12 The Relationship Between Children's Health and Intellectual Development

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The focus of this paper is on functional health status of children in the population. More specifically, we examine a single aspect of functional health status--intellectual development of children.* In a multivariate context, we examine the relationships between the health indexes and cognitive development of children from six to 11 years of age in Cycle II of the U.S. Health Examination Survey (HES). We present the first set of such estimates for a representative sample of non-institutionalized white children in the United States. We compare them with existing findings for underdeveloped countries, Great Britain, and low income families in the United States.

In choosing to study intellectual development, we are adopting the view (similar to Haggerty and others, 1975; Mushkin 1977) that the benefits from investments in children's health should not be restricted to the usual narrow list of increases in longevity, decreases in morbidity, and reductions in curative medical care outlays. Indeed, we have come to believe that enhanced intellectual development is an important source of benefits from investments in children's health. While our results do not themselves provide sufficient information for a full cost-benefit analysis of expenditures on child health, they do contain policy-relevant insights about potential benefits in terms of "physical" (cognitive development) units.

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* For a partial survey of the literature on relationships among earnings, schooling, health, and intelligence of adults and children, see Grossman (1975).

I. ANALYTICAL FRAMEWORK AND CURRENT LITERATURE

Whenever decision makers, such as firms or households, must allocate scarce resources among competing goals, economists can provide useful insights into their behavior. Parent-child relationships clearly involve such allocation. While it is not easy to define what is meant by the "well-being" of children, factors such as their health, intelligence, school performance, school attainment, social behavior, and lifetime earnings undoubtedly play an important role. To enhance any of these components of children's welfare, parents must allocate to their children some part of their own limited resources--their own time or goods and services purchased in the market.

Our analytical framework is based on two propositions. One is the above notion that parents must allocate scarce resources between a child's well-being (the child's life "quality") and other competing goals. These competing goals include not only the parents' own consumption, but also the consumption of other children in the family. This framework builds upon the important distinction between the quantity and "quality" of children that is stressed in much of the literature on the economics of fertility and optimum family size (for example, Becker and Lewis, 1973; Willis, 1973; O'Hara, 1975). The second proposition, embedded in the household production function approach to consumer behavior, is that consumers produce their basic objects of choice with their own time and inputs of goods and services purchased in the market (Becker, 1965; Lancaster, 1966; Muth, 1966). This insight is of particular relevance in dealing with children's health and cognitive development because parents do not buy these objects of choice directly in the market.

Cognitive development of children can be perceived by applying a multivariate production function. This production function would involve such factors as time inputs of the child and of his parents and teachers; the child's genetic endowment; his current and past health; and various aspects of the child's school and home environment, the latter shaped to a large extent by parents. For example, it has been suggested that an increase in parents' schooling (one important aspect of the home environment) makes parents more efficient in the transmission of knowledge to their children (see Grossman, 1975, 1972; Leibowitz, 1974; Michael, 1972). The production function of cognitive development interacts with parents' income and their preferences at various prices to determine the level of cognitive development of each of their children.

With regard to the specific role of children's health in the above framework, it is widely recognized that poor health can pose a threat to the cognitive development of children (Wallace, 1962; Birch and Gussow, 1970). Health problems can limit the amount of information acquired in the home and in school by reducing the amount of time available to acquire such information, as well as by reducing the amount acquired in a given period of time. Ultimately, intelligence, years of formal schooling completed, earnings, and other measures of well-being in adulthood can be affected by poor health in childhood. Yet the empirical work in this area is sparse. In fact, Birch and Gussow (1970), whose book focuses on the effects of health on learning, point out that most of the evidence they bring to bear on the issue is indirect because "...there has been little investigation of the specific relationships between the physical status of poor children and either their mental development or their school achievement" (p. 10). In the rest of this section, we highlight the literature that suggests a relationship between various aspects of children's health and their cognitive development. The studies cited here, as well as others, are discussed in greater detail in section III.

Most of the literature relating health to the intellectual development of children focuses on the effects of malnutrition. Pediatricians argue that malnutrition in early childhood can inhibit intellectual development because a brain growth spurt occurs in the first two years of human life, during which time the interneural network is formed (Scrimshaw and Gordon, 1968; Lewin, 1975). Deficient diets at this time can slow the spurt and thereby permanently affect intellectual development. Since early brain growth is largely a process of protein synthesis, a diet that is deficient in this nutrient may be especially damaging. In fact, a number of studies in underdeveloped and developing economies show that children who were severely malnourished in infancy have below average mental capacity (as measured by intelligence quotient (IQ) or similar tests), language proficiency, school performance, and adaptive capacity at subsequent ages (Scrimshaw and Gordon, 1968; Birch and Gussow, 1970; Correa, 1975; Stoch and Smythe, 1976). Moreover, members of the malnourished group tend to be shorter and thinner and to have smaller head circumferences than their well-nourished peers, sometimes even after having recovered from the spell of malnutrition. Richardson (1976) and others caution, however, that conclusions drawn from these studies are suggestive, rather than definitive, because malnourished children grow up in an environment with a substantial number of obstacles besides inadequate nutrient intake that could slow intellectual growth.

Mild or moderate malnutrition in school age children has been less frequently studied and has less dramatic effects. It has been associated with poor judgment, inattention, and a heightened risk of illness, all of which might ultimately affect intellectual development (Birch and Gussow, 1970; Heller and Drake, 1976; Popkin and Lim-Ybanez, 1977). These findings are especially relevant for the United States because, while we do not experience much severe malnutrition, researchers still report substantial variations in nutritional adequacy (Christakis, 1968; Center for Disease Control, 1972; Acosta, 1974; Driskel and Price, 1974; Owen, 1974; Sims and Morris, 1974; Endozien and others, 1976).

The relationship between intellectual development and other dimensions of children's health is documented in a variety of studies. Birch and Gussow (1970) reviewed the evidence that low birth weight and prematurity can have detrimental effects on the later intellectual development of children. Wallace (1962) and Kessner (1974) mentioned a few small studies that relate health problems, such as hearing loss, to poor school achievement. Haggerty, Roghmann, and Pless (1975) discussed the impact of chronic conditions on school attendance and performance in a sample of Rochester, New York children (but reached few definitive conclusions). Leveson, Ullman, and Wassall (1969) cited a number of studies indicating that about five to seven percent of persons dropping out of high school in the United States have done so primarily because of illness. Grossman (1975) found that the self-rated status of students during years of high school attendance has a positive effect on years of college completed. Cooney (1977) summarized evidence tentatively suggesting that deficient intellectual development due to poor health might lead, ultimately, to juvenile delinquency and other forms of deviant behavior. In sum, these studies strongly suggest the existence of positive effects of good health and nutrition on intellectual development.

In the above brief review of the literature, we have repeatedly used the phrase "effect of health on intellectual development"; further, in section III we employ health measures as independent variables in ordinary least squares multiple regressions with IQ or school achievement as the dependent variable. Yet it would be a mistake to interpret the findings that we have mentioned in this section, or the statistically significant health effects that we report in section III, as indisputable evidence of causal relationships running from health to cognitive development. There are at least three plausible alternative interpretations. (1) Our statistical results might partially reflect causality that runs from cognitive development to health. For example, Miller (1974) reports a negative correlation between intelligence and accidents, a major cause of morbidity and mortality in children, in his study of children in Newcastle Upon Tyne, England. He interprets IQ as the causal agent in this correlation. (2) Statistically significant effects of health on IQ might be due to the omission from the regression analysis of genetic and environmental factors that are common to both health and cognitive development (although in our work we try to control for as many of these as possible). (3) Certain relationships that we report might not partially or even totally reflect health effects at all. To cite one illustration, breast-feeding might foster the development of the brain and the central nervous system and reduce the risk of illness, thus promoting intellectual development during the first year of life.* On the other hand, breast-feeding might simply serve as a proxy measure of both the amount of time mothers spend with their children and families' preferences for children.

It would also be a mistake to interpret the findings in this section solely on the basis of environmental effect as opposed to genetic effect. Without becoming involved in the controversy concerning the relative importance of heredity and environment in the determination of IQ, we wish to point out that our health indexes have both genetic and environmental components. For instance, part of the variation in birth weight can be attributed to a woman's knowledge of appropriate practices during pregnancy and to the amount and quality of the prenatal care she receives, while part of the variation is genetic. In addition, genetic differences may induce environmental changes. That is, parents may respond to the inherited characteristics of children by either compensating or reinforcing the effects of a favorable or unfavorable inheritance.** In the empirical work reported below, we make only a modest effort to sort out the separate effects of heredity and environment. Nevertheless, as long as some portion of the variability in our health indexes and IQ measures can be attributed to environmental influences, our findings will have relevance for public policy. Bloom's (1964) penetrating survey of studies of the development of various human characteristics provides a compelling reason to believe that the relationships we uncover are not solely genetic, but reflect environmental influences as well. Bloom also points out that the development of IQ and achievement occurs early in the life cycle, but he summarizes evidence that suggests that 50 percent of the development of IQ measured at age 17 takes place after age four, while 67 percent of the development of general achievement measured at age 18 takes place after age six.

In summary, the aim of our empirical research is to uncover significant health-IQ and health-achievement relationships rather than to establish causality or to provide definitive interpretations of these relationships. We adopt this strategy because none of our techniques represents a controlled experiment and because we lack knowledge about the underlying structure that generates the sample observations. The causal nature of the relationships that we uncover can be established by other persons with different samples and methods. However, our findings can serve as a useful first step in an assessment of government policies with respect to

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* See section III for references.

** For more detailed discussions of the effects of endowments on optimal investments in children by parents, see Becker and Tomes (1976) and Edwards and Grossman (1977).

children. Our task is to fill a gap in the existing literature by documenting relationships, in a multivariate context, between health and cognitive development for a representative sample of white children in the United States.

II. DATA AND MEASUREMENT OF VARIABLES

The Data Set

As mentioned before, our data set is Cycle II of the HES conducted by the National Center for Health Statistics (NCHS, 1967a). Cycle II is a nationally representative sample of 7,119 non-institutionalized children aged six to 11 years, examined over the 1963-65 period.* This sample is an exceptionally rich source of information about children's health, their intellectual development, and the characteristics of their families. More specifically, the data comprise each child's complete medical and developmental histories provided by the parent, birth certificate facts, information on family socioeconomic characteristics, and a school report with information on current school performance and classroom behavior provided by teachers or other school officials. Most important, there are objective measures of health from detailed physical examinations, and there are also scores on psychological (including vocabulary and achievement) tests. The physical examinations and the psychological tests were administered by the Public Health Service.

Although the sample contains children of all races, we restrict our analysis to white children only. This procedure allows us to avoid the problem associated with potential "cultural biases" in IQ and achievement tests. These biases could also be dealt with by separately analyzing the data for white and black children. (Indeed, in preliminary estimation, there were statistically significant racial differences in the set of variable coefficients so that separate estimates by race would be called for in any case.) Separate analysis is not undertaken for blacks, however, because the black sample is too small to permit reliable coefficient estimates. The full Cycle II sample contains 6,100 whites, 987 blacks, and 32 "others."

Our sample is further limited by excluding children who do not live with both of their natural or adoptive parents or for whom there were missing data. (Information most typically absent were birth weight, school absenteeism, and income, with a disproportionate number of missing data from families where a foreign language is spoken in the home.)

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* For a full description of the sample, the sampling technique, and the data collection, see NCHS (1967a).

Children who live with foster parents, stepparents, guardians, or single, widowed, or divorced parents are excluded to control for the effects of marital instability. Examination of the excluded observations indicates that they have lower IQ and achievement scores and poorer health. Thus, our final sample of 3,599 children may be regarded as an advantaged subgroup of the Cycle II data set. Regression results are reported for boys and girls pooled because coefficient estimates were not found to differ significantly by sex.

The IQ, achievement, and health variables are defined in table 1. Means and standard deviations of these variables are shown in Appendix table A-2.

Measures of Health

The issue of how to measure children's health is very much an unresolved one, even among professionals in the area of public health.* Recent studies of children's health in the United States have used data taken from one or more of the following categories: measures of disability, measures related to the incidence of abnormal conditions, and measures derived from parental assessments of children's health (Wallace, 1962; Mechanic, 1964; Mindlin and Lobach, 1971; Talbot and others, 1971; Kaplan and others, 1972; Hu, 1973; Schack and Starfield, 1973; Kessner, 1974; Haggerty and others, 1975; Inman, 1976). Although we followed the precedent of these earlier studies, some of the above measures (disability and the incidence of certain physical conditions) are not entirely appropriate because we wanted measures of the child's "permanent" state of health (his prospect for life preservation and normal functioning) rather than short-run deviations from that permanent state. Much childhood disability results from the natural sequence of childhood diseases and acute conditions that do not reflect on the child's permanent state of health. Of course, there is a positive correlation between the two in the sense that a child with poor permanent health is more likely to contract acute conditions and to have them for a more extended time period.**

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* This is true not only for children's health, but also for adult's health. Sullivan (1966), Berg (1973), and Ware (1976) discuss the general issue of measuring health; and Starfield (1975) and Schack and Starfield (1973) focus on the specific problem of measuring children's health.

** Birch and Gussow (1970) discuss how nutrition (clearly a determinant of permanent health status) and disease are intimately related.

Table 1. Definition of Health Variables and Cognitive Development.

Variable name	Definition	Source a/
A. Cognitive development		
WISC	Child's IQ as measured by vocabulary and block design of the Wechsler Intelligence Scale for Children, standardized by the mean and standard deviation of four-month age cohorts	4
WRAT	Child's school achievement as measured by the reading and arithmetic subtests of the Wide Range Achievement Test, standardized by the mean and standard deviation of six-month age cohorts	4
B. Past health		
LIGHT1	Dummy variable that equals one if child's birth weight was under 2,000 grams (4.4 pounds)	2
LIGHT2	Dummy variable that equals one if child's birth weight was equal to or greater than 2,000 grams but under 2,500 grams (5.5 pounds)	2
BFED	Dummy variable that equals one if the child was breast-fed	1
LMAG	Dummy variable that equals one if the mother was less than 20 years old at birth of child	1
HMAG35	Dummy variable that equals one if the mother was more than 35 years old at birth of child	1
HMAG40	Dummy variable that equals one if the mother was 40 years old or more at birth of child	1

Table 1. Definition of Health Variables and Cognitive Development. (Continued)

Variable name	Definition	Source a/
FYPH	Dummy variable that equals one if parental assessment of child's health at one year was poor or fair, and zero if it was good	1
C. Current health		
SEEG	Dummy variable that equals one if uncorrected binocular distance is abnormal and child usually wears glasses	3,1
NSEEG	Dummy variable that equals one if uncorrected binocular distance vision is normal and child usually wears glasses	3,1
NRMAL	Dummy variable that equals one if uncorrected binocular distance vision is normal and child does not wear glasses	3,1
IHEAR	Dummy variable that equals one if hearing is abnormal	3
ABN	Dummy variable that equals one if physician finds a "significant abnormality" in examining the child (other than an abnormality resulting from an accident or injury)	
IHEIGHT	Height, standardized by the mean and standard deviation of one-year age-sex cohorts	3
IWEIGHT	Weight, standardized by the mean and standard deviation of one-year age-sex cohorts	3
IDECAY	Number of decayed primary and permanent teeth, standardized by the mean and standard deviation of one-year age-sex cohorts	3

Table 1. Definition of Health Variables and Cognitive Development. (Continued)

Variable name	Definition	Source a/
PFHEALTH	Dummy variable that equals one if parental assessment of child's health is poor or fair and zero if assessment is good or very good	1
PFGHEALTH	Dummy variable that equals one if parental assessment of child's health is poor, fair, or good and zero if assessment is very good	1
ACC	Dummy variable that equals one if parent reported that the child had one or more accidents from infancy to the present	1
SCHABS	Dummy variable that equals one if child has been excessively absent from school for health reasons during the past six months	5
D. Alternative current health and current weight measures		
TALL	Dummy variable that equals one if child's height is greater than two standard deviations above the mean for the relevant age-sex cohort	3
SHORT	Dummy variable that equals one if child's height is two standard deviations or more below the mean for the relevant age-sex cohort	3
FAT	Dummy variable that equals one if child's weight is greater than two standard deviations above the mean for the relevant age-sex cohort	3
THIN	Dummy variable that equals one if child's weight is two standard deviations or more below the mean for the relevant age-sex cohort	3

a/ The sources are 1 = medical history form completed by parent, 2 = birth certificate, 3 = physical examination, 4 = psychological examination, 5 = school form.

In some situations, a single overall health index might be desired--to parsimoniously describe the health status of a population, or to provide a guide for the allocation of public funds, for example. However, use of a single health index in this study would conceal, rather than reveal, a number of important associations of special policy relevance. This is because the various components of health that we studied (described below) reflect different dimensions of overall health status, and there is no reason to believe that these components of health status all interact with IQ and achievement in exactly the same way.

A total of 13 dimensions are used as descriptive of health status and these are represented by 19 health variables. These variables are defined precisely in table 1. They are divided into two subsets: a set of past health measures and a set of current health measures. Past health measures refer to the child's health prior to the health examination survey (they relate primarily to the child's infancy), while the current measures refer to health at the time of the examination. Some of these variables are self-explanatory and some are further clarified below:

(1) Breast-feeding contributes to the nutritional status of infants and, therefore, is used as an index of early nutrition (see, for example, Mata, 1978). In addition, infants receive from their mothers' milk antibodies that help protect them from acute illnesses during infancy. Whether or not the child was breast-fed is denoted by the dummy variable MBFED.

(2) Mother's age at the time of birth, represented by three dummy variables (LMAG, HMAG35, and HMAG40), is considered a measure of health in infancy because relatively older mothers have been found to have a greater frequency of infants in poor health, while relatively younger mothers, though they may be in better physical health, are more likely to have unwanted conceptions and consequently seek less prenatal care.

(3) Uncorrected binocular distance vision is defined as abnormal if it is worse than 20/30 (NCHS, 1972a). All children were examined <u>without</u> glasses. Therefore, the vision variables (SEEG, NSEEG, NRMAL) distinguish four categories of children: those with abnormal vision who wear glasses (SEEG), those with normal vision who wear glasses (NSEEG), those with normal vision who do not wear glasses (NRMAL), and those with abnormal vision who do not wear glasses (the omitted category).

(4) A child is defined as having abnormal hearing (denoted IHEAR) if, in his best ear, the average threshold decibel reading over the range of 500, 1,000, and 2,000 cycles per second (cps) is greater than 15. These are the

frequencies that occur most frequently in normal speech. A threshold of less than 15 decibels above audiometric zero at these frequencies is classified as corresponding to "no significant difficulty with faint speech" by the Committee on Conservation of Hearing of the American Academy of Ophthalmology and Otolaryngology (NCHS, 1970a).

(5) "Significant abnormalities" reported by the examining physician include heart disease (congenital or acquired); neurological; muscular, or joint conditions; other congenital abnormalities; and other major diseases. The presence of one or more of these abnormalities is denoted by the variable ABN.

(6) Current height and weight are standard indicators of children's nutritional status (for example, NCHS, 1970b, 1975; Seoane and Latham, 1971); and good nutrition is an obvious and natural vehicle for maintaining children's health. It is well-known that physical growth rates differ by age and sex. Therefore, for any observation, our height variable (denoted IHEIGHT) is the difference between the child's actual height and the mean height for his age-sex group divided by the standard deviation of height for that age-sex group. Current weight (denoted IWEIGHT) is computed in a similar manner. The use of the variables IHEIGHT and IWEIGHT is consistent with the view that the relationships among nutrition, IQ, and achievement are continuous ones; these variables make our results comparable with those of several other studies discussed in section III. We do, however, show how the estimated effects are altered when discrete height and weight dummy variables (TALL, SHORT, FAT, THIN) replace the continuous variables. An advantage of using the discrete forms of these variables is that it allows for non-monotonic relationships between height or weight and IQ.

(7) The number of decayed permanent and primary teeth (denoted IDECAY), adjusted for age and sex, as are height and weight, is interpreted as an additional measure of nutrition and a correlate of basic components of health that affect cognitive development but are difficult to measure.

Measures of Cognitive Development

In relating health indexes to cognitive development, two measures are used as alternative dependent variables: an IQ measure derived from two subtests of the Wechsler Intelligence Scale for Children (WISC) and a school achievement measure derived from the reading and arithmetic subtests of the Wide Range Achievement Test (WRAT). Both measures are scaled to have means of 100 and standard deviations of 15 for each age-group (four-month cohorts are used for WISC and six-month cohorts are used for WRAT). The inadequacies of these variables as indexes of overall intellectual development are well-known. Nevertheless, they continue to be widely used because they provide readily obtainable tests that are roughly comparable across a diverse population.

WISC is a common IQ test, similar to (and highly correlated with results from) the Stanford-Binet IQ test (NCHS, 1972b). The full test consists of 12 subtests, but only two of these were administered in the HES. The IQ estimates, based on the vocabulary and block design subtests, are very highly correlated with those based on all 12 subtests (NCHS, 1972b). WRAT is a single achievement test that can be given to children of varying ages. In particular, the same test was given to all children in the HES except the 12-year olds. The latter group is excluded from our sample. The two tests used in the HES were found to "...have reasonably good construct validity as judged by their relationship to conventional achievement tests" (NCHS, 1967b).

Other Independent Variables

All regressions include a basic set of non-health-related variables. These variables are sex of child, whether the child is the first born in the family, whether the child is a twin, whether the child attended kindergarten or nursery school; other variables include size of family, years of formal schooling completed by the mother and by the father, labor force status of the mother, family income, whether a foreign language is spoken in the home, region of residence, and size of place of residence. These variables are defined in more detail in Appendix table A-2. We do not discuss their effects on IQ or school achievement in this paper, but it should be realized that all estimated health effects control for (hold constant) the effects of these variables.

III. RESULTS

Overview

Ordinary least squares multiple regression equations for the dependent variables WISC (IQ) and WRAT (school achievement) are given in Appendix table A-3. When WRAT is the dependent variable, two equations are estimated. The first contains the same set of independent variables as the WISC regression, while the second includes WISC as an additional independent variable. If variations in IQ as measured by WISC are due mainly to genetic factors, the second regression will give a more accurate picture of the effect of environmental factors on school achievement than the first. Of course, WISC has both an environmental and a genetic component. Therefore, the two WRAT regressions may be regarded as estimates, both upper and lower bound, of the impact of environmental factors on school achievement.*

Table 2 contains coefficient estimates of the 19 past and current health indexes. In general, IQ and achievement are positively related to positive correlates of health, and many have statistically significant effects on IQ and school achievement. The effects of health on school achievement are reduced in absolute value when IQ is held constant, but the pattern of statistical significance is not dramatically altered. In particular, only the coefficients of the number of decayed permanent and primary teeth (IDECAY) and of birth weight between 2,000 and 2,500 grams (LIGHT2) become insignificant.

Past Health Effects

Birth weight.--The results in table 2 suggest that low birth weight, especially under 2,000 grams (under 4.4 pounds), is damaging to subsequent intellectual development. For example, these coefficients imply that everything else being equal, a child who weighed under 2,000 grams at birth has an IQ four to five points lower on average than a child of normal weight at birth.** This magnitude is about one-third of a standard deviation in the WISC measure. Corresponding coefficients for WRAT imply that low birth weight is associated with a deficiency of more than one-half a standard deviation in the achievement measure. Somewhat surprisingly, absolute effects are at least as large in the high income sample as in the low income sample (see table 3).

The important effects of birth weight have been noted in a number of studies (see Birch and Gussow, 1970, for a review), though not in a multivariate context using a large representative sample. Studies of the effects of birth weight on IQ or achievement by income or social class are less common. Examples are Drillien (1964); Wiener (1965); and Davie and others (1972). In general, these studies report

* If WRAT embodies genetic variations in ability that are not captured by WISC, the equation with WISC held constant would no longer provide a lower bound estimate of the effect of environmental factors on WRAT.

** Cycle II does not distinguish children who are born prematurely, so we cannot determine to what extent low birth weight is a result of prematurity or of other factors. The coefficients of LIGHT1 and LIGHT2 reflect the average effects of prematurity and of low birth weight for full-term infants.

Table 2. Coefficients of Health Variables in WISC or WRAT Regressions. a/

Independent variable	WISC		WRAT		WRAT b/	
	Regression coefficient	F	Regression coefficient	F	Regression coefficient	F
FYPH	-.37	(0.24)	-.29	(0.17)	-.13	(0.04)
LMAG	-1.87	(4.98)	-.82	(1.08)	.00	(0.00)
HMAG35	1.68	(4.75)	.48	(0.43)	-.27	(0.17)
HMAG40	-.56	(0.17)	-.30	(0.05)	-.05	(0.00)
BFED	1.84	(16.57)	1.50	(12.54)	.70	(3.42)
LIGHT1	-5.17	(8.03)	-9.33	(29.40)	-7.05	(21.44)
LIGHT2	-2.46	(5.73)	-1.96	(4.09)	-.88	(1.04)
SEEG	1.00	(0.74)	.40	(0.13)	-.04	(0.00)
NSEEG	-2.86	(4.70)	-1.66	(1.78)	-.40	(0.13)
NRMAL	-.93	(0.99)	-1.33	(2.29)	-.92	(1.40)
IHEAR	-3.65	(1.93)	-9.20	(13.84)	-7.60	(12.06)
ABN	-2.31	(9.74)	-3.46	(24.44)	-2.44	(15.49)
IWEIGHT	-.22	(0.63)	.112	(0.18)	-.01	(0.00)
IHEIGHT	1.23	(17.81)	1.32	(23.22)	.78	(10.31)
IDECAY	-.79	(12.16)	-.40	(3.47)	-.05	(0.07)
PFHEALTH	-1.13	(1.12)	-2.68	(7.06)	-2.18	(5.98)
PFGHEALTH	.06	(0.02)	-.34	(0.70)	-.37	(1.06)
ACC	-.22	(0.17)	-.27	(0.29)	-.18	(0.15)
SCHABS	-.09	(0.01)	-.70	(0.56)	-.66	(0.03)

a/ Source: Appendix, table A-3. The critical F values at the five percent level of significance are 2.69 on a one-tailed test and 3.84 on a two-tailed test.

b/ Based on a regression that includes WISC as an independent variable.

Table 3. Coefficients of Health Variables in WISC or WRAT Regressions with Family Income--Health Interactions. a/

Dependent variable	FYPH	LMAG	HMAG35	HMAG40	MBFED	LIGHT1	LIGHT2	SEEG	NSEEG
			Family income < $7,000						
WISC	.78 (0.62)	-1.95 (3.96)	2.40 (4.74)	-1.35 (0.56)	1.70 (7.65)	-3.74 (2.08)	-1.37 (1.07)	.04 (0.991)	-3.11 (2.76)
WRAT	.08 (0.01)	-.41 (0.20)	1.23 (1.40)	-.36 (0.04)	1.73 (8.97)	-8.18 (11.17)	-1.84 (2.18)	-1.63 (0.96)	-2.62 (2.20)
WRAT b/	-.26 (0.10)	.44 (0.29)	.17 (0.04)	.24 (0.03)	.99 (3.70)	-6.54 (9.10)	-1.24 (1.27)	-1.65 (1.26)	-1.25 (0.64)
			Family income ≥ $7,000						
WISC	-2.05 (2.99)	-1.38 (0.84)	.95 (0.78)	.15 (0.01)	2.07 (10.11)	-6.20 (6.01)	-4.42 (7.39)	1.84 (1.35)	-2.40 (1.65)
WRAT	-.91 (0.66)	-1.67 (1.38)	-.20 (0.04)	-.85 (0.19)	1.31 (4.58)	-10.38 (18.94)	-2.36 (2.78)	1.91 (1.63)	-.63 (0.13)
WRAT b/	-.004 (0.00)	-1.06 (0.72)	-.61 (0.46)	-.92 (0.28)	.40 (0.55)	-7.65 (13.13)	-.42 (0.10)	1.10 (0.69)	.43 (0.08)

Table 3. Coefficients of Health Variables in WISC or WRAT Regressions with Family Income--Health Interactions. a/ (Continued)

Dependent variable	NRMAL	IHEAR	ABN	IWEIGHT	IHEIGHT	IDECAY	PFHEALTH	PFGHEALTH	ACC	SCHABS
					Family income < $7,000					
WISC	-1.31 (0.94)	-1.64 (0.26)	-2.14 (4.64)	-.59 (2.18)	1.78 (19.18)	-.94 (11.51)	-1.88 (2.13)	.002 (0.00)	-.47 (0.38)	1.51 (1.39)
WRAT	-1.49 (1.37)	-7.36 (5.80)	-3.32 (12.56)	-.34 (0.81)	1.90 (24.65)	-.68 (6.78)	-2.55 (4.40)	-.44 (0.62)	-.26 (0.13)	.65 (0.29)
WRAT b/	-.91 (0.66)	-6.65 (6.04)	-2.38 (8.23)	-.08 (0.06)	1.12 (10.86)	-.27 (1.33)	-1.72 (2.57)	-.44 (0.79)	-.05 (0.01)	-.01 (0.00)
					Family income ≥ $7,000					
WISC	-.45 (0.12)	-8.57 (3.59)	-2.57 (5.27)	.16 (0.16)	.63 (2.27)	-.56 (2.15)	-.08 (0.002)	.27 (0.18)	.04 (0.002)	-2.57 (2.62)
WRAT	-1.14 (0.87)	-13.28 (9.70)	-3.65 (11.98)	.10 (0.07)	.73 (3.48)	.07 (0.04)	-3.52 (3.72)	-.07 (0.01)	-.25 (0.13)	-2.85 (3.64)
WRAT b/	-.94 (0.75)	-9.51 (6.35)	-2.52 (7.29)	.03 (0.01)	.46 (1.73)	.32 (1.01)	-3.49 (4.66)	-.19 (0.13)	-.27 (0.18)	-1.72 (1.70)

a/ F statistics are in parentheses. The critical F values at the five percent level of significance are 2.69 for a one-tailed test and 3.84 for a two-tailed test.
b/ Based on a regression that includes WISC as an explanatory variable.

less than 20 years old at birth are about two points less than those of children whose mothers were between the ages of 20 and 35 at birth. Similarly, the coefficient of HMAG35 implies that IQ scores of children whose mothers were over the age of 35 at birth are about 1.5 points higher than those of children whose mothers were between the ages of 20 and 35 at birth. The last result and the failure to uncover a negative IQ differential for children whose mothers were at least 40 years old at birth are somewhat puzzling. One possible explanation is that women who give birth later in life spend more time with their children. A second possibility is that the health risks associated with birth at later ages (documented by Birch and Gussow, 1970) are already accounted for by variables such as low birth weight. The coefficients in table 3 reveal that the effects of mother's age at birth in the low income sample are similar to those in the combined sample. On the other hand, in the high income sample, no significant effects are observed. We offer no explanation of these results, except to note that the prevalence of births to young mothers is twice as high in the low income sample as in the high income sample (9.70 percent versus 4.10 percent).

Broman and others (1975) report a non-linear relationship between IQ and mother's age in the U.S. Collaborative Perinatal Project. Their finding that those children whose mothers were relatively young have lower IQ scores is consistent with ours. The same comment applies to their finding that children of older women do not exhibit impaired intellectual development.

Parental assessment of infant health status.--The parents' assessment of the overall health status of their children at age one year (FYPH) does not have a significant relationship with either the IQ or achievement measure. This statement holds, with one exception, for estimates computed both with and without income interactions. We offer two explanations for the lack of significant effects of this variable. First, since FYPH reports the response to a rather general question concerning past health status (as opposed to MBFED, which refers to a very specific past event, or PFHEALTH and PFGHEALTH, which refer to current health status), it is plausible that it contains a relatively large amount of measurement error. Second, FYPH may reflect aspects of infant health status that are more accurately measured by the other past health measures.

Current Health Effects

Height and weight.--The continuous current height variable (IHEIGHT) has positive and statistically significant coefficients in the three cognitive development regressions in table 2. Children who are one standard deviation above average in height for their age score more than one point higher on average on IQ and achievement tests. On the other hand, there is essentially no relationship between the continuous current weight variable (IWEIGHT) and cognitive development. This is not an altogether surprising result; height is a better summary measure of the lifetime nutritional status of the child, while weight primarily conveys information about his current nutritional status.

Even though height (adjusted for age) is a standard measure of nutritional status, it has been argued that the effect of height on IQ does not reflect nutritional effects at all but rather unmeasured genetic factors that simultaneously affect both height and IQ. Evidence concerning the validity of this argument can be gleaned from the separate estimates by income class. If the relationship between height and IQ was due primarily to unmeasured genetic effects, there would be no reason to observe differences in the strength of the relationship between income classes.* On the other hand, if height does reflect nutritional status, and if high income children as a group were better able to achieve their genetic potential because they were better nourished on average, variations in height would be associated with larger IQ effects in the low income sample than in the high income sample. This is exactly what we do find (see table 3). The height coefficients in the low income sample are more than twice as large as those in the high income sample.

These differences in the height coefficients by income class can also be used to provide a rough estimate of the "pure" effect of height on IQ due to nutrition. If all of the variation in height in the high income sample was caused by genetic factors (some of which simultaneously affect both height and IQ), while variation in height in the low income sample was caused by both genetic and nutritional variations, the difference in the height coefficients in the two samples would provide an estimate of the pure height effect due to nutrition. Under these assumptions, comparison of the coefficients in the samples of both high and low income suggest that, in the low income sample, the nutrition effect accounts for two-thirds of the value of the coefficient of height. An alternative rough estimate of the relative nutritional (or non-genetic) effect in the case of achievement is obtained by comparing the relationships between height and WRAT in the regressions where WISC is and is not held constant. If the unmeasured genetic factors common to height and achievement are held constant by including WISC in the regression, the ratio of the height coefficients in the alternative WRAT

* It is also possible to obtain a lower coefficient of height in the high income samples simply because the unmeasured genetic factors have a diminishing effect as IQ rises (average IQ as measured by WISC is higher in the high income sample than in the low income sample).

equations will indicate what proportion of the height effect on WRAT is accounted for by variations in nutrition. The ratio of these two coefficients equals three-fifths. The agreement between alternative estimates of the relative contribution of nutrition is striking.

Another interpretation of the height-IQ relationship is given by Tanner (1966), who claims that their positive correlation results partially from common individual patterns of both physical growth and the development of mental ability. He argues that the relationship between height and IQ would attenuate if adults were observed rather than children. While our data do not allow us to determine to what extent our results are caused by individual differences in patterns of development, Douglas, Ross, and Simpson (1965) analyze the relationship between cognitive development and height for 15-year-olds, holding constant stage of puberty as well as social class and family size, and still report strong positive associations.

A number of studies have examined relationships among height, weight, and intellectual development in both developed and developing countries.* Most of these studies have employed continuous height and weight measures. We review the findings for developed countries. Miller (1974) reports a positive relationship between IQ and achievement scores at age 11 and height at age five in Newcastle Upon Tyne, England. Douglas, Ross, and Simpson (1965) find positive relationships between height and cognitive development not only for British 15-year-olds, but also for seven and 11-year-olds. Broman, Nichols, and Kennedy (1975) do not uncover significant relationships between concurrent height and IQ measures in the U.S. Collaborative Perinatal Project. Yet their findings are not inconsistent with ours because they control for head circumference, which is highly correlated with height. They do uncover positive and significant relationships between IQ at four years of age and weight at one year of age for whites, and between IQ at four years and weight at four months and at four years of age for blacks.

In addition to our work with continuous height and weight measures, we estimate our basic equations replacing these variables with discrete indexes that identify very tall, very short, very heavy, and very thin children. A somewhat different pattern of relationships among height, weight, IQ, and school achievement emerges (see table 4). In particular, very thin children have very low WISC and WRAT

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* A number of major studies have been carried out in the developing countries. These include the research of Selowsky and Taylor (1973), Richardson (1976), Popkin and Lim-Ybanez (1977), and Klein and others (1972).

Table 4. Coefficients of Dummy Variables for Current Height Current Weight in WISC or WRAT Regressions. a/

Dependent variable	Tall	Short	Fat	Thin
Combined				
WISC	.67 (0.20)	-2.19 (1.65)	-.23 (0.05)	-12.55 (6.04)
WRAT	2.59 (3.46)	-2.04 (1.61)	-.52 (0.30)	-15.25 (10.01)
WRAT b/	2.30 (3.48)	-1.07 (0.57)	-.42 (0.25)	-9.68 (5.17)
Family income < $7,000				
WISC	1.53 (0.42)	-2.44 (1.43)	-1.29 (0.91)	-13.16 (5.44)
WRAT	1.07 (0.23)	-2.24 (1.37)	-.35 (0.07)	-14.32 (7.23)
WRAT b/	.39 (0.04)	-1.16 (0.47)	.22 (0.03)	-8.48 (3.25)
Family income ≥ $7,000				
WISC	-.001 (0.00)	-.72 (0.05)	.96 (0.47)	-15.09 (1.48)
WRAT	3.78 (4.41)	-1.51 (0.26)	-.40 (0.09)	-23.70 (4.10)
WRAT b/	3.79 (5.67)	-1.19 (0.20)	-.83 (0.50)	-17.01 (2.71)

a/ F statistics in parentheses. The critical F values at the five percent level of significance are 2.69 on a one-tailed test and 3.84 on a two-tailed test.

b/ Based on a regression that includes WISC as an independent variable.

scores. Although the height coefficients are not always statistically significant, taller children have above average scores, while shorter children have below average scores. In interpreting these results, the reader is cautioned that the prevalence of thin children is extremely small (.17). We leave the question of whether height and weight relationships are discrete, continuous, or a mixture of the two as an issue for future research.

Number of decayed primary and permanent teeth.--We find that the number of decayed primary and permanent teeth, adjusted for age and sex (IDECAY), has negative significant effects on cognitive development, except when WRAT is the dependent variable and WISC is held constant. There are several alternative ways to interpret this finding. Some part of the relationship may result from reverse causality; that is, more intelligent children may be more compliant with a program of preventive dental care. Some part of the relationship may reflect unmeasured variations in the family's interest (preferences) in caring for both the physical health and mental development of the child. Finally, the estimated coefficients may reflect the effects of nutrition.

Differences in the coefficients of IDECAY by income class (see table 3) provide some evidence that nutrition is indeed an important explanatory factor. If IDECAY reflects solely the effects of reverse causality and preferences, there would be no reason for its coefficients to vary by income class. However, if IDECAY also reflects nutritional status, and if a larger proportion of the variation in IDECAY in the low income sample (as compared to the high income sample) results from variation in nutrition, the coefficient of IDECAY would be larger in the low income sample. Both for WISC and WRAT, the coefficients of IDECAY indicate a larger negative effect in the low income sample, suggesting that nutrition is at work.

Abnormal hearing.--All three regression coefficients of abnormal hearing (IHEAR) are negative in table 2, and are statistically significant when WRAT is the dependent variable. The importance of poor hearing in the determination of school achievement is revealed by the following comparison. When all other variables, including WISC, are held constant, children with poor hearing have a WRAT score that is approximately 7.5 points lower than children with normal hearing. This difference exceeds the seven-point difference in the mean WRAT score in the high income sample as compared to the low income sample. As shown in table 3, the preceding comparison is even more dramatic when the effect of poor hearing is allowed to interact with family income. Based on the last line in this table, in the high income sample, children with poor hearing have a WRAT score that is approximately 9.5 points lower than children with normal hearing. One explanation for the relatively strong relationship between poor hearing and WRAT in the high income sample is that high income children attend schools of higher average quality and that poor hearing and school quality interact in their effects on IQ and achievement. Clearly, this explanation is speculative. It could be tested, however, by means of a controlled experiment in which attempts were made to improve hearing levels of children in different school environments, and the subsequent trends in cognitive development compared.

Hu (1973) finds an insignificant, positive effect of hearing correction on IQ in a sample of children from low income families in Pennsylvania (see table 3). Our results are not directly comparable with his because children with abnormal hearing who have had their hearing corrected cannot be identified in the health examination survey (HES).* Further, Hu's analysis suffers from the difficulty that his coding scheme gives children with a corrected defect a higher score than children with no defect.

Binocular distance vision.--The set of three dummy variables denoting whether or not the child has normal vision and whether or not he wears glasses are, in general, not statistically significant. This is true both for the full sample and for the two income classes. The one exception is the variable NSEEG in the WISC equation. That is, children with normal vision who wear glasses have WISC scores almost three points lower, on average, than children with abnormal vision who do not wear glasses. This effect persists in each income class, although it is no longer statistically significant. A possible explanation for this puzzling result is that NSEEG might partially measure the quality of medical care received by children; that is, children who receive prescriptions for glasses when their eyesight is normal may be receiving the lowest quality care among all children in the sample.

It might seem surprising that children with abnormal uncorrected distance vision who wear glasses do not have higher IQ and achievement scores than children with abnormal uncorrected distance vision who do not wear glasses (see the coefficients of SEEG). One explanation of this result is that the effects of poor vision on school learning might not manifest themselves until ages beyond the age range in Cycle II of the HES. A related point is that the prevalence of abnormal uncorrected binocular distance vision is higher at ages 12 through 17, for example, than at ages six through 11 (NCHS, 1973b). Finally, poor medical care for vision problems has been documented by

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* In particular, children who wore hearing aids were examined without them. To the extent that these aids are beneficial, we understate the impact of abnormal uncorrected hearing on IQ and school achievement.

Kessner (1974), who finds that 40 percent of children in a low income sample who were tested with their glasses failed a visual acuity test.

In contrast to our findings, Hu (1973) uncovers a positive and significant relationship between IQ and vision correction, though his study is marred by a coding scheme that gives children with corrected vision a higher score than children with no defect. Douglas, Ross, and Simpson's (1967) findings are more similar to our own. They report that in the British National Survey of Health and Development, children with abnormal distance vision have higher IQ and achievement scores than children with normal vision. They argue that this is because nearsighted children are more interested in intellectual activities and less interested in physical activities than their peers with normal vision. As shown by the difference between the coefficient of SEEG and the coefficient of NRMAL, a similar tendency is present in the Health Examination Survey.*

Significant abnormalities.--The presence of significant abnormalities (ABN) has large negative and significant effects on both IQ and achievement (except when WISC is held constant in the WRAT equation). Children with such abnormalities have IQ scores on average nine points lower than children without abnormalities. Examination of the coefficients by income class indicates that the effects are about the same in both income classes.

Excessive school absence due to illness.--The coefficients of the dichotomous variable for excessive school absence due to illness in the past six months (SCHABS) are negative, but not statistically significant, in table 2. The estimates by income class (table 3), however, do reveal that excessive absence for health reasons is damaging to the IQ and achievement of children from high income families but not to children from low income families. It is possible to attribute this result, as in the case of poor hearing, to the effects of higher average school quality in the high income sample.

Douglas and Ross (1965) also examine the effects of school absenteeism. They report a negative association between achievement and the incidence of school absence due to illness except for children from upper middle class families. We have no explanation of the difference between our results and theirs.

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* This result might also reflect reverse causality from IQ and achievement to poor vision due to excessive use of the eyes.

Parental assessment of children's current health status.--Parents' assessment of their child's current health as poor or fair as compared to good or very good (measured by the variable PFHEALTH) is associated with significantly lower achievement scores. These scores are from two to three points lower for children whose current health is assessed as poor or fair. In contrast, no significant effects are reported for IQ. The above results hold for the separate income classes, as well as for the full sample. The finding that current health assessment has an effect on achievement and not on IQ makes sense because the latter is not likely to respond to the transitory variations in health represented by the parents' current assessment (remember that these estimates hold constant variables that represent many aspects of the child's permanent health status).

Accidents.--The dichotomous variable indicating whether or not the child has had one or more accidents since infancy has very small negative coefficients, not significantly different from zero in all cases. The aspects of health that are independently reflected by this variable do not appear to interact with IQ and school achievement.

Income and Race Differences in IQ and Achievement

To assess the overall impact of health on IQ and achievement, a measure summarizing the combined effects of all health variables is needed. Such a measure cannot be constructed for an abstract case. Rather, two specific cases are examined: differences between children from high and low income families and between children from black and white families. More precisely, we use the coefficients in table 2 and Appendix table A-3 to calculate what proportion of low income-high income and black-white differences in WISC and WRAT can be accounted for by differences in the average health characteristics of these groups.

The resulting computations are summarized in tables 5 and 6. Table 5 shows how many of the gross differences in WISC and WRAT between the two income classes disappear if the low income class is given the income distribution, the mean parents' schooling, mean family size, and mean health levels of the high income sample, and if the relationship between WISC (or WRAT) and the explanatory variables was the same in both income classes. Similarly, table 6 shows how the gross black-white differentials in WISC and WRAT scores change if blacks are given the white values of the socioeconomic and health variables and if the effects of these variables on WISC and WRAT are the same for blacks and whites. The family income calculations are based on the six income dummy variables defined in Appendix table A-1. The parents' schooling calculations are based on the separate effects of

Table 6. Children's Health, Parents' Schooling, and Family Income Components of Difference in WISC between White and Black Children. a/

Component	Absolute	Percentage b/ of gross difference
WISC (gross difference = 14.778)		
Children's health	.179	1.21
Family size	.501	3.39
Family income	1.548	10.48
Parents' schooling	2.990	20.23
WRAT (gross difference = 10.910)		
Children's health	.132	1.21
Family size	.470	4.31
Family income	1.392	12.76
Parents' schooling	2.642	24.22
WRAT (with WISC)		
Children's health	.054	.50
Family size	.249	2.28
Family income	.708	6.49
Parents' schooling	1.316	12.06
WISC	4.833	44.30

a/ Computations are based on a regression that uses the continuous current height and weight variables and does not allow for interaction effects between family income and children's health.

b/ These percentages will not, in general, add up to 100 for two reasons. First, the calculations do not incorporate the effects of the entire set of explanatory variables (indeed, these percentages could sum to more than 100 if the variables excluded from the calculations made a negative contribution to the difference in WISC or WRAT). Second, even if all variables in the regression equation were used, there is still random variation in WISC and WRAT that our equations cannot explain or predict.

mother's schooling and father's schooling. These are crude estimates to the extent that variations in parents' education and income and family size lead to variations in health levels, the full effects of parents' education, income, and family size will be larger than those given in the tables.

From table 5, it is clear that almost all of the differences in WISC and WRAT between the high and low income subsamples can be accounted for by differences in the socioeconomic and health variables included in the calculations. Moreover, it is noteworthy that about 10 percent of the gross difference is related to health factors alone. These results are to be contrasted with the case of black-white differentials.* In the latter case, a much smaller percentage of the gross difference in WISC or WRAT is accounted for by the variables in our table, and only about one percent of the difference can be attributed to the set of health variables. Thus, health differences as measured in this study do not appear to provide an important explanation for racial differences in IQ and achievement. Clearly, a complete explanation of the black children's 15 point deficit in IQ and 11 point deficit in school achievement would constitute an extremely important accomplishment for both social science and public policy.

In conclusion, we view the estimates in tables 5 and 6 as little more than one way to summarize regression results. These estimates convey three tentative results: (1) differences in IQ and achievement between children in high and low income classes are due in part to differences in health, (2) the health component of the IQ or achievement difference is much less important than either the family income component or the parents' schooling component, and (3) black-white differences in IQ and achievement scores are much harder to explain than are income differences, with black-white health differences playing a minimal role.

IV. SUMMARY AND IMPLICATIONS

Does poor health, as measured by the indicators we have employed, contribute to retarding the cognitive development of children? Based on a representative sample of white children in the United States, our tentative answer is that it does. With family background and home environment variables held constant, many of the health measures that we have used in this paper have significant effects on IQ and school achievement. In addition, either taken as a single set or in two separate subsets (the health variables measured in infancy

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* The black sample, like the white sample, includes only children who live with both of their natural (or adoptive) parents.

and those measured currently), the health variables make a statistically significant contribution to the explanation of variations in school achievement, even when IQ is held constant.

With regard to the effects of specific health indicators, birth weight, breast-feeding, nutritional status (as reflected by height and by the number of decayed permanent and primary teeth), and poor hearing stand out as important correlates of IQ and achievement. Low birth weight is as damaging to children from high income families as to children from low income families. Nutritional status effects are more important in the low income sample, while poor hearing and excessive school absence due to illness are more important in the high income sample.

Our results are useful whether or not the mechanism by which a given health variable alters cognitive development is fully understood. In the case where the mechanism is known, our results can be used to identify the appropriate kinds of government intervention. A case in point is the role of poor hearing in the determination of school achievement. Here we feel confident that the basic force at work is a causal relationship running from hearing problems to school learning. Alternatively, when effects of certain variables are large, but mechanisms are not well-understood, our findings suggest the nature of additional research that is required to formulate public policy, rather than the appropriate policies per se. Consider, for example, our result that current height is an important determinant of cognitive development in children from low income families. This result has a very definite policy implication if the mechanism at work is a positive correlation between height and nutritional status. The policy implication is much less clearcut if the mechanism at work is a common genetic inheritance of height and mental ability.

We view the empirical work in this paper as preliminary or ongoing rather than definitive or final. Due to the preliminary nature of the work, we have not hesitated to suggest alternative explanations of certain findings, to speculate and to be provocative in discussion results, and to propose a partial agenda for future research. Instead of repeating the items on this agenda that were mentioned in section III, we conclude the paper by suggesting two new ones. The first is an investigation of health and cognitive development relationships at later stages in the child's life cycle. In particular, one could determine if some of the strong relationships between indicators of early health and IQ and achievement taper off as the child grows. The second is a longitudinal study of the change in cognitive development for the same child between two different ages as it relates to initial levels of health or to changes in health. The latter study would be particularly useful because of evidence summarized by Bloom (1964) that the rate of growth of cognitive development is more responsive to environmental factors than to the initial level of cognitive development.

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Table A-1. Definition of Basic Variables in WISC or WRAT Regressions.

Variable name	Definition
TWIN	Dummy variable that equals one if child is a twin
FIRST	Dummy variable that equals one if child is the first born in the family
KIND	Dummy variable that equals one if child attended kindergarten or nursery school
MWORKPT MWORKFT	Dummy variables that equal one if the mother works part-time or full-time, respectively
MALE	Dummy variable that equals one if child is male
FLANG	Dummy variable that equals one if a foreign language is spoken in the home
MEDUCAT	Years of formal schooling completed by mother
FEDUCAT	Years of formal schooling completed by father
Y1 Y2 Y3 Y4 Y5 Y6	Dummy variables that equal one if family income is greater than or equal to $3,000 (Y1); greater than or equal to $4,000 (Y2); greater than or equal to $5,000 (Y3); greater than or equal to $7,000 (Y4); greater than or equal to $10,000 (Y5); greater than or equal to $15,000 (Y6)
NEAST MWEST SOUTH	Dummy variables that equal one if child lives in Northeast, Midwest, or South, respectively
URB1 URB2 URB3 NURB	Dummy variables that equal one if child lives in an urban area with a population of three million or more (URB1); in an urban area with a population between one million and three million (URB 2); in an urban area with a population less than one million (URB3); or in a non-rural and non-urbanized area (NURB); omitted class is residence in a rural area
LESS20	Number of persons in the household 20 years of age of less

Table A-2. Means and Standard Deviations of Dependent and Independent Variables, Whites, Ages 6-11, Mother and Father Present. (n = 3599)

Variable	Mean	Standard deviation
WISC	103.1937	13.9535
WRAT	103.1773	12.8378
LIGHT1	.0128	.1123
LIGHT2	.0411	.1986
BFED	.3037	.4599
LMAG	.0697	.2547
HMAG35	.1042	.3056
HMAG40	.0308	.1729
FYPH	.0839	.2773
LESS20	3.6163	1.6371
SEEG	.0709	.2566
NSEEG	.0431	.2030
NRMAL	.8377	.3687
IHEAR	.0058	.0762
ABN	.0806	.2722
IHEIGHT	.0371	.9673
IWEIGHT	.0596	.9982
IDECAY	-.0674	.9643
PFHEALTH	.0417	.1999
PFGHEALTH	.4451	.4970
ACC	.1678	.3738
SCHABS	.0428	.2024
TALL	.0206	.1419
SHORT	.0153	.1227
FAT	.0464	.2104
THIN	.0017	.0408
TWIN	.0233	.1510
FIRST	.2895	.4536
KIND	.7313	.4433
MWORKPT	.1373	.3422
MWORKFT	.1373	.3422
MALE	.5115	.4999
FLANG	.1020	.3027
MEDUCAT	11.2431	2.7456
FEDUCAT	11.2698	3.4444
Y1	.9011	.2986
Y2	.8361	.3703
Y3	.7497	.4333
Y4	.4793	.4996
Y5	.2212	.4151
Y6	.0614	.2401
NEAST	.2390	.4265
MWEST	.3279	.4695
SOUTH	.1759	.3808
URB1	.1976	.3982
URB2	.1256	.3314
URB3	.1814	.3854
NURB	.1500	.3572

Table A-3. Ordinary Least Squares Regressions of WISC and WRAT. a/

Independent variable	WISC Regression coefficient	F	WRAT Regression coefficient	F	WRAT Regression coefficient	F
TWIN	-3.04	4.92	-1.08	0.70	.26	0.05
MWORKFT	-1.92	10.26	-1.25	4.91	-.41	0.66
MWORKPT	.59	0.99	.38	0.46	.12	0.06
MEDUCAT	.92	77.82	.72	54.08	.32	13.07
FEDUCAT	.63	52.95	.60	54.17	.32	19.76
MALE	3.05	57.96	-2.69	50.74	-4.03	143.61
FLANG	-1.73	6.08	.53	0.64	1.29	4.86
FIRST	-.01	0.00	.66	2.02	.67	2.61
KIND	1.03	3.51	-.31	0.35	-.76	2.75
Y1	1.62	2.53	-1.83	3.64	-2.55	9.00
Y2	.66	0.40	3.04	9.53	2.76	9.98
Y3	1.08	1.92	1.86	6.34	1.38	4.47
Y4	.72	1.66	.09	0.03	-.23	0.23
Y5	1.75	7.28	.78	1.64	.01	0.00
Y6	.69	0.52	-.56	0.39	-.87	1.19
LESS20	-.59	18.76	-.56	18.68	-.30	6.72
FYPH	-.37	0.24	-.29	0.17	-.13	0.04
LMAG	-1.87	4.98	-.82	1.08	.00	0.00
HMAG35	1.68	4.75	.48	0.43	-.27	0.17
HMAG40	-.56	0.17	-.30	0.05	-.05	0.00
BFED	1.84	16.57	1.50	12.54	.70	3.42
LIGHT1	-5.17	8.03	-9.33	29.40	-7.05	21.44
LIGHT2	-2.46	5.73	-1.96	4.09	-.88	1.04
SEEG	1.00	0.74	.40	0.13	-.04	0.00
NSEEG	-2.86	4.70	-1.66	1.78	-.40	0.13
NRMAL	-.93	0.99	-1.33	2.29	-.92	1.40
IHEAR	-3.65	1.93	-9.20	13.84	-7.60	12.06
ABN	-2.31	9.74	-3.46	24.44	-2.44	15.49
IWEIGHT	-.22	0.63	-.11	0.18	-.01	0.00
IHEIGHT	1.23	17.81	1.32	23.22	.78	10.31
IDECAY	-.79	12.16	-.40	3.47	-.05	0.07
PFHEALTH	-1.13	1.12	-2.68	7.06	-2.18	5.98
PFGHEALTH	.06	0.02	-.34	0.70	-.37	1.06
ACC	-.22	0.17	-.27	0.29	-.18	0.15
SCHABS	-.09	0.01	-.70	0.56	-.66	0.63
WISC					.44	993.82
CONSTANT	85.06		89.71		52.21	
Adj.R^2	.27		.25		.40	
F	33.37		27.67		57.68	
n	35.99		35.99		35.99	

a/ Regressions include three region and four residence variables. The critical F values at the five percent level of significance are 2.69 on a one-tailed test and 3.84 on a two-tailed test.

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