NEONATAL PHYSIOLOGIC JAUNDICE AND VISUAL-MOTOR DEVELOPMENT AT AGE SIX YEARS

by

Elaine Shaw Sorensen

A thesis submitted to the faculty of The University of Utah in partial fulfillment of the requirements for the degree of

Master of Science

College of Nursing

The University of Utah

March 1979

THE UNIVERSITY OF UTAH GRADUATE SCHOOL

SUPERVISORY COMMITTEE APPROVAL

of a thesis submitted by

Elaine Shaw Sorensen

I have read this thesis and have found it to be of satisfactory quality for a master's degree.

Date

Mary J. Banigan, R.N., M.S.
Chairman, Supervisory Committee

I have read this thesis and have found it to be of satisfactory quality for a master's degree.

Date

Beryl R.N., Ph.D.
Member, Supervisory Committee

I have read this thesis and have found it to b master's degree.

Date

P. EdD.

THE UNIVERSITY OF UTAH GRADUATE SCHOOL

FINAL READING APPROVAL

To the Graduate Council of The University of Utah:

I have read the thesis of Elaine Shaw Sorensen in its final form and have found that (1) its format, citations, and bibliographic style are consistent and acceptable; (2) its illustrative materials including figures, tables, and charts are in place; and (3) the final manuscript is satisfactory to the Supervisory Committee and is ready for submission to the Graduate School.

February 7, 1979
Date

Approved for the Graduate Council

ABSTRACT

Recognizing that kernicterus and other forms of brain damage result from high levels of neonatal bilirubinemia, the study sought to determine whether or not a relationship exists between hyperbilirubinemia at levels below 20 mg. %, or those of physiologic jaundice, in full-term, otherwise healthy, infants and visual-motor developmental scores at age six years. The study also described perinatal, familial, and environmental background of the study population in terms of various demographic factors.

The study population consisted of 24 white children. Variables were highest total serum bilirubin levels recorded as neonates and scores on the Developmental Test of Visual-Motor Integration administered at six years of age.

None of the attempted correlations between newborn total serum bilirubin levels and visual-motor developmental test scores demonstrated a statistically significant relationship.

Scores on individual items of the developmental test were also examined. It was noted that the item testing directional confusion was failed at a higher frequency than other items, though not significantly higher than might be expected in the general population.

From the study, recommendations for statistical recognition of a multiplicity of perinatal and environmental factors as they may be related to neonatal hyperbilirubinemia and subsequent development are offered.

ACKNOWLEDGMENTS

My deepest thanks to administrators, parents, and children of the Weber County School District for their helpful cooperation; to Bruce Haslam and Leonard Dabb for their interest and help in the statistical analysis; to Darlene Adams for her counsel in the use of the developmental evaluation instrument; and to Mary Banigan, Beryl Peters, and Harry Bluhm for their constant patience and support.

Greatest love and gratitude go to Cliff, Brian, and Chad for all they are.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

The association between extreme hyperbilirubinemia or "jaundice" during the neonatal period, especially in prematurity, and subsequent kernicterus or other types of brain damage has long been recognized. However, "physiologic jaundice", or less marked hyperbilirubinemia in the full-term infant is sometimes viewed as a consequence of the immaturity of the newborn, and not likely to produce long-term neurological or developmental effects, an idea persisting through history:

> . . . we find that "icterus neonatorum" . . . is merely one of the results of the revolutions which take place in the infantile organism during birth . . . Certain external causes of the affection are not usually referred to, but bad nursing and the exposure to a cold or polluted atmosphere, exercise a powerful influence . . .
>
> In this simple form of "icterus neonatorum", scarcely any treatment is required. Mild laxative medicines, such as syrup of rhubarb, and, if necessary, with simple diaphoretics, include all that is usually necessary under such circumstances. (Frerichs, 1879)

The investigator questions such a division between pathological and physiological jaundice. Since it is the presence of bilirubin itself that causes the cellular neurological damage (Behrman, 1970; Maisels, 1972), question arises as to whether or not neurological or developmental deficits can be associated with the lower levels of serum bilirubin observed in physiologic jaundice.

Literature Review

Information regarding bilirubin and its effects on neonatal development is abundant in the literature. Bilirubin is the catabolic end product of heme, which comes primarily from circulating hemoglobin (Maisels, 1975). It exists in the serum in two forms: conjugated (direct) and unconjugated (indirect). Conjugated, or direct-reacting, bilirubin is called such because the free bilirubin molecule undergoes conjugation with a glucuronide radical in the liver. As a result, the bilirubin complex is water-soluble, and normally excreted through the biliary tree or kidneys.

Unconjugated bilirubin has not been converted in the liver, and thus is fat-soluble and not excreted through the kidneys or biliary tree, but has an affinity for fat and brain tissue (Korones, 1976). Clinical jaundice results from accumulated unconjugated bilirubin in the serum and tissues of the skin (Behrman, 1973). The toxicity of bilirubin is due to its action directly upon the cell membrane and intracellular constituents of brain tissue (Odell, 1970). Generally, the damage of kernicterus is thought to be largely in the basal ganglia. However, Odell, Bruce, and Rosenberg (1970) propose the idea that other cranial nuclei may be affected, such as the hippocampus, where learning, memory, and perceptual functioning could be impaired without necessarily causing the typical athetosis characteristic of kernicterus.

Numerous conditions, including hemolysis in blood incompatibilities and effects of prematurity contribute to pathological hyperbilirubinemia.

However, this study is concerned mainly with conditions associated with physiologic jaundice in the normal, full-term infant.

The mechanisms involved particularly in physiologic jaundice have been summarized according to the following categories: increased bilirubin load on the liver, defective uptake of bilirubin from the plasma, defective bilirubin conjugation, deficiencies in bilirubin excretion, and problems with hepatic circulation (Levi, Gatmattan, & Arias, 1970; Maisels, 1972, 1975). Other factors may include the fact that normal neonates produce more than twice the adult rate of bilirubin due to the proportionately larger red cell mass and to new hemoglobin break-down (Klaus & Fanaroff, 1973; McCrae, 1976). Some authors feel that physiologic jaundice may be caused by normally occuring delayed development of the glucuronyl transferase system, necessary for the conjugation of bilirubin in the liver (Gartner & Arias, 1970; Kempe, Silver, & O'Brien, 1976; Korones, 1976; McCrae, 1976). Other factors may be limited albumin-binding capacity (Maisels, 1975), inadequate early feeding, which may reduce bilirubin uptake by the liver (Maisels, 1972; McCrae, 1976), or inhibition of conjugation by hormones present in breast milk (McCrae, 1976).

Factors delineating physiologic jaundice in the full-term infant summarized from the literature are the following:

1. The infant is otherwise well (Korones, 1976).

2. Onset of clinical jaundice, which occurs when serum total bilirubin levels exceed 5 mg. % (Behrman, 1973) occurs: After 24 hours

of life (Behrman, 1973; Korones, 1976; Waechter & Blake, 1976), or after 48 hours of life (Kempe et al., 1976; Klaus & Fanaroff, 1973).

3. Rate of serum total bilirubin increase does not exceed 5 mg.% per 24 hours (Behrman, 1973).

4. Peak levels of serum total bilirubin occur at ages: 3-4 days (Behrman, 1973; Klaus & Fanaroff, 1973; Korones, 1976), 5-7 days (Kempe et al., 1976).

5. Maximum total serum bilirubin levels do not exceed: 12 mg.% (Kempe et al., 1976; Klaus & Fanaroff, 1973; Korones, 1976; Maisels, 1972), or 15 mg.% (Behrman, 1973; Waechter & Blake, 1976).

6. Duration of clinical jaundice is not beyond the first week to ten days of life (Behrman, 1973; Klaus & Fanaroff, 1973; Korones, 1976; Maisels, 1975).

Obviously, distinguishing pathologic jaundice from physiologic jaundice can become a complex task. Defining factors seem rather arbitrarily dependent upon experience. Maisels (1975) states, "to label such jaundice as 'physiologic' appears to be a contradiction in terms which is frought with danger." Indeed, no matter what the cause, if the end result is increased unconjugated bilirubin levels, a study of long-term developmental effects seems warranted.

It is generally accepted that total serum bilirubin levels above 20 mg.% are dangerously prone to produce kernicterus (Korones, 1976; McCrae, 1976). However, Holmes, Miller, and Smith (1968) suggest

that lesser degrees of hyperbilirubinemia could be related to lesser degrees of cerebral impairment, perhaps too mild to be detected in infancy, but recognizable in later years, that bilirubin effects could be regarded more in terms of a continuum rather than in terms of pathology or physiology. Buckfield (1972), too, poses the question of whether hyperbilirubinemia of insufficient severity to produce frank kernicterus may impair central nervous system development. Maisels (1972) further asserts that "late manifestations of brain damage from hyperbilirubinemia may be far more subtle than the classically described syndrome of athetosis and deafness" of kernicterus.

Numerous studies of the effects of hyperbilirubinemia in premature or low birth weight infants have been reported. In one study, nine of fourteen infants exhibited neurological damage with peak total serum bilirubin levels of 9.4 mg.% to 15.6 mg.% (Gartner, Snyder, Chabon, & Bernstein, 1970). Ackerman, Dyer, and Leydorf (1970) report kernicterus in five of seven small prematures at bilirubin levels from 18.5 mg.% to 23.2 mg.%. Delayed growth has also been associated with bilirubin levels from 13 mg.% to 19 mg.% (Mussa & Colombo, 1965). Another study of prematures with unconjugated bilirubin levels greater than 15 mg.% demonstrated significant delays in auditory discrimination and achievement in maze testing at age five years (Ehrlich, Shapiro, Kimball, & Huttner, 1973).

Ironically, phototherapy treatment for hyperbilirubinemia also seems to exert some deterrent effect on growth of pre-term infants.

However, there also seems to exist a "catch-up" period when normal growth resumes (Hodgman & Teberg, 1970; Wu, Lim, Hodgman, Kakosky, & Teberg, 1974). Though no such findings were encountered in term infants, such possibilities must be considered.

More relevant to this study are the various results of research on full-term infants. In a study of 23,000 full-term and pre-term infants at age eight months, a significant positive relationship between increasing hyperbilirubinemia at levels lower than 23 mg.% and the incidence of low mental and motor developmental scores was demonstrated (Boggs, Hardy, & Frazier, 1967). A similar study by Hardy and Peeples (1971) of 4,000 infants exhibited strong association between serum bilirubin levels in the newborn period and subsequent low ratings on eight-month psychological evaluations and twelve-month neurological examinations. The association became stronger at bilirubin levels above 19 mg.%, especially in low birth weight infants, though the trend was also evident in normal weight infants. Upadhyay's study (1971) of twenty children with neonatal bilirubin levels above 20 mg.% matched with children with levels below 20 mg.% demonstrated significantly more neurological deficits at birth, age four months, age eight months, and four years in the group with higher levels. However, the fact that deficits were discovered in the group with lower bilirubin levels provokes interest in study of that particular population.

Holmes, Miller, and Smith (1968) tested eighty-two children from ages four to seven years who had bilirubin levels from 15 mg.% to 24 mg.%

as infants. No significant relationship was discovered between the bilirubin levels and low scores on physical, audiometric, and motor development tests. Mores, Fargasova, and Minarikova (1959) also demonstrated no significant correlation between psychomotor and hearing function and newborn bilirubin levels of 1 mg.% to 38 mg.% in a follow-up study of forty-eight children at ages six months, one year, two, and four years.

At age five years, I.Q., visual-motor development, memory, and distractibility were tested in thirty-two children who had suffered neonatal jaundice. No correlation was evident between developmental scores and bilirubin concentrations. However, a correlation was demonstrated between developmental scores and bilirubin serum protein saturation studies, suggesting that the saturation index may be a more effective test for pathological bilirubin measurement in the newborn (Odell et al., 1970).

Van Camp (1964) showed I.Q. scores at ages three to fifteen years to be lower in children with bilirubin levels of 10 mg.% to 37 mg.% than in a control group, in a study of forty-one full-term and ten premature infants. Varying developmental deficiencies in 13 mg.% of 235 four-year-olds with neonatal bilirubin levels over 15 mg.% were reported by Hyman and Keaster (1962).

Other interesting related studies include a German study of twenty children of ages one to seven years who had suffered hyperbilirubinemia complicated by neonatal illness of various sorts. Of these, nine exhibited

deficiencies in neurological and psychological development (Chelius, Bohme, & Dettmer, 1971). Another in Denmark of 9,191 children reported neonatal hyperbilirubinemia levels from 8 mg.% to more than 16 mg.%, when combined with asphyxia, to increase frequency of brain damage from asphyxia from two to ten times (Zachau-Christiansen, 1967).

Though studies vary in content, method, and results, the problem remains conclusively unresolved, that there exists a possibility that neurological development is affected by bilirubin levels in infancy lower than the recognized danger level of 20 mg.%.

Literature findings suggest a need for follow-up developmental evaluation of full-term infants with hyperbilirubinemia of physiologic jaundice. Most studies encountered evaluated largely I.Q., hearing, or psychomotor development. It seems that other areas, such as perceptual or visual-motor development bear investigation. A descriptive view of various related perinatal, familial, and environmental factors may also be valuable. This type of information is noticeably lacking in previous studies. A sparcity of contributions from the field of nursing to the study of the problem is evident. Certainly, such a study is important to the body of nursing knowledge, both at the level of influencing care of newborns and in later assessment and management of developmental problems.

Purposes

The purposes of this study were to (1) describe the perinatal, familial, and environmental background of the subjects in terms of selected demographic variables and (2) to determine whether or not visual-motor or perceptual developmental delays occured in six-year-old children who suffered physiologic jaundice as infants.

Research Questions

The major research question of the study was: Does a relationship exist between total serum bilirubin levels of less than 20 mg.% in normal full-term neonates and difference-scores on a visual-motor developmental evaluation at age six years?

From the major research question evolved several related supporting research questions. These included the following:

A. Does a relationship exist between total serum bilirubin levels as described and scores interpreted as "pass" or "fail" on a developmental evaluation of the described population?

B. Does there exist a difference in scores on a developmental evaluation between a population of six-year-old children who suffered physiologic jaundice as infants and children of the same age in the general population?

C. Does a relationship exist between difference-scores on a developmental evaluation and neonatal bilirubin levels in groups with

extremely high or low bilirubin levels?

D. Were any one or more items on the developmental evaluation passed or failed more frequently by the study population than would be expected in the general population?

Definitions

For the purposes of this study, the following definitions were formulated:

Total Serum Bilirubin Levels. The highest of the measurements so designated on the newborn hospital chart, taken at any point during the normal three to four day newborn hospitalization period.

Normal Full-Term Neonate. Newborn whose estimated gestational age was 38 to 40 weeks, if given on the hospital chart, or whose birth-weight was 2500 Grams or more. The infant must be otherwise healthy and the product of a single birth.

Difference-Scores. The difference between the subjects' actual chronological age in months and the age-score achieved on the developmental evaluation, given in months.

Developmental Evaluation. The Developmental Test of Visual-Motor Integration (Beery & Buktenica, 1967): the standardized test of visual perception and motor co-ordination, designed by Beery and Buktenica, and described by Buros (1972) and Hoepfner, Stern, and Nummedal (1971).

Method

The study population was obtained from voluntary responses to explanatory letters sent to kindergarten and first grade children at two elementary schools. By appointment, volunteers were then given the Developmental Test of Visual-Motor Integration by the investigator. At the same time, parental consent for the release of information from newborn hospital records and completion of a demographic questionnaire were obtained. Thus, descriptive data was obtained from the demographic questionnaire; total serum bilirubin levels and data determining qualification as full-term neonate was obtained from the hospital newborn records; and visual-motor developmental scores were computed from the developmental evaluation tool, the Developmental Test of Visual-Motor Integration. Various statistical evaluations were performed on the data in efforts to demonstrate the relationships proposed by the research questions.

CHAPTER II

METHOD

The method is presented in sections pertaining to subjects, instruments, and procedure.

Subjects

The investigator was referred to principals of two elementary schools of the Weber County School District by the appropriate administrators. The principals sent letters, composed by the investigator, explaining the study and seeking voluntary participation, to parents of kindergarten and first grade children of those schools. Responses were returned to the school via the children. Several children who attended other schools in the same general geographic area also volunteered after learning about the study from various sources. This population was selected because of the noticeable sparcity of similar studies on children in this age group, and because of the availability, homogeneous nature, and geographic stability of the general population of the area.

Thirty-two subjects were invited to participate. However, of this number, three had no record of bilirubin studies as infants, four had newborn hospital records which had been "misplaced" in a transition of those records to microfilm and were unavailable, and one was born at a

hospital outside the state of Utah, causing difficulty obtaining the newborn record for various reasons. Thus, the final study population consisted of 24 white children: 10 males and 14 females. Ages ranged from 4 years 7 months to 7 years 9 months, with a mean age of 6 years 2 months. All subjects were reportedly healthy with histories of good health as newborns, except for the physiologic jaundice.

Instruments

The instruments utilized for collection of data were the Developmental Test of Visual-Motor Integration, a demographic questionnaire, and individual newborn hospital records.

The instrument employed in the testing of the visual-motor or perceptual developmental level of the subjects was the Developmental Test of Visual-Motor Integration. This developmental test was chosen because of its availability through a children's evaluation agency and because of the ease, simplicity, and availability of aid in its administration and interpretation. It is a test of 24 geometric forms arranged in order of increasing difficulty. Individual scores are calculated according to the number of forms successfully reproduced by the subject prior to three consecutive failures (Beery & Buktenica, 1967). Advantages of the test to this study include its ease in administration and interpretation, appropriateness for the age of the subjects, and the fact that scores are given as age equivalents in year and month. Separate age equivalents

are offered for each sex on each item. The test was standardized on 1039 children in Illinois (Buros, 1972). Buros describes the standardization as adequate for suburban children of ages five to thirteen. Disadvantages cited by Buros (1972) are that the scoring contains some subjectivity, that prediction studies for various age levels are not well provided, and that reliability information is not complete. Hoepfner, Stern, and Nummedal (1971) evaluate the test as poor in normed technical excellence, though fair in measurement validity, examiner appropriateness, and administrative usability. They rank the test on approximately the same level as Rutgers Drawing Test, Screening Test of Academic Readiness, and the Slosson Drawing Coordination Test.

The demographic questionnaire was designed by the investigator to describe the population, assure a fairly homogeneous nature of the population, and to provide additional data that may relate to the effects of the newborn hyperbilirubinemia or to subsequent developmental status of the subjects. Odell, Bruce, and Rosenberg (1970) cite the need for recognition in this type of research of such variables as "genetic endowment, maternal health during gestation, nutrition, critical period of imprinting, economic status, educational opportunity, etc." The questionnaire offered an attempt to recognize similar factors and to deal with them in a systematic manner in order to observe their relationship to the major variables of bilirubin and developmental status.

The newborn hospital record was employed as an instrument only as a source for perinatal data related to the study.

Procedure

Data collection was accomplished Spring through Autumn of 1978. As stated, subjects were volunteered by parents by means of a letter of consent returned to the investigator through the school which the subjects attended, and by direct contact with the investigator. Appointments were then made for testing of each child at school or at home, depending on the desire of the parents. The Developmental Test of Visual-Motor Integration was administered to each child in his or her mother's presence, according to the method prescribed by the test manual. Mothers then completed the demographic questionnaire and consent forms for the entire procedure and for the disclosure to the investigator of the newborn hospital record of the child. All tests and questionnaires were administered in person by the investigator.

Data concerning each subject as a newborn was obtained from hospital newborn charts. Data sought from these records included bilirubin saturation index, time and duration of bilirubin measurements and elevations, treatments such as phototherapy and exchange transfusion, and other factors related to bilirubinemia and their possible influence on subsequent development, such as delivery problems, size measurements, Apgar, birth injury or illness, vital signs at birth, time of first feeding,

feeding methods, etc.

At neither hospital was the bilirubin saturation index performed. Therefore, the highest total serum bilirubin recorded during the newborn hospital stay was employed as the dependent variable. The range of bilirubin levels was 1 to 19 mg.%, with a mean of 12.31 mg.%, within the criteria set for physiologic jaundice.

Scores on the Developmental Test of Visual-Motor Integration were given as developmental ages in years and months. The range of these was 4 years 1 month to 10 years 11 months. For simplicity in statistical analysis, these were converted to ages in months, giving an "age-score". Subjects' actual chronological ages were also converted to months and the difference between these two factors was computed as another score, the "difference-score". Thus, a difference-score of zero would be expected if the subject achieved exactly at his age level. These scores ranged from -27 to +61, with a mean of 4.5, median of 0 and mode of 9. For alternative statistical analysis, a "pass" or "fail" was also assigned according to whether or not the subject achieved his chronological age level.

The Pearson Product-Moment Correlation was employed to test the major research question, of whether or not a relationship exists between bilirubin levels and visual-motor developmental scores. Other statistical procedures employed in related questions were: (A) the Point Biserial Correlation, (B) t-test, (C) Pearson Product-Moment Correlation,

and (D) Chi Square, respectively.

The research design was that of an analytic, observational, or correlational type, where the research questions suggest the explanation of an observed pattern by identifying an association among factors. Since the major variables of bilirubin levels and developmental test scores cannot be truly manipulated as in a pure experimental study, both variables in this correlational type of study are essentially dependent variables (Friedman, 1972). A control group was not employed, since the instruments of measurement had already been standardized on large, random, "normal" populations, and because of the evident precedent of the majority of similar previous studies cited being without control groups. Statistical analysis was performed on the TRS-80 and Univac 1100 computers.

CHAPTER III

RESULTS

Presentation of results begins with an observation of the general description of the background of the study population followed by results of statistical analysis of data concerned with the research questions proposed.

Descriptive Background

An interesting general view of the perinatal, familial, and environmental background of the population was offered by a general examination of the descriptive data from the demographic questionnaire and the newborn hospital record. Certainly, this information is important before considering the more quantitative results related to the major research questions of the study.

The age of subjects' mothers at the time of testing ranged from 26 to 42 years. Mean age was 34.3 years. Fathers' ages ranged from 29 to 44 years, with a mean of 37.2 years. A general idea of socioeconomic status was extracted from a view of parents' educational levels and occupations. These are summarized in Table 1.

A view of health of status of subjects' parents was obtained to further describe familial background of the study population. This information is summarized in Tables 2 and 3.

Table 1

Educational Levels and Occupations of Parents

	Father		Mother	
	No.	%	No.	%
Educational Levels				
High School Graduation	1	4.16	7	29.17
Some College	7	29.17	12	50.00
College Graduation	9	37.50	5	20.83
Graduate Degree	7	29.17	0	0.00
Totals	24	100.00	24	100.00
Occupations				
Professional (professor, attorney, dentist)	5	20.83	0	0.00
Managerial (office manager, business owner)	5	20.83	0	0.00
Educational (school teacher)	3	12.50	0	0.00
Sales	1	4.17	0	0.00
Clerical (clerk, office worker, secretary)	1	4.17	4	16.67
Technical (craftsman, technician, skilled laborer)	6	25.00	2	8.33
Unskilled (farmer, homemaker, unskilled laborer)	3	12.50	18	75.00
Totals	24	100.00	24	100.00

Table 2

Summary of Mothers' Health

	No Major Health Problems		Health Problems			Totals	
	No.	%	No.	%		No.	%
General history	20	83.33	4	16.67	(2 phlebitis, 1 hypertension, 1 thyroid problem)	24	100.0
Pregnancy with subject	15	62.50	9	37.50	(2 phlebitis, 2 bleeding, 2 edema, 1 toxemia, 1 hypertension, 1 infection)	24	100.0
Other pregnancies	16	66.67	8	33.33	(problems not described)	24	100.0
Present	21	87.50	3	12.50	(1 hypertension, 1 thyroid problem, 1 cancer)	24	100.0

Table 3

Summary of Fathers' Health

	No Major Health Problems		Health Problems			Totals	
	No.	%	No.	%		No.	%
General history	22	91.67	2	8.33	(1 rheumatic fever, 1 asthma)	24	100.0
Present	22	91.67	2	8.33	(1 thyroid problem, 1 hearing problem)	24	100.0

All mothers reported regular pre-natal care during the pregnancy with the subjects, reflected by the time of the first consultation with a physician during pregnancy and the number of physician visits prior to delivery. Ten mothers reported taking the following medications during the pregnancy with the subjects: progesterone (3), anti-emetic (2), antibiotics (1), anti-histamines (1), narcotic (1), thyroid supplement (1), and diethylstilbesterol and progesterone (1).

Twenty-three subjects were born at the same hospital; one was born at another hospital in the same community. Twenty-one subjects were born by vertex presentation, vaginal delivery. One was born breech, and two born by Caesarean section. Mean length of labor preceding delivery was 5.67 hours. One reported delivery problem of posterior lie, and another of precipitous delivery. No other problems of labor or delivery were reported.

Three subjects recorded injury or problems at birth. These were cyanosis, residual rhonchi, and forceps mark on face. First vital signs and first feeding times were requested, but records seemed too inconsistent and unreliable to allow accuracy. Infant feeding methods were reported as 13 breast-fed and 11 using formula. Gestational age was not given on hospital records, so this was computed from a comparison of due date and birth date. Mean gestational age, according to this gross system, was 39.8 weeks. Further perinatal data is summarized on Table 4.

Table 4

Summary of Neonatal History

	Range	Mean
Birth weight	2620 - 5100 Gms.	3300 Gms.
Birth length	45 - 75 cms.	53.08 cms.
Head circumference	32.75 - 38.00 cms.	34.68 cms.
Chest circumference	30 - 37 cms.	33.17 cms.
Apgar - 1 minute	7 - 9	8.2
Apgar - 5 minutes	8 - 10	9.1
Total serum bilirubin	1 - 19 mg.%	12.31 mg.%

Birth order of subjects ranged from first child to seventh. Mean birth order was 3.2. Number of siblings ranged from 0 to 6. Mean was 3. Six reported siblings with health problems. These problems were reported as allergies (2), mental retardation (2), asthma (2), and croup. Twenty, or 83.33%, of the subjects reported that one or more siblings had jaundice as newborns.

All subjects except two reported good present health. These two reported present allergy problems. None reported emotional problems. Eight reported illness as infants. Infant conditions reported were allergy (2), bladder infections (2), respiratory infections (2), ear infections (1), and diarrhea (1).

Twenty subjects lived with both parents. Four lived with mother and stepfather. The mean number of times subjects had changed location of residence was 1.25. Fifteen subjects had attended some type of pre-school.

Thus, the foregoing background information was included in efforts to describe the study population and to provide and recognize the multiplicity of factors that may relate to the major variables involved in the research questions.

Results pertaining to the major and related research questions of the study are better understood after a view of the resultant variables of the study, total serum bilirubin levels and developmental test scores. These are summarized in Table 5.

Major Research Question

To answer the major research question, does there exist a relationship between total serum bilirubin levels of less than 20 mg.% in normal full-term neonates and difference-scores on a visual-motor development evaluation at age six years, the Pearson-Product Moment Correlation was performed, with the highest total serum bilirubin levels and the Developmental Test of Visual-Motor Integration difference-scores as variables. The Pearson r of -.012 was not significant at the .05 level, thus implying that no significant relationship exists between the variables.

One developmental test score of +61 seemed particularly high.

Table 5

Bilirubin Levels and Developmental Test Scores

Subject	Chronological Age	Age Score	Difference Score	Pass-Fail	Total Serum Bilirubin -- mg.%
1	58	67	9	P	14
2	77	74	-3	F	12
3	93	131	38	P	10
4	70	77	7	P	19
5	55	49	-6	F	18
6	76	63	-13	F	13
7	91	86	-5	F	14
8	86	104	18	P	18
9	69	95	26	P	7
10	88	79	-9	F	13
11	72	88	16	P	14
12	60	63	3	P	14
13	76	70	-6	F	10
14	74	96	21	P	16
15	88	67	-21	F	9
16	72	52	-20	F	9
17	68	77	9	P	18
18	90	63	-27	F	13
19	74	66	-8	F	8
20	78	74	-4	F	11
21	62	54	-8	F	12
22	70	131	61	P	10
23	78	100	22	P	12.5
24	79	88	9	P	1

Note: Chronological age and Age-Scores are given in total number of months.

To extract this from the study in order to respond to the research question with extremes deleted, the highest score of +61 and lowest score of -27 were eliminated from the population. The Pearson Product-Moment Correlation was again computed on total serum bilirubin levels and developmental test difference-scores. The resulting r of .095 was again not significant at the .05 level. Thus, no statistically significant relationship was observed between total serum bilirubin levels and developmental test difference-scores in the population as described.

Related Research Questions

(A) A related, supporting question of whether or not there existed a relationship between total serum bilirubin levels and developmental test scores interpreted as "pass" or "fail" was posed. Answer was sought, employing the Point Biserial Correlation. The result was $r_{pb} = .118$, significant at the .10 level. Thus, passing or failing the developmental test was not noted to be related significantly to bilirubin levels. Further computation ($r_{pb}^2 = .0139$) shows that only 1.39% of total variance of bilirubin level could be accounted for by the level of visual-motor development.

(B) Another related question of whether or not a significant difference existed between the age-scores on the developmental evaluation of the study population and expected scores of children of the same chronological ages in the general population, was tested by computation

of a correlated, related, or dependent t-test on the variables of subjects' actual ages and subjects' age-scores. The resulting t-score of 1.112 was not significant at the .05 level.

Another similar comparison of the study population with the general population was done using the single-sample t-test, responding to the question of existence of a significant difference between the difference-scores of the study population and the expected difference-score of zero. The resulting t-score was 1.397, with a significance of .20. Thus, no significant difference was observed.

(C) Most total serum bilirubin levels were clustered around the median of 12.75. These mid-area levels were removed from the population in order to examine any significant relationship existing in the extreme high (16 mg. % and above) and low (9 mg. % and below) levels. A t-test on the developmental scores of these groups was performed, seeking to ascertain whether a significant difference existed between the scores of the developmental test and bilirubin levels of the "extreme" groups. The resulting t of .705 shows no statistically significant difference.

(D) Since items of the Developmental Test of Visual-Motor Integration measure various aspects and levels of visual-motor development, the test itself was examined to learn if one or more particular items were failed or passed more than might be expected. Individual items of the developmental test were studied to ascertain whether one or more were failed or passed by the study population more than might

be expected in the general population, as determined by norms established by the test designer. Table 6 shows the results of this examination.

Items no. 12 and 15 seem to show more passing or failing scores than other items of the test. Item no. 12, concerned with testing of directional confusion, showed 8 passes and 7 failures of an expected 0 failures and 15 passes from the entire population. The average failure rate on all other items to that point was 1.9, with responses on most of those items hovering around this average figure. From this observation, question arose as to whether the number of actual passing scores was significantly less than that expected in the general population. To analyze this statistically, the Chi Square was computed. The result ($x^2 = .2177$) was not significant at the .05 level.

The same test was employed on a more limited population of only those subjects whose chronological ages were at or below the expected achievement age of item no. 12, that is only those of the population expected to pass the item. The resulting x^2 was .4444, again not significant at less than the .05 level.

Item no. 15 showed 13 passes, though no one of the study population was of the age level expected to pass the item. The Chi Square was again employed to determine significance of this observation. The resulting x^2 of .2434 was not statistically significant.

Table 6

Expected and Actual Passing Scores on Individual Items of the Developmental Test of Visual-Motor Integration by Six-Year-Old Children

Item No.	Expected Number Passing	%	Actual Number Passing	%
1	24	100.00	23	95.83
2	24	100.00	24	100.00
3	24	100.00	24	100.00
4	24	100.00	24	100.00
5	24	100.00	22	91.67
6	24	100.00	23	95.83
7	24	100.00	20	83.33
8	22	91.67	20	83.33
9	21	87.75	20	83.33
10	20	83.33	18	75.00
11	20	83.33	17	70.83
12	15	62.50	8	33.33
13	13	54.17	15	62.25
14	6	25.00	7	29.17
15	0	0.00	13	54.17
16	0	0.00	6	25.00
17	0	0.00	6	25.00
18	0	0.00	4	16.67
19	0	0.00	1	4.17
20	0	0.00	0	0.00

CHAPTER IV

DISCUSSION

The data and analysis in regard to the major and related research questions suggest that there is no correlation between the bilirubin levels of newborn physiologic jaundice and levels of achievement on the perceptual and visual-motor test administered at age six years.

Even with possible factors of skewness eliminated, such as by deleting extreme developmental scores or by comparing extreme bilirubin level groups, the data analysis consistently failed to support the hypothesis inferred in the original major research question. At no point did subjects perform any differently than might be expected in the general population.

Though no statistical significance was demonstrated, the general research offers some valuable information for discussion. Perhaps, from this investigation, the health care community may continue to accept the ideas proposed by some that the danger area in bilirubin levels in the full-term infant lies at higher levels, such as at the proposed level of 20 mg.% (Korones, 1976; McCrae, 1976), and that newborn jaundice reflected by total serum levels below 20 mg.% in the otherwise healthy full-term infant indeed demonstrate a "physiological" rather than

"pathological" process. However, the investigator notes that other factors in this particular study suggest the need for further research rather than formulation of a final conclusion.

The study offered several other noteworthy areas for discussion. The high incidence of failure on the item of the visual-motor test related to directional confusion, though not statistically significant, suggests that this may be an area for further research, that physiologic jaundice may be related to a more isolated, particular type of perceptual development. In that case, replication of the study, using a more specified instrument would be suggested.

It is conceivable that some of the descriptive data may have influenced the variables of the inferred hypotheses more than originally assumed. This particular population seemed to show a remarkably high level of socio-economic status, reflected by the high level of education among subjects' fathers (66.7% were college graduates and 29.2% had obtained graduate degrees), and by the high number of professional and managerial occupations listed by fathers. Other areas of interest were the average age of parents (fathers: mean 37.2 years; mothers, 34.3 years), large average family size of four children, number of subjects (15) who had attended pre-school, the geographic stability of the population, and the lack of subjects of minority ethnic background.

It is also interesting to note the incidence of maternal illness during pregnancy (9 of 24), and the number of subjects whose siblings

had suffered neonatal jaundice (20 or 24). Of family illnesses reported, allergy problems were reported more than any other.

These observations suggest that numerous factors other than those tested may relate to the dependent variable, total serum bilirubin levels, to a greater degree perhaps than visual-motor development. The study certainly suggests that such other factors might be considered beyond the descriptive level, that perhaps statistical analysis such as partial correlations and multiple regression analysis, supported by literature investigation would provide a means of discovery of new, even more exciting and applicable knowledge regarding hyperbilirubinemia of physiologic jaundice and its effects.

The investigation attempted to exhibit the existence of a relationship between total serum bilirubin levels of physiologic jaundice and visual-motor developmental status at age six years. While this relationship was not demonstrated, other factors stimulating future research and contribution to the body of health knowledge were discovered.

APPENDIX A

INITIAL LETTER TO PARENTS EXPLAINING THE STUDY AND SEEKING VOLUNTARY PARTICIPATION

Elaine S. Sorensen, R.N.
Graduate Student
University of Utah
2304 North Cheryl Way
Layton, Utah 84041

Dear Parent:

A study is being conducted on kindergarten children born in Ogden who had jaundice, high bilirubin, or who were "yellow" as newborns, to determine present general developmental status. This study is mainly concerned with normal children who may have had mild to moderate degrees of jaundice as babies.

If your child had the condition described, the voluntary participation of you and your child in this study would be very helpful. Participation would include the following:

1. An appointment would be made for your child for a simple developmental evaluation to be done at his or her school. Your attendance there would be invited and encouraged. The evaluation includes a simple test involving recognition of pictures and drawing figures by your child, and completion of a questionnaire by you. The entire procedure would require less than one-half hour.

2. The hospital newborn record of your child would be studied to determine the actual degree of jaundice and related factors.

Questions about the study are welcomed at any time, and you are free to withdraw from participation at any point. No part of the study will be done without your specific written consent. All information regarding individual children will be kept strictly confidential. All records of names will be destroyed immediately following the testing, before final information is compiled. Results of the study as a whole will be available to you if desired.

Your participation would be a valuable contribution. Please complete and sign the attached form and return it to school with your child. Thank you.

Sincerely,

_____ I am interested in participating in the study. I understand that I will be contacted within the near future regarding my child's participation.

Father's name_____

Mother's name_____

Child's name_____ Birthdate_____

Address_____ Telephone_____

_____ I do not wish to participate in the study.

Comments or questions_____

_____
Signature of Parent or Legal Guardian

APPENDIX B

DEMOGRAPHIC QUESTIONNAIRE

Child_____ Sex M or F
(name or number)

Birthdate_____

Hospital where born_____

BACKGROUND INFORMATION

Child's Father:

Age_____ Highest grade or degree completed_____ Occupation_____

Has child's father ever had any serious or chronic illness? List_____

Does he now have any serious or chronic health condition? List_____

Blood type_____

Child's Mother:

Age_____ Highest grade or degree completed_____ Occupation_____

Has child's mother ever had any serious or chronic illness? List_____

Does she now have any serious or chronic health condition? List_____

Blood type_____

Please answer the following questions in regard to the pregnancy with the child participating in this study:

Did you have any of the following problems during pregnancy: (circle)
high blood pressure, swelling of hands or feet, bleeding ? others (list)_____

Did you take any medication or drugs during pregnancy? (list)_____

During which month of the pregnancy did you first consult a physician?____

How often during the pregnancy did you see a physician?_____

How long was your labor with this child?_____

Were forceps used in the delivery?_____

List any problems with any other pregnancies or deliveries._____

Child

Order of birth in family_____ Number of brothers and sisters_____

Do any of the brothers or sisters have any serious or chronic health problems? List._____

Did any brothers or sisters have jaundice as newborns? (How many)_____

How was child fed as an infant? (Circle) bottle, breast (If breast, for how long?)_____

Has he/she lived with both parents all his or her life?_____

How many times has the child moved or changed residence in his or her life?_____

Did he or she attend any type of pre-school?_____

Does he or she now have any serious or chronic health problems? (List)___

_____

Did he or she have any health problems as an infant? (List)_____

List any learning or emotional problems you feel he or she may have.____

_____

Has he or she ever been hospitalized? If so, how many times and for what condition?_____

APPENDIX C

INFORMATION FROM HOSPITAL RECORD

MOTHER

Parity

EDC

Single Birth?

Presentation

Type of Delivery

Problems in Labor or Delivery

Blood Type

Length of Labor

Anesthetic

NEWBORN

Birthdate Time

Weight Length

Chest Circ. Head Circ.

Est. Gestational Age

VS

Feeding Method

Time of First Feeding:

water br. or form.

Apgar

Birth injuries

Serum Total Bilirubin

Date Time mg.%

Sat. index.

Phototherapy

Date Time Duration

REFERENCES

Ackerman, B., Dyer, G. Y., & Leydorf, M. M. Hyperbilirubinemia and kernicterus in small premature infants. Pediatrics, 1970, 45, 918-925.

Beery, K. E., & Buktenica, N. A. Developmental test of visual-motor integration. Chicago: Follett, 1967.

Behrman, R. E. (Ed.). Neonatology. Saint Louis: C. V. Mosby, 1973.

Behrman, R. E. Summary of a symposium on phototherapy for hyperbilirubinemia. Birth Defects: Original Article Series, 1970, 6, 131-136.

Boggs, T. J., Hardy, J. B., & Frazier, T. M. Correlation of neonatal serum total bilirubin concentrations and developmental status at age eight months. The Journal of Pediatrics, 1967, 71, 553-560.

Buckfield, P. M. Neonatal at risk factors. New Zealand Medical Journal, 1972, 75, 266-272.

Buros, K. K. (Ed.). The seventh mental measurements yearbook (Vol. 2). Highland Park, N. J.: Gryphon Press, 1972.

Chelius, H. H., Bohme, K., & Dettmer, U. Uberden einflub der hyberbilirubinamie auf die korperlich-geistige entwicklund der erkrankten neugeborenen. Geburtshilfe Frauenheilkd, 1971, 31, 823-529.

Ehrlich, C. H., Shapiro, E., Kimball, B. D., & Huttner, M. Communication skills in five-year-old children with high-risk neonatal histories. Journal of Speech and Hearing Research, 1973, 16, 522-529.

Frerichs, F. T. A clinical treatise on diseases of the liver (Vol. 1) (C. Murchison, trans.). New York: W. Wood, 1979.

Friedman, H. Introduction to statistics. New York: Random House, 1972.

Gartner, L. M., & Arias, I. M. Formation, transport, metabolism and excretion of bilirubin. The New England Journal of Medicine, 1970, 280, 1330-1345.

Gartner, L. M., Snyder, R. N., Chabon, R. S., & Bernstein, J. Kernicterus: high incidence in premature infants with low serum bilirubin concentrations. Pediatrics, 1970, 45, 906-917.

Hardy, J. B., & Peeples, M. O. Serum bilirubin levels in newborn infants: distributions and associations with neurological abnormalities during the first year of life. Johns Hopkins Medical Journal, 1971, 128, 265-272.

Hodgman, J. E., & Teberg, A. Effect of phototherapy on subsequent growth and development of the premature infant. Birth Defects: Original Article Series, 1970, 6, 75-82.

Hoepfner, R., Stern, C., & Nummedal, S. G. (Eds.). CSE-ECRE preschool/kindergarten test evaluations. Los Angeles: University of California at Los Angeles Graduate School of Education, 1871.

Holmes, G. E., Miller, J. B., & Smith, E. E. Neonatal bilirubinemia in production of long-term neurological deficits. American Journal of Diseases of Children, 1968, 116, 37-43.

Hyman, C. B., & Keaster, J. Hearing loss in children with neonatal hyperbilirubinemia. Journal of the American Woman's Association, 1962, 17, 733-734.

Kempe, C. H., Silver, H. K., & O'Brien, D. Current pediatric diagnosis and treatment (4th ed.). Los Altos: Lange Medical Publications, 1976.

Klaus, M. H., & Fanaroff, A. A. Care of the high-risk neonate. Philadelphia: W. B. Saunders, 1973.

Korones, S. B. High risk newborn infants (2nd ed.). Saint Louis: C. V. Mosby, 1976.

Levi, A. J., Gatmattan, Z., & Aria, I. M. Deficiency of hepatic organic anion-binding protein, impaired organic anion uptake by liver and "physiologic" jaundice in newborn monkeys. The New England Journal of Medicine, 1970, 283, 1136-1139.

Maisels, M. J. Physiologic jaundice of the newborn. Pediatric Clinics of North America, 1972, 50, 454-501.

Maisels, M. J. Neonatal jaundice. In G. B. Avery (Ed.), Neonatology. Philadelphia: J. B. Lippincott, 1975.

McCrae, W. M. Kernicterus in the newborn. Nursing Times, July 1976, pp. 1086-1088.

Mores, A., Fargasova, I., & Minarikova, E. The relation of hyperbilirubinemia in newborns without isoimmunization to kernicterus. Acta Pediatrica Scandia, 1959, 48, 590-602.

Mussa, G. C., & Colombo, M. L. Influenza dell'ittero fisiologico intenso e prolungato sull'accrescimento dell'immaturo. Minerva Pediatrica, 1965, 17, 244-245.

Odell, G. B. The distribution and toxicity of bilirubin. Pediatrics, 1970, 46, 16-25.

Odell, G. B., Storey, G. N. B., & Rosenberg, L. A. Studies in kernicterus: III. The Journal of Pediatrics, 1970, 76, 12-21.

Upadhyay, Y. A longitudinal study of full-term neonates with hyperbilirubinemia to four years of age. Johns Hopkins Medical Journal, 1971, 128, 273-277.

Van Camp, D. Psycological evaluation of children who had neonatal hyperbilirubinemia. American Journal of Mental Deficiency, 1964, 68, 803-806.

Waechter, E., & Blake, F. C. Nursing care of children (9th ed.). Philadelphia: J. B. Lippincott, 1976.

Wu, P. Y., Lim, R. C., Hodgman, J. E., Kokosky, J. J., & Teberg, A. J. Effect of phototherapy in preterm infants on growth in the neonatal period. The Journal of Pediatrics, 1974, 85, 563-566.

Zachau-Christiansen, B. Complications during pregnancy, delivery, and neonatal period in relation to development in the first year. Acta Neurologica Scandia, 1967, 63, 43-44.

VITA

Name	Elaine Shaw Sorensen
Birthdate	March 3, 1949
Birthplace	Ogden, Utah
Colleges and degrees	Weber State College, Ogden, Utah A.A., 1970
	University of Utah, Salt Lake City, Utah, B.S., 1972
Professional Positions	Community Counselor, Operation Outreach Appalachian Project, Pippa Passes, Kentucky
	Staff Nurse - Latter-Day Saints Hospital, Salt Lake City, Utah
	Staff Nurse - Saint Benedict's Hospital, Ogden, Utah
	Health Missionary, Church of Jesus Christ of Latter-Day Saints Colombia, South America
	School Nurse - Ogden City School District, Ogden, Utah
	Community Health Nurse Weber County Health Department Ogden, Utah
	Associate Instructor University of Utah College of Nursing, Salt Lake City, Utah

Honors	"Outstanding Scholarship in the Field of Nursing" - Weber State College
	Phi Kappa Phi
Professional Affiliations	Utah State Nurses Association American Nurses Association