact
on educational outcome, and Ramey et al. (1992) stated the main predictors of mental development were race, maternal education, and the use of social support. The majority of the mothers in this present study were white (58.1%), 29% percent were Hispanic, and 6.5 percent were black. Information on the SES for the 39 percent of the sample population of this present study was not available, therefore no inferences about the SES could be made.

Several studies support the conclusion that maternal interactions and the environment influence infant development (Als, 1986; Barnard et al., 1984; Ramey et al., 1992). Ramey et al. (1992) stated that maternal interactions may be influenced by the mother's SES, education, and use of social support. Feingold (1991) reported the level of maternal and paternal education to be significantly correlated with the quality of the home environment. The quality of home environment was positively correlated with infant development in Feingold's (1991) study. The quality of the home environment plus maternal and paternal education may have an additive or interactive effect on infant development. More in-depth research is needed to investigate the impact of environment, including parental education, on infant development.

**Maternal Education and Birth Weight**

Maternal education and birth weight had no significant interactive effect on infant development. Once again this
result may be related to the 1. small sample size, 2. the limited variance in the number of years of education in relation to development, or 3. because the sample of infants was from an intervention group. The expected results were to have been an additive effect of birth weight and education on the infant development.

The sample was involved in the Newborn Follow-up Clinic and received early intervention services. The early intervention services included: Physical therapy (74.2% of this sample received this care); occupational therapy (51.6%); developmental home services (74.2%); speech and language services (29%); and feeding services (22.6%). The nurse practitioner, physicians and psychologist all included developmental teaching with family focused involvement during each follow-up visit.

Data from the Infant Health and Development Program (IHDP) (1990) indicated that early intervention services resulted in cognitive gains. Larger treatment effects, such as increased cognitive scores, were seen for heavier birth weight infants (2001-2500 grams) than for lighter birth weight infants (<2000 grams). These results suggest that biologic factors may play a role in limiting the effectiveness of some interventions. Maternal education and environmental influences may have a limited influence in this investigator's present study on infants' developmental outcomes because the infants were mostly less than or equal
to 1200 grams and had a more fragile health status than relatively healthy premature infants of heavier birth weight. The controversy in the literature and inconsistent results demonstrates a need for further research in this area.

**Exploratory Data**

**Hospital Days/Oxygen and Developmental Outcome**

There was a significant correlation between the number of hospital days and the level of development in this sample. The babies' number of days in the hospital (adjusted age) in relation to the MDI was significant ($p = .006$) and in relation to the PDI ($p = .010$). There was a statistically significant relationship between hospital days and MDI ($p = .001$) (for chronologic age), and between hospital days and PDI ($p = .001$) (for adjusted age). The total number of days on oxygen was also found to have a significant relation to MDI ($p = .001$) and to the PDI ($p = .006$) for the adjusted age. When infants' chronological age was used, there was a significant correlation ($p = .022$) between number of days on oxygen therapy and the MDI, and the PDI ($p = .021$).

Infants with additional complications require longer hospitalizations and more oxygen than stable neonates and put the child at risk for developmental delays. The co-morbidity of the infant appears to increase the risk of developmental delay. Bergman and Farrell (1992) stated that
the more complications and problems the child encountered, both prenatally and postnatally, the more likely the child will encounter developmental delays and motor difficulties.

**Bronchopulmonary Dysplasia and Developmental Outcome**

Improved survival rate of low birth weight infants (<1500 grams) has led to an increased number of neonatal intensive care graduates who have chronic lung disease (bronchopulmonary dysplasia) (Bergman & Farrell, 1992; Hack & Fanaroff, 1989). Results of this study indicated that there was a significant relationship between bronchopulmonary dysplasia (BPD) and infant development. The infants who had BPD were more likely to have lower Bayley Mental scores (chronological [r value = -.5808, p = .002]; adjusted [r value = -.5908, p = .002]) than those who did not have BPD. Babies who had BPD were more likely to have lower scores measured by the Bayley Scale for motor development (chronological [r value = -.4206, p = .036]; adjusted [r value = .4719, p = .020]).

Prediction of developmental outcome in infants with BPD is inconclusive in the literature. Most of the studies are based on a small number of infants followed only until two years of age, so residual effects on schoolage children are largely unknown (Bergman & Farrell, 1992). Some studies suggest that the disease process of BPD causes adverse effects in developmental outcome, and other studies maintain that negative outcome is related to a host of complicating
factors in the perinatal period, and that BPD is merely a contributing factor (Vohr, Coll, Lobato, Yunis, O'Dea & Oh, 1991; Teberg, Penna, Finello, Aguilar & Hodgman, 1991; Luchi, Bennett & Jackson, 1991; Whitaker et al., 1990, Bergman & Farrell, 1992). Some studies report that Respiratory Distress Syndrome and BPD are less important than birth weight, perinatal asphyxia, sepsis, IVH, and other perinatal factors in predicting developmental outcome (Robertson, Etches, Goldson & Kyle, 1992; Ludman, Halperin, Driscoll, J., Driscoll, Y. & Belmont, 1987; Piekkala, Kero, Sillanpaa & Erkkola, 1987; Jarvenpaa et al., 1991; Luchi et al., 1991). However, other investigators report BPD as a more important indicator of developmental problems than birth weight, gestational age, or IVH (Meisels, Plunkett, Roloff, Pasick & Stiefel, 1986; Bozynski, Nelson, Matalon, O'Donnell, Naughton, Vasan, Meier & Ploughman, 1987).

Long term follow-up of infants with BPD has been limited due to small sample populations, and the follow-up has been of relatively short duration. The long term follow-up studies include predominately white middle class families because the indigent population is difficult to locate and they have a high attrition rate (Laskey et al., 1987; Vohr, Bell & Oh, 1982; Meisles et al., 1986; Bozynski et al., 1987).

Comparing results across studies is difficult because of the diversity of sample characteristics, variations in
assessment tools, time and length of follow-up, and definitions of handicapping conditions across studies (Bergman & Farrell, 1992).

**Gestational Age and Developmental Outcome**

Results of this study indicated that infants' gestational age were significantly correlated to their mental and motor development (for both chronological and adjusted age). The correlation between the MDI and gestational age was significant for chronological age \((p = .000)\) and the adjusted age \((p = .037)\). The correlation between the PDI and gestational age was statistically significant for chronological \((p = .003)\), but not for the adjusted age \((p = .088)\). The correlation between the PDI and gestational age was not statistically significant for the adjusted age, perhaps because the children's age was adjusted for prematurity. The motor tasks necessary to pass the test were not as difficult developmentally for the adjusted age group compared to the chronological age group.

**Intraventricular Hemorrhage and Developmental Outcome**

This study did not find a significant correlation between IVH and motor/mental development, most likely due to the small sample size. Most investigators found that small IVH was not associated with developmental outcome, but severe hemorrhage carried a substantial risk for developmental delays and neurologic impairments (Bergman & Farrell, 1992; Bennett et al., 1990).
Bennett et al., (1990) found through multiple statistical analysis of different subgroups of subjects consistently indicated severe IVH (grade III and IV) to be a better predictor of the overall neuro-developmental outcome than the grade of periventricular echodensity. Forty-eight percent of LBW infants (mean birth weight 1268 grams) were followed up at 18 months of age by the Bayley Scales of infant development. One half (44.4%) of the subjects developed cerebral palsy or developmental retardation.

Whitaker's et al. (1990) study findings confirmed the conclusions of Bennett et al. (1990). Persistent severe parenchymal echodensity, lucency, or persistent ventricular enlargement in LBW infants scored significantly lower on the Bayley Mental Developmental Index than non-injured infants.

The overview of this study helps to provide an understanding of the range of developmental outcomes possible in infants of low birth weight and very low birth weight. Low birth weight infants are known to be at risk for multiple medical and neuro-developmental morbidities and predictions of infant development with complications such as IVH, and BPD is inconclusive in the literature (Robertson et al., 1992; Bergman & Farrell, 1992; Vohr et al., 1991). Many complications exist in neonates of low birth weight and it is difficult to assess and tease out the factors that cause developmental delays. Low birth weight, BPD, IVH, prolonged hospitalization, and increased oxygen demands are
just a few of the factors in this study that show an increase in the risk for developmental delay.

**Strengths and Limitations of the Study**

It is important to identify both the strengths and the limitations of this study to help set boundaries for the generalization of the study findings (Burns & Grove, 1987).

**Strengths**

The following strengths were inherent in the study:

1. The agency selected was appropriate for generating the type and size sample needed for the study.
2. The study extended current knowledge about risk factors, including information on co-morbidity (BPD, hospital days, prolonged oxygen use, gestational age). Additional factors significantly effecting infant development were identified in this study.
3. The subjects' data were collected from a chart review and therefore the subjects' human rights were at minimal risk.
4. Documented that, even in an intervention group, there was increased incidence of developmental delay.

**Limitations**

The following limitations were restrictions in the study and may decrease the generalization of the findings to the general population.
1. The sample was not a random sample.
2. The sample received developmental interventions, and there was no control group for comparison.
3. Measurement of the variables was limited to one time assessment without longitudinal follow-up.
4. The sample size was too small for measurement of some variables such as IVH in relation to the developmental outcome.
5. This was an ex post facto research, and was a systematic empirical inquiry in which the investigator does not have direct control over the independent variables because they have already occurred (Kerlinger, 1964).
6. "Inferences about the relations among the variables are made, without direct intervention, from concomitant variation of independent and dependent variables" (Kerlinger, 1964, p. 379).

Implications for Nursing Practice

The increased survival of the low birth weight infants puts an increased strain on the health care system and society. Supportive nursing care with structured home based nursing interventions can enhance development and will thus indirectly increase cost savings (Brooten et al., 1986). Services need to be provided prior to evidence of developmental delay, and services need to be continued for all those infants that demonstrate the need.
Child development is most rapid in the first year of life and timing of the interventions are important when the child runs the risk of missing an opportunity to learn during a state of maximum readiness (Knowles, 1991). Those infants with longer hospital stays, increased number of days on oxygen, and decreased weight are at greatest risk and may need different types of nursing intervention. The child may have difficulty learning the task later, so it is important to provide services to those in need. Public law 99-457 has stimulated a reassessment of how programs for the young children with special needs are organized, and has provided a new emphasis on community-based, family-centered systems of care (Blackman et al., 1992). Teaching has a positive impact on the home environment and could impact the development of the child (Feingold, 1991). The literature supports and emphasizes early intervention with family centered teaching.

**Implications for Research and Nursing Practice**

The use of current research and information about infant development is necessary to identify infants and the families in need of intervention prior to the discharge from the neonatal intensive care. Continued research is needed to assess what the family needs are and how to best provide the services. Nursing influence can start right after birth and continue to influence the infant's development in the community by providing teaching for appropriate family interactions (Lott, 1989).
Early intervention may begin at any time between birth and school-age, and it is important to begin as soon as possible. Three primary reasons for intervening at an early age are: to provide support and assistance to the families; to maximize the child's and family's benefit to society; and to provide optimal development for the child (Knowles, 1991). This study suggests that infants of lower birth weight, especially those of less than 1500 grams, are at risk for complications, longer hospital stay, more days on oxygen, and have a higher probability of developmental delays. This population needs to be followed closely and over an extended time. Research is needed in longitudinal studies including follow-up into the schoolage years. Limited research is available on the low birth weight infants at school age.

Recommendations for Further Research

The recommendations for further research by this investigator are as follows;

1. More in-depth research is needed to investigate the infant characteristics of infants with BPD and IVH in order to help understand the range of developmental outcomes possible in the infant with BPD and IVH. This controversy in the literature and inconclusive results demonstrates a further need for research in this area.

2. Research on the outcomes of nursing interventions on LBW and VLBW infants and their families is necessary and very important.
3. Development and testing of the tools used to measure infant development are needed to provide more accurate and consistent results, especially when measuring the environment and maternal education in relation to development.

4. More longitudinal studies are needed for the population of LBW and VLBW infants, especially into the school-age years.

5. Further exploration of the environment, including other maternal characteristics such as education, home environment, social class, and ethnicity are needed to establish a developmental learning environment and distinguish those families at greater risk of having problems.

Summary

Results of this study confirm birth weight is significantly related to infant mental development and motor development for chronologic age. In addition, this study identified infants with BPD, longer hospital stay, and extended oxygen use to be at greater risk for developmental delay than children without comorbidity. Results of the study did not demonstrate a statistically significant relation between maternal education and infant mental and motor development. However, it is this author's opinion that education and intervention are the necessary tools to help increase optimal child development, family stability,
and benefits to society from the family and the child. Nurses must begin to use the information from this study and other studies to provide appropriate interventions for the high risk infants and their families.

Early intervention with highly structured programs with frequent monitoring of the family's and child's behavior and development, family focused teaching, and assessment for services will provide maximum benefits to the family and society.
APPENDIX A

NICU FOLLOW-UP CONSENT FORM

You and your child are being invited to participate in the NICU FOLLOW-UP Program. This program provides a clinical service to the infants and children who received care for certain problems while they were in the intensive care nursery and who are eligible for the Arizona Department of Health Services NICP. This service may include testing for mental, developmental and nervous system problems and for how well the infant is growing. Sometimes problems are found during the tests. If problems are found we will try to help you and your pediatrician find more tests and/or the right treatment.

Information from these tests will be used to learn how infants who were patients in the NICU are growing and how well they are doing as they get older.

If you agree to participate, you will be asked to let us use this information to help your child and to help other children who will be NICU patients in the future. Your child's identity will remain confidential and his/her name will not be used. There are no risks to permitting use of this information.

I have read the above consent form or had it read to me. The nature, demands, risks and benefits of the project have been explained to me. I understand that I may ask questions
and that I am free to withdraw from the project at any time without affecting my child's medical care. I understand that I do not give up any of my legal rights by signing this form. I also understand that this consent form will be filed in an area designated by the Human Subjects Committee with access restricted to Dr. Devyani Raval or authorized representatives of the Department of Pediatrics.

Parent/Guardian ____________________________ Date ____________________________

Witness ____________________________

Patient's Name ____________________________
APPENDIX B
NEWBORN FOLLOW-UP CLINIC MEDICAL RISK CRITERIA

High Risk Conditions and Treatment Modalities:

Jet Ventilation

Extracorporeal Membrane Oxygenation (ECMO)

Home Oxygen

< 1250 gms at birth

< 28 weeks gestation

Abnormal neurological or Assessment of Pre-term Infant Behavior (APIB) evaluation

Seizures for other than metabolic reasons

Small for Gestational Age (SGA) SYMMETRICAL

Substance Abuse in utero (Cocaine, heroin, multiple drugs)

Congenital viral infections (Cytomegalovirus-CMV, herpes, AIDS)

Intraventricular hemorrhage (IVH) Grades III & IV

Periventricular Leukomalacia (PVL)

Hydrocephalus

Meningitis

Retinopathy of Prematurity (ROP) Grades III & IV

Apgar < 4 at 5 minutes

Confirmed hearing impairment

Severe meconium aspiration

Symptomatic Hypoglycemia

Persistent Pulmonary Hypertension (PPH)
Moderate Risk Conditions:
Exchange transfusions for ABO/Rh disease or other causes
  with bilirubin > 25 mg%
1250 - 1500 grams at birth
28 - 32 weeks gestation
SGA asymmetrical
IVH Grades I & II
Intermittent Positive Pressure Ventilation (IPPV) < 7 days
Prolonged Apnea/Bradycardia
Shock/Hypotension
Sick infants of Diabetic Mother
Microcephaly
ROP - Grades I & II
Hyperbilirubinemia requiring exchange transfusion or
Hyperbilirubinemia with total over 20, or free above .1.
Infants treated with surfactant
Dysmorphic infants or infants diagnosed with congenital anomalies
APPENDIX C

PERIODICITY OF VISITS

a. Children who meet the High Risk Criteria and continue to have normal results at each visit:

First Visit: 4 months adjusted age (Gesell)
Second Visit: 8 months adjusted age (Gesell)
Third Visit: 14 - 16 months adjusted age (Gesell)

If results are normal:
Fourth Visit: 18 - 24 months adjusted age (Gesell)
Fifth Visit: Four - Five Year Pre-Kindergarten Screening (Meisel's Early Screening Inventory)

b. Children who meet the High Risk Criteria and have abnormal results:

First Visit: 4 months adjusted age (Gesell)
Second Visit: 8 months adjusted age (Gesell)
Third Visit: 12 - 14 months adjusted age (Gesell)
Fourth Visit: 18 - 20 months adjusted age (Bayley)
Fifth Visit: Two years adjusted age (Gesell)
Sixth Visit: Three Year Chronological Age (Speech)
Seventh Visit: Four - Five Year Chronological Age with Psychological test

c. Children who meet the Moderate Risk Criteria and have normal results:

First Visit: 6 months adjusted age (Gesell)
Second Visit: 12 months adjusted age (Gesell)
Third Visit: 18 - 24 months adjusted age (Gesell)

Fourth Visit: Four - Five Year Chronological Age with Pre-Kindergarten Screening (Meisel's Early Screening Inventory)

d. Children who meet the Moderate Risk Criteria and have abnormal results follow the visit schedule of the children who meet the high risk criteria and have abnormal results.
EXCEPTIONS:

1. If the children are placed in intervention, the family should be contacted to return to the clinic at least once a year for reevaluation. If the parent prefers, a telephone interview can be substituted. In addition, the parents should request that the interventionist send updated reports of the child's progress to the newborn follow-up clinic.

2. If the children are involved in a special study (ECMO, JET, etc.), the schedule of visits will follow the periodicity stated in the study protocol. A four - five year pre-school screening is scheduled for those children who are considered normal at 24 months. If the pre-kindergarten screening results warrant a more in-depth developmental evaluation, they will be scheduled with the appropriate staff in the clinic.
REFERENCES


