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EFFECTS OF VARYING GRADES OF INTRAVENTRICULAR HEMORRHAGE ON NEURODEVELOPMENTAL OUTCOME AND EARLY INTERVENTION

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ABSTRACT

EFFECTS OF VARYING GRADES OF INTRAVENTRICULAR HEMORRHAGE ON NEURODEVELOPMENTAL OUTCOME AND EARLY INTERVENTION

BY

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The developmental outcome scores and the intellectual functioning scores of 61 children having suffered varying degrees of intraventricular hemorrhage were analyzed to determine if there is a difference in neurodevelopmental outcome based on the severity of the hemorrhage. The 61 youngsters having intraventricular hemorrhages were matched with no bleed low birth weight peers on sex, socioeconomic status, race, gestational age, and mean birth weight for gestational age. Ability scores between the affected and the no bleed comparison group were compared. Furthermore, information on referral rate, age at referral, and type of service provided for these youngsters is presented. Blind re-reads of ultrasounds were conducted to attain inter-rater agreement on the grading of the intraventricular hemorrhage. This resulted in an 89 percent agreement rate between readings.

The existing research literature on survivors with intraventricular hemorrhages has lead to inconsistent results regarding neurologic sequelae and intellectual functioning. The present investigation finds that Grade I and Grade II youngsters develop much like their no bleed

low birth weight peers. The notion of guarded optimism for Grade IV children is supported as these youngsters, for the most part, have severe delays across many domains.

At a mean age of 20 months, intellectual functioning scores differed significantly based on the mean score for the severity of the hemorrhage. However, when referral rates and days in the RNICU are controlled, significant differences in intellectual functioning scores cannot be attributed solely to severity of the hemorrhage.

Although there was a significant difference in referral rate based on the grade of the hemorrhage, there was no significant difference in overall referral rate between affected and no bleed comparison cohorts. The mean age of referral was clearly related to the severity of the hemorrhage, however. The public school systems' special education programs were the most frequent service providers for these children and their families. While other resources are available, they were cited with little frequency.

The implications of these findings are discussed in terms of their practical meaning for personnel working with these children. Recommendations for public policy and future research are suggested.

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CHAPTER 1

INTRODUCTION

With the advent of Neonatal Intensive Care Units and the advancement of medical technology, a greater number of premature, low birth weight infants are surviving. However, a major hazard for these low birth weight neonates is the occurrence of intraventricular hemorrhage. A periventricular-intraventricular hemorrhage is a lesion in the developing brain affecting anywhere from little to all of the ventricular area depending on its extent and severity. The incidence of intraventricular hemorrhage in infants weighing less than 1,500 grams or born less than 35 weeks gestation has been reported as approximately 40 to 45 percent (Volpe, 1981), with others reporting incidence as high as 50 to 60 percent (Stewart, Thornburn, Hope, Goldsmith, Lipscomb, and Reynolds, 1983). Intraventricular bleeds have been divided into four grades based on the severity and extent of the bleed (see Papile, Burstein, Burstein, and Koffler, 1978), with Grade I representing a mild bleed and Grade IV representing a severe bleed. Diagnosis of an intraventricular hemorrhage involves recognition of the clinical features by attending medical personnel and utilization of a suitable screening procedure (i.e.,

portable cranial ultrasonography, EEG, CT scan, or positron emission tomography). Ultrasound scan of the neonatal cranium is the procedure of choice in the diagnosis of intraventricular hemorrhages (Volpe, 1987).

Followup of these infants who have experienced intraventricular hemorrhages has recently become a focus of interest in the medical field as the use of the ultrasound has allowed more accurate diagnosis of the severity and extent of the bleed. Sauerbrei, Digney, Harrison, and Cooperberg (1981) report that ultrasound has high sensitivity (96%) and specificity (94%) in diagnosing intraventricular bleeds. According to the Illustrated Stedman's Medical Dictionary (1982), sensitivity refers to the ability to determine the presence of an intraventricular hemorrhage (true positive results as a proportion of the total of true positive and false negative results), while specificity refers to the proportion of individuals with negative results for presence of intraventricular hemorrhage (true negative results as a proportion of the total of true negative and false positive results).

Despite the technological advances in diagnosis, followup studies have for the most part focused on small numbers of infants. More intriguing are inconclusive results reported in followup studies. Many researchers (Catto-Smith et. al., 1985; Krishnamoorthy, Shannon, et. al., 1979; Leonard et. al., 1983; Thornburn et. al., 1983;

and Williamson, Desmond, Wilson et. al., 1983; 1982) have found a relationship between gradation of hemorrhage and incidence of disability. Others (Krishnamoorthy, Kuehnle et. al., 1984; Papile, Munsick-Bruno et. al., 1983; Palmer et. al., 1982; and Papile, Munsick et. al., 1979) have found no difference in neurologic and/or developmental outcomes between those having suffered mild bleeds (usually defined as Grade I and Grade II) and controls. Tekolste, Bennett and Mack (1985) contend that only Grade IV bleeds lead to aberrant neurologic and/or developmental outcomes, while Schub, Ahmann, Dykes, Lazarra, and Blumenstein (1981) report that even marked intraventricular bleeds (Grade IV) does not preclude good neurologic and/or developmental outcome. Still others (Papile et. al., 1983; 1979) find that infants with Grade III or IV intraventricular hemorrhage have much poorer neurologic and/or developmental outcome. Therefore, despite the increase in research on children with intraventricular hemorrhages, the neurologic sequelae and the intellectual functioning of survivors with intraventricular bleeds remains largely undefined.

Existing research has had many flaws, including failure to: differentiate among grades of hemorrhage when reporting findings (Grade I and II children are often grouped together as are Grade III and IV children concealing possible differences between those groups of children); apply outcome measures consistently across

samples using an appropriate cut-off score to determine an abnormality when reporting intellectual functioning; provide extensive followup; and control for factors such as socioeconomic status and duration of hospital stay which may influence outcome. In addition, sample sizes in the majority of the studies have been small, ranging from nine youngsters to sixty-three youngsters having experienced intraventricular hemorrhages.

Importance of Present Research

It is important for researchers and practitioners from the medical, psychological, and educational fields to determine whether children who suffer varying degrees of intraventricular hemorrhages indeed show greater prevalence of physical handicaps and lower psychological scores as they grow older. Bleeding in the brain will undoubtedly impact later functioning and, from the perspective of the clinician, it is crucial to determine whether these youngsters are at greater future risk for neurodevelopmental and/or cognitive delays thus leading to increased involvement in special education programming or other supplemental services. It is important to determine to what extent these youngsters remain at greater risk. Furthermore, it is important that the psychological testing be completed by qualified examiners who are familiar with the administration requirements and who have dealt with the infant and preschool population (see Aylward, 1987). With the passage in 1986 of the Preschool

Education of the Handicapped Act, Public Law 99-457, it is also important to determine the percentage of infants/toddlers with intraventricular hemorrhages who are receiving supplemental services, and to identify the type of service received. If it can be demonstrated that youngsters who survive varying degrees of intraventricular hemorrhage remain at greater risk for future impairments, be they developmental or neurological, then physicians, school psychologists, and preprimary teachers will need to continue to monitor these youngsters' progress through the school years. While researchers focusing on high-risk, low birth weight infants (Bennett et. al., 1983; Drillien et. al., 1980; Kitchen et. al., 1980; Kitchen et. al., 1987; Klein et. al., 1985; Ross, Lipper, and Auld, 1985,1986; Vohr and Garcia Coll, 1985) have found that early developmental delays may be transient, and that a great percentage of these children attend normal schools when they reach school age, little is known whether this pattern may also apply to high risk, low birth weight infants who have suffered an intraventricular hemorrhage.

Synopsis of the Present Investigation

This study was designed to investigate the short-term and long-term sequelae in youngsters who have survived varying degrees of intraventricular hemorrhage. The study focused primarily on the psychological test scores of these infants and children. This research seeks to discover (1) to what extent the presence of an

intraventricular hemorrhage affects a youngster's ability to meet age-appropriate developmental milestones, (2) whether the presence of an intraventricular hemorrhage has an effect on intellectual functioning.

Another major objective of the present research is to determine the incidence of early intervention with these children and to document the type of service (i.e., educational, medical, social) being provided for these youngsters and their families. Of particular interest is the incidence/percentage of children having experienced intraventricular hemorrhage who are currently receiving early intervention service. Will those children who survive varying degrees of intraventricular hemorrhage be referred more frequently than their no bleed premature cohorts? And, will the type of service being requested be of a different nature based on the degree of the intraventricular hemorrhage? Furthermore, are there age differences between affected and no bleed youngsters when the referrals are made?

CHAPTER 2

REVIEW OF RELATED LITERATURE

The Review of Related Literature discusses and analyzes two areas impacting the present study. The first area of investigation describes the medical literature related to intraventricular hemorrhages. The review discusses the incidence, neuropathology, and pathogenesis of periventricular-intraventricular hemorrhages. An attempt has been made to briefly describe the clinical features and the diagnostic procedures used to grade the severity of the hemorrhage.

The second area of investigation focuses on research related to the outcome for infants and children having diagnosed intraventricular hemorrhages. Studies examining the intellectual and neurological prognosis of intraventricular hemorrhage youngsters are presented in order to demonstrate their inconclusive findings.

Finally, the major points of the literature review are summarized, and implications of the literature are related to the objectives of the present study. In addition, the specific distinctions between this study and previous studies are delineated.

Neonatal Periventricular-intraventricular Hemorrhage

Volpe (1979) describes four major, clinically important types of neonatal intracranial hemorrhages: subdural hemorrhages, which are related to trauma; primary subarachnoid hemorrhages, which are related to trauma or "hypoxic" events; intracerebellar hemorrhages; and periventricular-intraventricular hemorrhages. According to Volpe's (1987) analysis, the periventricular-intraventricular hemorrhage is the most important of the varieties of neonatal intracranial hemorrhages because its relative frequency is common and its usual clinical gravity is serious. Because more infants less than approximately 32 weeks gestation continue to survive due to the advancement of medical technology and the advent of Regional Neonatal Intensive Care Units and since the intraventricular hemorrhage is characteristic of the premature infant, the prevalence of this lesion has reached nearly epidemic proportions in modern neonatal intensive care facilities. Pape and Wigglesworth (1979) and Larroche (1979) have documented the direct inverse relationship between gestational age and incidence of intraventricular hemorrhages. Coupled with the increase in survival rates of lower gestational age infants, the clinical importance of this lesion is likely to continue to rise.

Incidence

The incidence of intraventricular hemorrhage in infants weighing less than 1,500 grams or born less than 35 weeks gestation is approximately 40 to 45 percent (Ahmann et. al., 1980; Hawgood et. al., 1984; Tekolste et. al., 1985; and Volpe, 1981). However, several researchers have reported higher incidences. Kosmetatos et. al. (1980) indicated an incidence of 58 percent in their sample of premature infants, while Catto-Smith et. al. (1985) reported an incidence of 61 percent. Stewart, Thornburn et. al. (1983) claimed periventricular-intraventricular hemorrhages were detected in 50 percent of their preterm infants, while Cooke (1981) reported intraventricular hemorrhage to be present in 51 percent. It appears that greater frequency of periventricular-intraventricular hemorrhage is observed in infants born with less than 32 weeks gestation.

Neuropathology

The most complete neuropathological description is provided by Volpe (1981) who notes that periventricular-intraventricular hemorrhage emanates from small vessels, principally capillaries, in the subependymal germinal matrix. In most infants, the hemorrhage originates in the matrix at the level of the head of the caudate nucleus and foramen of Monro. Yet, in premature infants less than 28 weeks of gestation, the lesion often originates at the level of the body of the caudate nucleus, and in mature

infants from the choroid plexus. Approximately 80 percent of cases of periventricular-intraventricular hemorrhage rupture through the ependyma and fill the ventricular system. Blood tends to collect in the posterior fossa, where an obliterative arachnoiditis is a frequent sequelae. Particularly severe lesions extend into the cerebral parenchyma, and such examples may be followed by the development of a porencephalic cyst. In addition, acute hydrocephalus may result with severe lesions. Thus, the major neuropathologic complications of periventricular-intraventricular hemorrhage include hemorrhagic intracerebral involvement, hydrocephalus, germinal matrix destruction and cyst formation, and accompanying hypoxic-ischemic lesions. Papile et. al. (1980) report that hydrocephalus is unlikely in infants with mild bleeds, whereas the frequency of hydrocephalus among infants with Grade III and IV hemorrhage is 40 percent and 70 percent, respectively.

Because most intraventricular hemorrhages originate in the caudate nucleus and the caudate nucleus is responsible for motor functioning, an interference with functioning of the motor system would be expected in affected youngsters regardless of the grade of the bleed. The birth injury to the brain may result in mild motor delays or severe motor disabilities depending on the extent and severity of the intraventricular hemorrhage. While the brain damage is nonprogressive, a severe bleed

frequently will involve disorders in the sensory, cognitive, and affective areas. Children with extensive damage frequently have damage to visual, auditory, associative, and language areas as well. Thus, the greater the severity and extent of the bleed, the more one would expect developmental disabilities and impaired cognitive functioning. However, structural abnormalities do not necessarily correlate with function and Levene (1987) suggests it is misleading to believe that larger lesions indicate poor outcome. Neurodevelopmental outcome may be better predicted by the rate of clinical recovery from the insult (Levene, 1987). Thus, although infants cannot regenerate new brain cells after the insult, they can easily form new connections between existing neurons. This process appears to be fundamental to learning and infants appear to have the greatest brain plasticity (Kotulak, 1980).

Pathogenesis

The pathogenesis of periventricular-intraventricular hemorrhage is related to several factors concerned with the distribution and regulation of cerebral blood flow, intravascular pressure, vascular integrity, and extravascular environment (Volpe, 1981). These factors combine, particularly in the premature infant subjected to an asphyxial insult, to result in periventricular-intraventricular hemorrhage. For a complete discussion of how these factors combine refer to Volpe (1981).

Clinical Features

The principal setting for periventricular-intraventricular hemorrhage is a premature infant with respiratory distress syndrome severe enough to require mechanical ventilation. The time of onset of hemorrhage, defined most clearly in recent years by serial cranial ultrasonography, is the first day of life in approximately 50 percent of affected infants, and by 72 hours approximately 90 percent of the lesions can be identified (Levene et. al., 1982; Perlman and Volpe, 1982; Tejani et. al., 1984; and Volpe, 1987). Szymonowicz and Yu (1984) reported that 63 percent of affected infants bled on the first day, and 57 percent showed extension of the initial hemorrhage on serial scans. Furthermore, they reported a median age of 16 hours when the hemorrhage was first detected, and a median age of 48 hours when the hemorrhage reached its maximum extent.

Volpe (1987) describes three basic clinical syndromes that accompany periventricular-intraventricular hemorrhage. The first is catastrophic deterioration, and usually occurs in the infant with a major hemorrhage. In this case, the deterioration evolves in minutes to hours and consists of a deep stupor or coma, respiratory abnormalities, generalized tonic seizures, pupils fixed to light, eyes fixed to vestibular stimulation, and flaccid quadriparesis. The second clinical syndrome is saltatory deterioration, and usually occurs in the infant with

smaller hemorrhages. In this case, the deterioration evolves over many hours, and the deterioration often ceases, only to begin anew after several hours. This stuttering course may continue for days. The most common presenting signs include an alteration in the level of consciousness, a change (usually a decrease) in the quantity and quality of spontaneous and elicited motility, hypotonia, and subtle aberrations of eye position and movement. The third clinical syndrome is the clinically silent syndrome. In this case, the neurological signs may be so subtle that they are overlooked. Interestingly, Lazarra et. al. (1980) found that only approximately 50 percent of cases of intraventricular hemorrhage were correctly predicted to have the lesion on the basis of clinical criteria. Clinical signs correlating with intraventricular hemorrhage were an unexplained fall in hematocrit or its failure to rise with transfusion, tense (not bulging) fontanelle, increase or decrease in spontaneous activity, seizures, abnormal eye signs, and decreased tone (Lazarra et. al., 1978; and Williamson et. al., 1983). The data presented by Lazarra et. al. (1980) indicate that even careful, serial clinical assessments may fail to reveal a distinct constellation of signs indicative of the lesion. Therefore, relying solely on clinical features could result in underestimating the number of infants affected by mild intraventricular hemorrhage.

Diagnosis

Diagnosis of an intraventricular hemorrhage usually begins with recognition of the clinical setting and is followed by a convenient screening procedure which is believed to be reliable by the medical profession. Volpe (1981) argues that in light of the high incidence of intraventricular hemorrhage in small premature infants in neonatal intensive care units, all premature infants should be considered at high risk and should be screened. However, this is rarely the procedure followed.

Ultrasonography has become the procedure of choice in the diagnosis of intraventricular hemorrhage. Prior to 1978, there could be no definitive series. Any reports prior to the advent of CT scanning or cranial ultrasonography include subjects in whom the diagnosis of periventricular-intraventricular hemorrhage was made on the basis of either clinical or laboratory data. Goldstein and Donn (1984) caution that the unreliability of those diagnoses makes the reports suspect. Thus, it has only been since the advent of ultrasonography that more reliable diagnoses, from the medical perspective, have been made. Advantages of ultrasound scanning include excellent coronal and sagittal views, as well as excellent data on the degree and distribution of ventricular dilation (Volpe, 1981). Sauerbrei, Digney et. al. (1981) confirm the adequacy of using ultrasonography by describing the high sensitivity (96%) and specificity

(94%) of the method in diagnosing intraventricular hemorrhages. Pape et. al. (1983) also provide data on ultrasonography's effectiveness indicating the method can be used with confidence.

Grading the Severity of the Hemorrhage

Intraventricular hemorrhages have been divided into four grades based on the severity and extent of the bleed (Papile, Burnstein, Burnstein, and Koffler, 1978; Volpe, 1987):

Grade I - isolated subependymal hemorrhage or germinal matrix hemorrhage with no or minimal intraventricular hemorrhage (<10% of ventricular area affected).

Grade II - intraventricular hemorrhage without major ventricular dilation (10 to 50% of ventricular area).

Grade III - intraventricular hemorrhage with ventricular dilation (>50% of ventricular area, usually distends lateral ventricle).

Grade IV - intraventricular hemorrhage with parenchymal hemorrhage.

Other researchers (Shankaran et. al., 1982), following the above gradation system to some extent, have chosen to divide intraventricular hemorrhages into mild, moderate, and/or severe hemorrhages. A mild hemorrhage is one confined to the subependymal periventricular region or is accompanied by a small amount of blood in the normal-

sized lateral ventricle. A moderate hemorrhage refers to an intermediate amount of blood in an enlarged lateral ventricle. A severe hemorrhage is one which fills the entire lateral ventricle forming a cast, and/or reveals intracerebral extension of the hemorrhage. While the above grading systems are routinely utilized in all studies involving intraventricular hemorrhages, there is an absence of data determining interrater agreement on the grade of the bleed.

Outcome

The prognosis for infants and children having suffered intraventricular hemorrhage is varied. Short-term and long-term outcomes remain undefined for these youngsters. The clinical picture currently ranges from no observable clinical findings to developmental delays to the complete spectrum of cerebral palsy (Murphy Peterson, 1986). However, researchers doing followup studies with these children have come up with inconsistent findings, especially when considering long-term outcome.

Short-term Outcome

Short-term outcome is used to refer to the mortality rate and the development of progressive ventricular dilation during infancy (Szymonowicz and Yu, 1986; Volpe, 1987). Analysis of these data indicate that the short-term outcome relates clearly to the severity of the hemorrhage. Volpe (1987) provides the following

compilation of data based on short-term outcomes (See Table 1).

Long-term Outcome

Relationship between gradation of hemorrhage and incidence of disability. The most commonly reported long term outcome data with intraventricular hemorrhage youngsters suggests a relationship between the grade of the hemorrhage and the incidence of disability. Children with Grade I bleeds are more likely to attain normal intellectual scores and be free from major neurological deficits, while children with Grade IV bleeds, when they survive, are more likely to have intellectual deficits as well as major neurological impairments. Specific studies supporting this viewpoint are now reviewed.

Krishnamoorthy et. al. (1979) reported on fifteen infants who had documented intraventricular hemorrhages and had been followed for an average of 24 months. Their developmental assessment was based on the Denver Developmental Screening Test (DDST), and the researchers then calculated a developmental quotient based on a ratio of developmental age to chronological age. They defined their neurologic and developmental status as: **Normal**- developmental quotient greater than 80 with no neurologic abnormality; **Mild Deficit** - developmental quotient of 70 to 80 without neurologic signs, or developmental quotient greater than 80 with one or more mildly abnormal neurologic signs such as mild hypotonia, hypertonia, ankle

TABLE 1

Short-term Outcome Related to Severity of Intraventricular Hemorrhage.

Severity of Hemorrhage	Mortality Rate (%)	Progressive Ventricular Dilation (% Survivors)
Mild	15	5
Moderate	20	25
Severe	40	55
Severe + hemorrhagic intracerebral involvement	60	80

Taken from JJ Volpe (1987), Neurology of the Newborn (2nd edition), Philadelphia: WB Saunders Company, p. 333.

clonus, abnormal transillumination, speech and language immaturity, borderline visual or hearing impairment, or behavior problem; **Moderate Deficit** - developmental quotient of 50 to 70 alone or with significant neurologic deficit such as spasticity, hemiplegia, spastic diplegia, severe hypotonia, and significant visual or hearing deficits; and **Severe Deficit** - developmental quotient less than 50 with a significant neurologic deficit such as the above examples and others such as quadriplegia and choreoathetosis.

Krishnamoorthy et. al. (1979) found a strong correlation between the degree of hemorrhage and subsequent neurological outcome ($P < .001$). Among the twelve toddlers with Grade I or Grade II hemorrhage, there were none with moderate or severe deficits. However, all three toddlers with Grade III or Grade IV hemorrhage had moderate or severe deficits. Likewise, there was a strong correlation between the degree of hemorrhage and the subsequent developmental outcome ($P < .001$). Six of twelve children with Grade I or Grade II intraventricular hemorrhage were normal with respect to developmental outcome, while those with Grade III or IV hemorrhage demonstrated mild or severe deficits. Krishnamoorthy et. al. (1979) conclude that if there is a Grade I or II intraventricular hemorrhage, continuing intensive care is warranted with qualified optimism; while if there is a Grade III or IV intraventricular hemorrhage, guarded

pessimism is indicated as the prognosis for these infants is uniformly poorer.

Thornburn et. al. (1981) detected abnormalities in forty-three percent of their premature sample (n=95). Followup of 66 infants at a median age of 45 weeks revealed that thirty-eight percent of the thirteen infants with more extensive hemorrhages (Grade III or IV) had evidence of major handicaps. At the same time, of the eleven infants with Grade I or II hemorrhages all but one were falling within normal limits (X^2=28.60, P<0.0005).

Williamson et. al. (1982) described the early neurodevelopmental status of twenty-eight low birth weight infants surviving neonatal intraventricular hemorrhage. Their followups were conducted at the ages of three, six, nine, eighteen, and thirty months. They noted cerebral palsy in nine of their infants, and eight infants with severe bleeds developed post-hemorrhagic hydrocephalus. At a mean age of 19.7 months, five infants were considered normal, eight were suspect, and fifteen were abnormal. Infants with Grade I or II hemorrhage had significantly better outcome than those with Grade III or IV hemorrhage (X^2 with Yates correction=5.166; .01<P<.025).

Williamson et. al. (1983) conducted another prospective study which focused on twenty-nine hemorrhage children last evaluated at a mean age of three and one-half years. Ten of these children had normal neurologic outcome, and four had minimal abnormalities. Intellectual

performance was normal for fourteen youngsters, mildly delayed for seven, and in the retarded range for eight. Twelve children (41%), at three years of age, had handicapping conditions severe enough to warrant admission to special education programs in the public school. The grade of intraventricular hemorrhage was related significantly to neurologic outcome (X^2=8.19, P<.01). Both grade of intraventricular hemorrhage (P<.025) and birth weight (P<.025) were correlated significantly with the need for special education. Intellectual performance was related not only to grade of hemorrhage and birth weight, but also to paternal social class (P<.025).

Leonard et. al. (1983) found that neurodevelopmental outcomes for the complicated hemorrhage group (Grade III and IV) were significantly poorer (P<.05) than for those with uncomplicated hemorrhages. The incidence of moderate/severe abnormalities was found to be higher in the complicated hemorrhage group. In addition, no infant with abnormal outcome in the complicated hemorrhage group had a cognitive deficit alone.

Stewart et. al. (1983) reported followup data on preterm infants (n=46) at 18 months of age. Only eight percent of the infants with uncomplicated intraventricular hemorrhages exhibited major or minor neurological or developmental sequelae at followup. By contrast, seventy-one percent of the infants whose ventricles became enlarged (Grade III and IV) had neurological and/or

developmental abnormalities at followup. The proportion with sequelae depended on the cause and extent of the enlargement.

Catto-Smith et. al. (1985) described the effect of neonatal intraventricular hemorrhage on neurodevelopmental outcome at age two. Thirty-two percent of their sample (n=18) had intraventricular hemorrhage. Analysis of their data yields an apparent trend between the gradation of the hemorrhage and the incidence of disability ($P<0.01$, Fisher's exact test).

Fawer, Calame, and Furrer (1985) looked at neurodevelopmental outcome at twelve months of age. They found that infants with small lesions developed as well as children with normal ultrasound scans, whereas infants with more diffuse or extensive lesions had poorer prognoses. They claim that the outcome of a cerebral injury seems to depend on the type, the size, and the location of the lesion, and to some extent on the neuroplasticity of the developing brain.

The above literature confirms the relationship between gradation of hemorrhage and incidence of neurologic and/or developmental sequelae. In general, many researchers (Fenichel, 1985; Gaiter, 1982; Ment et. al., 1982) agree that motor dysfunction serves as the most characteristic abnormality present in intraventricular hemorrhage infants, as their motor scale scores reflect a downward trend. Yet, whether the grade of the hemorrhage

and the incidence of disability always coincide is questionable.

Severe grades of hemorrhage and disabilities. While mortality rates for youngsters with Grade III or IV intraventricular hemorrhage remain high (40 to 60 percent (Volpe, 1987)), there is much interest in survivors' neurological and developmental outcomes. While one might immediately assume that the outlook for these youngsters is dim, research indicates mixed prognostic findings.

Papile et. al. (1979) conducted a followup of intraventricular hemorrhage infants who were alive at 12 months post term. Two of six Grade III toddlers had minor neuromotor handicaps, while two more had major neuromotor handicaps. Furthermore, one of the toddlers had a Bayley Scale Developmental Index of less than 80 which was considered abnormal. One of the three toddlers with Grade IV bleeds had a minor neuromotor handicap, while two had major neuromotor handicaps. All three of these toddlers had Bayley Scale Developmental Index scores of less than 80. Therefore, a significant relationship between Grade III and IV bleeds and major neuromotor handicaps and Developmental Index less than 80 was supported ($P<0.05$).

In another study, Papile et. al. (1983) again supported their earlier findings indicating that infants with Grade III or IV intraventricular hemorrhages have much poorer outcome. Of fourteen infants with Grade III

hemorrhage, two were normal, seven were suspect, and five were abnormal. Four of these infants were multihandicapped. Of seventeen infants with Grade IV hemorrhage, two were normal, two were suspect, and thirteen were abnormal. Multihandicaps were present in ten of these infants.

Naulty et. al. (1983), attempting to understand the neurodevelopmental outcome of infants with Grade III intraventricular hemorrhage, conducted a matched-pair design study. These infants were evaluated at three month intervals until they were 12 months corrected age. Neurologically, eight of the ten infants with hemorrhages had abnormal findings, as compared to only three of the controls. Developmentally, six of the ten infants with hemorrhages showed significant delays on the Bayley Scale of Infant Development. Only two of the controls demonstrated developmental delays. Thus, eight of the ten youngsters with Grade III hemorrhages had identifiable deficits. While neuromuscular deficits appear to predominate, Naulty et. al. (1983) point out that infants with Grade III intraventricular hemorrhages have widespread damage.

Using the Bayley Scales of Infant Development and the Stanford-Binet Intelligence Scale, Tekolste, Bennett, and Mack (1985) found that on average, children with intraventricular hemorrhages demonstrate developmental indexes in the normal range, but about ten points lower

than children without hemorrhages. In addition, they suggest that the outcome of children with Grades I, II, and III bleeds appears to be similar in terms of both incidence of major abnormalities and developmental scores, with outcome only in Grade IV youngsters being clearly aberrant. Thus, this study implies a better prognosis for Grade III survivors than do Naulty et. al. (1983).

Schub et. al. (1981) present even more intriguing data relating to the outcome of Grade IV hemorrhage youngsters. Their followup of thirteen children with Grade IV hemorrhage conducted at 34 months corrected age revealed that eight had good outcome (no neurologic deficit and Developmental Index > 90), three had intermediate outcome (no, or minor neurologic deficit, and Developmental Index between 70 and 90), and only two had poor outcomes (significant neurologic deficits or Developmental Index < 70). Therefore, marked intraventricular hemorrhage did not preclude good outcome since sixty percent of the survivors were judged to have good outcomes.

Sostek et. al. (1987) examined the developmental outcomes of preterm infants with varying degrees of intraventricular hemorrhages at one and two years of age as measured by Bayley Scale mental and motor scores. They concluded that more than half of the children in the most severe groups were functioning within the normal range at 2 years of age. Therefore, they also support a

more optimistic outlook for youngsters having been diagnosed with severe intraventricular hemorrhage.

In the study by James et. al. (1987) conducted over the period from January 1978 to January 1986, a significant number (n=21) of infants with Grade III and IV hemorrhages were found to have severe handicaps, primarily in the motor areas. However, a subgroup (n=8) of the Grade III and IV infants were noted to have normal intellectual performance despite the varying degrees of motor handicaps. Furthermore, eighteen percent of the group (n=39) had both normal intellectual and motor development. They conclude that the presence of Grade IV hemorrhage and/or seizures, plus shunt infections are predictors of poorest outcome.

Ment et. al. (1985) reported findings on the serial neurodevelopmental follow up evaluations of 142 very low birth weight neonates, 63 of whom were known to experience neonatal intraventricular hemorrhage. Although the number of infants surviving with Grade III and IV hemorrhage was small (n=4, and n=1, respectively), they report no differences in the developmental scores at any of the evaluation dates (three months to 30 months corrected age) for these youngsters. Furthermore, they report infrequent neurologic impairments in the intraventricular hemorrhage groups. Thus, a more optimistic outcome for children having experienced severe intraventricular hemorrhages is supported by this particular study as well.

Because many infants with Grade III and IV bleeds require shunting, the developmental outcome of those having progressive post-hemorrhagic hydrocephalus treated with surgical placement of a ventriculo-peritoneal shunt is also of interest. Liechty et. al. (1983) followed nineteen infants of < 1,500 grams who were shunted over the first year of life. Bayley Scale of Infant Development indexes revealed that fourteen of seventeen survivors were at high risk for moderate to severe motor and intellectual impairment. They conclude that shunting procedures performed after progressive ventricular enlargement has taken place are not likely to result in normal development of the infant < 1,500 grams birth weight.

Likewise, Boynton et. al. (1986) found infants sustaining Grade IV hemorrhage were more likely to score less than 52 on the motor scale of the Bayley Scales of Infant Development. Of the nine infants they followed who had both seizures and Grade IV hemorrhage, all of them had scores less than 52. In addition, these infants were more likely to have more than two handicaps than were infants with lesser grades of hemorrhage.

Grade I and II hemorrhage youngsters versus controls and their neurodevelopmental outcome. Infants with intraventricular hemorrhage have long been suspected to not fare as well as their non-intraventricular hemorrhage peers at the time of neurodevelopmental assessment.

However, many medical personnel and researchers have wondered about the differences between those children having experienced milder (Grades I and II) degrees of intraventricular hemorrhages and their no bleed premature peers. Surprisingly, the current literature tends to indicate that those children with milder hemorrhage appear to function as well as their no bleed premature peers.

Papile et. al. (1979) found that the twelve Grade I and II infants in their study were functioning equal to their controls at one year post term. In addition, no major developmental handicaps were noted. Similarly, Ment et. al. (1982) followed twenty-one Grade I and Grade II infants. At the corrected age of 12 months, they found no statistically significant differences in either Bayley Scale mental or motor scale indexes between the mild hemorrhage youngsters and their controls.

In the prospective neurological and developmental assessments conducted by Palmer, Dubowitz, Levene, and Dubowitz (1982), fourteen intraventricular hemorrhage infants were followed to 12 months corrected age. Palmer and co-workers (1982) reported no difference in Griffith's Developmental Quotients between toddlers with and without intraventricular hemorrhage. They did find, however, that the neurological and developmental deficits seemed to be related more closely to the presence of post-hemorrhagic ventricular dilation than to the size of the initial hemorrhage itself.

The followup study reported by Papile, Munsick-Bruno, and Schaefer (1983) also supports the notion that the outcome for infants with Grade I and II intraventricular hemorrhage is similar to that of infants with no intraventricular hemorrhage. At 24 months corrected age, seventeen of the Grade I infants (n=39) had normal developmental assessments. Furthermore, sixteen had no visible handicaps. Of the Grade II infants (n=18), the majority (n=11) had normal developmental assessment as well as no visible handicaps (n=9). The results for those experiencing intraventricular hemorrhage are strikingly similar to the results presented for infants without intraventricular hemorrhage.

Ment et. al. (1985) examined long term survivors experiencing Grade I and Grade II intraventricular hemorrhage. They report that mean Bayley Scale mental index scores for the Grade I and Grade II toddlers are similar to controls at 18 months corrected age. In addition, scores on the Stanford-Binet Intelligence Scale at 30 months between the groups were not significantly different.

Krishnamoorthy et. al. (1984) looked extensively at infants surviving Grade II intraventricular hemorrhage. The twelve infants were followed to a mean age of four and one-half years. Using Bayley scores and McCarthy scores, they found that nine children (75%) had intelligent quotients within the normal range (mean IQ of 101). Of

the remaining three children, one had an intelligence quotient in the low normal range (IQ of 80), and two had intelligence quotients in the borderline range (mean IQ of 70). Thus, the authors suggest a favorable developmental outcome for youngsters surviving with Grade II intraventricular hemorrhage. Yet, instead of the sixteen percent of children expected to fall one standard deviation below the mean, they find twenty-five percent. This suggests that children with Grade II intraventricular hemorrhage remain at greater risk for lower cognitive functioning scores than do children in the normal population.

While much interest has focused on controls and mild intraventricular hemorrhage youngsters, Leonard and co-workers (1983) remind us that despite having normal CT scans, low birth weight infants not experiencing intraventricular hemorrhage can still have complications. In their study, twenty percent of the very low birth weight infants still had some type of medical and/or psychological abnormality despite having normal CT scans at birth. Of that twenty percent, nine percent had moderate to severe abnormalities. Conversely, forty-five percent of the infants with intraventricular hemorrhage were developing normally, while twenty-nine percent demonstrated some abnormality.

Group by time interaction of grade of hemorrhage and outcome. A unique study by Scott et. al. (1984) reports on the results of neurodevelopmental followup of 88 of 106 consecutive preterm survivors with birth weights of 1,250 grams or less. Of the 106 neonates, 46 had experienced intraventricular hemorrhage of some degree. Twenty-five neonates had Grade I hemorrhage, seventeen had Grade II hemorrhage, two neonates had Grade III hemorrhage, and two neonates had Grade IV hemorrhage. Using analysis of variance, Scott et. al. (1984) detected a significant group x time interaction indicating a significant downward trend in neurodevelopmental outcome over time in the intraventricular hemorrhage group relative to the non-intraventricular hemorrhage group. Scott et. al. (1984) conclude that this significant downward trend suggests that the long term neurodevelopmental prognosis of preterm neonates may indeed be compromised, even in the lesser grades of hemorrhage.

Summary and Implications

The following is a summary of the main points of this review of literature:

1. The advent of Regional Neonatal Intensive Care Units and the advancement of medical technology have allowed a greater number of premature, low birth weight neonates to survive.

2. Many of these premature, low birth weight infants are experiencing intraventricular hemorrhages. Incidence figures range from 40 to 61 percent, with most incidence studies indicating 40 to 45 percent of those weighing less than 1,500 grams or born less than 35 weeks gestation being affected. Furthermore, these figures increase when infants born less than 32 weeks are taken into consideration.
3. The advent of ultrasonography has permitted what are believed to be reliable diagnoses of intraventricular hemorrhage (presence and grade of hemorrhage) to be made.
4. Short-term outcome data indicate that mortality rate and the development of progressive ventricular dilation are clearly related to the severity of the hemorrhage.
5. Long-term followup of these infants has yielded inconsistent results. For the most part, a large number of studies have supported the notion that there is a relationship between gradation of hemorrhage and incidence

of disability. However, other researchers have found a significant number of toddlers with severe intraventricular hemorrhages to be functioning exceptionally well.

6. Methodological limitations make the current results difficult to interpret.
   a. Sample sizes have, in general, been small, and some studies have grouped the more severe hemorrhage children in order to have an acceptable number of children representing that group.
   b. Followup periods have been limited to the first two years of life, with longer followup periods being the exception.
   c. Research studies to date have generally been conducted by medical personnel whose primary concern is survival of the neonate and later neurological development. While many researchers have looked at the same developmental outcome instruments, each researcher has selected a different cut-off score for classifying a child as "abnormal" or

intellectually impaired (ranging from less than 80 to less than 50).

d. Socioeconomic status of the infant's family has largely been ignored as a variable possibly influencing these youngsters' outcome. However, data in other areas looking at continuity and change in developmental scores have reflected the intermediating role of socioeconomic status. (See Hoy, Bill, and Sykes, 1988; Kopp, 1983; Willerman, Browman, and Fiedler, 1970). It has frequently been found that poverty exacerbates problems attributed to prematurity, whereas middle to high income levels minimize developmental difficulties in the preterm child with time (Willerman, Browman, and Fiedler, 1970).

e. Most studies to date have used descriptive statistics and chi square distributions for their data analysis. More researchers have begun to use analysis of variance to compare differences between groups, but little has been done to look at trends within the data.

f. Many studies suggest significant findings; however, it is difficult to ascertain whether the significance is practical or statistical. Researchers will frequently cite the significance level but will not provide the actual test statistic.

7. Infants with intraventricular hemorrhage have long been suspected to not fare as well as their unaffected peers at the time of neurodevelopmental assessment. Yet, studies have indicated that, for the most part, children with mild grades of intraventricular hemorrhage appear to function as well as their unaffected peers.

8. Only one study (Williamson et. al., 1983) considered admission to Special Education services for this population. Yet, the study reports only an overall percentage of those receiving services at age three, and gives no indication of the type of service being provided or when the service was initiated.

As the medical field continues to increase its capacity to bring premature, low birth weight infants into this world, the impact of intraventricular hemorrhage on long term neurodevelopmental outcome needs to be clarified. The current literature provides few answers or little direction for neonatologists, educators, and parents. Many studies have been plagued by small sample size, especially in the more severe hemorrhage groups, and this makes the findings difficult to interpret or generalize. Furthermore, while testing instruments have been standard across the studies, different arbitrary cut-off scores indicating intellectual deficits have been imposed as a criterion of abnormality. Other flaws in the current literature include failure to consider the role of socioeconomic status, race, and other important matching variables, and the use of simple data analysis techniques which provide information on only the tip of the iceberg. The importance of outside services and support for these infants and their families has been ignored in current studies. Yet, since these children are at high risk for neurodevelopmental problems, it is reasonable to expect that these children would be requiring supplemental services of some sort.

Justification for the Present Research

This study looked at the long-term outcome of infants and children having intraventricular hemorrhages. Compared to the existing data, this study focused on a

larger number of intraventricular hemorrhage youngsters than has been done previously, as well as focusing on a lengthier followup period. In addition, subjects were matched on mean birth weight for gestational age, gestational age, sex, race, and socioeconomic status. Other important variables, such as duration of hospital stay, ventilation required, and method of delivery were also controlled statistically. Furthermore, cognitive performance data were collected by personnel trained in the area of psychology and education. Thus, intellectual deficits can be classified in accordance with state guidelines. Similarly, while many researchers have used the Denver Developmental Screening Test as an outcome measure, little emphasis has been placed on the areas (personal/social, language, fine motor, and gross motor) in which the deficits or delays occur. While previous studies report no inter-rater reliability for ultrasound readings, this study determined the consistency of ultrasound readings.

This study also takes an important step in advancing the existing knowledge in this field by examining the incidence and type of early intervention provided for these children. It is important for practitioners, in the medical, psychological, and educational fields, to be aware of the supplementary services which are required by these youngsters as they grow. Implications of this research pertain not only to the medical field and its

interventions with these infants as they are fighting to keep them alive after birth, but also could have a direct bearing on types of services being provided to these youngsters and their families in both the public and private sectors.

CHAPTER 3

METHODOLOGY

Overall Design

This study was retrospective in nature, and focused on the neurodevelopmental outcome of premature infants born at 35 weeks gestation or less, and/or weighing less than 1,500 grams. Meeting just one of the above conditions was sufficient for inclusion in the study. Every child attending the Developmental Assessment Clinic (DAC) for followup, who was diagnosed as having an intraventricular hemorrhage, had his/her chart reviewed for each successive visit. Because of the retrospective nature of this study, there was no direct contact with the subjects.

In addition, children diagnosed as having intraventricular hemorrhage were matched with no bleed premature, low birth weight peers. These children were matched on the following variables: gestational age, sex, race, mean birth weight for gestational age, and socioeconomic status. In addition, duration of hospital stay in the Regional Neonatal Intensive Care Unit (RNICU), ventilation required, presence of convulsions, and method of delivery (Caesarean versus vaginal) were controlled

statistically. No bleed premature infants who were matched also had their charts reviewed for successive visits.

Motor and Developmental Assessment

Following discharge from the RNICU, infants are followed in the Developmental Assessment Clinic (DAC). Functioning is periodically assessed, beginning around six months of age and continuing until seven years of age, at regular intervals. (See Table 2). After an infant's first visit to DAC a return visit is scheduled between nine months and one year later.

On each visit to the DAC, the youngster is seen by an audiologist, a psychologist, a physical therapist, a neonatologist, and a nurse. Thus, an audiological evaluation, a psychological evaluation, a physical and neurological evaluation, and current weights and measurements are obtained for each child. Psychological functioning is assessed using the Denver Developmental Screening Test (DDST), the Bayley Scales of Infant Development, the Stanford-Binet Intelligence Scale, Form L-M, or the Stanford-Binet Intelligence Scale: Fourth Edition. (See Appendix A for description of measures). The instrument used is based on the child's age, the number of the current visit, and the condition of the child. Whether the child is currently being serviced by a special education school program is also taken into consideration. In general, tests of intellectual

TABLE 2

General Guidelines for DAC Return Visits.

Appointment	Age
First	6 to 9 months
Second	Around 15 months
Third	2 years old
Fourth	3 years old
Fifth	4 years old
Sixth	5 years old
Seventh	6 years old

functioning are not given to children enrolled in school programs. Therefore, on a first visit, every infant is typically given the DDST; on the second visit the mental portion of the Bayley Scales of Infant Development is typically administered; and some form of the Stanford-Binet or the DDST is typically used on the third visit. (See Table 3). All scores are corrected for gestational age until the age of two years.

The physical and neurological evaluations are conducted by the physical therapist and the neonatologist. The physical therapist uses a checklist to attain an estimate of where the fine and gross motor skill development falls in relation to the child's age. Neurological abnormalities as well as the overall skill attainment are recorded. The neonatologist conducts an extensive neurological examination, based on Amiel-Tison and Grenier (1980) to evaluate muscle tone, primitive reflexes, deep tendon reflexes, protective and equilibrium reactions, and range of motion. These results are also recorded.

Research Questions

Based upon the data available from the motor and developmental assessment and the previously stated research objectives (see Introduction), the following questions have been generated.

1. How does the presence of an intraventricular hemorrhage affect a youngster's ability to meet

TABLE 3

Psychological Assessment Instruments Administered Based on Child's Age.

Age Ranges	Tests Typically Administered
6 to 12 months	Denver Developmental Screening Test
14 to 30 months	Bayley Scales of Infant Development - Mental Portion
	Denver Developmental Screening Test
2 years, 6 months to 6 years, 0 months	Denver Developmental Screening Test
	Stanford-Binet Intelligence Scale, Form L-M
	Stanford-Binet Intelligence Scale: Fourth Edition

age-appropriate developmental milestones in the areas of personal/social skills, fine motor skills, language skills, and/or gross motor skills?

a. Is there a difference in reaching developmental milestones as measured by the Denver Developmental Screening Test between infants who have Grade I, Grade II, Grade III, or Grade IV hemorrhages at the time of their first visit to the Developmental Assessment Clinic? In which area(s) is (are) the skill(s) delayed or deficient?

b. Is there a difference in milestone attainment as measured by the Denver Developmental Screening Test between toddlers and children who have Grade I, Grade II, Grade III, or Grade IV hemorrhages on subsequent visits? Specifically, which skill(s) is (are) delayed or deficient?

2. Does the presence of an intraventricular hemorrhage have an effect on intellectual functioning?

a. What is the difference in cognitive performance, as measured by the Bayley Scales Mental Developmental Index scores or Stanford-Binet IQ scores,

between children who have intraventricular hemorrhages and children who do not have intraventricular hemorrhages?

3. What percentage of children having experienced intraventricular hemorrhage currently receive early intervention service:
   a. based on the gradation of the hemorrhage?
   b. compared to the matched comparisons?
4. At what age is the referral for service being made and for what type of service (school or other supplemental service)?
   a. Is age of referral and type of service delivered related to severity of the intraventricular hemorrhage?

Sample

The subjects of this study were the premature, very low birth weight infants born at Sparrow Hospital and placed in the hospital's RNICU between January 1983 and December 1987. Infants transferred into the hospital's RNICU were not included in the study. Infants diagnosed by ultrasonography as having intraventricular hemorrhage within 72 hours of birth comprise the bulk of the current sample. Blind reads of the ultrasonography were made by one neonatologist, and the intraventricular hemorrhage was graded based on the Papile classification (Papile et. al.,

1978). For this study, another neonatologist conducted blind reads of a subsample of the ultrasounds and graded the intraventricular hemorrhage. A random selection of eighteen ultrasounds were re-read. Four of the ultrasounds had been rated as no bleed, four of the ultrasounds had been rated as Grade I, two had been rated Grade II, four had been rated Grade III, and four had been rated Grade IV. The two neonatologists agreed on sixteen of eighteen gradings for an 89 percent agreement, which is considered an acceptable agreement rate. Disagreements resulted on one Grade I and one Grade III ultrasound.

During the time period encompassing January 1983 and December 1987, 39.6 percent (seventy-six infants) of the premature low birth weight neonates in the RNICU had some form of intraventricular hemorrhage (Grades I through IV). Of these infants, 34 had Grade I or Grade II hemorrhage, while 42 had Grade III or IV hemorrhage. (See Table 4 for specific breakdown). Fifteen infants were dropped from the study for varying reasons. Of the fifteen youngsters, eleven never attended the DAC followup; three had gestational ages greater than 35 weeks and weighed greater than 1,500 grams; and one infant was a transfer to Sparrow's RNICU. The remaining sixty-one youngsters served as subjects in this study. Of these youngsters, twenty-one had Grade I bleeds, ten had Grade II bleeds, twenty had Grade III bleeds, and ten had Grade IV bleeds. (See Table 4).

TABLE 4

Number of Infants Diagnosed With Intraventricular Hemorrhage According to Grade of Hemorrhage.

Grade	Total Number of Youngsters	Sample Number of Youngsters
Grade I	23	21
Grade II	11	10
Grade III	25	20
Grade IV	17	10

Sixty-one premature very low birth weight children who had not been diagnosed with intraventricular hemorrhage within 72 hours of birth but who were admitted to the RNICU served as comparisons. A master list was used to identify possible candidates for the comparison group. Children were first matched on sex and date of birth (month and year). Then mean birthweight and gestational age were compared. Possible candidates' files were then reviewed for race and socioeconomic status data. Candidates who matched the data of the intraventricular hemorrhage youngsters on five of the six variables were selected for the comparison group. These childrens' files were also reviewed for successive visits to the DAC.

Table 5 shows the descriptive statistics for the 122 children for whom data were collected. Males represent sixty-four percent of the sample, while the remaining thirty-six percent of the sample consists of females. Eighty-five percent of the children were white while fifteen percent were Black or Hispanic. Using Duncan's (1961) socioeconomic index for occupations, a unidimensional scale, sixty-five percent of the children came from middle income families, while thirty-five percent came from low income families. A random selection of 25 files were re-examined by an economics graduate student. Agreement on assignment of socioeconomic status based on the reported parental occupation resulted in twenty-three cases (92%). Disagreements occurred in cases

TABLE 5

Characteristics of Youngsters in Total Sample (n=122)

Sex	Freq.	Pct.
Male	78	64
Female	44	36

SES	Freq.	Pct.
Middle	79	65
Low	43	35

Race	Freq.	Pct.
White	104	85
Black	14	12
Hispanic	4	3

Ventilation	Freq.	Pct.
Yes	108	88
No	14	12

Status	Freq.	Pct.
Active	84	69
Inactive	38	31

Convulsions	Freq.	Pct.
Yes	16	13
No	106	87

Referral	Freq.	Pct.
Yes	59	48
No	63	52

Method of Delivery	Freq.	Pct.
Caesarean	87	71
Vaginal	35	29

	Mean	S.D.	Range
Birth Weight	1357	446.07	397 to 2438 grams
Gestational Age	29	2.3	25 to 34 weeks
RNICU Stay	57	31.25	10 to 180 days
Total Visits to DAC	3	1.54	1 to 7 visits

Age (in months)	Mean	S.D.	Range
First Visit	6	3.31	2 to 36 months
Second Visit	16	6.31	9 to 42 months
Third Visit	29	6.08	17 to 52 months
Fourth Visit	41	7.10	28 to 62 months
Fifth Visit	52	5.97	44 to 65 months
Sixth Visit	61	3.70	56 to 66 months
Seventh Visit	68		

involving single parents whose occupation was not thoroughly recorded.

The average birth weight for children in the sample was 1357 grams (range 397 to 2438 grams) and the average gestational age was 29 weeks (range 25 to 34 weeks). Table 5 indicates that the average length of stay in the RNICU for these children was 57 days (range 10 to 180 days). Seventy-one percent of the youngsters were delivered by Caesarean section, while twenty-nine percent were delivered vaginally. A majority of these children (88 percent) required mechanical ventilation after their birth. As infants, thirteen percent of the children suffered convulsions for which they were treated.

Further examination of Table 5 shows that sixty-nine percent of the children in the sample were still attending the followup sessions at DAC. The remaining thirty-one percent of the children had not returned for their next followup and had been inactivated. The average number of visits to DAC for youngsters in the sample was three (range 1 to 7 visits). Children were, on average, six months at the first visit (range 2 to 36 months), sixteen months at the second visit (range 9 to 42 months), twenty-nine months at the third visit (range 17 to 52 months), forty-one months at the fourth visit (range 28 to 62 months), fifty-two months at the fifth visit (range 44 to 65 months), sixty-one months at the sixth visit (range 56 to 66 months), and sixty-eight months at the seventh

visit. Table 5 also shows that of the 122 children comprising the sample, forty-eight percent were referred by the DAC staff for some type of supplemental service.

Many studies to date have provided only the overall characteristics of the subjects in the sample. However, researchers studying high-risk infants (Cohen, 1986; Kiely and Paneth, 1981) have criticized the existing literature for its failure to provide the characteristics of different subgroups within the studied sample. Therefore, the descriptive statistics for each of the subgroups in this sample (comparison group and Grade I through Grade IV intraventricular hemorrhage youngsters) will be discussed separately.

Comparison Group

As previously stated, of the 122 children in the sample, 61 served as matched comparisons. Table 6 shows the descriptive statistics for this group. It can be seen that sixty-four percent of the children are male, eighty-four percent are White, and sixty-two percent are from middle income families. The average birth weight for this group was 1468 grams (range 709 to 2438 grams) and the average gestational age was 29 weeks (range 25 to 34 weeks). Forty-eight days was the mean length of stay in the hospital's RNICU (range 10 to 180 days). A majority of these youngsters were delivered by Caesarean (77 percent) and required mechanical ventilation (85 percent).

TABLE 6

Characteristics of Youngsters in Comparison Group (n-61)

Sex	Freq.	Pct.
Male	39	64
Female	22	36

SES	Freq.	Pct.
Middle	38	62
Low	23	38

Race	Freq.	Pct.
White	51	84
Black	8	13
Hispanic	2	3

Ventilation	Freq.	Pct.
Yes	52	85
No	9	15

Status	Freq.	Pct.
Active	41	67
Inactive	20	33

Convulsions	Freq.	Pct.
Yes	--	--
No	61	100

Referral	Freq.	Pct.
Yes	28	46
No	33	54

Method of Delivery	Freq.	Pct.
Caesarean	47	77
Vaginal	14	23

	Mean	S.D.	Range
Birth Weight	1468	468	709 to 2438 grams
Gestational Age	29	2.4	25 to 34 weeks
RNICU Stay	48	32	10 to 180 days
Total Visits to DAC	3	1.42	1 to 7 visits

Age (in months)	Mean	S.D.	Range
First Visit	6	1.14	4 to 9 months
Second Visit	17	5.35	10 to 36 months
Third Visit	29	5.85	24 to 52 months
Fourth Visit	40	6.88	28 to 60 months
Fifth Visit	51	6.98	44 to 65 months
Sixth Visit	59	3.46	56 to 66 months
Seventh Visit	68		

None of the children in the comparison group suffered from convulsions.

Table 6 indicates that the average number of visits to DAC for these children was three (range 1 to 7 visits). Sixty-seven percent still attend DAC followup. Age statistics indicate an average age of six months at the first visit (range 4 to 9 months), seventeen months at the second visit (range 10 to 36 months), twenty-nine months at the third visit (range 24 to 52 months), forty months at the fourth visit (range 28 to 60 months), fifty-one months at the fifth visit (range 44 to 65 months), fifty-nine months at the sixth visit (range 56 to 65 months), and sixty-eight months at the seventh visit. Of these 61 children, forty-six percent were referred by DAC for some type of supplemental service. In general, this group compares favorably to the youngsters experiencing intraventricular hemorrhage. Lack of convulsions and greater birth weight distinguish the no bleed comparison group from the intraventricular hemorrhage groups.

Grade I Intraventricular Hemorrhage

Table 7 shows the descriptive statistics for the twenty-one children having diagnosed Grade I intraventricular hemorrhage. Sixty-seven percent are males, ninety-one percent are White, and seventy-six percent are from middle income families. The average birth weight was 1309 grams (range 795 to 2041 grams) and the average gestational age was 29 weeks (range 26 to 34

TABLE 7

Characteristics of Youngsters With Grade I IVH (n-21)

Sex	Freq.	Pct.
Male	14	67
Female	7	33

SES	Freq.	Pct.
Middle	16	76
Low	5	24

Race	Freq.	Pct.
White	19	91
Black	2	9
Hispanic	--	--

Ventilation	Freq.	Pct.
Yes	19	91
No	2	9

Status	Freq.	Pct.
Active	13	62
Inactive	8	38

Convulsions	Freq.	Pct.
Yes	2	9
No	19	91

Referral	Freq.	Pct.
Yes	6	29
No	15	71

Method of Delivery	Freq.	Pct.
Caesarean	13	62
Vaginal	8	38

	Mean	S.D.	Range
Birth Weight	1309	404	795 to 2041 grams
Gestational Age	29	2.4	26 to 34 weeks
RNICU Stay	58	23	14 to 90 days
Total Visits to DAC	3	1.59	1 to 6 visits

Age (in months)	Mean	S.D.	Range
First Visit	7	2.02	2 to 12 months
Second Visit	17	6.30	9 to 30 months
Third Visit	29	7.38	19 to 39 months
Fourth Visit	39	1.98	36 to 42 months
Fifth Visit	52	7.23	48 to 63 months
Sixth Visit	60		

weeks). The mean length of stay in the RNICU was 58 days (range 14 to 90 days), and ninety-one percent of the youngsters required mechanical ventilation. The majority were delivered by Caesarean (62 percent) and very few suffered convulsions (9 percent).

The average number of visits to DAC remains three (range 1 to 6 visits). Sixty-two percent of these children continue to attend DAC followup. Age statistics for each visit can be seen in Table 7. Of the twenty-one children, twenty-nine percent have been referred by DAC for supplemental service.

Grade II Intraventricular Hemorrhage

The descriptive statistics for the ten children having diagnosed Grade II intraventricular hemorrhage can be seen in Table 8. The majority of these youngsters are male (60 percent) and White (80 percent). In contrast to the other groups, sixty percent of these children come from low income families. The average birth weight was 1230 grams (range 705 to 1985 grams), the average gestational age was 29 weeks (range 25 to 33 weeks), and the mean length of stay in the RNICU was 62 days (range 35 to 88 days). The majority were delivered by Caesarean (60 percent), required ventilation (90 percent), and did not suffer from convulsions (80 percent).

This group's average number of visits to DAC was two (range 1 to 5 visits), and sixty percent continue to attend. Age statistics for each visit can be seen in

TABLE 8

Characteristics of Youngsters With Grade II IVH (n-10)

Sex	Freq.	Pct.
Male	6	60
Female	4	40

SES	Freq.	Pct.
Middle	4	40
Low	6	60

Race	Freq.	Pct.
White	8	80
Black	1	10
Hispanic	1	10

Ventilation	Freq.	Pct.
Yes	9	90
No	1	10

Status	Freq.	Pct.
Active	6	60
Inactive	4	40

Convulsions	Freq.	Pct.
Yes	2	20
No	8	80

Referral	Freq.	Pct.
Yes	3	30
No	7	70

Method of Delivery	Freq.	Pct.
Caesarean	6	60
Vaginal	4	40

	Mean	S.D.	Range
Birth Weight	1230	410	705 to 1985 grams
Gestational Age	29	2.1	25 to 33 weeks
RNICU Stay	62	18	35 to 88 days
Total Visits to DAC	2	1.27	1 to 5 visits

Age (in months)	Mean	S.D.	Range
First Visit	7	1.16	5 to 8 months
Second Visit	19	7.97	12 to 38 months
Third Visit	28	2.52	24 to 30 months
Fourth Visit	44	5.66	40 to 48 months
Fifth Visit	60		

Table 8. Of these ten children, thirty percent have been referred for supplemental service.

Grade III Intraventricular Hemorrhage

Of the twenty youngsters diagnosed with Grade III intraventricular hemorrhage, the majority are male (70 percent), White (85 percent), and from middle income families (65 percent). (See Table 9). The average birth weight was 1292 grams (range 397 to 2168 grams), the average gestational age was 29 weeks (range 25 to 32 weeks), and the mean length of stay in the RNICU was 68 days (range 26 to 151 days). The majority were delivered by Caesarean (70 percent), required ventilation (95 percent), and did not suffer from convulsions (80 percent).

Table 9 indicates that the average number of visits to DAC was three (range 1 to 6 visits) and that eighty percent are still active. Age statistics for each visit are reported in Table 9. Unlike other groups previously discussed, sixty percent of these children were referred for supplemental service.

Grade IV Intraventricular Hemorrhage

Descriptive statistics for the ten youngsters with Grade IV intraventricular hemorrhage can be found in Table 10. This table indicates that fifty percent of the youngsters are male, while fifty percent are female. The majority are White (90 percent) and come from middle income families (80 percent). The average birth weight

TABLE 9

Characteristics of Youngsters With Grade III IVH (n=20)

Sex	Freq.	Pct.
Male	14	70
Female	6	30

SES	Freq.	Pct.
Middle	13	65
Low	7	35

Race	Freq.	Pct.
White	17	85
Black	3	15
Hispanic	--	--

Ventilation	Freq.	Pct.
Yes	19	95
No	1	5

Status	Freq.	Pct.
Active	16	80
Inactive	4	20

Convulsions	Freq.	Pct.
Yes	4	20
No	16	80

Referral	Freq.	Pct.
Yes	12	60
No	8	40

Method of Delivery	Freq.	Pct.
Caesarean	14	70
Vaginal	6	30

	Mean	S.D.	Range
Birth Weight	1292	436	397 to 2168 grams
Gestational Age	29	2.0	25 to 32 weeks
RNICU Stay	68	31	26 to 151 days
Total Visits to DAC	3	1.73	1 to 6 visits

Age (in months)	Mean	S.D.	Range
First Visit	7	3.66	4 to 21 months
Second Visit	16	6.85	10 to 38 months
Third Visit	26	4.83	17 to 35 months
Fourth Visit	45	7.78	36 to 60 months
Fifth Visit	52	1.53	50 to 53 months
Sixth Visit	62		

TABLE 10

Characteristics of Youngsters With Grade IV IVH (n=10)

Sex	Freq.	Pct.
Male	5	50
Female	5	50

SES	Freq.	Pct.
Middle	8	80
Low	2	20

Race	Freq.	Pct.
White	9	90
Black	--	--
Hispanic	1	10

Ventilation	Freq.	Pct.
Yes	9	90
No	1	10

Status	Freq.	Pct.
Active	8	80
Inactive	2	20

Convulsions	Freq.	Pct.
Yes	8	80
No	2	20

Referral	Freq.	Pct.
Yes	10	100
No	--	--

Method of Delivery	Freq.	Pct.
Caesarean	7	70
Vaginal	3	30

	Mean	S.D.	Range
Birth Weight	1040	235	652 to 1500 grams
Gestational Age	28	2.0	25 to 32 weeks
RNICU Stay	85	32	46 to 136 days
Total Visits to DAC	3	1.81	1 to 6 visits

Age (in months)	Mean	S.D.	Range
First Visit	9	9.44	3 to 36 months
Second Visit	17	10.11	12 to 42 months
Third Visit	31	9.13	24 to 49 months
Fourth Visit	46	10.87	39 to 62 months
Fifth Visit	53		
Sixth Visit	66		

was 1040 grams (range 652 to 1500 grams), the average gestational age was 28 weeks (range 25 to 32 weeks), and the mean length of stay in the RNICU was 85 days (range 46 to 136 days). The majority were delivered by Caesarean (70 percent), required ventilation (90 percent), and suffered convulsions (80 percent).

The average number of visits to DAC remains at three (range 1 to 6 visits), and eighty percent continue to attend followup. Age statistics for each visit can be seen in Table 10. All ten of these youngsters were referred for supplemental service.

Data Analysis

To answer the research questions which have been generated, the following statistical methods were used.

1. Chi Square: The chi-square statistic was used to determine if presence of an intraventricular hemorrhage had an effect on meeting developmental milestones (Research Question 1, Part a and b). This test statistic was first used to determine whether there was a difference in overall Denver Developmental Screening Test results based on the grade of the intraventricular hemorrhage at the time of the first visit. When empty cells occurred in the analysis, Grade I and II youngsters were grouped and Grade III and IV infants were grouped together. Denver Developmental Screening Test results were rated as normal or abnormal. Questionable results were considered abnormal for this part of the analysis in order to take

into account the difficulties beginning to emerge. (See Appendix A for information regarding operationalization of normal, questionable, and abnormal). In this manner a clear distinction between infants able to meet age-appropriate developmental milestones and infants demonstrating emerging or present delays/deficits in reaching developmental milestones is attained. In addition, given the current emphasis on at-risk children and the possibility of early intervention, placing these children with questionable results in the abnormal category could increase their chances of receiving early intervention service. If this were the case, the emerging difficulties could be ameliorated at an earlier age. While this grouping of questionable results with the abnormal results will lead to an increase in the number of false positives, it is more in line with the current at-risk philosophy. Additionally, of the thirty-seven children having abnormal results, twenty-seven (73%) were referred for supportive services. Thus, the inclusion of the questionable results in the abnormal category can be justified in part by their high referral rate. After the overall Chi-square was examined, frequencies of areas of delays/deficits (personal/social, fine motor, language, and gross motor) were tabulated. The same procedure was used to determine if there were differences in Denver Developmental Screening Test outcomes at subsequent visits.

2. Loglinear Analysis: Loglinear analysis was used to determine if presence of an intraventricular hemorrhage had an effect on meeting developmental milestones (Research Question 1, Part a and b). Unlike the chi square statistic, the loglinear analysis allowed investigation of youngsters' ability to meet milestones without having to group intraventricular hemorrhage subgroups together when empty cells were found. Thus, differences between Grade I, Grade II, Grade III, and Grade IV youngsters could be determined.

3. Multiple Regression, Matched T-Test, Analysis of Variance, Student-Newman Keuls, Bartlett-Box F, and Cochran's C: Multiple regression, matched t-test, and analysis of covariance were used to determine whether there were differences between no bleed peers and children having suffered intraventricular hemorrhages (Research Question 2). The dependent variable was the intellectual functioning score as measured by the Bayley Scales of Infant Development, the Stanford-Binet, Form L-M, or the Stanford-Binet: Fourth Edition. Independent variables included the presence and grade of intraventricular hemorrhage, birth weight, age at time of testing, gestational age, socioeconomic status, sex, race, duration of hospital stay, ventilation required, presence of convulsions, and method of delivery. In cases where children were receiving services or interventions, the intervention was also considered an independent variable.

The intellectual functioning score typically used for this analysis was each child's test result at the first visit. (See Appendix B for test intercorrelations). However, in cases were there was fluctuation of scores over visits (increase or decrease of ten points or more), the mean intellectual functioning score was used. Post-hoc analysis was conducted using Student-Newman-Keuls procedure. In addition, homogeneity of variance was checked using Cochrans C and Bartlett-Box F.

3. Frequency counts, percentages, descriptive statistics, and Pearson correlation: Data collected dealing with referrals, early intervention, and supplementary services was analyzed using frequency counts, percentages, and descriptive statistics (Research Questions 3 and 4). A correlation coefficient was calculated to determine if there was a correlation between grade of hemorrhage and referral or participation in supplementary services (Research Question 3). It was assumed that some children would have skipped visits to the DAC and some children would have become inactive due to their failure to show up at a scheduled appointment or due to parents' wishes to discontinue the Clinic followup. In cases where charts were incomplete, analysis was based only on the visits attended.

Limitations

The youngsters to be considered for this study are limited to those who were born in Sparrow Hospital and who

were placed in the hospital's Regional Neonatal Intensive Care Unit (RNICU) between January 1983 and December 1987. This may create a problem of generalization. It is possible that several of the children who would qualify for this study will be lost due to their failure to participate in the Developmental Assessment Clinic (DAC) followup. Thus, no data will be available on these children, and they will be lost to followup.

A further limitation is that the psychological and neurological data have been gathered by different personnel who are assigned different dates of service in the Clinic. This could be a potential problem because examiner interaction with the child, and the examiner's ability to gain the child's optimal performance could vary. Furthermore, these personnel have access to each infant's hospital discharge summary, so they have knowledge of the infant's course during the RNICU hospital stay. How this knowledge affects the personnel dealing with the infant, if at all, cannot be partialled out. Because DAC does not collect data on actual parental income or highest level of education completed, socioeconomic status has been determined using Duncan's (1961) socioeconomic index relying on the reported parental occupation found in the file. This may result in an overestimation or underestimation of socioeconomic status. Because parental occupation is being used as the sole factor in determining socioeconomic status, it is

possible that other factors which may be responsible for differentiation between groups are overlooked.

Another limitation of this study involves the procedure used to analyze intellectual functioning data. Although intraventricular hemorrhage youngsters were matched with no bleed peers of the same age, it was not uncommon for these youngsters to have been given different assessment instruments at the same visit. Frequently one member of the matched pair would be given a Denver Developmental Screening Test while the other member would be given a Stanford-Binet, Form L-M. This resulted in the youngsters having incomparable measures for the particular visit. However, there was not a tendency for one group to be administered a more reliable/valid scale. Additionally, children frequently missed visits and when they were rescheduled their age no longer matched that of their assigned comparison. This resulted in inconsistent gathering of intellectual functioning data. Therefore, the statistical differences which emerge in the context of this area should be evaluated cautiously.

While this study focuses on a larger number of children with intraventricular hemorrhages, the sample sizes for particular analyses are still limited. This is especially the case in examining Grade II intraventricular hemorrhage children and the type of interventions they receive as only three children are currently serviced. Thus, results should be cautiously interpreted.

This study does not attempt to determine which factors affect favorable or unfavorable outcome for children surviving intraventricular hemorrhages. However, it does control for major factors (socioeconomic status, gestational age, sex, race, and birth weight) which could affect outcome. This study also does not look at which factors lead to referrals for special education and/or other supplementary services. While this is of interest, further research would be needed to isolate these factors.

CHAPTER 4

RESULTS AND DISCUSSION

Overview

The principal focus of this investigation was to determine the effects of intraventricular hemorrhage on children's development. The analysis has focused on the ability of youngsters with intraventricular hemorrhage to meet developmental milestones and their intellectual test scores. In addition, it has looked at the incidence of early intervention and has attempted to describe the types of services provided for these youngsters and their families. When appropriate, the intraventricular hemorrhage youngsters have been compared to matched no bleed comparisons in order to determine whether presence of an intraventricular hemorrhage places them at greater risk.

In the first part of this chapter, the findings that relate to the attainment of the developmental milestones are examined. Besides examining the overall level of milestone attainment, a look at the particular areas of delay/deficit is provided. The second section of this chapter investigates the level of intellectual functioning of intraventricular hemorrhage children and their matched

comparisons. In the third section, the information regarding early intervention is explored. The fourth section describes the age of referral for supplemental services and provides a general exploration of the types of services utilized by these youngsters and their families.

Developmental Milestone Attainment

The first research question seeks to determine whether the presence of an intraventricular hemorrhage affects a youngster's ability to meet age-appropriate developmental milestones in the areas of personal/social skills, fine motor skills, language skills and/or gross motor skills. More specifically, it attempts to determine whether there is a difference between infants who have Grade I, Grade II, Grade III, or Grade IV intraventricular hemorrhages at the time of their first visit and on subsequent visits. In addition, the areas in which skills are delayed or deficient are investigated.

To answer the issue of developmental milestones, results of the Denver Developmental Screening Test results were compared. Results were classified as normal or abnormal. In this manner, normal classifications represent the group of infants able to attain age-appropriate developmental milestones in all areas, while abnormal classifications represent the group of infants demonstrating emerging or present delays/deficits in attaining age-appropriate milestones. Those infants with

questionable results were classified as abnormal in order to take into account the difficulties beginning to emerge. Chi square was calculated to determine if significant differences existed in developmental milestone attainment based on the grade of the hemorrhage. Because empty cells were found in the analysis, Grade I and II youngsters were grouped and Grade III and IV youngsters were grouped.

At the time of the first visit the chi square was statistically significant (X^2=8.92 with Yates correction, P<.003) suggesting that there is a difference in milestone attainment. Of the thirty-one Grade I and II infants, twenty-five had normal results, while six had abnormal results. (See Table 11). Of the thirty Grade III and IV infants, twelve had normal results while eighteen had abnormal results. The loglinear analysis was also statistically significant (Likelihood Ratio Chi Square=10.42, df=3, P=.013) supporting the notion that there is a difference between Grade I, Grade II, Grade III, and Grade IV infants in attaining developmental milestones. Specific areas of delay and/or deficit at the time of the first visit can be seen in Table 12. It is apparent that delays or deficits in the motor areas (fine and gross motor) are the most common.

This finding is consistent with the literature and suggests that motor dysfunctions are quite prevalent in intraventricular hemorrhage infants. Fenichel (1985), Gaiter (1982), and Ment et. al. (1982) found that, in

TABLE 11

Number of Infants With Normal and Abnormal Denver Developmental Screening Test Results at First Visit.

	Normal	Abnormal
Grade I and II	25	6
Grade III and IV	12	18

TABLE 12

Percentage of Children with Skill Deficit or Delay on the Denver Developmental Screening Test at the First Visit According to Grade of Hemorrhage.

	Grade of Hemorrhage			
	Grade I (n=21)	Grade II (n=10)	Grade III (n=20)	Grade IV (n=10)
Personal/Social	--	10%	5%	20%
Fine Motor	10%	20%	20%	70%
Gross Motor	14%	10%	40%	90%
Language	--	20%	10%	20%

general, the motor scores of intraventricular hemorrhage infants reflected a downward trend. This motor dysfunction does appear to serve as the most characteristic abnormality present in intraventricular hemorrhage infants regardless of the severity of the hemorrhage.

The chi square was also statistically significant (X^2=10.83, P<.01) for subsequent visits suggesting that as these children grow older there continues to be a difference in attaining age-appropriate developmental milestones. Eighteen of the thirty-one Grade I and II youngsters had normal results; the remaining thirteen had abnormal results. (See Table 13). However, while eight of the thirty Grade III and IV children had normal results, twenty-two had abnormal results. The loglinear analysis was also statistically significant (Likelihood Ratio Chi Square=6.498, df=3, P=.090) suggesting that as these children grow older there are still differences between Grade I, Grade II, Grade III, and Grade IV youngsters in meeting developmental milestones. Table 14 reveals the areas of delays/deficits in skill attainment. It is apparent that the motor domain continues to be affected. Yet, for youngsters with Grade IV hemorrhages, the delays/deficits are now occurring in all skill areas.

Thus, it can be said that there is a significant difference between youngsters who have Grade I, II, III,

TABLE 13

Number of Children With Normal and Abnormal Denver Developmental Screening Test Results on Subsequent Visits.

	Normal	Abnormal
Grade I and II	18	13
Grade III and IV	8	22

TABLE 14

Percentage of Children with Skill Deficits or Delays on the Denver Developmental Screening Test on Subsequent Visits According to Grade of Hemorrhage.

	Grade of Hemorrhage			
	Grade I (n=21)	Grade II (n=10)	Grade III (n=20)	Grade IV (n=10)
Personal/Social	--	10%	5%	70%
Fine Motor	10%	20%	25%	90%
Gross Motor	5%	20%	50%	100%
Language	14%	10%	15%	60%

or IV hemorrhages in their ability to attain age-appropriate developmental milestones. At the time of the first visit, those infants having Grade III or Grade IV intraventricular hemorrhages are already demonstrating significantly more difficulty in reaching developmental milestones than are those infants with Grade I or Grade II intraventricular hemorrhages. This significant difference in reaching developmental milestones also continues to exist on subsequent visits.

These findings confirm those of Papile et. al. (1979; 1983) indicating that infants with Grade III or IV intraventricular hemorrhage have poorer outcomes. These findings also support Williamson et. al. (1982; 1983) suggesting that infants with Grade I or II hemorrhage have significantly better outcomes than those with Grade III or IV hemorrhage. When looking at the areas of delays/deficits, motor dysfunction is the most typical for all grades of bleeds. However, over time, deficits/delays for Grade IV children are found in the personal/social, fine motor, language, and gross motor areas. Naulty et. al. (1983) also found that while neuromuscular deficits appear to predominate, the damage is extensive and widespread. Therefore, across domain delays/deficits for these children are not unexpected.

Intellectual Functioning

The second research question seeks to determine whether there is a difference in cognitive performance

between children who have intraventricular hemorrhages and children who do not have intraventricular hemorrhages, but who are premature.

To answer this question, either the first intellectual functioning score or the mean intellectual functioning score was determined for each child, as was the child's age at the time the intellectual assessment was given. As the intraventricular hemorrhage youngsters had been matched with a comparison on sex, race, socioeconomic status, gestational age, and mean birth weight for gestational age, one-way analyses of variance (ANOVAS) were conducted comparing the groups on the variables. The results of these ANOVAS indicated there were no significant differences between the hemorrhage youngsters and the comparisons in sex, race, socioeconomic status, and gestational age. There was, however, a statistically significant difference in birth weight ($F=8.01$, $P<.005$) with the mean birth weight for the comparison group being higher than the mean birth weight for the hemorrhage youngsters (1468 grams versus 1246 grams). A matched T-test was conducted to compare intellectual functioning between pair members. A statistically significant difference was found ($T=-3.13$, $df=37$, $P=.003$) suggesting that members of the pair suffering from an intraventricular hemorrhage are scoring lower on the average.

Twenty-six of the 122 children had not been administered an intellectual assessment instrument on any visit. In order to ascertain whether these children were part of a homogeneous group, subgroup membership and Denver Developmental Screening Test results were viewed. Of those twenty-six, eight were from the comparison group, seven had Grade I hemorrhages, three had Grade II hemorrhages, five had Grade III hemorrhages, and four had Grade IV hemorrhages. Examination of these youngsters' Denver Developmental Screening Test revealed that thirteen had normal results, nine had questionable results, and four had abnormal results. This suggests that these children not having been administered an intellectual assessment are not representative of a specific severity of hemorrhage or of an inability to meet developmental milestones. Rather, these youngsters appear to be randomly distributed across subgroup membership and DDST result categories.

Table 15 describes the intellectual functioning scores for the remaining ninety-six children at a mean age of 20 months (S.D.=10.14) taking into account the severity of the hemorrhage. (See Appendix C for specific breakdown of classification by grade of hemorrhage). Statistically significant variation between groups was found when the mean intellectual functioning scores were used. The results of the ANOVA are reviewed in Table 16. The mean intellectual functioning scores for Grade I and Grade II

TABLE 15

Mean Intellectual Functioning Score According to Severity of Hemorrhage.

	Mean	S.D.	Cases
Comparisons	92.11	16.80	53
Grade I	92.86	13.89	14
Grade II	91.57	12.61	7
Grade III	79.87	22.30	15
Grade IV	64.71	26.15	7

Bartlett-Box F= 1.65, P=.160

TABLE 16

Analysis of Variance of Intellectual Functioning Score by Group.

	D.F.	Mean Square	F	Sig.
Between Groups	4	1524.2618	4.7503	.0016
Within Groups	91	320.8781		

children are practically the same as the mean intellectual functioning score for the comparison group. Post-hoc tests using the Student-Newman-Keuls procedure found Grade IV youngsters to be significantly different from the comparison group, Grade I, and Grade II youngsters in their intellectual functioning. No other pairs of groups were significantly different at the .05 level.

Papile et. al. (1979), Palmer et. al. (1982), and Ment et. al. (1985) have reported similar findings. With regards to Grade III and Grade IV youngsters, unlike the studies of Schub et. al. (1981) who found eight of thirteen youngsters with Developmental Indexes greater than 90 and Ment et. al. (1985) who found no differences in developmental scores, these results suggest that the mean intellectual functioning scores are 12 to 27 points lower, respectively, than the mean intellectual functioning score for the comparison group. Although the mean scores for the no bleed comparison group and the Grade I and Grade II children are in the lower extremes of the average range (falling between the 29th and 33rd percentiles), these mean scores are lower than would be expected considering the mean for the instrument administered is 100 (the 50th percentile). Given the assumption of a normal curve and that cut-off points in decision-making are in the low end of the distribution, a greater number of youngsters (approximately eight percent) than the expected two percent will fall in the mentally

retarded range. This indicates that these youngsters are almost four times at greater risk for mental retardation.

With the completion of these computations, the results were examined using multiple regression for possible confounding variables which could be statistically controlled in the next phase of the analysis. Two variables were significantly related to subgroup membership and intellectual functioning score (whether or not the child was referred for supplemental services or early intervention, P=.0003; and number of days in the RNICU, P=.0156).

Analysis of variance and multiple classification analyses were conducted using the covariates. The results of the ANOVA using referral as a covariate are shown in Table 17. An examination of this table reveals that while referral is a significant covariate, even controlling for it results in significant differences in intellectual functioning scores based on presence of the hemorrhage. The multiple classification analysis suggests that the grand mean of 88.27 increases by 3.59 points for the comparison group; increases by 1.68 for the Grade I youngsters; increases by 2.24 for the Grade II youngsters; decreases by 7.25 for the Grade III children; and decreases by 17.23 points for the Grade IV children.

Similarly, the ANOVA using days in the RNICU as a covariate can be seen in Table 18. This table also reveals that while days in the RNICU is a significant

TABLE 17

Intellectual Functioning Score By Intraventricular Hemorrhage With Referral as Covariate.

	D.F.	M.S.	F	Sig.
Covariate				
Referral	1	6316.566	22.189	.000
Main Effect				
IVH	4	840.052	2.951	.024
Explained	5	1935.355	6.799	.000
Residual				

TABLE 18

Intellectual Functioning Score By Intraventricular Hemorrhage With Days in RNICU as Covariate.

	D.F.	M.S.	F	Sig.
Covariate				
RNICU	1	3549.466	11.478	.001
Main Effect				
IVH	4	978.996	3.166	.018
Explained	5	1493.090	4.828	.001
Residual				

covariate, there are still significant differences in intellectual functioning scores based on the grade of the hemorrhage. The multiple classification analysis indicates that the grand mean of 88.27 increases by 2.86 points for the comparison group; increases by 5.17 points for the Grade I youngsters; increases by 3.30 for the Grade II children; decreases by 7.49 for Grade III youngsters; and decreases by 19.24 points for Grade IV children.

The intellectual functioning score was then examined controlling for both referral and days in the RNICU. These results can be seen in Table 19. Examination of this table suggests that when referral and days in RNICU are controlled, there no longer are significant differences in intellectual functioning scores based solely on the severity of the hemorrhage.

TABLE 19

Intellectual Functioning Score by Intraventricular Hemorrhage With Referral and Days in RNICU as Covariates.

	D.F.	M.S.	F	Sig.
Covariates	2	4599.979	16.890	.000
Referral	1	5650.492	20.748	.000
RNICU	1	2883.393	10.587	.002
Main Effects				
IVH	4	464.578	1.706	.156
Explained	6	1843.045	6.767	.000
Residual	89	272.345		

The mean intellectual functioning scores of Grade I and Grade II children are similar to those of the no bleed

comparisons. Yet, statistically significant variation between groups was found, primarily due to the differences between the sample mean and the subgroup means. Post-hoc comparisons using the Student-Newman-Keuls procedure indicate significant differences between Grade IV children and the comparison, Grade I, and Grade II children.

These findings confirm the results of Papile et. al. (1979), Palmer et. al. (1982), and Ment et. al. (1985). When controlling separately for two significant covariates, referral and days in the RNICU, there are still significant differences in mean intellectual functioning scores based on the severity of the hemorrhage. However, when the two covariates are controlled concomitantly, the differences in mean intellectual functioning scores based on the severity of the hemorrhage cease to exist. This suggests that factors other than presence of a hemorrhage are predictors of outcome. It is possible that members of the comparison group who were in the RNICU for lengthy stays and were later referred for early intervention had some other medical or neurological problem serious enough to impair cognitive functioning. Perhaps youngsters in the comparison group and in the intraventricular hemorrhage group differed on another variable that was not controlled. For example, infants requiring lengthy stays in the RNICU are frequently nutritionally deficient, and this would have a bearing on development of cognitive

functioning whether a bleed was present or not. James et. al. (1987) and Palmer et. al. (1982) have also suggested that poor outcome cannot be attributed solely to the presence of an intraventricular hemorrhage.

Early Intervention Incidence

The third research question seeks to determine the percentage of children currently receiving early intervention services. The first part of the question seeks to ascertain the percentage of children receiving early intervention service based on the gradation of the hemorrhage. The second part seeks to compare the percentage of intraventricular hemorrhage children receiving services to the percentage of children in the comparison group receiving services.

To answer this question consideration was given to whether the child was referred by the DAC staff. Chi square was calculated to determine if significant differences existed in referral rate based upon the presence or absence of an intraventricular hemorrhage. Again, because empty cells were found, Grade I and II youngsters were grouped and Grade III and IV youngsters were grouped.

A comparison of the children with intraventricular hemorrhages present indicates that there is a significant difference in referral rate based on the degree of the hemorrhage (X^2=10.27 after Yates correction, $P<.002$). Twenty-two of the thirty-one Grade I and II youngsters had

not been referred while nine had been referred. However, only eight of the thirty Grade III and IV youngsters had not been referred while twenty-two had been referred. (See Table 20). Thus, the greater the severity of the hemorrhage, the more likely the child had been referred for early intervention services.

TABLE 20

Number of Children Referred for Early Intervention Service Based on Severity of Hemorrhage.

	Referred	Not Referred
Grade I and II	9	22
Grade III and IV	22	8

When comparing intraventricular hemorrhage youngsters to comparisons, the results suggest there are no significant differences in referral rate based on presence or absence of an intraventricular hemorrhage (X^2=0.13, P<.72). Twenty-eight of the sixty-one comparisons had been referred (46%) while thirty-one of the sixty-one hemorrhage children had been referred (51%). Similarly, thirty-three of the comparisons had not been referred for services while thirty of the hemorrhage youngsters had not been referred. (See Table 21). Thus, it is apparent that low birth weight children also remain at greater risk for need of future services and their developmental functioning needs to be monitored over time. Examination

of differences in referral rates based on sex indicates no statistically significant differences (X^2=1.09, P=0.29), although forty-one males were referred while eighteen females were referred.

TABLE 21

Number of Children Referred for Early Intervention.

	Referred	Not Referred
Hemorrhage Present	31	30
Hemorrhage Absent	28	33

Despite having normal CT scans, Leonard et. al. (1983) found that twenty percent of their low birth weight sample had complications while forty-five percent of those experiencing intraventricular hemorrhages were developing normally. Although the percentages differ in this study, we are again reminded that normal CT scans do not preclude referral for supplementary services of some sort. Vohr and Garcia Coll (1985) reported that 54% of their 42 low birth weight sample required special education or resource help at seven years of age. These reported percentages are similar to those found in this study. While there are no differences in referral rate between comparison and intraventricular hemorrhage youngsters, the differences may appear in the type of services provided for these youngsters. This possibility is examined in the next section.

Age at Referral and Type of Service Provided

The fourth research question seeks to determine the mean age of referral based on the severity of the intraventricular hemorrhage. Additionally, a determination of whether age of referral is related to severity of the hemorrhage is desired. Moreover, a description of the types of services these youngsters and their families are receiving is provided.

In order to answer this question, the mean age of referral for each subgroup was calculated (See Table 22). The Pearson correlation was significant suggesting severity of hemorrhage is related to age of referral ($r=-.69$, $P<.001$). To test whether there were differences in mean ages of referral based on the severity of the hemorrhage ANOVA tables were developed. The results appear in Table 23. The significant F ratio supports the notion that significant differences in mean age of referral based on the severity of the hemorrhage exist. In general, the more severe the hemorrhage the earlier the child is referred for some form of intervention. Post-hoc comparisons using the Student-Newman-Keuls procedure indicate significant differences between Grade IV children and comparison, Grade I, and Grade II children in mean age of referral. Additionally, significant differences between Grade III and comparison, Grade I, and Grade II youngsters are also found. It is important to note that of the Grade I children, two are visually impaired and

TABLE 22

Mean Age of Referral By Grade of Intraventricular Hemorrhage.

	Mean (months)	S.D.	Range
Comparisons	19.5	10.63	5 to 39 months
Grade I	26.3	15.30	7 to 38 months
Grade II	27.0	10.82	15 to 36 months
Grade III	6.5	5.35	1 to 21 months
Grade IV	5.5	4.43	1 to 14 months

Cochrans C=.457, P=.010

TABLE 23

Analysis of Variance of Age of Referral by Intraventricular Hemorrhage.

	D.F.	Mean Square	F	Sig
Between Groups	4	880.1773	9.61	.0001
Within Groups	54	91.5895		

were referred for service at seven months of age. Similarly, four of the Grade IV children and three of the Grade III children were referred for service prior to the RNICU discharge. The existing literature does not discuss referrals or mean ages at referral, so future studies will be needed to determine the representativeness of these findings.

Age of referral was found to be related to sex. The Pearson correlation was significant suggesting sex is related to age of referral (r=-.28, P=.016). The mean age of referral was 17.78 months (S.D.=12.2) while the mean age of referral for females was 10.50 months (S.D.=10.4). Thus, females, on the average, are referred for supplementary services earlier than males. However, the higher percentage of males in this study suggests that these results be interpreted cautiously.

As for the types of services being provided for these youngsters, a rather limited range of possibilities were cited. By far, the most common service provider was the public school system. Other services included followup at the hospital for physical therapy, followup by the public health nurse, involvement in community mental health, and involvement in local programs (such as the Michigan State University Motor Clinic and the Infant/Toddler program).

Williamson et. al. (1983) were the only ones to look at services provided for their intraventricular hemorrhage sample. Yet, they focused solely on admission to special

education and reported that at three years of age, twelve children (41%) had handicapping conditions which warranted services by the public school system. Educational labels and types of services provided were not ascertained. No other study reviewed examined this area of interest.

For those children serviced by their school system, the educational label used to qualify them for special education services was attained. The labels used were consistent with federal guidelines and included PrePrimary Impaired (PPI), Physically or Otherwise Health Impaired (POHI), and Severely Multiply Impaired and Severely Mentally Impaired (SXI/SMI). (See Appendix D for definitions). Table 24 summarizes these data.

Because these children have complicated medical histories, it is not surprising to find that the most frequent label is that of POHI. Yet, there is a transition of labels over time. For those in the comparison group and the Grade I hemorrhage group, labels change from POHI to PPI. However, for those youngsters having Grade IV hemorrhages, labels change from POHI to SMI/SXI.

Of interest also is the type of service received in the school system based on the educational label (See Table 25). For the twenty-four youngsters in the comparison group, the most frequent service is that of speech and language (54%), followed closely by physical therapy (36%) and occupational therapy (36%). Similarly,

TABLE 24

Use of Educational Labels to Classify Youngsters for Special Education Services.

	Educational Label		
	PPI	POHI	SMI/SXI
Comparisons	8	16	--
Grade I	4	2	--
Grade II	1	2	--
Grade III	--	12	--
Grade IV	--	4	6

PPI-Preprimary Impaired; POHI-Physically or Otherwise Health Impaired; SMI/SXI-Severely Mentally Impaired and Severely Multiply Impaired.

TABLE 25

Percentage of Youngsters Receiving Specialized Service at School.*

	PT	OT	S&L	SW
Comparisons (n-24)	36%	36%	54%	--
Grade I (n-6)	33%	--	67%	--
Grade II (n-3)	100%	100%	--	--
Grade III (n-12)	92%	33%	8%	17%
Grade IV (n-10)	90%	60%	50%	10%

PT-Physical Therapy; OT-Occupational Therapy; S&L-Speech and Language; SW-Social Work.

*Percentages do not add to 100 because a child may receive more than one type of service.

for the six Grade I youngsters, the primary service involves speech and language (67%). A small percentage (33%) also receive physical therapy. The three Grade II children receive occupational therapy (100%) and physical therapy (100%) as their only services in the school. The twelve children with Grade III hemorrhages receive more extensive services at school including physical therapy (92%), occupational therapy (33%), social work (17%) and speech and language (8%). Even more comprehensive services are received by the ten children with Grade IV hemorrhages. Physical therapy is the most common service (90%) followed by occupational therapy (60%), speech and language (50%), and social work (10%).

Although the school system was the most frequent service provider for these youngsters, several other sources were cited. Table 26 indicates the percentage of children receiving other forms of supplemental services. The supplemental service most typical for the comparison group involved followup at the hospital with the physical therapist (36%). A public health nurse and community mental health were less frequently involved (seven percent and four percent, respectively). The Grade I children also received extensive followup by a physical therapist at the hospital (67%). Community mental health was involved with a small percentage of there children and their families (17%). For Grade II youngsters, the only other supplemental service cited was followup by a public

health nurse (33%). Youngsters with Grade III hemorrhages received followup at the hospital by the physical therapist (75%), followup by a public health nurse (33%) and were involved in other local programs (17%). The Grade IV children received followup at the hospital by a physical therapist (30%) and followup by a public health nurse (40%). A small percentage of these Grade IV youngsters (10%) were also receiving support from community mental health.

TABLE 26

Percentage of Youngsters Receiving Other Forms of Supplemental Services.*

	PT at Hospital	Public Health Nurse	Community Mental Health	Other Programs
Comparisons (n=28)	36%	7%	4%	--
Grade I (n=6)	67%	--	17%	--
Grade II (n=3)	--	33%	--	--
Grade III (n=12)	75%	33%	--	17%
Grade IV (n=10)	30%	40%	10%	--

*Percentages do not add to 100 because a child may receive more than one type of service.

The existing literature dealing with intraventricular hemorrhage children does not discuss mean age at referral or types of services provided. However, the Tenth Annual Report to Congress on the Implementation of the Education of the Handicapped Act (1988) does report on the type of service provided for the 3- to 5-year-old handicapped

population. For this age range, the majority (69%) were classified as speech impaired followed by being classified as mentally retarded (8%) and learning disabled (8%). Statistics for the State of Michigan indicate the majority (70%) of handicapped 3- to 5-year-olds were classified as speech impaired. Learning disabled (12%), POHI (6%), and mentally retarded (5%) were the other classifications most frequently applied.

The current study supports the notion that the majority of children in the 3- to 5-year-old range are classified as speech impaired. Furthermore, the results indicate that POHI and MR labels are frequently used with this population. Interestingly, none of the youngsters in the sample were classified learning disabled at the time of the study. While this is discrepant from the national and state statistics, this difference may be attributed to local preferences in label usage. The value of label usage will be further discussed under recommendations for public policy.

Summary

This chapter has attempted to summarize the results of this research project. Each research question was discussed in turn with the applicable results.

The first research question looked at developmental milestone attainment. Statistically significant differences in meeting age-appropriate developmental milestones already existed at the time of the first visit.

Furthermore, these significant differences continued to exist on subsequent visits.

The area most affected by delays or deficits was the motor domain. This confirms prior research suggesting that motor dysfunctions appear to be the most characteristic abnormality present in intraventricular hemorrhage infants regardless of the severity of the hemorrhage.

The second research question determined whether differences in cognitive performance existed between children having intraventricular hemorrhages and children in the comparison group. It was found that Grade I and Grade II children had mean intellectual functioning scores strikingly similar to the comparison group--all in the lower extreme of the average range. However, Grade III and Grade IV children had lower mean scores by 12 and 27 points, respectively.

When examining intellectual functioning scores covarying for significant variables separately, differences in outcome were still due to the severity of the hemorrhage. However, when covarying for significant variables concomitantly, the differences in mean intellectual functioning scores were no longer found to be due to the severity of the hemorrhage.

The third research question determined the incidence of children receiving early intervention services. A significant difference in referral rate based on the

severity of the hemorrhage was found. However, at the same time, the overall referral rate of children having experienced intraventricular hemorrhages was not significantly different from the overall referral rate of their no bleed comparison peers.

The fourth research question revealed the mean age of referral and provided a description of the types of services provided for these youngsters. The mean age of referral was affected by the severity of the hemorrhage with greater severity warranting referral at an earlier age. As for services provided, the public school system was the most frequent provider. Educational labels were discussed while other service providers were also briefly described.

CHAPTER 5

SUMMARY AND RECOMMENDATIONS

This dissertation was designed to investigate the neurodevelopmental outcome of youngsters having survived varying degrees of intraventricular hemorrhage. Particularly, the research sought to discover to what extent the presence of an intraventricular hemorrhage affected youngsters abilities to meet age-appropriate developmental milestones and whether the presence of an intraventricular hemorrhage had an effect on intellectual functioning. Incidence on early intervention as well as mean age at referral and types of services provided were also documented.

Subjects for this study were 61 premature infants/children born at 35 weeks gestation or less, and/or weighing less than 1,500 grams who had confirmed intraventricular hemorrhages based on an ultrasound taken 72 hours after birth. These infants were matched with 61 no bleed low birth weight peers on gestational age, sex, race, mean birth weight for gestational age, and socioeconomic status. All children had their charts reviewed for successive visits to the Developmental Assessment Clinic at Sparrow Hospital.

The chi square statistic and loglinear analysis were used to determine if presence of an intraventricular hemorrhage had an effect on meeting developmental milestones. Multiple regression, matched T-tests, and analysis of variance were used to determine whether there were differences in intellectual functioning between no bleed comparison peers and children having experienced intraventricular hemorrhages. Post-hoc tests were conducted using Student-Newman-Keuls procedure. Frequency counts, percentages, descriptive statistics, and correlations were used to analyze the data dealing with referrals, early intervention incidence, and types of services provided.

Compared to the existing literature, this study focused on a larger number of intraventricular hemorrhage youngsters, as well as focusing on a lengthier followup period. In addition, subjects were matched on variables deemed important. Other significant variables were controlled statistically. While previous studies reported no inter-rater agreement on grading the hemorrhage, this study determined the consistency of ultrasound readings. Furthermore, by looking at incidence and type of early intervention provided for these youngsters, this study takes an important step forward in advancing the existing knowledge in this area.

In this chapter, the implications of the present results are examined more closely in terms of their

practical meaning for medical personnel, school psychologists, and other specialists who would be working with children having suffered varying degrees of intraventricular hemorrhages. To best summarize the findings, each research question is presented separately. Recommendations for clinical practice, public policy, and research are offered in the final section of the chapter.

Developmental Milestone Attainment Summary

At the time of the first visit to DAC, a statistically significant difference in meeting age-appropriate developmental milestones already exists. Grade I and Grade II infants are able to meet age-appropriate milestones, while Grade III and Grade IV infants are already demonstrating areas of delays or deficits. The same statistically significant difference continues to exist on subsequent visits.

An investigation into the areas of delays or deficits clearly indicates that motor dysfunctions are the most typical. This is consistent with the current literature which cites motor dysfunctions as the most characteristic abnormality present in intraventricular hemorrhage infants (Fenichel, 1985; Gaiter, 1982; Ment et. al., 1982). The delays/deficits in the motor domain are such that even on subsequent visits the motor dysfunctions continue to be the most prevalent for these youngsters. Given that the lesion originates in the caudate nucleus, neuropathology

would suggest that motor development should be affected in these children.

Comparing the areas of deficits/delays across grades of hemorrhages, more areas are delayed or deficient as the severity of the hemorrhage increases. This is especially the case over time as, on subsequent visits, the Grade IV hemorrhage children display delays/deficits in all skill areas assessed. Thus, it is apparent that for Grade IV youngsters delays/deficits in fine motor, gross motor, personal/social, and language skills are not uncommon. This supports the notion that youngsters with Grade IV intraventricular hemorrhages have widespread damage.

Intellectual Functioning Summary

Analysis of the matched pairs found the intellectual functioning score between members to be statistically different, with the youngsters in the no bleed comparison group having a higher intellectual score, on the average, than their affected cohort. Statistically significant variation between groups was found when the mean intellectual functioning scores were used. No bleed comparison, Grade I, and Grade II youngsters had mean intellectual scores in the average range. Yet, it must be noted that these youngsters' mean score is in the normal range but between the 29th and 33rd percentile. Meanwhile, Grade III youngsters had a mean score in the borderline range, and Grade IV children had a mean score in the mentally retarded range. These findings add

support to the notion that Grade I and Grade II youngsters function similar to their no bleed low birth weight peers in the cognitive domain. The results also support the belief that the extensive damage of Grade III and Grade IV hemorrhages has a definite long lasting impact on the child's cognitive performance in a downward direction.

Two variables which were significantly related to subgroup membership and the outcome measure were identified (whether or not the child was referred, and the number of days the child was in the RNICU). When examining the intellectual functioning scores covarying for each variable separately, the results indicate that significant differences in outcome measures are still present based on the severity of the hemorrhage. However, when controlling for the two variables concomitantly, the differences in intellectual functioning scores are no longer found to be due to the severity of the hemorrhage. It is interesting to note that the number of days a child spends in the RNICU is related to the child's condition at birth and to the amount of medical management needed before the child can be discharged from the unit. Therefore, it is not surprising to find that the greater the severity of the hemorrhage, the longer the mean stay in the RNICU. Similarly, whether or not a child has been referred for supplemental service is also an indicator of severity of the child's difficulties. Given that when these variables are controlled, the results indicate that

presence of an intraventricular hemorrhage does not have a significant impact on the intellectual score suggests that other factors may play a major role in impacting the intellectual score. It is possible that members of the no bleed comparison group may have had other medical or neurological problems that had an impact on cognitive functioning. It may be that nutritional deficiencies are impairing cognitive development among bleed and no bleed subjects.

Early Intervention Incidence Summary

Results dealing with the incidence/percentage of children receiving early intervention services indicate that there is a significant difference in referral rate based on the degree of the hemorrhage. Twenty-nine percent of the Grade I and Grade II youngsters had been referred, while seventy-three percent of the Grade III and Grade IV children had been referred. This suggests that the greater the severity of the hemorrhage the more likely the child had been referred for early intervention. This again lends support to the notion of extensive/widespread damage in Grade III and IV youngsters requiring referral for supplementary service.

However, when comparing intraventricular hemorrhage children to high-risk premature children who have not suffered intraventricular hemorrhages, there is no statistically significant difference in referral rate. These results suggest that, to the degree this sample of

children represented the population of high-risk premature youngsters typically followed up, presence of an intraventricular hemorrhage does not result in a higher referral rate. The overall referral rate of children having suffered intraventricular hemorrhages is similar to the overall referral rate of their no bleed low birth weight peers. Yet, this referral rate is far higher than that for the normal population. Additionally, this finding points out the importance of continued followup with no bleed premature infants as they remain at greater risk for future involvement in supplementary services as well.

Age at Referral and Type of Service Provided Summary

This study found that the mean age of referral is indeed affected by the severity of the intraventricular hemorrhage with Grade III and IV children being referred earlier than comparison and Grade I and II children. Grade IV children were referred at a mean age of 5.5 months, and Grade III children were referred at a mean age of 6.5 months. Children with Grade II hemorrhages were referred at a mean age of 27 months while youngsters with Grade I hemorrhages were referred at a mean age of 26.3 months. Children in the comparison group were referred at a mean age of 19.5 months. Therefore, in general, the more severe the hemorrhage, the earlier the referral for supplementary service is made.

The most frequent service provider for both affected and no bleed children is their school system. Investigation of the educational labels used to qualify these youngsters for special education services reveals some interesting similarities and differences. Across groups, the label typically found is that of POHI. Given that all of these children are premature, have complicated medical histories, and are closely followed by their pediatricians the high use of the POHI label is expected. What is surprising is the transition of labels over time. For those children in the comparison group and those having Grade I hemorrhages, the POHI label is changed to PPI as they grow older. Yet, for those children with Grade IV hemorrhages, the label changes from POHI to SXI/SMI. Due to the small number of Grade II children currently receiving services, little can be said about the use of educational labels with this subgroup. Likewise, all of the Grade III youngsters have retained their POHI label so far.

There is also an apparent difference in the type of service received based on the severity of the hemorrhage. Children in the comparison group and children with Grade I hemorrhages receive their primary service from the speech and language therapist. Grade II youngsters receive their primary service from the occupational therapist and the physical therapist. Caution again must be taken when interpreting these results as only three children with

Grade II hemorrhages in the sample are receiving any type of service from the school system. Those youngsters with Grade III and IV hemorrhages receive more extensive/comprehensive services. Their service providers often include the physical therapist, the occupational therapist, the speech and language therapist, and the school social worker.

Limited involvement in sources outside the school system were cited in these youngster's records. The most frequent service involved followup with the physical therapist at the hospital. The public health nurse and community mental health were also mentioned as supplementary services used by these children and their families. A very small number of children reported also being involved in programs provided by the local university designed to foster childrens' development.

Recommendations for Clinical Practice

Clinicians need to consider the extent and severity of an intraventricular hemorrhage as well as the possible implications for future functioning depending on the area of the brain affected by the lesion. Children having suffered varying degrees of intraventricular hemorrhage are bound to come in contact with a wide variety of professionals, including medical, psychological and educational specialists during their lifetime. This investigation widely supports the existing literature suggesting that children having suffered Grade I and Grade

II intraventricular hemorrhages function similar to their no bleed low birth weight peers in that they have mean intellectual functioning scores in the Average range; and they are able to meet age-appropriate developmental milestones within normal limits. While these youngsters demonstrate delays in motor development as infants, these delays appear to dissipate as the children grow older. For the clinician working with the mild grades of intraventricular hemorrhage, it is important to watch these children's development and not push for a referral simply because there is a hemorrhage present. At the same time, while these youngsters, as a whole, have intellectual quotients in the Average range, their scores place them between the 29th and 33rd percentiles. Because decision-making cut-off points are in the lower extreme, the clinician must be aware of how this may impact special education placement. Instead of the two percent expected to fall in the mentally retarded range, one would expect approximately eight percent of these youngsters to fall in the mentally retarded range. Therefore, it is evident that these children remain at high risk for future impaired cognitive functioning and involvement in supportive services.

This study also supports the continued concern for children who have Grade III and, especially, Grade IV intraventricular hemorrhages. These youngsters show deficits and delays in meeting developmental milestones as

infants, and continue to show the deficits and delays as they grow older. Furthermore, the majority of these children have intellectual functioning scores in the Borderline/Mentally Retarded range. Therefore, clinicians dealing with the more severe grades of intraventricular hemorrhage should carefully monitor these youngsters' progress and should not hesitate to make referrals at the time of discharge when appropriate. This study found that children with Grade III and IV intraventricular hemorrhages were referred by a mean age of five and one-half and six and one-half months of age, respectively. Once a referral is made, the clinician needs to be aware of the comprehensive nature of services necessary to meet the family and child's needs as well as the long-term need for continued support/services.

The clinician also needs to be cognizant of the issue of gender. Pape and Wigglesworth (1979) reviewed literature describing male:female sex ratios indicating more males suffer from intraventricular hemorrhage. This study confirms these data as 72% of the intraventricular hemorrhage sample was male. Thus, males appear to be at greater risk for suffering intraventricular hemorrhages which could lead to greater probability for future involvement in supportive services. In this study, thirty-four percent of those referred for early intervention were male while fifteen percent were female. It was found that females tended to be referred at an

earlier mean age, but this finding needs to be cautiously interpreted because of the large percentage of males comprising this sample.

The mediating role of socioeconomic status must also be considered. Previous studies show that socioeconomic status has a significant effect on change in mental ability performance. Children having lower class scores demonstrate a decline in mean mental ability performance while children having higher class scores demonstrate an increase in mean mental performance (Ross, Lipper, and Auld, 1985; and Vohr and Garcia Coll, 1985). While this study did not find socioeconomic status to have a significant impact on cognitive functioning, this may be due to the nature of the data which included only parental occupation as a determinant of socioeconomic status. Schneider (1986) has described a cluster system which would allow for a more accurate index of socioeconomic status providing one has access to all the necessary information. Yet, if mental ability scores of low income premature infants decline over time, then the clinician needs to make sure these youngsters receive supportive services in maximizing their cognitive domain.

Recommendations for Public Policy

There is considerable support with regard to differentiation and identification of children having diagnosed intraventricular hemorrhages. The evidence in this investigation suggests that grading the severity of

the bleed through use of ultrasound is an acceptable method as blind reads resulted in 89% agreement in grading the hemorrhage between neonatologists. However, in order to consistently check on agreement of grading the hemorrhage, hospitals should conduct routine checks of ultrasounds by different physicians/radiologists. Hospital personnel share their knowledge regarding intraventricular hemorrhages making parents aware of the current research in the area resulting in parents forming preconceived notions of what level of development their child will achieve based on the grading of the bleed. Therefore, it would be prudent to double check gradings to give parents accurate information. Furthermore, many hospitals do not perform ultrasounds on infants unless they demonstrate the clinical features suggesting a possible intraventricular hemorrhage. Yet, whenever possible it would be advisable to routinely screen premature infants with ultrasounds so as to not miss the clinically silent syndrome.

Under the Preschool Education of the Handicapped Act (1986), Public Law 99-457, handicapped children under the age of five must be serviced by the public school system. The Tenth Annual Report to Congress on the Implementation of the Education of the Handicapped Act (1988) reports that children between the ages of three and five comprised six percent of the special education population during the 1986-1987 school year. Further evaluation will be needed

to determine if premature low birth weight youngsters are over-represented in special education and whether current categories result in separate, distinct handicaps. It would also be interesting to note the percentage of children referred who are actually placed in special education. Many school personnel are reluctant to use "harsh" labels (SMI/SXI) with a youngster of this age and tend to use more "benign" labels (PPI and POHI). The use of these labels allows the child to be serviced while giving the parent time to adjust to their child's condition. Furthermore, it allows the school personnel to wait until the child is older and the stability of the intellectual score has improved before making difficult educational planning decisions. The literature on the predictive power of infant tests indicates that infants who score in the mentally retarded range during their first year of life have a high probability of obtaining scores in the mentally retarded range during their school years (See Brooks-Gunn and Lewis, 1983). Yet, infants who are slow at an early age may gain rapidly at subsequent ages. Thus, assessments of handicapped or developmentally disabled infants should always be followed by retesting when the child is older (Sattler, 1988). This again helps assure that sound educational planning decisions result.

Of particular concern for the subgroup of children with intraventricular hemorrhages are the delays/deficits

in motor functioning. The majority of these youngsters are receiving services from the physical therapist and the occupational therapist in the school system. Yet, it appears that the amount of service provided is not sufficient as many of these youngsters are supplementing their physical therapy through the hospital. Further evaluation into the needs of these children in the motor area will be necessary if we wish to determine the amount of time and the number of contact hours necessary in order to benefit these children.

Research Recommendations

Future investigation needs to continue following up children with varying degrees of intraventricular hemorrhages over time and annually reassessing them. This will be especially important in determining the transient nature of problems in children with milder degrees of hemorrhages. Ideally, the children and their environment would be assessed using multiple measures including those which not only tap cognitive and developmental domains, but also temperament, parent/child interactions, and availability of support in the community for each family. Comparing these youngsters with hemorrhages to their premature low birth weight cohorts as well as to their term peers will continue to expand existing knowledge regarding similarities and differences between these groups of youngsters.

Whether or not children with milder degrees of hemorrhages will show delays or deficits through elementary school has yet to be determined. One wonders if these children will be in special education classrooms in greater numbers or if they will be able to attend school in a regular classroom. While this study suggests that cognitive functioning between children with milder grades of intraventricular hemorrhage and no bleed premature peers falls in the same range, it is apparent that intellectual scores alone do not assure school success and these children remain at risk for involvement in special education programming. Besides, given that the mean scores fall in the lower extreme of the average range, one must wonder how these children (both bleed and no bleed) will fare against their term peers. Of interest also is what will happen to the Grade III youngsters. At the time of this investigation, those labelled were all POHI. How these educational labels change will be interesting to observe and will provide us with more knowledge about the complexities of a Grade III hemorrhage.

Another area requiring further research centers upon those children with diagnosed severe hemorrhages who are succeeding despite the diagnosis. The literature on Grade III and IV youngsters has focused on the group as a whole. This study found eight youngsters (36%) with Grade III and IV hemorrhages to be functioning intellectually in the

high average to average range. However, one must wonder what ameliorating effects in the children and/or in the environment allow these youngsters to overcome their expected gloomy futures. This again points to the importance of inter-rater reliability in grading the hemorrhages based on the ultrasound for, at this point, it may be possible that these success stories are actually misread ultrasounds. Until this is consistently checked, the literature will remain inconsistent.

A need also exists for future research to investigate the causes of problems associated with low birth weight and intraventricular hemorrhages. This study found that intellectual functioning scores were affected not only by the severity of the hemorrhage, but by length of stay in the hospital and whether or not the child was referred for supplementary services. The complex nature of factors impacting the intellectual functioning of low birth weight children needs to be further investigated.

Regardless of what questions future research wishes to address, the importance of establishing longitudinal studies in which assessment instruments are consistently applied cannot be stressed enough. Children with diagnosed intraventricular hemorrhages are in no way a homogeneous group. Yet, precisely what differentiates one group from the other is still being sorted out. Furthermore, the kinds of support at the educational and community levels needed by these youngsters and their

families is just beginning to surface. As a clinician it seems essential that we understand this heterogeneous group of youngsters in order to meet their needs as they grow older. If this investigation can shed some light on some of the unending questions and can be used as a stepping stone for future investigations, then its purpose will have been met.

APPENDICES

APPENDIX A: DESCRIPTION OF TEST INSTRUMENTS

Bayley Scales of Infant Development
Denver Developmental Screening Test
Stanford-Binet Intelligence Scale, Form L-M
Stanford-Binet Intelligence Scale: Fourth Edition

BAYLEY SCALES OF INFANT DEVELOPMENT
(Bayley, N., 1969, Psychological Corporation)

This test is designed to yield a three-part evaluation of a child's developmental status during the first 2½ years of life. According to Bayley, "The primary value of the development index is to provide the basis for establishing a child's current status, and thus the extent of any deviation from normal expectancy" (1969, p. 4). Functions of the Bayley Scale include:

1. The Mental Scale assesses sensory-preceptual acuities, discrimination, and the ability to respond to these; the early acquisition of "object permanency" and memory, learning and problem-solving ability; vocalization and early evidence of the ability to form generalizations and classifications which are the basis of abstract thinking. Results are expressed as a standard score, the MDI, or Mental Development Index.
2. The Motor Scale provides a measure of body control, coordination of the large muscles and finger manipulatory skills. Results are expressed as a standard score, the PDI, or Psychomotor Development Index.
3. The Infant Behavior Record assesses the child's social and objective orientations toward his environment as expressed in attitudes, interests, emotions, energy, activity, and tendencies to approach or withdraw from stimulation (pp. 3–4).

Split-half reliability coefficients for the mental scale range from .81 to .93, with a median value of .88. Split-half coefficients for the motor scale range from .68 to .92, with a median of .84. Bayley attributes the lower coefficients for the motor scale to the fact that it has about half as many items as the mental scale (Bayley, 1969).

Evidence for the validity of the tests is limited, the primary evidence being an increase in performance with an increase in age. Bayley also reports correlation between the MDIs and the Stanford-Binet IQs for groups of children 24, 27, or 30 months of age. The correlations range between .47 for children who are 30 months of age to .57 for the total group. The scales were standardized on a sample of 1262 children selected to reflect the proportion of children from 2 through 30 months of age in various subgroups (sex, race, socioeconomic status, rural-urban, geographic region) as described in the 1960 census.

Taken from: H.L. Swanson and B.L. Watson (1982). Educational and Psychological Assessment of Exceptional Children: Theories, Strategies, and Applications (pp. 143-144). St. Louis: C.V. Mosby.

Denver Developmental Screening Test
(Frankenburg, Dodds, Fandal, Kazuk, & Cohrs, 1975)

The Denver Developmental Screening Test (DDST) is an individually administered instrument designed to detect developmental deviations in young children. It is perhaps the most widely used norm-referenced developmental screening test. The 1975 DDST is essentially the same as the 1967 edition except for a change in the interpretation of scores. The authors state that the DDST should be used only for screening, not as a definitive predictor of current or future adaptive behavior or intelligence. They further state that the test should not be used to generate a diagnostic label. The test is used with children from birth to 6 years old. The items are arranged in four sections: Personal-Social, Fine Motor-Adaptive, Language, and Gross Motor. The test items are designed to measure skills that correlate with normal child development. Some test materials are meant to elicit responses in the child, although many other items can be administered through an interview with the parents.

Description

Personal-Social (23 items)—Essentially, these tasks measure a child's ability to take care of himself and to relate to other people. The section includes such tasks as playing peek-a-boo, imitating housework, and dressing and undressing.

Fine Motor-Adaptive (30 items)—This section measures fine-motor dexterity, drawing ability and recognition, and manipulation of objects. It includes tasks such as building a tower with blocks, reaching for objects, and scribbling spontaneously.

Language (21 items)—This section measures a child's ability to perceive, understand, and express language. It includes tasks such as turning to a spoken voice, imitating speech sounds, and naming pictures.

Gross Motor (31 items)—This section measures the child's ability to sit, stand, walk, and jump.

Taken from: R.L. Taylor (1984). Assessment of Exceptional Students: Educational and Psychological Procedures (pp. 91-94). Englewood Cliffs: Prentice Hall.

Interpretation of Results

Each item on the DDST is presented on the test form in a developmental sequence (see Figure 6-1). A developmental age is reported at which 25 percent, 50 percent, 75 percent, and 90 percent of "normal" children passed each item. For instance, the item "Bangs 2 cubes held in hands" is passed by 25 percent of "normal" children at 7 months, by 50 percent at $8\frac{1}{2}$ months, by 75 percent at 10 months, and by 90 percent at $12\frac{1}{2}$ months. Each item that is passed and failed thus yields such developmental information, and a profile is formulated for the examinee. The DDST profile is then interpreted as "normal," "questionable," "abnormal," or "untestable." An "abnormal" profile is assigned when a child has two or more delays (failing an item in which 90 percent of "normal" children of the same age can pass) in two or more sections. A "questionable" profile is interpreted when there are two or more delays in one section. A child who refuses to perform a majority of the items is considered "untestable." Other criteria for "abnormal" and "questionable" are stated in the manual.

Technical Characteristics

Normative sample. 1,036 children between the ages of 2 weeks and 6.4 years; nonhandicapped only; only from Denver, Colorado.

Reliability. Test-retest with 20 children yielded 95.8 percent agreement on the items passed. Interrater reliability (having more than one examiner score the results) resulted in 80 percent to 95 percent agreement.

Validity. The Stanford-Binet or the Bayley Scales of Infant Development were administered to 236 children. For those with an "abnormal" profile on the DDST, the mean IQ was 69.1. For those with a "questionable" and or "normal" profiles, the mean IQs were 83.8 and 95.7, respectively. The use of intelligence measures to establish the validity has been questioned.

STANFORD-BINET INTELLIGENCE SCALE
(Terman, L., and Merrill, M., 1960 revision, Houghton Mifflin)

The Stanford-Binet Intelligence Scale is recommended for use with subjects from 2 years of age through adulthood. (For a more extensive review of the test, see Anastasi, 1976.) Practically speaking, the test is seldom used in school systems for children over 10 or 12 years of age because of its length and the time required for administration (Sattler, 1974). In such cases, the WISC-R or the WAIS is normally used. The Stanford-Binet contains a series of items, increasing in difficulty, grouped by age level starting at 2 years of age and progressing to adulthood. There are six test items and an alternate item for each age level, with the exception of the average adult level, which has eight items and an alternate item. Test items appearing at each age level are shown in Table 5-5, and the table suggests the number of months given toward the subject's mental age (MA). In other words, MA is determined by adding to the basal age the month of credit earned above the basal age. Deviation IQs are determined from standard scores on an assumed mean of 100 and standard deviation of 16. As an illustration of the content of various subtests, a description is provided for year 6:

1. Vocabulary: Child gives the meanings or definitions of words of varying difficulty
2. Differences: Child states a difference between certain animals and objects (such as a bird and a dog).
3. Mutilated pictures: Child looks at a card on which there are objects with parts missing, and child is asked to tell what parts are missing.
4. Number concepts: Child is asked to count out a specified number of blocks.
5. Opposite analogies: Child completes statements that express analogies.
6. Maze tracing: Child is shown a picture of a schoolhouse and a little boy and is then asked to draw the shortest path between the boy and the schoolhouse.
   Alternate: response to pictures level II: Child is asked to look at pictures and describe them.

Terman and Merrill stated (1960) that intelligence is regarded as general mental adaptability, and thus an inspection of their scale reveals a variety of subtests measuring a considerable range of mental abilities. Sattler (1965) has analyzed the functions of the 1960 scale based on item-content categories. The schema includes seven major groupings:

1. Language: Includes vocabulary items at the prekindergarten level (vocabulary referring to the number of words the child can define) and quality of vocabulary (measured by such tests as abstract words, rhymes, word naming, definitions, and comprehension of verbal relations).
2. Memory: Subclassified into meaningful, nonmeaningful, and visual memory; some other designations for this category include rote auditory memory, ideational memory, and attention span.
3. Conceptual thinking: Primarily concerned with abstract thinking.
4. Reasoning: Subclassified into verbal and nonverbal reasoning: verbal absurdity items are examples of this category; pictorial and orientation problems are examples of nonverbal reasoning items; reasoning refers to the perception of logical relations, discrimination ability, and analysis and synthesis.
5. Numerical reasoning: Includes arithmeti-

Taken from: H.L. Swanson and B.L. Watson (1982). Educational and Psychological Assessment of Exceptional Children: Theories, Strategies, and Applications (pp. 136-138). St. Louis: C.V. Mosby.

Age level		Number of items plus alternate (A)	Months added to MA for each item passed
Years	Months		
2	0	6 plus A	Subject must pass all items for the test to be valid
2	6	6 plus A	1 month
3	0	6 plus A	1 month
3	6	6 plus A	1 month
4	0	6 plus A	1 month
4	6	6 plus A	1 month
5		6 plus A	2 months
6		6 plus A	2 months
7		6 plus A	2 months
8		6 plus A	2 months
9		6 plus A	2 months
10		6 plus A	2 months
11		6 plus A	2 months
12		6 plus A	2 months
13		6 plus A	2 months
14		6 plus A	2 months
Average Adult		8 plus A	2 months
Superior Adult I		6 plus A	4 months
Superior Adult II		6 plus A	5 months
Superior Adult III		6 plus A	6 months

cal problems, with content closely related to school learning.

6. Visual motor: Contains items of manual dexterity, eye-hand coordination, and perception of spatial relations; constructive visual imagery may include such items as paper folding.
7. Social intelligence: Closely related to the reasoning category; social intelligence includes social maturity and social judgment; comprehension and finding reason items reflect social judgment; items concerning obeying simple commands, response to pictures, and comparison illustrate social maturity.

The 1960 scale reflects the validity of the two forms of the 1937 scale. A .82 correlation exists between the 1960 scale and the 1937 scale, suggesting a high level of agreement. A biserial correlation of the 1960 scale is .66 with a .61 for all tests in the two forms of the 1937 scale. Standardization was originally done on 3184 persons, with approximately 100 boys and 100 girls at each age. Age scales are postulated on the assumption of fairly regular and progressive increases in mental growth.

Stanford-Binet Intelligence Scale: Fourth Edition (Thorndike, R.L., Hagen, E.P., and Sattler, J.M., 1986, Riverside Publishing)

The Stanford-Binet Intelligence Scale: Fourth Edition (SB:FE) is a revision of the 1960 Stanford-Binet Intelligence Scale, Form L-M. The instrument is appropriate for appraising the cognitive skills of individuals from ages 2 to adult.

The instrument is comprised of fifteen subtests which measure four broad areas of cognitive abilities: Verbal Reasoning, Abstract/Visual Reasoning, Quantitative Reasoning, and Short-Term Memory. The Composite Score (mean of 100 and standard deviation of 16) appraises general reasoning ability. In addition, scores for the four areas described above, any combination of these four area scores, and individual test scores for all fifteen subtests are available.

This instrument was standardized on 5,013 individuals in 17 age groups between the ages of 2-23 years. The stratified sample was representative of the 1980 census. Internal consistency reliabilities for the Composite Score range from .95 to .99 (median .97). Correlations between the SB:FE and other criterion measures (SB:L-M, WISC-R, WPPSI, K-ABC) range from .27 to .91. The median r of .80 supports the concurrent validity of the SB:FE.

Taken from: J.M. Sattler (1988). Assessment of Children (3rd edition), San Diego: Jerome M. Sattler.

APPENDIX B: TEST INTERCORRELATIONS

PEARSON CORRELATION COEFFICIENTS

Denver1 Thru Denver6 With Denver1 Thru Denver6

	D1	D2	D3	D4	D5	D6
D1	1.000 (122) P- .	.7798 (55) P-.000	.6903 (43) P-.000	.6281 (30) P-.000	.6325 (12) P-.014	1.000 (4) P- .
D2	.7798 (55) P-.000	1.000 (55) P- .	.6138 (21) P-.002	.7333 (14) P-.001	.6455 (7) P-.059	1.000 (2) P- .
D3	.6902 (43) P-.000	.6138 (21) P-.002	1.000 (43) P- .	.8182 (16) P-.000	-.1667 (7) P-.360	. (2) P- .
D4	.6281 (30) P-.000	.7333 (14) P-.001	.8182 (16) P-.000	1.000 (30) P- .	.5774 (8) P-.067	1.000 (3) P- .
D5	.6325 (12) P-.014	.6455 (7) P-.059	-.1667 (7) P-.360	.5774 (8) P-.067	1.000 (12) P- .	1.000 (3) P- .
D6	1.000 (4) P- .	1.000 (2) P- .	. (2) P- .	1.000 (3) P- .	1.000 (3) P- .	1.000 (4) P- .

(Coefficient/(Cases)/1-Tailed sig)

"." is printed if a coefficient cannot be computed

PEARSON CORRELATION COEFFICIENTS

IQ1 Thru IQ6 With IQ1 Thru IQ6

	IQ1	IQ2	IQ3	IQ4	IQ5	IQ6
IQ1	1.000	.4851	1.000	.	.	.
	(12)	(6)	(2)	(0)	(0)	(0)
	P- .	P-.165	P- .	P- .	P- .	P- .
IQ2	.4851	1.000	.7722	.3719	-.9177	-.0357
	(6)	(70)	(23)	(15)	(4)	(5)
	P-.165	P- .	P-.000	P-.086	P-.041	P-.477
IQ3	-1.000	.7722	1.000	.8620	.7160	1.000
	(2)	(23)	(39)	(12)	(4)	(2)
	P- .	P-.000	P- .	P-.000	P-.142	P- .
IQ4	.	.3719	.8620	1.000	-.2627	.7450
	(0)	(15)	(12)	(24)	(6)	(3)
	P- .	P-.086	P-.000	P- .	P-.308	P-.232
IQ5	.	-.9177	.7160	-.2627	1.000	.9660
	(0)	(4)	(4)	(6)	(11)	(4)
	P- .	P-.041	P-.142	P-.308	P- .	P-.017
IQ6	.	-.0357	1.000	.7450	.9660	1.000
	(0)	(5)	(2)	(3)	(4)	(7)
	P- .	P-.477	P- .	P-.232	P-.017	P- .

(Coefficient/(Cases)/1-Tailed sig)

"." is printed if a coefficient cannot be computed

PEARSON CORRELATION COEFFICIENTS

Denver1 Thru Denver6 With IQ1 Thru IQ6

	D1	D2	D3	D4	D5	D6
IQ1	-.7066	-.8810	-1.000	.	.	.
	(12)	(5)	(2)	(1)	(0)	(0)
	P-.005	P-.024	P- .	P- .	P- .	P- .
IQ2	-.4478	-.8365	-.6754	-.7949	-.6466	-.5960
	(70)	(25)	(31)	(21)	(9)	(3)
	P-.000	P-.000	P-.000	P-.000	P-.030	P-.297
IQ3	-.5008	-.5647	-.0721	-.7177	.1172	.
	(39)	(24)	(9)	(15)	(6)	(2)
	P-.001	P-.002	P-.427	P-.001	P-.413	P- .
IQ4	-.5037	-.6203	-.4878	-.9529	.	.
	(24)	(16)	(17)	(3)	(5)	(1)
	P-.006	P-.005	P-.023	P-.098	P- .	P- .
IQ5	-.5609	-.6082	-.7420	-.8058	.	.
	(11)	(9)	(9)	(6)	(3)	(2)
	P-.036	P-.041	P-.011	P-.026	P- .	P- .
IQ6	-.7720	-.9615	-.9341	-.9457	.	.
	(7)	(6)	(6)	(4)	(4)	(0)
	P-.021	P-.001	P-.003	P-.027	P- .	P- .

(Coefficient/(Cases)/1-Tailed sig)

"." is printed if a coefficient cannot be computed

APPENDIX C

Intellectual Functioning Score Classification by Severity of Intraventricular Hemorrhage.

	CONTROLS (n=53)	GRADE I (n=14)	GRADE II (n=7)	GRADE III (n=15)	GRADE IV (n=7)
HA	9	2	--	2	--
A	24	7	4	4	2
LA	13	2	1	--	--
B	3	2	2	3	--
MR	4	1	--	6	5

Classification	IQ Score Range
HA-High Average	110-119
A-Average	90-109
LA-Low Average	80-89
B-Borderline	70-79
MR-Mentally Retarded	69 and below

APPENDIX D

Definitions of Educational Labels Used in Special Education with Intraventricular Hemorrhage Youngsters.

"Preprimary impaired" defined.

"Preprimary impaired" means a child through 5 years of age whose primary impairment cannot be differentiated through existing criteria...and who manifests an impairment in one or more areas of development equal to or greater than 1/2 of the expected development for chronological age, as measured by more than one developmental scale, which cannot be resolved by medical or nutritional intervention.

Determination of physically or otherwise health impaired.

The physically or otherwise health impaired shall be determined through the manifestation of a physical or other health impairment which adversely affects educational performance and which may require physical adaptations within the school environment.

Determination of severely multiply impaired.

The severely multiply impaired shall be determined through the manifestation of all of the following behavioral characteristics:

(a) Multiple handicaps in the physical and cognitive domains.

(b) Inability to function within other special education programs which deal with a single handicap.

(c) Development of less than the expected rate for the age group in the cognitive, affective, or psychomotor domains.

Determination of severely mentally impaired.

The severely mentally impaired shall be determined through manifestation of all of the following behavioral characteristics:

(a) Development at a rate approximately 4 1/2 or more standard deviations below the mean as determined through intellectual assessment.

(b) Lack of development primarily in the cognitive domain.

(c) Impairment of adaptive behavior.

Taken from the Michigan Special Education Rules (1984)

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