

REPRODUCTIVE AND ENVIRONMENTAL CASUALTIES: A REPORT ON THE 10-YEAR FOLLOW-UP OF THE CHILDREN OF THE KAUAI PREGNANCY STUDY

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ABSTRACT. The effects of perinatal complications and quality of environment were studied in a cohort of 1955 births and a selected sample of 1956 births in the Kauai Pregnancy Study. The 10-year follow-up of the 866 children utilized records, teachers' ratings, and group tests as screening devices and diagnostic examinations by psychologists, pediatricians, and allied disciplines. Independent environmental ratings of socioeconomic status, educational stimulation, and emotional support were based on home interviews. Differences found between children with and without perinatal stress centered on a small group of survivors of severe complications who had a significantly higher proportion of major physical handicaps, predominantly of the central nervous and sensory systems, a

higher proportion of I.Q.'s below 85 and lower mean scores on the factors V, R, N, and P of the Primary Mental Abilities Test. No differences were found between children with and without perinatal complications in the proportion of poor grades and the incidence of language, perceptual, and emotional problems, except for those in institutions. Environmental ratings showed a significant association with intellectual, achievement, and emotional problems at age 10. Many more children were affected by unfavorable environment than by severe perinatal stress. *Pediatrics*, 42:112, 1968, PREGNANCY COMPLICATIONS, PSYCHOLOGY—EDUCATIONAL, PERINATAL INFLUENCES, SOCIAL CONDITIONS, CHILD BEHAVIOR DISORDER—ETIOLOGY, KAUAI PREGNANCY STUDY.

IN A RECENT ISSUE OF *PEDIATRICS*¹ we reported on the cumulative effect of perinatal complications and deprived environment on the physical, intellectual, and social development of 2 year olds who represented a time sample of all children born in an entire community consisting of several ethnic and all socioeconomic groups. Using the combined tools of pediatricians and psychologists, we found a significant increase in the proportion of preschool children considered to be below normal in all aspects of their development with increas-

ing severity of perinatal stress. The developmental lag was especially pronounced for children suffering from severe perinatal complications. However, the quality of the early home environment, as measured by socioeconomic status, family stability, and mother's education, had also a significant effect on both the mental and social development of preschool children, and the effect increased with the severity of perinatal complications.

The purpose of the present paper is to report on a follow-up of these children at

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age 10 in order to identify problems that affected children's performance in school (achievement, intellectual, emotional, and physical) and to relate them to degree of perinatal stress and quality of environment. In contrast to the preschool age, more achievement demands are now made on these children, and the validity and reliability of our measuring instruments for the assessment of intellectual functioning, behavior problems, and physical status have increased. Furthermore, there has been a more extended time period during which the home environment could influence the child's development through the presence or absence of material opportunities, intellectual stimulation, and emotional support. More time has passed to allow the children to recover from the effects of perinatal stress and the slow maturers may have had an opportunity to "catch up."

Specifically the purposes of this report are: (1) to give a perspective of the relative magnitude of achievement, intellectual, emotional, and physical problems among school-age children drawn from all socioeconomic and several ethnic groups in an entire community; (2) to evaluate the long-term consequences of perinatal complications on the development of school-age children with the diagnostic tools of the physician, psychologist, and speech and hearing specialist and through the use of teachers' observations and available records; and (3) to compare the relative contribution of quality of home environment and degree of perinatal stress to achievement, intellectual, emotional, and physical problems of school-age children.

REVIEW OF LITERATURE

During the past two decades a number of investigators, both in the United States and in Europe, have reported the results of prospective studies in which children with perinatal complications have been followed through school-age.²⁻²³ Children with perinatal complications have been evaluated over a wide age range, from nursery school through junior high school and a variety of

functions have been studied. Not every investigator employed the same criteria for the selection of his subjects, nor did he study the same functions. Children were selected because of a special condition at birth (anoxia) or place of birth (teaching hospital); only a few completed studies²⁻⁶ and two studies in progress^{6,7} have followed their subjects at more than one time in their lives to observe changes in the effect of perinatal complications on behavior over time. The need for longitudinal studies of the effect of perinatal complications has been recently highlighted by Teuber and Rudel⁸ who presented evidence from studies of brain-injured children and adults that some behavioral manifestations increase with age, some diminish with age, and still others remain fairly stable. Appendix I contains a review of the 14 studies summarized in Table I.

The results of the majority of prospective studies of the effect of perinatal complications on school-age children point to the following conclusions: (1) deficits in abstracting (conceptual) and perceptual ability are more frequently found in older children who suffered perinatal stress; (2) impairment in gross motor and neurological status are more frequently found among younger children who suffered perinatal stress; (3) problems in the area of emotional and social development are found both in early and later childhood, among such children, but little information is available on the quality of the environment and emotional support for these children; and (4) the most inconsistent results have appeared in the studies of the effect of perinatal complications on "general" intelligence. About half of the prospective studies report lower test scores for children who have undergone perinatal stress than for normal controls; fewer differences, however, are found among older children.

The effect of environmental stimulation or deprivation on intelligence test results, no doubt, is a major factor contributing to the differences reported. In future studies there is a real need to analyze the relative

contribution of environmental effect and perinatal stress independently.

PROCEDURES AND METHODS

Study Group

The setting and the characteristics of the population of Kauai have been described in previous papers.^{24,25} The children in this follow-up belong to several ethnic groups—children of Japanese ancestry constitute 34% of the study group, Hawaiians and part-Ha-

waiians contribute 24%, Filipinos make up 18%, and 8% are Caucasians (6% Portuguese, 2% Anglo-Saxon). The remaining 15% are principally mixtures of ethnic groups other than Hawaiian. The population's health indices and the availability and quality of medical care and special educational services compare favorably with most mainland communities.

The study group consists of 866 children: a time sample of 750, approximately 90% of

TABLE I
SUMMARY OF FINDINGS OF PROSPECTIVE STUDIES—RELATIONSHIP BETWEEN PERINATAL COMPLICATIONS AND OUTCOME AT SCHOOL AGE

Reference	Age at Follow-up (yrs)	Type of Impairment						
		I.Q.	Reading	Abstracting	Perceptual	Motor	Neurological	Personality
11	2.5-11.8	+						
15	5-8							+
3	7	0	?	+	+	?	0	+
17	7-11.5	0	0		+	+	+	0
16	7-12							+
5	8	+		+	+			0
12	3-19 median 10.2	+			0		?	+
13	5-15 median 11.7	+						
14	3-18 "prepuberty"	+						+
18	5-12	0			0	0		
19	8-11	0						
21	13-14	0						
22	"School-age"	0						0
23	10-14	0						

+ = Significant impairment found in children with perinatal complications.

0 = No significant impairment found in children with perinatal complications.

? = Suggestive impairment found in children with perinatal complications.

the live births on the island of Kauai, Hawaii, in 1955, and, from the cohort of 1956 births, the 116 children who had moderate to severe perinatal complications. Losses to the follow-up consisted of 38 deaths, 96 moved away from Hawaii, and 4 refusals. The mean age of the children at the time of the follow-up was 10 years 6 months, with a range from 9 to 11 years.

Assessment of Perinatal Status

A detailed description of the methods used for the assessment of perinatal complications has appeared in a previous report.¹ Reviewing the extensive records of the Kauai Pregnancy Study, a pediatrician had scored the severity of some 60 conditions occurring during the prenatal, labor and delivery, and neonatal periods and arrived at a "perinatal stress score": 0—no stress, 1—mild, 2—moderate, and 3—severe stress. Among the time sample 56% were recorded as having no perinatal stress, 31% had mild, 10% had moderate, and 2% had severe stress. For four children there was insufficient information to be scored. Socio-economic status, ethnic origin, and age of mother had no significant effect on the distribution of the perinatal scores.

Assessment of 10-year Status

The 1965-1966 follow-up used the following data for initial screening: (1) a summary of information from records of physicians and hospitals for children with reported physical handicaps, illnesses, or accidents; (2) a summary of information from records of the Bureau of Crippled Children, the Divisions of Mental Retardation and Mental Health, and the Special Services departments of the public schools; (3) a summary of cumulative records including grades, group intelligence and achievement test scores, and results of hearing, speech, and vision tests conducted at school; (4) a checklist filled out by the current teacher, including grades in reading, arithmetic, and writing, and information on physical, intellectual, and emotional problems observed in the classroom; (5) a sum-

mary of a home interview with the mother including reported illnesses, accidents, hospitalizations, and behavior problems observed in the home; and (6) results of two group examinations, the SRA Primary Mental Abilities Test (Elementary Form) and the Bender-Gestalt test, administered and scored by qualified examiners according to standard directions.^{26,27}

A panel of the resident study staff, a pediatrician, a psychologist, and a public health nurse reviewed the information collected for each child. Data were available on all parameters for all children, including those in institutions. If additional information was needed to confirm the presence of an intellectual, emotional, or physical problem, further diagnostic examinations were initiated. Thirty percent of the follow-up group were examined by appropriate specialists (psychologist, pediatrician, audiologist, ophthalmologist, and/or neurologist). The largest number (about two-thirds) were psychological examinations, using a variety of tests (the WISC, individual Bender-Gestalt, Draw-a-Person, Graham-Kendell Memory for Design test, Rorschach, and TAT); 20% of the diagnostic examinations were pediatric, 7% were speech, hearing, and vision; and 11% used the services of other specialists.

The combined screening and diagnostic information was used by the panel to decide on the presence or absence of the following types of problems.

SCHOOL ACHIEVEMENT PROBLEMS—current grades D or F in reading, or arithmetic; grade placement 1 year or more below chronological age; in special classes or institutions for the retarded.

INTELLECTUAL PROBLEMS—I.Q. below 85 on group PMA or individual WISC test.

PERCEPTUAL PROBLEMS—group Bender-Gestalt error score of 4 or more (according to the Koppitz Developmental Scoring System) and PMA factor P (perceptual acuity and speed) or S (space) more than one standard deviation below PMA I.Q.

LANGUAGE PROBLEMS—a discrepancy between verbal and non-verbal subtests on

the PMA or WISC, with the verbal subtests markedly inferior to the non-verbal.

EMOTIONAL PROBLEMS—the following types of emotional problems were identified through the use of behavior checklists and personality tests (Rorschach, TAT, DAP).

Chronic nervous habits—tics; compulsive, persistent mannerisms; thumbsucking; nail-biting; stammering or stuttering; lisping or other infantile articulation defects.

Hyperkinetic symptoms—extremely hyperactive, unable to sit still; marked inability to concentrate, distractible; extremely irritable.

Persistently withdrawn—shy, lack of self-confidence; feelings hurt easily; very unhappy, depressed most of the time; unusual fear or anxiety.

Persistently over-aggressive—acts out problems; constantly quarreling and bul-

lying; overly contrary and stubborn; violent temper; destructive.

PHYSICAL PROBLEMS—the presence of physical health problems was determined by using existing health records and information concerning illnesses and accidents reported by the mother and confirmed by the physician and hospital involved. If additional diagnostic examinations were judged necessary by the panel, referrals were made to appropriate specialists to verify diagnoses.

Of the children in the time sample for whom any defect or health problem was noted, almost three-quarters had problems so minor they interfered little if at all with normal functioning. Most of these were allergies known to be prevalent in Hawaii. Significant physical problems included in our analyses were severe congenital defects: spina bifida, atresias of the intestinal,

TABLE II

PREVALENCE OF SCHOOL ACHIEVEMENT, INTELLECTUAL, EMOTIONAL, OR PHYSICAL PROBLEMS AMONG THE BOYS AND GIRLS IN THE 1955 COHORT
KAUAI, HAWAII, 1965-1966

Type of Problem	Percent with Specified Problem			Results of Chi-square Test†
	Boys (369)	Girls (381)	Total (750)	
Any school achievement problem	51.0	37.0	43.9	$\chi^2 = 14.37^\dagger$
D or F in reading, writing, or math	46.9	33.6	40.1	$\chi^2 = 13.21^\dagger$
one or more grade below CA	13.0	6.0	9.5	$\chi^2 = 10.33^\dagger$
MR class or institution	2.4	2.1	2.3	$\chi^2 = 0.10$
Any intellectual problem	26.0	20.5	23.2	$\chi^2 = 3.12$
I.Q. below 85	11.4	10.0	10.7	$\chi^2 = 0.35$
perceptual problem	11.4	12.6	12.0	$\chi^2 = 0.22$
language problem	9.2	4.7	6.9	$\chi^2 = 5.63^*$
Any emotional problem	30.9	22.0	26.4	$\chi^2 = 7.12^\dagger$
chronic nervous habits	8.4	5.0	6.7	$\chi^2 = 3.39$
hyperkinetic symptoms	8.7	3.2	5.9	$\chi^2 = 10.14^\dagger$
persistently withdrawn	9.5	8.1	8.8	$\chi^2 = 0.41$
persistently overaggressive	7.3	6.8	7.1	$\chi^2 = 0.06$
Significant physical handicap	6.0	6.0	6.0	$\chi^2 = 0.00$

* Significant at the 5% level.

† Significant at the 1% level.

‡ Test of independence for 2×2 contingency tables; presence of problem by sex.

Numbers in parentheses indicate number of subjects studied.

genitourinary and auditory systems, congenital heart anomalies, cleft lip and palate, cerebral palsy, and developmental defects of the central nervous system. Also included were defects involving vision or hearing, hernia, hydrocele, thyroglossal duct, pilonidal sinus, and orthopedic problems. Some substantial handicaps were acquired due to accidents (blindness, organic epilepsy, orthopedic problems), due to infections (hearing loss due to chronic otitis media, uveitis, chronic urinary tract infection, tuberculosis), or to other causes (Legg-Perthe's disease, Letter-Siewe syndrome, hemolytic anemia and severe asthma).

Assessment of Environment at Age 10

Environmental ratings were based on home interviews conducted by two public health nurses and a social worker familiar with the community and trained in the use of a standardized interview. The main purpose of the interview was to obtain information from the family, preferably the mother, pertinent to the quality of the environment in which the child had grown up to age 10. A clinical psychologist rated this information for all children on three dimensions: socioeconomic status, educational stimulation, and emotional support. Ratings were made on a 5-point scale from very favorable (1) to very unfavorable (5). The items on which the ratings were based and the guidelines for scoring appear in Appendix II. The methods used, including a reliability check, were based on a pretest of 75 ten-year olds who were not a part of the study group.

THE SOCIOECONOMIC STATUS rating combined information on father's occupation, income level, steadiness of employment and condition of housing. It was based primarily on father's occupation, which was categorized into five groups: professional (1) semi-professional, proprietor and managerial (2), skilled trade and technical (3), semi-skilled (4), day-labor and unskilled (5). The correlation between SES rating and parental occupation (U.S. Census

Classification) was .67. The 10-year ratings show a downward trend compared with those made at age 2. This can be accounted for by the fact that the 10-year data included more observations than were available at age 2. Most of the shift is the result of including income in terms of plantation pay scales in the SES ratings. This resulted in the classification of most of the semi-skilled occupations in the low bracket. Also, the economy of the island has been depressed in recent years by the closing of many pineapple plantations and canneries.

THE EDUCATIONAL STIMULATION rating took into account the opportunities provided by the home for enlarging vocabulary, the quality of language models available, the educational level of the parents, the intellectual interests and activities, the work habits emphasized in the home, the availability of learning supplies, books, and periodicals, and the opportunity provided to explore various aspects of the larger environment (library use, special lessons, recreational activities). It was based on a rating schedule first utilized by R. Wolf and R. Dave of the University of Chicago in a study of the relationship between environmental process variables and intelligence and achievement of fifth graders in the Midwest reported by Bloom^{28,29} and adapted for the Kauai setting. Reliabilities reported by Wolf for the environmental ratings ranged from .89 to .95.²⁹ Wolf and Dave reported a correlation of .69 between the overall rating of intellectual stimulation in the home and the I.Q.'s of fifth graders and a correlation of .80 with achievement test scores.^{32,33}

While we are aware of the element of subjectivity inherent in these ratings, their demonstrated reliability and usefulness for this age group seemed encouraging enough to warrant their use in our follow-up study.

THE EMOTIONAL SUPPORT rating took into account the information given in the home interview on interpersonal relations between parents and child, opportunities for satisfactory identification, kind and amount

of controls used, and the presence or absence of traumatic experiences. Items concerning methods of discipline, ways of expressing approval, tension, and conflict in the family were included among the interview questions. The items on which the rating was based had been shown to be related to children's cognitive and personality development in the longitudinal studies, (reported by Bloom²⁸) and studies on the relationship between patterns of parent-child interaction and the language development and reading achievement of school-age children.³⁰ Only those items were included in which satisfactory rater-agreement had been demonstrated in previous studies.²⁸

All environmental ratings were made independently of any knowledge of the perinatal score of the children and the results of the 10-year follow-up study. The intercorrelations between the three environmental dimensions ranged from .37 to .57.

For the purpose of this analysis the environmental ratings on each dimension were combined into a condensed scale: "Very high and High" (1, 2), "Medium" (3), and "Low and Very Low" (4, 5).

FINDINGS

Magnitude of Achievement, Intellectual, Emotional, and Physical Problems at age 10

Table II indicates that 40% of the children in the time sample received grades of D or worse in one or several of the basic skills subjects. In each subject (i.e., reading, writing, and arithmetic), better than one fourth of all children had grades of D and about 5% had F's.

Ten percent of the children were in a grade below chronological age and 2.3% were in special classes for the mentally retarded or in institutions. Girls had fewer achievement problems than boys and a

TABLE III

PERCENT OF SCHOOL ACHIEVEMENT, INTELLECTUAL, EMOTIONAL, OR PHYSICAL PROBLEMS AMONG THE CHILDREN IN EACH OF THE PERINATAL STRESS GROUPS
KAUAI, HAWAII, 1965-1966

Type of Problem	Severity of Perinatal Stress				Results of Chi-Square Test†
	None (421)	Mild (233)	Moderate (172)	Severe (36)	
Any school achievement problem	43.7	42.5	43.0	58.3	$\chi^2 = 3.29$
D or F in reading, writing, or math	41.8	38.2	39.5	38.9	$\chi^2 = 0.77$
one or more grade below CA	10.7	7.7	7.6	16.7	$\chi^2 = 4.28$
MR class or institution	1.0	1.7	3.5	16.7	$\chi^2 = 37.59†$
Any intellectual problem	22.6	20.2	29.1	36.1	$\chi^2 = 7.43$
I.Q. below 85	9.7	10.7	9.9	30.6	$\chi^2 = 14.91†$
perceptual problem	12.1	11.2	15.7	16.7	$\chi^2 = 2.50$
language problem	7.1	4.3	8.2	0.0	$\chi^2 = 5.53$
Any emotional problem	24.9	24.9	33.8	27.7	$\chi^2 = 5.34$
chronic nervous habit	7.9	4.3	9.9	11.2	$\chi^2 = 5.66$
hyperkinetic symptoms	5.7	4.4	8.1	8.3	$\chi^2 = 3.04$
persistently withdrawn	8.3	9.1	10.5	2.8	$\chi^2 = 2.37$
persistently overaggressive	7.1	7.3	6.4	5.6	$\chi^2 = 0.25$
Significant physical handicap	5.2	4.7	7.0	22.2	$\chi^2 = 17.73†$

† Significant at the 1% level.

‡ Test of independence for 2×4 contingency tables; presence of problem by perinatal stress. Numbers in parentheses indicate number of subjects studied.

smaller proportion placed in grades below their chronological age.

About 11% of the children had I.Q.'s below 85, i.e., were in the "slow learner" or below average range of intelligence.

About 12% of the children were classified as having perceptual problems on the basis of poor Bender-Gestalt test scores and results of other tests of visual-motor development. Of these perceptual problems two-thirds were serious enough to interfere with school achievement as judged by the panel. No sex differences were apparent at this age.

About 7% of all children had language problems, i.e., verbal subtest scores markedly inferior to non-verbal test scores; almost all were serious enough to interfere with school achievement. Twice as many boys as girls were classified in this category.

About a fourth of all children had some behavior problems; about one out of every six children (17%) had problems severe enough to interfere with school achievement, as judged by the panel. More boys than girls were among them. Sex differences were apparent among the incidences of "chronic nervous symptoms" and "hyperkinetic behavior."

Only about 6% of all children at ages 10 to 11 had significant physical handicaps; 4% were of congenital origin and 2% were acquired.

Perinatal Complications Versus Outcome at Age 10

It can be seen in Table III that the greatest effects of perinatal stress on functioning at age 10 were found in the proportion of children who required placement in special classes or institutions, had I.Q.'s below 85, and had significant physical health problems.

There was a significant difference in mean PMA I.Q.'s between children who had undergone severe perinatal stress (mean I.Q.: 97) and those with moderate (mean I.Q.: 102.5), little, or no stress (mean I.Q.: 103). Significant differences between the perinatal groups were also

found for four individual PMA factor scores: verbal comprehension (V), reasoning (R), perceptual acuity and speed (P), and numerical ability (N). It must be kept in mind, however, that these differences, though statistically significant, amount to only 6 to 7 points for the extreme groups (severe versus no complications).

A somewhat higher percentage of children with severe and moderate perinatal complications had "chronic nervous habits" and "hyperkinetic" symptoms than those with mild or no stress, but the difference was not statistically significant.

We found no significant differences between the perinatal stress groups in the percentage of poor grades received in reading, writing, and arithmetic and in the percentage of children who had language or perceptual problems, except for those placed in institutions. When we controlled for age we found no differences in group Bender-Gestalt error scores between children with and without perinatal stress. Likewise, we found no differences between the perinatal stress groups in the total percentage of behavior problems at age 10.

Quality of Home Environment Versus Outcome at Age 10

Independent ratings of each environmental factor showed significant associations with outcomes at age 10, except for major physical handicaps. Our findings strongly support an admonition recently made by Corah, *et al.*³ in their discussion of their 7-year follow-up of the effects of perinatal anoxia: "Some caution must be employed in generalizing from . . . findings of differences between anoxics and normals . . . when it is possible for such effects to be relegated to secondary position by environmental forces."

SOCIOECONOMIC STATUS: Socioeconomic status showed a significant association with achievement, intellectual, and emotional problems (persistent aggressiveness) among the 10-year-olds on Kauai, as shown in Table IV. The relationship between these outcomes and SES, however, was not as

TABLE IV

PERCENT OF CHILDREN WITH SCHOOL ACHIEVEMENT, INTELLECTUAL, EMOTIONAL, OR PHYSICAL PROBLEMS BY EACH OF THE THREE ENVIRONMENTAL VARIABLES
KAUAI, HAWAII, 1965-1966

Type of Problem	Socioeconomic Status				Educational Stimulation				Emotional Support			
	Very High (83)	Medium (297)	Very Low (482)	Chi-Square Test†	Very High (133)	Medium (381)	Very Low (448)	Chi-Square Test†	Very High (219)	Medium (332)	Very Low (311)	Chi-Square Test†
Any school achievement problem	19.3	32.0	55.4	$\chi^2=62.84^\dagger$	14.3	29.5	61.6	$\chi^2=126.19^\dagger$	30.6	37.6	59.8	$\chi^2=51.59^\dagger$
D or F in reading, writing, or math	18.1	30.3	50.2	$\chi^2=48.54^\dagger$	12.0	28.5	56.0	$\chi^2=104.66^\dagger$	27.8	36.4	53.0	$\chi^2=36.32^\dagger$
one or more grades below CA	2.4	5.4	13.3	$\chi^2=18.41^\dagger$	0.0	3.6	16.1	$\chi^2=47.50^\dagger$	4.6	6.0	16.7	$\chi^2=29.30^\dagger$
MR class or institution	1.2	1.3	3.1	$\chi^2=3.03$	2.2	0.4	3.6	$\chi^2=7.88^*$	1.8	0.3	4.8	$\chi^2=14.80^\dagger$
Any intellectual problem	14.5	16.8	29.7	$\chi^2=20.58^\dagger$	9.8	15.3	33.3	$\chi^2=46.78^\dagger$	16.0	20.2	33.1	$\chi^2=23.97^\dagger$
I. Q. below 85	3.6	6.4	15.2	$\chi^2=19.02^\dagger$	2.3	3.9	18.1	$\chi^2=47.02^\dagger$	4.6	6.6	20.3	$\chi^2=42.33^\dagger$
perceptual problem	7.2	10.1	15.4	$\chi^2=6.76^*$	7.5	8.9	16.7	$\chi^2=13.04^\dagger$	10.5	12.0	15.1	$\chi^2=2.59$
language problem	3.6	3.4	8.5	$\chi^2=9.09^*$	1.5	4.3	8.9	$\chi^2=12.28^\dagger$	3.2	5.1	9.6	$\chi^2=10.10^\dagger$
Any emotional problem	14.5	23.9	30.9	$\chi^2=11.32^\dagger$	14.3	22.8	33.3	$\chi^2=22.01^\dagger$	13.2	20.5	43.4	$\chi^2=70.07^\dagger$
chronic nervous habits	4.8	7.4	7.9	$\chi^2=0.91$	6.8	7.1	7.8	$\chi^2=0.18$	2.7	8.4	9.6	$\chi^2=9.48^\dagger$
hyperkinetic symptoms	7.2	5.0	6.2	$\chi^2=0.69$	3.0	4.3	7.8	$\chi^2=6.13^*$	3.2	5.7	8.0	$\chi^2=5.32$
persistently withdrawn	4.8	7.1	10.4	$\chi^2=4.13$	5.3	8.9	9.6	$\chi^2=2.33$	7.3	4.2	14.5	$\chi^2=21.60^\dagger$
persistently overaggressive	2.4	4.7	9.1	$\chi^2=8.16^*$	1.5	3.2	10.9	$\chi^2=22.73^\dagger$	0.9	3.6	14.8	$\chi^2=46.82^\dagger$
Significant physical handicap	4.8	5.7	6.7	$\chi^2=0.56$	6.0	4.3	7.4	$\chi^2=2.87$	5.5	5.1	7.7	$\chi^2=2.10$

* Significant at the 5% level.

† Significant at the 1% level.

‡ Test of independence for 2×3 contingency tables; presence of problem by environmental rating. Numbers in parentheses indicate number of subjects studied.

pronounced as the association with the other environmental ratings.

Our findings with 10-year-olds on Kauai are consistent with recent findings by Dave and Wolf²⁹ who studied the homes of fifth grade children in a community in the Midwest comprising urban, suburban, and rural areas. Wolf²⁹ reports a correlation of .40 between SES and children's I.Q. at age 10, but he finds a correlation of .69 between ratings of educational stimulation in the home and children's I.Q.'s. Dave³³ reports a lower correlation between SES and fifth grade achievement (.50) than between ratings of educational stimulation and achievement test scores (.80).

Both the Dave and Wolf studies^{29,32,33} and ours were done within a normal range of home environments rather than among extreme conditions. A general index of social status or economic well-being may be a less sensitive indicator of the qualities of the home that have a lasting effect on children's cognitive or personality development than the intellectual stimulation and the emotional support given.

As in the 2-year follow-up, socioeconomic status did not differentiate among children with major physical handicaps. The lack of a consistently unfavorable effect due to low socioeconomic status may be explained by the fact that financial means did not keep Kauai parents and children from access to excellent medical and public health facilities close at hand.

EDUCATIONAL STIMULATION: The educational stimulation received in the home differentiated better than the other environmental dimensions between children with and without achievement problems, I.Q.'s below 85, language, and perceptual problems. This is in agreement with recent findings reviewed by Bloom²⁸ and Freeberg and Payne,³⁰ that parental stimuli to the development of language skills may well be one of the most important variables in the effect of the home environment on children's cognitive development.

Of the children on Kauai whose homes were rated "high" and "very high" in educa-

tional stimulation (on the basis of opportunities provided for enlarging the child's vocabulary, availability of books, intellectual leisure-time activities, and encouragement of disciplined work habits), only 14% (9) had achievement problems in school. In contrast to this, 62% (276) of the children in whose homes few or none of these opportunities were available had difficulties with the basic skill subjects in school. Only 21 of the 378 children who had poor grades or were in special classes came from the group with severe perinatal complications.

Only about 2% (3) of the children from homes rated "high" and "very high" in educational stimulation had I.Q.'s below 85, in contrast to 18% (80) of the children from homes with "low" and "very low" educational stimulation. Only 11 out of the 94 children with I.Q.'s below 85 had undergone severe perinatal stress.

Only 1.5% (2) of the children from homes with "high" and "very high" educational stimulation had language problems, in contrast to 9% (40) of those coming from homes with "low" and "very low" educational stimulation.

Among children from homes rated "low" and "very low" in educational stimulation, the proportion of perceptual problems was more than twice as high (16.7%) as among those from homes with "high" and "very high" educational ratings (7.5%).

The majority of children with language problems (40 of 54) and the majority of children with perceptual problems (75 of 110) came from homes rated "low" and "very low" in educational stimulation.

EMOTIONAL SUPPORT: Ratings of emotional support in the home differentiated better than the other environmental dimensions between children with and without behavior problems.

About 13% (29) of the children from homes rated "high" in emotional support (stable home, parents present, sharing activities with children, express approval of child, and reasoning used for discipline) were judged to have some behavior problems; about half of these had problems seri-

TABLE V

10-YEAR MEAN PMA I.Q. SCORES AND STANDARD DEVIATIONS FOR EACH OF THE THREE ENVIRONMENTAL VARIABLES BY SEVERITY OF PERINATAL STRESS
KAUAI, HAWAII, 1965-1966

<i>Environmental Variable</i>	<i>Severity of Perinatal Stress</i>				<i>Results of 2-way Analysis of Variance*</i>	
	<i>None</i>	<i>Mild</i>	<i>Moderate</i>	<i>Severe</i>		
Socioeconomic status						
very high and high	112 (11)	113 (12)	114 (11)	110 (1)	S	F=26.04†
medium	108 (12)	106 (13)	105 (12)	101 (13)	P	F= 2.03
very low and low	99 (11)	100 (11)	99 (12)	94 (14)	S×P	F= 0.21
Educational stimulation						
very high and high	115 (10)	114 (10)	112 (12)	114 (7)	ED	F=49.22†
medium	105 (11)	109 (11)	106 (11)	106 (7)	P	F= 0.87
very low and low	98 (11)	98 (11)	97 (12)	92 (13)	ED×P	F= 0.65
Emotional support						
very high and high	108 (12)	107 (11)	105 (12)	100 (13)	EM	F=28.04†
medium	105 (11)	106 (12)	105 (11)	104 (10)	P	F= 6.67†
very low and low	98 (11)	99 (12)	97 (15)	86 (11)	EM×P	F= 1.76

* Symbols used to designate variables analyzed are: (S) socioeconomic status, (ED) educational stimulation, (EM) emotional support, and (P) perinatal stress.

† Significant at the 1% level.

Numbers in parentheses are standard deviations.

ous enough to interfere with school achievement. In contrast to this, 43% (135) of the children from homes with "low" emotional support had some behavior problem and two thirds of these children had behavior problems serious enough to interfere with school achievement.

The majority of all children with emotional problems grew up in an unfavorable environment. Only 10 of the 231 children with emotional problems came from the group with the most serious perinatal complications

Effect of Perinatal Stress and Environmental Factors on PMA

When we look at the PMA I.Q. distribution by both degree of perinatal stress and amount of educational stimulation, it is quite apparent that the differences in mean I.Q.'s between children born into and growing up in the most and least favorable home environments is much larger than that between children from the most and

the least severely stressed perinatal groups.

At age 10, perinatal stress accounts for much less of the variance in PMA I.Q. scores than the quality of the environment. The effect of environmental deprivation is much more powerful than was apparent at age 20 months, even with the children who had no perinatal complications (Table V).

For example, at age 20 months we found only a 4 point difference in mean Cattell I.Q. between children from the least and the most favorably rated environments who were free of perinatal complications. At age 10, the difference in mean PMA I.Q. scores between children with favorable and unfavorable environmental ratings, but without perinatal stress had increased considerably, with the most pronounced differences apparent on educational stimulation rating.

Except for the institutionalized, the children with severe perinatal stress who had grown up in homes rated "high" in educational stimulation did not differ from children without perinatal stress who were

raised in homes with favorable educational stimulation. Both groups achieved mean PMA I.Q. scores well above the average at age 10. The mean difference in PMA I.Q. between children with severe perinatal stress coming from homes rated "high" and from homes rated "low" in educational stimulation was much larger.

The relationship of the "emotional support" ratings of the home to children's PMA I.Q.'s at age 10 is not as strong as the association between educational stimulation in the home and intelligence test scores of the children. Similar findings have been reported in several studies of parental attitudes and achievement motivation (as revised by Freeberg and Payne).³⁰ Their ratings of child-mother interaction in the home were related to changes in I.Q. scores from the preschool to the elementary school years. They found that high achieving children were less dependent upon their mothers for emotional support and that mothers of children whose I.Q.'s increased from the preschool to the elementary school years showed less affection and were less protective but stressed acceleration more.

COMMENT

From the results of our analysis of the relative contribution of perinatal stress and quality of environment to children's problems at school age, we conclude that the concern with a continuum of "reproductive casualties" needs to be complemented by a much greater concern with the "environmental casualties." The largest group of sufferers at school age are not the children who endured perinatal complications, but the children of *The Other America* Michael Harrington wrote about so movingly.³¹

The gradient of retarded physical, intellectual, and social development that appeared with increase in severity of perinatal complications at age 2 has pretty much "washed out" by age 10, except for a residue of the most severely stressed children. The remainder of the children who had undergone severe and moderate perinatal

stress survived the first decade of their lives with amazing resiliency and flourished if they were born into and grew up in homes with some educational stimulation and emotional support. The study children who contributed the overwhelming number of problems in school failure, stunted intellectual growth, and emotional immaturity had little or no perinatal stress, but they have had to cope with a world lacking either in material opportunities, intellectual stimulation, or emotional support.

We are aware of the need for caution in the use of environmental ratings. However, our results are quite consistent with recent findings by Bloom²⁸ that demonstrated the effects of educational stimulation in the home on children's intelligence and achievement and with the findings reviewed by Freeberg and Payne³⁰ of the nature of parental influence on cognitive and personality development in early childhood. In spite of the somewhat different criteria used for assessing the quality of the environment at ages 2 and 10, similar strong associations were found between the poor family environment and unfavorable outcomes. By age 10 the effect is seen to handicap the child in meeting the great demands of the school years.

On the positive side of the picture, we can say that at age 10 the majority of the children who survived severe perinatal stress are in regular school and doing satisfactorily. These children, recently the focus of a number of retrospective and prospective studies, seem to have responded well to the concern of their parents and the medical and allied professions who rallied to their support. They are, however, a minority of the children who really need help.

While the gap between the development of the perinatal "casualties" and their normal age peers has narrowed as a result of progress in medicine, the gap between the majority of the children of poor, uneducated, or emotionally confused parents and the children from "favorable" homes has increased with respect to I.Q. scores, in retarded or warped emotional and social de-

velopment, and in their lack of basic communications skills so essential for survival in a technological society.

INFERENCES

What is needed to help these children is a new outlook among the helping professions that requires not only additional studies of perinatal complications, nor duplication of special services for the already well tended "middle class" child, but also a willingness to change old habits of diagnosis and remediation. What is needed are multi-disciplinary screening centers that can spot early the children who have the greatest risk of becoming developmental failures. Not only does this include children with bad birth histories but also those born into homes with little educational stimulation, emotional support, and material advantages. Communities must find ways to provide the essential learning experiences and emotional support for these children while there is still time for them to develop their potential and avoid irreparable damage. What is needed for the majority of children who have problems in school are not further "diagnostic" studies by the already overworked professionals, but the expenditure of some time and interest by adults, whether professional or volunteer tutors, who care enough to help these youngsters overcome a basic skill problem, to capture the joy in learning, to gain self-confidence, to have an adult model worth emulating.

In our recent concern with providing health and educational services for underprivileged preschool children through Head Start, we should not forget the many children in the lower elementary grades whose problems could still be remedied by relatively short-term intervention before a deep sense of failure and frustration has settled on them as they enter adolescence and adulthood devoid of self-confidence and hope because they know only failure.

SUMMARY

The effects of perinatal complications and quality of environment were studied on

the island of Kauai in a cohort of 1955 births and in a selected sample of 1956 births with moderate and severe perinatal stress. The 10-year follow-up of the 866 children used information provided by records, teachers, and group tests as a screening device and added to it diagnostic examinations by psychologists, neurologists, pediatricians, and allied disciplines.

The quality of the home environment was determined through information provided in a home interview and rated on three dimensions: socioeconomic status, educational stimulation, and emotional support. The diagnosis of achievement, intellectual, behavior, and physical problems, and the environmental ratings were made independently from each other and without any knowledge of the children's perinatal score.

Differences found between children with and without perinatal complications were less pronounced than at age 2 and centered on a small group of survivors of severe perinatal stress. These children had a significantly higher proportion of major physical handicaps, predominantly of the central nervous and sensory systems, and a higher proportion of I.Q.'s below 85 and of placement in special classes and institutions. They also had significantly lower mean scores on the verbal comprehension, reasoning, perceptual, and numerical factors of the Primary Mental Abilities test.

However, no differences were found between children with and without perinatal complications in the proportion of poor grades obtained in basic skill subjects (reading, writing, and arithmetic) and in the incidence of language, perceptual, and behavior problems, aside from those children who were in institutions.

Environmental ratings on all three dimensions showed a significant association with achievement, intellectual, and emotional problems at age 10. The overwhelming number of children with problems at age 10 had relatively little or no perinatal stress, but they had grown up in homes low in socioeconomic status, educational stimu-

lation, and emotional support. More than 10 times as many children were affected by deprived environment than by severe perinatal stress, indicating the need to refocus the emphasis about diagnosis and remediation from "reproductive casualties" to the "environmental casualties."

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APPENDIX I

Table I presents a summary of findings of prospective studies in which children with perinatal complications have been followed through school-age. Included are only studies which have used as controls children of the same age born without perinatal complications. Excluded from the summary are prospective studies limited to the development of prematures, such as Knobloch and Pasamanick's and Drillien's investigations.^{9,10}

The function that has been most frequently measured in 12 prospective studies of children with perinatal complications has been general intelligence. Whether or not impairment was found by an investigator seemed to depend on the age range tested, the control of socioeconomic variables, the completeness of the follow-up sample, and the type of intelligence test used. Five studies which used individual intelligence tests, had complete follow-up samples, and were controlled for the effect of the environment showed a 4 to 12 point deficit in mean I.Q., a greater incidence of below average I.Q.'s, and a greater variability in I.Q.'s of children with perinatal complications.^{5,11-14}

Five of eight follow-up studies of children with perinatal complications reported problems in emotional and social development for children who have undergone perinatal complications, ranging from ratings of maladjustment to anxiety, immaturity, emotional lability, nervousness and negativistic behavior observed in the home, in school, and in the clinic.^{3,12,14-16} Age ranges studied were fairly wide (about 3-19) and, with the exception of one study,³ little information was available on the intelligence level of the children and the quality of the environment they grew up in. Most samples were drawn from clinic populations.

Five investigators^{3,5,12,17,18} evaluated the perceptual-motor abilities of school-age children with perinatal complications and compared them with normal controls on visual-motor tests, tests of perceptual attention, and figure-ground tests. In three studies^{3,5,7} where the age range was relatively narrow and the effect of maturation on perceptual ability was controlled, significant impairment was found among school-age children with perinatal complications. The two prospective studies in which children with perinatal complications were followed in both earlier and later childhood report visual-motor impairment only in the later follow-ups.^{3,5}

Three studies each evaluated the gross motor coordination and the neurological status of school-age children with perinatal complications. Results are ambiguous, with one study each reporting positive findings,¹⁷ one negative findings,¹⁸ and one questionable findings.³ These studies reflect the difficulty of finding reliable and well standardized instruments that detect minimal impairment rather than gross deficit. They also indicate the need to control for age.

The ability to conceptualize, to classify words or objects into abstract categories, has been investigated in only two prospective studies, but it seems to be a promising area of investigation. Significant deficits in abstracting ability were found among 7 and 8 year olds with perinatal complications.^{3,5}

In contrast to Kawi and Pasamanick's²⁰ retrospective findings of a relationship between reading disorders and perinatal complications, the results of two prospective studies have been ambiguous, possibly because of the young age of the children studied.^{3,17} This area, an important one for school achievement, needs to be more systematically explored.

The five prospective studies which find no significant impairment among school-age children with perinatal complications tend to cover a wide age range and report considerable sample loss in their follow-up.^{18,19,21-23}

APPENDIX II

Items in family interview used in arriving at environmental ratings in the 10-year follow-up study.

Items 1, 2, 3, 4, and 30 provide the basis for the socioeconomic status rating.

Items 5-14 provide the basis for the educational stimulation rating.

Items 3, 4, 15-18, 20-29 provide the basis for the emotional support rating.

1. Father's occupation; level.
2. Father's employer.
3. Has the father worked steadily since _____ was born? If no, why not? For how long not employed? When?
4. Has the mother worked outside the home since _____ was born? If yes, full time or part time? When? Who took care of the child?
5. Father's education (last grade of regular school completed). Did he go to high school on Kauai? Was all schooling received outside U.S.?
6. Mother's education (last grade of regular school completed). Did she go to high school on Kauai? Was all schooling received outside U.S.?
7. Is English the usual language spoken in your home? Is another language also spoken? Did _____ learn to understand this language? To speak it? To what extent do your children speak pidgin at home? To what extent do you or your husband speak pidgin at home?
8. Did someone often read books to this child before he entered school? Who?
9. Does _____ often read books or magazines other than those required by the school?
10. What kinds of things do you read? Specify.
11. What kinds of things does your husband (wife) read? Specify.
12. Does _____ have outside interests, such as lessons, group activities, hobbies? If so, list.
13. Does he have homework? If so, does he

usually complete it? Where does he do his homework (describe conditions)?

14. Do you and your husband (wife) discuss with each other _____'s school work? If yes, explain.

15. Is _____ given responsibility for doing certain things? If so, what?

16. Does _____ have several friends his own age? If not, explain.

17. Are there adults outside the family _____ likes to be with? If so, who?

18. Have any of the following things happened to your family in the last 10 years? Indicate by inclusive dates. a. Separation from spouse? b. Desertion of spouse? c. Death of spouse? d. Divorce? e. Remarriage? f. Serious illness? g. Hospitalization (long or frequent)? h. Serious worries? i. Drinking problem? j. Frequent quarrels? k. Other?

19. Have you used the services of any social agency since this child was born? If so, which, and inclusive dates and reason.

20. Do you do things together as a family? If so, what?

21. Do you and _____ do things together? If so, give examples.

22. Does your husband (wife) and _____ do things together? If so, give examples.

23. Does _____ talk about his activities or problems with you? If so, give examples.

24. Does _____ talk about his activities or problems with his father (mother)? If so, give examples.

25. What are some of the things _____ does that please you? Specify.

26. How do you let him (her) know that you are pleased? How does the father (mother) let him (her) know when he (she) is pleased?

27. Is this child easy to manage? Explain.

28. Do you and your spouse have difficulty in agreeing on how to manage this child? Explain.

29. Does _____ usually do what you tell him to do? If he does not, how do you try to make him mind?

30. House (circle); poor (crowded, bare necessities); average (adequate room and equipment); good (plenty of room, well equipped).