DOCUMENT RESUME

ED 360 786 EC 302 358

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TITLE Predictors of Developmental Outcomes for Infants Who Are Medically Fragile.
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SPONS AGENCY Department of Education, Washington, DC.
PUB DATE 26 Mar 93
CONTRACT HS90010001
NOTE 20p.; Paper presented at Society for Research in Child Development Conference (New Orleans, LA, March 25-28, 1993).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS At Risk Persons; Biological Influences; *Child Development; *Disabilities; Handicap Identification; Infants; Neonates; *Neurological Impairments; *Perinatal Influences; Prediction; Predictive Measurement; *Predictor Variables; Special Health Problems; Young Children
IDENTIFIERS *Medically Fragile

ABSTRACT

This paper presents results of a preliminary study which evaluated medical birth data as potential predictors of developmental outcome, and developed and tested an instrument designed for this purpose. Forty low birthweight children, all of whom had experienced neonatal intraventricular hemorrhage, were evaluated at school age (66 months) on the Battelle Developmental Inventory (BDI) and results were correlated with neonatal risk factors and birth characteristics. Of 15 variables correlating with the BDI, the variables with the highest correlations with developmental outcome were the number of days spent in the Neonatal Intensive Care Unit and the degree of neurological damage. These variables were found to be more predictive than other commonly used variables including birthweight, gestational age, and APGAR scores. The study also found that adding demographic and social variables only slightly increased the amount of variance explained in the outcome measure. Attached tables detail study findings. (Contains 19 references.) (DB)

PREDICTORS OF DEVELOPMENTAL OUTCOMES FOR INFANTS WHO ARE MEDICALLY FRAGILE

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Paper presented at the 1993 Society for Research in Child Development Conference, March 26, 1993, New Orleans, Louisiana.

Work reported in this paper was supported in part with funds from the U.S. Department of Education (Contract #HS90010001) to the Early Intervention Research Institute at Utah State University, Logan, UT.

PREDICTORS OF DEVELOPMENTAL OUTCOMES FOR INFANTS WHO ARE MEDICALLY FRAGILE

Introduction

The past decade has seen a tremendous increase in research focused on low birthweight infants (Escobedo, 1988), whose development is often delayed or impaired (Lefebve, Bard, Veilleux, & Martel, 1988). Infants considered "medically fragile" (i.e., those who have already experienced serious health complications such as neurological insults, respiratory distress, etc.) are even more at-risk for later disabilities than infants who are simply low birthweight or premature. Medically fragile infants are more likely to experience cognitive, motor, social, and visual abnormalities or delays than other premature infants (e.g., Bozynski et al., 1984; Landry et al., 1990; Vohr et al., 1989). In recent years, the number of medically fragile infants who require professional intervention has increased due to advances in medical technology and reduced mortality rates (Rosenthal, 1991).

Problem Statement

While the effectiveness of early intervention with medically fragile children has been demonstrated (e.g., IHDP, 1990; Resnick, Armstrong, & Carter, 1988), there remains an overwhelming need for earlier and more accurate predictors of developmental outcomes (Bennett, 1987). More accurate predictors would help focus intervention efforts (giving those children who need the most help more intervention), which in turn would impact the cost-effectiveness of intervention programs (Barnett, 1986) and parent stress. However, traditional indicators of infant status (e.g., APGAR scores) are not particularly good predictors of later development, and few measures of neonatal health status have been used in the literature (e.g., IHDP, 1990). Thus, clinicians are often forced to make decisions based solely on past experience (Page, 1986).

This paper outlines the results of a preliminary study designed to evaluate available medical birth data as potential predictors of developmental outcome and test an instrument designed for the same purpose.

Methods

Sample

Forty low birthweight children, all of whom experienced neonatal intraventricular hemorrhage (IVH), were part of a longitudinal study conducted at the Early Intervention Research Institute (EIRI). By 1992, these children had reached school age (66 months). Information regarding salient demographic variables of the sample is presented in Table 1, and information regarding pregnancy characteristics is presented in Table 2. Child birth and medical characteristics are presented as part of Table 3. As can be seen, this population was an average of ten weeks premature and was generally very low birthweight (mean of 1410g). The grade of IVH ranged from one to four (four being the most serious), with an average rating of 2.2. The number of days the infants spent in intensive care ranged from 0 to 97 (mean of 35.8, median of 20.5). There was great variability among the subjects on this variable, but no single outlier was identified.

Data Collection

Neonatal risk factors and birth characteristics were provided by two hospitals located in Salt Lake City, Utah. Some of this information, such as the number of days hospitalized, was rated on three-point scales, the Medical Status Index (MSI; Casto, 1992), in order to compute an overall rating of medical severity and to examine the usefulness of a medical severity rating scale (i.e., the MSI) as a predictor of later development. A copy of the instrument is included in the Appendix.

Child developmental outcome data were collected at the age of 66 months using the Battelle Developmental Inventory (BDI; Newborg, Stock, Wnek, Guidubaldi, & Svinicki, 1984), a norm-referenced test that assesses five developmental domains: personal/social, adaptive, motor, communication, and cognitive skills. The BDI has been used extensively with populations similar to those of this study (e.g., Christie, 1982), and it has proven to be both reliable and valid (Harrington, 1985).

Because other researchers have found that social variables, such as parental involvement, birth order, and socioeconomic status, are also powerful predictors of later outcomes (e.g., Siegel, 1988), relevant information was collected from the parents when their children were three months of age. This information was updated regularly as part of an annual assessment process.

Results

Over thirty neonatal risk factors were examined as part of this study. Several medical status variables (e.g., the occurrence of hyaline membrane disease and hyperbilirubinemia), were not statistically significantly correlated with later developmental status and were not examined. In addition, a few other variables (tachypnea, thrombocytosis, and porencephalic cysts) were excluded from analyses because too few children experienced these conditions.

The fifteen variables that were found to correlate at $r > \pm.20$ with BDI raw scores at sixty-six months of age are presented in Table 3. The MSI total scores correlated moderately low with developmental outcomes, much the same as the other variables examined here. The variables with the highest overall correlations with developmental outcome were: (a) the number of days spent in the Neonatal Intensive Care Unit (NICU) and (b) the degree of neurological damage. When these variables were examined across four previous assessments (given at 18, 30, 42, and 54 months of age), their correlations were highest among the several infant medical status variables. Thus, the findings presented here are consistent over time.

In searching for predictors of development at 66 months, a series of forced-enter and backward-elimination multiple regressions were conducted. The small sample size and intercorrelations of the independent variables made these analyses exploratory in nature. A summary of the results may be found in Table 4. Overall, the four variables that repeatedly manifested themselves in the analyses were the number of days spent in the NICU, the number of transfusions received, maternal diabetes, and the degree of neurological damage.

Because much of the research literature has focused on the social and demographic variables that may affect developmental outcome, these were also analyzed. Correlations between these variables and raw scores on the Battelle Developmental Inventory are presented in Table 5. A series of multiple regressions, similar to those reported above (with the same associated cautions), were performed in which these variables were examined along with the medical status variables. As can be seen in Table ȷ, the resulting optimal regression models differed from those produced in Table 4 on the BDI total score and on three of the BDI subscales. A slight increase in the amount of explained variance was achieved on these three subscales by including social and demographic variables in the regression models. However, on two of the BDI subscales, social and demographic variables were not significant predictors.

Overall, the two variables that appeared most often in these analyses were the number of days spent in the NICU and the education level of the father.

Discussion

Prediction of the developmental outcome of medically fragile infants is vital to providing timely and appropriate family and child services. This study attempted to identify useful, practical predictors of development at 66 months of age, which is approximately the time when children first enter school. First, correlational analyses revealed that several neonatal medical characteristics, including number of days spent in NICU and the degree of neurological damage, were much more highly correlated with later development than variables that are more often used in research and practice: birthweight, gestational age, and APGAR scores. This important finding suggests that early intervention programs may benefit from the use of these variables as rough estimates of which infants are at greatest risk for later developmental delays. Practitioners would then be able to focus intervention on those infants that may need it most, rather than by simply diffusing treatments to general populations of low birthweight or premature infants. However, due to the small population size of the present study and the moderately small amount of variance explained in developmental outcome, further research should be conducted to replicate these results.

These results also give support to calls from several researchers (e.g., Hoy, Bill, & Sykes, 1988) for researchers to exert greater control over the many other variables confounded with birthweight, such as those examined here (see Table 3). Simply reporting subjects' birthweight or gestational age is helpful, but it is not very useful unless other neonatal characteristics are presented along with it.

It was also found that condensing the neonatal health information on the MSI did not explain more of the variance in development than did many of the other variables examined. For example, the MSI was not as highly correlated with later development as was the number of days the child spent in the NICU. Upon further analysis, it was found that these two variables were highly correlated with each other (.82). This relationship may be due to the fact that the number of total days hospitalized and the number of days on the ventilator are two of the items on the scale, but it is also likely that poor medical status (as indicated by the MSI) typically calls for longer treatment in intensive care. The high correlation between these two variables might also explain why the MSI did not appear in any of the regression models. When it was forced-entered into the equations in place of the number of days spent in the NICU, the resulting percentages of explained variance were not nearly as high. The weaker predictive power of the MSI may also be due to the fact that such diverse, linear data were condensed on three-point scales, losing much of the variance associated with these variables in the process.

Finally, although the primary focus of this investigation was to identify early medical status variables that were predictive of developmental outcomes, the results of this study confirm previous researchers' claims that socioeconomic condition, parental occupation level, and years of parental education do have some affect on the quality of development (e.g., Kalmar & Boronkai, 1991; Larsen, 1985). It should be noted, however, that adding the demographic and social variables to the analyses only slightly increased the amount of variance explained in the outcome measures. Thus, it appears that with medically fragile infants, medical variables may be more important in predicting later outcome than socioeconomic or demographic ones, at least until the age of 66 months.

In summary, multiple factors influence child development. However, it is useful for practitioners and researchers alike to be able to predict later developmental outcomes. To that end, this study supports the use of available neonatal medical characteristic variables, particularly the amount of time spent in intensive care, as indicators of developmental vulnerability. These variables appear to explain more of the variance in developmental outcome of medically fragile infants than do more commonly used predictors in current research and practice.

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Table 1

Family Demographics

Characteristic	$\overline{X}$	Range	SD
Age of Mother	31.7	22-44	5.6
Age of Father	33.6	24-48	5.7
Mother's Education (in years)	13.2	9-17	2.1
Father's Education (in years)	13.8	8-17	2.3
Mother Employed (hrs/week)	18.2	0-45	17.7
Father Employed (hrs/week)	40.4	0-60	11.0
Income	$39,528	$2,500 - $75,000	$26,538
% 2-Parent Families	89		

Table 2

Maternal Pregnancy Characteristics

Characteristic	$\overline{X}$	Range	SD
Maternal Health Rating (higher scores better, 0-3 rating)	2.4	0-3	.8
Diabetes (%)	10		
Toxemia (%)	0		
Bleeding at First Trimester (%)	41		
Received 3 Trimesters Prenatal Care (%)	57		
No. of Previous Pregnancies	1.8	0-10	1.9

Table 3

Bivariate Correlations of Developmental Outcome at 66 Months and Birth Data

	Birth Data		BDI Raw Scores					
Birth Data	$\overline{X}$	SD	Personal/ Social	Adaptive Behavior	Motor	Communication	Cognitive	TOTAL
Birthweight	1410	620	.19	.22	.25	.18	.19	.20
Gestational age	30	3.2	.24	.27	.26	.19	.19	.24
APGAR	6.1	1.8	.02	.15	.33*	.11	.20	.20
Grade of IVH	2.2	1.1	-.19	-.28*	-.48**	-.22	-.34*	-.33*
Days in NICU	31	31	-.43**	-.41**	-.43**	-.46**	-.55***	-.47**
Respiratory distress(%)	10		-.34*	-.35*	-.42**	-.36*	-.44**	-.41**
Seizure disorder(%)	12		-.39**	-.37**	-.29**	-.38**	-.30*	-.36*
Lumbar puncture(%)	45		-.23	-.23	-.24	-.27	-.29*	-.26
Medical Status Index Total[a]	17.4	7.7	-.33*	-.34**	-.40**	-.34*	-.40**	-.38**
Neurological status[b]	2.0	1.5	-.29*	-.41**	-.59***	-.33*	-.44**	-.44**
Sensory status[c]	1.3	.8	-.27	-.16	-.19	-.20	-.21	-.20
Category of weight	2.0	1.5	-.31*	-.31*	-.32*	-.27*	-.29*	-.31*
Days on ventilator	2.3	1.9	-.28*	-.26*	-.30*	-.39*	-.39**	-.31*
Days hospitalized	3.5	1.5	-.28*	-.28*	-.24	-.30*	-.34*	-.29*

* $p \le 0.05$; ** $p \le 0.01$; *** $p \le 0.001$

Note: [a]Total score on the Medical Status Index (MSI; Casto, 1992)
[b]Degree of neurological damage, as indicated by neuro exam and grade of IVH; this and the following four are items on the MSI
[c]Stage of ROP and degree of hearing deficit

$\overline{X}$ = mean
SD = Standard Deviation

Table 4

Child Development Regressed on Birth Data

Dependent Variable (BDI)	Predictive Independent Variables ($p \leq .05$)	% of Variance Explained
Personal/Social	1. Maternal diabetes 2. Number of days in NICU	23%
Adaptive Behavior	1. Number of days in NICU 2. Number of transfusions	37%
Motor	1. Neurological status 2. Gestational age	34%
Communication	1. Number of days in NICU 2. Number of transfusions	24%
Cognitive	1. Number of days in NICU 2. Number of transfusions	27%
TOTAL	1. Number of days in NICU 2. Number of transfusions 3. Maternal diabetes	44%

* Due to small N size, only a few selected variables were entered in the initial models. Significant predictors ($p \leq .05$) were retained.

Table 5

Correlations of Maternal Characteristics and Demographics with Developmental Outcome at 66 Months

	Personal/ Social	Adaptive Behavior	Motor	Communication	Cognitive	Total
Pregnancy Characteristics						
Maternal Health Rating	.07	-.07	-.16	-.01	.05	-.07
Diabetes	-.20	-.15	-.09	-.30	-.25	-.20
Bleeding at 1st Trimester	-.22	-.15	-.01	-.21	-.20	-.15
Number of Previous Pregnancies	-.01	.06	.05	-.01	-.03	.01
Demographic Characteristics						
Age of Mother	-.11	-.03	.02	-.09	-.16	-.08
Age of Father	-.02	.06	.04	-.03	-.25	-.04
Mother's Education (years)	.16	.07	.09	.24	.21	.17
Father's Education (years)	.25	.13	.15	.36	.30	.27
Mother Employed (hrs/week)	-.30	-.20	-.22	-.26	-.25	-.24
Father Employed (hrs/week)	.11	.04	.15	.20	.26	.15
Income	.25	.19	.27	.27	.26	.28
Occupational Level (Mother)	.27	.19	.16	.27	.21	.25
Occupational Level (Father)	.24	.17	.28	.30	.26	.25

Table 6

Child Development Regressed on Birth Data

Dependent Variable (BDI)	Predictive Independent Variables	% of Variance Explained
Personal/Social	1. Number of days in NICU 2. Education of father	25%
Adaptive Behavior	1. Number of days in NICU 2. Number of transfusions	37%
Motor	1. Neurological status 2. Gestational age	34%
Communication	1. Number or days in NICU 2. Education of father	32%
Cognitive	1. Number of days in NICU 2. Education of father	38%
TOTAL	1. Number of days in NICU 2. Education of father 3. Number of transfusions	49%

* Due to small N size, only a few selected variables were entered in the initial models. Significant predictors ($p \leq .05$) were retained.

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MEDICAL STATUS INDEX

(35 Possible Points)

___ MSI A. Days on Ventilator ___

5 = More than 36 days
3 = 17-36 days
1 = 5-16 days

___ MSI B. Respiratory Status

5 = Chronic RDS, HMD, BPD
3 = Any RDS, HMD, BPD
1 = Pulmonary Medication

___ MSI C. Days Hospitalized ____

5 = More than 60 days
3 = 20-60 days
1 = 6-19 days

___ MSI D. Neurological Status

5 = Abnormal EEG, CT Scan/Ultra Sound, Grade IV IVH
3 = Abnormal Neuro Exam, Shunted Hydrocephalus, Grade III IVH
1 = Suspect Neuro Exam, Grades I and II IVH

___ MSI E. Sensory Status

5 = Stage IV ROP, Documented Deafness
3 = Stage II and II ROP, Abnormal Hearing Screening
1 = Resolved ROP, Normal Hearing Screening

___ MSI F. Birthweight ____

5 = Less than 1000 g
3 = 1000 to 1500 g
1 = 1500 to 2500 g

___ MSI G. Medical Complications ____

5 = More than 24 complications
3 = 16-24 complications
1 = 10-15 complications

MSI Total = ______________