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THE EFFECT OF LOW BIRTHWEIGHT ON THE HEALTH, BEHAVIOR, AND SCHOOL PERFORMANCE OF SCHOOL-AGED CHILDREN

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ABSTRACT

This study uses the 1988 Child Health Supplement of the National Health Interview Survey to examine the performance of school-aged children who were of low birthweight. We examine a number of indicators of school performance, health, and behavior. We examine these effects separately for children ages 6 to 10 and for children ages 11 to 15. In addition, we examine two sets of the age cohorts: one where all children are included, and one which excludes children who are attending special education. The latter category is meant to examine children who have not been identified as having problems in school which require special services. We find that low birthweight children are more likely to perform poorly in school than their normal birthweight peers, and they are more likely to experience health problems, even into their adolescence. We do not find significantly more behavior problems for low birthweight children compared to their normal birthweight peers.

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I. Introduction

From the mid-1960's to 1980, the neonatal mortality rate in the United States declined sharply. Most of this decline was due to technological advances in neonatology, resulting in a decline in the mortality of low birthweight infants. Since 1980, not only has the neonatal mortality rate continued to decline, but the incidence of low birthweight has increased. That is, our ability to prevent low birthweight births has worsened while our ability to increase the survival of low birthweight neonates has improved. The result is that we have an increased percentage of children who are low birthweight survivors.

Numerous studies have examined the mortality and morbidity rates of low birthweight survivors. Some findings are repeated in a variety of different types of studies: 1. The majority of low birthweight survivors appear normal in intelligence and neurological examinations; 2. Low birthweight survivors, however, are at an increased risk for health, neurological problems, and developmental delays; and 3. The risk of such problems increases with lower birthweight. In addition, some longitudinal studies are now finding that pre-school aged low birthweight survivors who tested in the normal functional range in their earlier years are at greater risk of difficulties while in school than their normal birthweight peers.

Much of the literature which assesses the functioning of low birthweight survivors focuses on medical or psychological assessments of the children. In examining outcomes, these studies use standardized medical diagnoses, neurological

test results, psychological analyses, and intelligence test results; some recent studies also rely on school achievement tests. Using standardized tests is advantageous because they utilize well-established norms of performance. However, relying on standardized tests also has disadvantages. First, low birthweight survivors tend to be affected by other risk factors in addition to low birthweight. The incidence of low birthweight, for example, is greater among poor women, women who were not married at the time of the birth, teen-aged mothers, and women who have a relatively low level of education. All of these risk factors potentially can affect the child's functioning. By not holding constant these other risk factors, researchers may overestimate the problems actually caused by low birthweight alone.

Second, standardized tests do not provide a complete picture of how low birthweight children are functioning. They do not necessarily give accurate predictions of how well they perform in school or how sick they may be. Also, standardized tests are not very useful to economists who may want to examine the cost implications of such morbidity. To an economist, it may be more important to examine the additional health and school resources these children need to enhance school performance, rather than the performance level itself. In addition, in the longer run, economists are interested in labor market and home production outcomes such as whether children drop out of school, if they become teen-age mothers, and if they are more likely to receive public assistance or pay taxes.

Third, many of the studies which use standardized tests follow children in longitudinal cohorts who were born in a particular hospital or geographic area. These

children tend to be similar in terms of social and economic background, and also have access to a similar set of resources such as medical care, early intervention, pre-schools, and school programs. By using a relatively homogeneous group of low birthweight survivors, with common backgrounds, medical interventions, and program services, researchers risk over-generalizing to the entire population of low birthweight survivors. For example, a geographic area having a better than average early intervention program, along with a relatively aggressive outreach to parents of low birthweight survivors, might demonstrate better than average outcomes in the children's later years when compared to areas without such services. Such a situation would lead to an underestimate of the impact of low birthweight on later outcomes of other children.

The purpose of this study is to examine school performance, health, and behavioral outcomes of low birthweight survivors while they are in school. We focus on children who are ages 6 through 15, addressing some of the research issues discussed above. First, we use a nationally representative sample of children, based on the 1988 National Health Interview Survey's Child Health Supplement. Second, we examine more pragmatic outcomes than many other studies--outcomes which have more economic (and less psychological) implications than many of these other studies. Third, we utilize a multivariate analysis, holding constant many of the social and economic risk factors which also affect school outcomes.

II. Background

Between 1970 and 1979, the neonatal mortality rate in the United States fell about 40%, from 15.1 deaths per 1,000 live births to 8.9. At the same time, the incidence of low birthweight declined by only 16%. Medical researchers agree that technological improvements in neonatology were major factors in the decline in the neonatal mortality rate. In the next decade, from 1980 to 1989, neonatal mortality fell another 27% while the incidence of low birthweight increased slightly. Not only are there more neonatal survivors, but survival rates have increased most dramatically at the lowest birthweights.

Low birthweight survivors born in the 1970's and early 1980's are now in school. Many researchers have examined how these survivors are performing in school. The school assessments are important for several reasons. First, this cohort of low birthweight children have had ample time to catch up to their normal birthweight peers. Second, school is their primary activity for many years. Third, school performance is an important predictor of how these children will function as adults. Below, we summarize some of the recent literature concerning how school-aged low birthweight survivors born after 1970 are now performing.

Our review of recent studies of school aged low birthweight children indicates that the preponderance of the studies examined children's performance on standardized intelligence and/or achievement tests. These include studies by Carran et al. (1989), Caputo et al. (1981), Astbury et al. (1987), Drillien et al. (1980), Lloyd et al. (1988), Lagerstrom et al. (1991A), Lagerstrom et al. (1991B), Hack et al. (1991), Rantakallio and von Wendt (1985), Hunt et al. (1988), Kitchen (1980), Klein et al.

(1988), Klein et al. (1989), McCormick et al. (1992), Vohr et al. (1991), Saigal et al. (1990), Vekerdy-Lakatos et al. (1989), Hawdon et al. (1990), Noble-Jamieson et al. (1982), Rikards et al. (1987), and Hack et al. (1992). These studies varied considerably in their methodologies and samples, as well as in selecting control subjects and/or variables. Many studies focused on cohorts of very low birthweight children born in a specific region. Most of these studies, however, did acknowledge the role of socio-economic status in determining both intelligence scores and achievement test levels of children.

Although findings differ, most studies conclude that the majority of (very) low birthweight school aged children score in the range of normal intelligence, but mean scores are below their normal birthweight peers. Average achievement test scores are also lower for (very) low birthweight children than for normal birthweight children. In fact, achievement test scores tend to show greater differences between the two groups than intelligence scores. Not all studies find significant differences, however. For example, a recent meta-analysis by Aylward et al. (1989) did not find significant IQ differences in some recent studies. In his analysis, differences in intelligence tests and achievement test results could also be attributed to the age at which children are tested, and to whether the cohort includes all low birthweight children or only those of very low birthweight (below 1500 grams).

A second set of studies, with some overlap, examine whether these children are experiencing school success as measured by grades, parent rating, teacher rating, grade repetition, and identification as a special needs student. Studies include: Carran

et al. (1989), Lagerstrom et al. (1991A), Lagerstrom et al. (1991B), Goldberg et al. (1992), Chaikind and Corman (1991), Rantakallio and von Wendt (1985), Klein et al. (1989), Alberman et al. (1985), Vohr et al. (1991), Kochanek et al. (1990), Lloyd et al. (1988), Zubrick et al. (1988), Vekerdy-Lakatos et al. (1989), McCormick et al. (1990), McGauhey et al. (1990), and Rikards et al. (1987). Most of these studies find that, although the great majority low birthweight children perform normally, they also exhibit a greater likelihood of experiencing difficulties in school. Again, school performance is worse for the very low, compared to the higher, low birthweight children.

In reviewing studies of behavior of school-aged children, there is less agreement on a measure of behavior than of intelligence, achievement, or school success. Most of the studies utilize standardized behavioral checklists administered to parents or teachers. Recent examples are: Lloyd et al. (1988), Hawdon et al. (1990), McCormick et al. (1990), Noble-Jamieson et al. (1982), McGauhey et al. (1990), Hack et al. (1992), Mc Cormick et al. (1992), Breslau et al. (1988), Drillien et al. (1980), Lloyd et al. (1988), Kitchen et al. (1980), Lagerstrom et al. (1990), and Hack et al. (1991). Rikards et al. (1984) have the child assessed directly by a psychologist, and Kochanek et al. (1990) use school classification as a measure of behavioral disorder. Because samples and assessment measures vary, results also vary. However, there is some evidence that low birthweight children have more behavior problems than their normal birthweight peers.

Most studies examining the health of school-aged children who were of low

birthweight, focus on neurological conditions such as visual-motor impairment, cerebral palsy, fine motor or gross motor impairment, seizure disorders, visual, and hearing problems. Some of these studies include, for example, those by Kitchen et al. (1980), Klein (1988), Klein et al. (1989), Astbury et al. (1987), Hack et al. (1991), Blennow et al. (1986), Rantakallio and von Wendt (1985), Vohr et al. (1991), Saigal et al. (1990), Vekerdy-Lakatos et al. (1989), Noble-Jamieson et al. (1982), Caputo et al. (1981), Drillien et al. (1980), Michelsson et al. (1984), Alberman et al. (1985), Hunt et al. (1988), and Hack et al. (1992). Some studies examine specific health problems such as growth [Rantakallio and von Wendt (1985), Rikards et al. (1987), and Vekerdy-Lakatos et al. (1989)]; or pulmonary function [Noble-Jamieson et al. (1982)]. Other studies investigate a range of chronic conditions or limits in activities of daily living (ADLs). McCormick et al. (1992), Overpeck et al. (1991), and McGauhey et al. (1990), for example, all utilize the 1981 National Health Interview Survey to examine chronic conditions, as well as parents' assessments of the child's overall health. Most of the studies described above find that many children who were of low birthweight seem to have normal health, but the incidence of neurological impairment or chronic health conditions seems to be greater for this group than for normal birthweight children.

This brief review of recent literature indicates that there has already been considerable examination of the functioning of low birthweight children into their school years. Most of the studies, which have a medical perspective, focus on the incidence of particular pathologies, rather than an examination of school success. The

exceptions are the studies which examine grades and/or grade repetition. In examining both behavior and health, again, the majority of the studies focus on long-term diagnoses of pathology, rather than on the ways such pathologies affect how the children perform in school.

Another criticism of many of these studies is that samples are drawn from one geographic location. Because availability of health and educational programs may vary, results from one area may not be applicable to other areas. That is, an area with better than average health and educational program availability for at-risk youngsters, for example, may ameliorate some of their problems, leading researchers to underestimate the effects of low birthweight on children living in areas with fewer resources when generalizing such results.

Although many of the above studies are longitudinal, they do not assume that health, behavior, and school performance problems may be fluid. Many studies find that children test in the normal range when they are younger, but that their tests reveal deficiencies as the children mature. These researchers assume that the problems were always there, but that they took some time to reveal themselves to researchers. And, they assume, once the problems are revealed, they cannot be surmounted. It would be useful to relax such assumptions, and to compare the younger children with older children. Although it may be true that some problems are not apparent at younger ages, it may also be true that children may overcome their problems, or may outgrow them.

Finally, many of the studies differ in the way they treat other factors which

may be related to functioning of the children. Since low birthweight occurs more frequently among children with other risk factors such as poverty, teenage parents, and/or single parents, it is extremely important to hold constant such risk factors. It is also important to assess the possible interactions between the other risk factors and low birthweight. Again, geographically limited studies provide limited results related to these other risk factors. For example, if low birthweight has a relatively worse impact on children from high risk families, then studies which examine only high risk families may overestimate the effects of low birthweight on the performance of children from average or low risk families.

Finally, in selecting the appropriate sample, many studies exclude those children who have the most severe disabilities, while several include these children. This makes it difficult to compare studies. For example, some researchers exclude children who are difficult to test. Others exclude children who are not in a regular school. Obviously, measured differences between the low birthweight children and their normal birthweight peers will be lessened when those with greater disability are excluded from the sample.

III. Empirical Analysis

We use the 1988 Child Health Supplement (CHS) released by the National Center for Health Statistics for our empirical test. See Chaikind and Corman (1991) for a fuller description of the data set. Data concerning these children are obtained by randomly selecting one child per household. Detailed information on the health, school

performance and behavior of each child is obtained by interviewing an adult in the household who is familiar with the child. In most cases, this is the child's mother. Because the mother's assessment of the child may be somewhat subjective, results of this study should be interpreted with caution.

There are many advantages to the 1988 CHS. First, the sample is nationally representative. Few studies have used nationally based data sets for their analyses. Exceptions are: McCormick et al. (1990), McGauhey et al. (1990) and Overpeck et al. (1989), which use the 1981 version of this data set; McCormick et al. (1992) which uses data from a multisite study; and Chaikind and Corman (1991), which uses this data set. Such a sample allows a range of availability of health and education inputs to the families. Thus, the average child in the sample might have had an average array of input availability. In addition, since the information is retrospective, geographic mobility does not preclude inclusion in the sample.

A second advantage of this sample is that there are multiple assessments of the child. Some are typical of many of the other studies, while others are based more on performance than on diagnosis. For example, the 1988 CHS includes a behavioral checklist but also asks questions such as how many times (if any) the child was suspended from school. This kind of sample allows multiple indicators for each of our three categories: school performance, behavior and health. It allows a comparison of the more clinical indicators with the more practical indicators. A third advantage of the 1988 CHS is that it includes many demographic and socio-economic variables, allowing these other risk factors to be held constant.

To mitigate against inaccuracies due to self-reporting, we have used a variety of measures for each of our three categories: school, behavior and health. We limit our sample to children who are between the ages of 6 and 15 and who are in school. Of the approximately 17,000 children in the CHS, our analyses examine the 6,500 to 7,500, who are in school, in our age category, and who do not have missing values for key variables. Because the effects of low birthweight on performance may differ at different ages, we perform all analyses separately for the younger half (aged 6 through 10) and the older half (aged 11 through 15) of our sample. We test for significant differences between the two age cohorts.[1] We perform all empirical analyses on the entire sample, and on a sub-sample of children who are not in special education. That is, we examine all children, and children who are classified as not having a disability by their school systems. Thus, our analysis can be compared both to the studies which exclude and those which include the children with disabilities with greater severity.

Table 1 lists all variables used in the analyses and presents means and standard deviations for all children and for children not in special education for both age cohorts. Table 1 differentiates between the dichotomous dependent variables and the continuous ones. Altogether, there are seventeen dichotomous dependent variables and ten continuous dependent variables.

In the dichotomous category, three measures are used for school performance. The first, REPEAT1, asks the respondent whether the child has ever repeated a grade. The second, REPEAT2, includes children who are reported to have repeated a grade

plus children who are currently below grade level (their age minus their current grade is seven or more). Approximately 19 percent of the older children, and about 17 percent of the older children not in special education have repeated a grade. A third variable, SCHOOLPERF, indicates how the respondent rated the child's school performance on a scale of 1 to 5, where 3 was average. If the child was rated below average, we coded the child yes for poor school performance. The fact that only 9 percent of all older children are rated below average(usually by their mother), and only 7 percent of older children not in special education are rated below average gives credence to the possibility of subjective parental ratings. Even fewer younger children are rated as performing below average in school. Similar to previous work by the authors, we include two variables indicating whether the child attends special education. SPECED1 indicates that the child attends special classes of any kind. About eight percent of the sample belongs in this category. Eight percent of older children and seven percent of younger children are in this category. SPECED2 indicates that the child attends special education for a learning, emotional, or developmental disability. In our sub-sample of children not in special education, we exclude all children in special education of any kind.

The next four variables indicate the child's behavior. SUSPEND indicates whether the child has ever been expelled or suspended from school. For continuous variables, NSUSPEND represents the total number of times the student was ever expelled or suspended. Eight to nine percent of the older children have been suspended. The respondent was asked a series of 32 questions comprising the NHIS

"Behavior Index." Questions ranged from "Dependent on Others" to "Very Strong Temper" to "Easily Confused." For each of these behaviors, the respondent asked whether it was often, sometimes, or not true for her child. We formulated two dichotomous variables from this index. BEHAVIOR1 indicates that "often true" was coded for at least one behavior. This was true for about a third of the sample. BEHAVIOR2 indicates that "often true" was coded for at least two behaviors. About fourteen percent of the sample has two or more behaviors "often true." For continuous variables, NBEHAVIOR1 ranges from zero to 28 out of a possible 32 for "often true." NBEHAVIOR2 ranges from zero to 26, for "sometimes true" to the behaviors. EMOPROBS is coded one when the respondent answered that the child has had emotional or behavioral problems. According to this variable, about fifteen percent of the sample has had some emotional or behavioral problems.

We tested eight dichotomous variables assessing the health of the child. We have chosen not to use many of the health utilization variables available in the data set because they may be indicators of family factors as well as of health. For example, the measure of trips to the doctor given in the CHS may reflect parental attitudes about illness and parental access to medical care, as well as the health of the child. However, we did include variables indicating hospitalizations, since these may be more objectively related to health than the doctor's visits. The respondent was asked a series of nine questions about the child's health such as: "health is excellent," "resists illness," and "recovers quickly." For each question, the respondent answered "mostly true" or "mostly false." HEALTH1 indicates that "mostly true" was coded at

least once; HEALTH2 indicates that "mostly true" was coded at least twice; and HEALTH3 indicates that "mostly true" was coded at least three times. "Mostly true" was coded one or more for forty percent of the sample, coded two or more for about twenty percent of the sample, and coded three or more for about nine percent of the sample. The respondent was also asked to rate the child's health as excellent, very good, good, fair, or poor. HEALTH4 indicates that the child's health was below very good, which is indicated for approximately twenty percent of the sample. HEALTH5 indicates that the child's health was rated below good (about two percent of the sample). LIMITS indicates that the child is limited in some range of activities, and was reported for about in about seven to eight percent of the overall sample and for about four percent of the children not in special education.

The respondent was also asked a detailed series of questions about the medical history of the child. CHRONHLTH indicates that the child has at least one chronic health condition. These health conditions relate to missing or impaired limbs or digits, hearing or vision problems, muscle or joint problems, neurological or cardiac problems, or other serious health conditions. SERIOUSHLTH indicates that the child has had a serious illness in the past twelve months such as frequent diarrhea or colitis, tonsillitis, anemia, etc.. Some chronic condition occurs in about twenty percent of the sample, and a serious illness in the past twelve months occurred in about 29% of the younger children and 26% of the older children. The *number* of chronic or serious health conditions are represented by continuous variables NCHRONICH and NSERIOUSH, respectively. HOSPCHRONIC indicates the number of nights that the

child was hospitalized for a chronic condition in the past year, HOSPSERIOUS indicates the number of nights that the child was hospitalized for a serious illness in the past year, and HOSPALL indicates the number of nights that the child was hospitalized for either type of illness in the past year. We exclude children who were hospitalized due to an accident, injury or poisoning. The means indicate few hospitalizations. NILLABSC indicates the number of days the child was absent from school due to illness. The mean was under four days for all four cohorts. NBEDDAYS indicates the number of days the child had to spend in bed due to illness during the past year, the mean was about three days for all four cohorts.

Independent Variables

Table 1 also shows means and standard deviations for the independent variables included for all of the twenty nine dependent variables. These are similar to those that appear in previous work by the authors (Chaikind and Corman 1991). Independent variables include: gender of the child (MALE), age of the child (AGE), a dichotomous variable indicating family poverty (POOR), a dichotomous variable for whether the mother was a teenager when the child was born (TEENMOM), family income (INCOME), a dichotomous variable for whether the child is black (BLACK), three dichotomous regional variables (NE, SOUTH, WEST), dichotomous variables for urbanization (CITY, SUBURB), a dichotomous variable indicating whether the child lives with both parents (TWOPAR), the level of education of the mother figure in the household (MOMED), the number of siblings (SIBS), and a dichotomous variable indicating whether the child weighed less than 2500 grams (LOWBW).

Altogether, there are fifteen independent variables.

Estimation

When estimating the effects of low birthweight on each of the seventeen dichotomous dependent variables, we perform a multivariate dichotomous logit estimation. Because we are only using a subsample of the CHS, children between the ages of 6 and 15, and because missing values preclude using the entire subsample, we do not use the population weights provided by the Survey. However, our analysis does hold constant many of the factors which would affect these weights, since households in the sample were selected based on independent variables such as race, income, and location. It should be noted that the CHS oversamples blacks, and the mean income in the sample is below the national median for families with children. Multivariate ordinary least squares (OLS) estimations are performed for the continuous dependent variables. All estimations are performed on four separate cohorts: All Children Ages 6-10, All Children Ages 11-15, Children Not in Special Education Ages 6-10, and Children Not in Special Education Ages 11-15. By excluding children who are classified in special education, we are excluding those with the most clearly defined and classifyable disabilities that prevent them from learning without some type of special services. Thus, this sample is more comparable to the studies which exclude children with obvious disabilities. Because the CHS only samples children who live at home, children with disabilities severe enough to require placement in a residential facility are not included in our sample.

IV. Results

Results showing the relationship of low birthweight to each outcome measure for the two cohorts of all children are presented in Table 2, and results for children not in special education are presented in Table 3. Each row in each table represents one result for a separate estimation. Each indicates the logit coefficient of the dichotomous low birthweight variable on the dichotomous dependent variable, holding constant the other fourteen independent variables. The effects of the other fourteen independent variables on the dependent variables are not shown in Tables 2 or 3, but a sample of the full set of results, using REPEAT2 as the dependent variable, appear in Table 4. For each of the dependent variables presented in Tables 2 or 3, the logit coefficient represents the estimated effect of low birthweight on the natural log of the odds ratio for the dependent variable. The standard error of this coefficient is also presented. For ease of interpretation, we have converted the logit coefficients into OLS-type coefficients, evaluated at the mean of the dependent variable.[2] Finally, we indicate the number of observations for each estimation.

The first five dependent variables measure school performance. Examining Table 2, for the younger cohort, all five of these variables have positive signs, indicating that low birthweight children have poorer school performance than normal birthweight children. Only one of these five variables, parent's report of poor school performance (SCHOOLPERF) is statistically significant, although all coefficients exceed their standard errors. For the older cohort, again all five coefficients are positive, however all except SCHOOLPERF are statistically significant. One interpretation of these results is that low birthweight has an adverse effect of school

performance, but that this effect is not identified or does not require special attention by the schools until the child is older. Results in Table 3 are quite similar. Even excluding the students who are classified in special education, there is compelling evidence of poorer school performance of low birthweight children. For the younger children, the parent's rating is statistically significant. In the older cohort, children who were low birthweight are significantly more likely to have repeated a grade. The magnitude of the effects can be assessed by examining the OLS-type coefficients. In the older cohort, low birthweight children are between five and eight percentage points more likely to repeat a grade than their normal birthweight peers. The issue of grade repetition is explored in greater detail, below.

The next four variables indicate the behavior of the children. For the younger cohorts, whether those in special education or not, the effects of low birthweight on behavioral problems is negative and statistically insignificant. Although most coefficients for the older cohorts are positive, only one is statistically significant--one of the behavior checklist variables for all children. For the subset of children not in special education, we find no significant effects of low birthweight on behavior problems.

The remaining eight variables measure the health of the child. Variables HEALTH1 through HEALTH3 are based on parents' responses to a checklist. HEALTH4 and HEALTH5 are based on subjective ratings of the child's health. Of the twenty coefficients for the four cohorts, nineteen are positive, and fifteen of the nineteen are statistically significant. The variable indicating limitations in activities is

positive in all four cohorts, and significant in three. Our findings imply that the children do not outgrow their health problems as they mature, nor is there evidence that health problems are confined to children who are identified with a disability--i.e. those in special education. The results which examine specific conditions indicate that both age cohorts of the low birthweight children are more likely to have experienced a serious (but not chronic) illness in the past year of the survey. Examining the magnitudes of these effects, the younger cohort not in special education are about five percentage points more likely to have a serious illness in the past year if they were low birthweight, and the low birthweight older cohort not in special education are about eight percentage points more likely to experience a serious illness in the year than their normal birthweight peers. These results suggest that the low birthweight children continue experience more illness than their normal birthweight peers, even into adolescence.

Our results indicate that the children's poor health is significantly related to their having been born below 2500 grams. Since health has the potential impact of adversely affecting school performance, we also explored the possible relationship of poor health to poorer school outcomes. In additional logit regressions (not shown), we estimated the effect of low birthweight on poor school outcomes, holding constant health, as well as the other independent variables.[3] Results indicate that, although poor health adversely affects school outcomes,[4] it does not significantly reduce the impact of low birthweight on school performance. This result implies that even if illnesses could be reduced for low birthweight children, they would still perform

more poorly in school than their normal birthweight peers.

OLS results for continuous variables are presented in Table 5, for all children, and in Table 6 for children not in special education, while Table 7 indicates the full OLS results for a sample continuous dependent variable, NILLABSC. The first three variables in Tables 5 and 6 refer to behavior-related variables. The only significant variable (and only for the younger children) is NBEHAVIOR2, which measures the number in the CHS behavior index in which "sometimes true" was answered. However, this variable has a negative sign, indicating that the younger low birthweight children are *less* likely to have behavioral problems than their normal birthweight peers. Altogether, this result is consistent with the logit results that low birthweight children generally do not have significantly worse behavioral problems than their normal birthweight peers, as measured by the CHS behavior index and by suspensions from school.

The other seven dependent variables in Tables 5 and 6 measure health of the children. The coefficients on NILLABSC indicate that children who were low birthweight are more likely to be absent from school, but the magnitude of this effect is small. In all four cohorts, the effect is less than a full day's absence. Low birthweight has significant effects on both number of chronic health conditions and the number of serious conditions. Again, these magnitudes are not large.[5] low birthweight increases the number of conditions by about .10 condition for each type of condition in each cohort. The last three variables refer to the number of hospital nights: for chronic illnesses, for serious illnesses, and for either type of illness.[6]

Low birthweight is significantly related to hospital nights for the younger cohort. The magnitude is that, on average, low birthweight children spend about one half more night in hospitals than normal birthweight children for serious or all illnesses. If low birthweight children "outgrow" their problems, here is the one area where such growth is revealed. Although the older children seem to be sick and absent from school as often as the younger children, such illnesses do not continue to result in greater hospitalizations for the low birthweight children as they age.

Summarizing the results, thus far, we find that children who were low birthweight are more likely to experience problems in school and to experience more health problems than their normal birthweight peers. Although the children continue to experience health problems into adolescence, their propensity to become so ill that they require hospitalization decreases as they age. We do not find significant behavioral problems, after holding constant demographic and socio-economic variables. This result is at odds with other studies such as McCormick et al. (1992), Drillien et al. (1980), Hack et al. (1992), and Lloyd et al. (1988). One possible reason for the disparate results is that those studies all concentrated on very low birthweight children, whereas the majority of the children in this study were in the higher low birthweight category. However, not all previous studies concur with the four cited above. Lagerstrom et al. (1990) find significant behavioral problems for girls, but not boys; Breslau et al. (1988) find significant behavioral problems for boys but not for girls; McGauhey et al. (1991) and McCormick et al. (1990), who both use the Child Health Supplement to the 1981 National Health Interview Survey do not

find strong behavioral differences between low and normal birthweight children.

Many previous studies explore possible interactions between socio-economic variables and low birthweight. For example, in our own previous work (Chaikind and Corman, 1991), we found that there was a large positive interaction between low birthweight and poverty in predicting whether or not a child would be in special education. In order to fully explore the potential interactions between SES and low birthweight affecting health, behavioral and school outcomes, we performed additional logit analyses and additional OLS regressions, using essentially the same variables, but including interaction terms for two of the variables indicating socio-economic status: mother's education and poverty.[7] Our results (not shown) indicate few significant interactions between low SES and low birthweight in predicting outcomes for school-aged children. Exceptions include finding a positive and significant interaction of low birthweight and poverty in explaining special education attendance--this result is consistent with our previous work. We did not, however, find a significant interaction between low birthweight and mother's low education in explaining special education. The only other variable found to have a positive interaction with low birthweight was the variable indicating whether the child was suspended from school. The interaction was only found for the older children, and when poverty was the interaction term. For the younger group, a strong negative interaction was found between poverty and low birthweight. Generally, our results indicate that although demographic and economic variables all affect childhood outcomes, significant interactions between the socio-economic variables and low

birthweight are, generally not found.[8]

In addition, we further test the impact of the overall magnitude of grade repetition due to low birthweight. The results presented above show that low birthweight is a significant predictor of the variable measuring whether the child has ever repeated a grade. However, it would be more helpful to ascertain whether the child will ever repeat a grade; that is, by the time secondary schooling is completed, how many more low birthweight children will repeat a grade than those who were not of low birthweight? In order to answer this question, we performed a multivariate estimation of the survival function for not repeating a grade. Holding the other variables constant at their mean values, for all ages and all children, we found that about 31 percent of low birthweight children will repeat a grade by grade 10. This compares with about 26 percent of normal birthweight children. Note that these results closely resemble those of Shepard and Smith (1989) who report that about 27 percent of children who were 15 years old in 1984 had repeated at least one grade.

V. Discussion

This study finds significant adverse effects resulting from low birthweight well into school-age for some children. Specifically, we find that low birthweight children are more likely to repeat a grade and are more likely to have additional health problems while in school when compared with normal birthweight children. These outcomes have economic and social consequences that go beyond the immediate health care and special education costs previously reported, and may have much longer term,

lifetime effects as well. The results shown in this paper also indicate that preventative efforts in terms of improved prenatal care, better nutrition, reduction in alcohol, tobacco and other substance abuse, and early intervention are likely to yield higher social returns than previously reported. The encouraging part of our research is that we find few significant behavioral problems in school-aged children due to low birthweight.

Grade repetition has immediate social costs. According to Shepard and Smith (1990), the average cost of repeating a grade is over $4,000 per child. In our sample, about 7.5% of the children were low birthweight. Given approximately three million children born per year, there are about 225,000 low birthweight survivors born per year. If five percent of these children will repeat one grade strictly due to the low birthweight--about 11,250 students per year-- this will result in a cost of about $45 million per cohort for grade repetition. However, the school costs of grade repetition are minor compared to the lifetime costs of poor school achievement. According to Grissom and Shepard (1989), students who were retained for a grade in school in samples from Chicago and Austin, Texas were at least twenty percentage points more likely to drop out of school than those who were not retained. High school dropouts, when compared to graduates and those who continue into college, have lower lifetime earnings, pay less taxes, commit more crimes, and require more social services, in general. For example, recent research by Currie and Cole (1991) examined adult outcomes for mothers who were behind in school at age 14. They found these mothers more likely to be poor, to be AFDC recipients, more likely to

have low birthweight children, and more likely to raise their children in a single parent household. Thus, their research indicates that poor school performance leads to poor adult outcomes, and can perpetuate these poor outcomes into the next generation.

Our results also indicate that children who were low birthweight continue to have more health problems than their normal birthweight peers. Comparing the older to the younger cohort, it is evident that the children do not necessarily outgrown their health problems as they mature. Thus, not only are health costs greater for the low birthweight children throughout their childhood, the health problems could continue into adulthood, as well. And, similar to poor schooling outcomes, poor health can lead to poorer labor force and other adult outcomes for these children.

These results provide further evidence that preventing poor pregnancy outcomes can have large savings in costs to our health, education and social services systems. In addition, the education community must be aware of the relationship between neonatal health and the educational needs of children. One recent report, recognizing this relationship, stated "Information about the health conditions of newborns provides the first warning of potential educational problems and a benchmark of the nation's progress in addressing prenatal risk factors." (US Department of Education, 1991, p.85) Early intervention programs are often cited as effective means for improving educational outcomes for low birthweight and other at-risk children. Studies, for example, have shown that early intervention from infancy through the preschool years may lead to improved child cognitive development, more

commitment to schooling, improvement in student's self-confidence, better classroom learning behaviors, and later, increased employability, reduced dependence on public assistance, and other positive outcomes. (Balasubramanian and Turnbull, 1988; Rauh et al., 1988; US House of Representatives, 1985).

Notes

1. We performed a chi-square test for differences in all of the coefficients for the younger and older children for both all children and those not in special education. These tests were performed for each of the dichotomous dependent variables. We found significant differences between the age cohorts for most of the school performance and health cohorts.

2. The OLS-type coefficient is calculated as b_i (P_0) $(1-P_0)$, using mean values of the probabilities.

3. That is, we ran logit estimations for REPEAT1, REPEAT2, AND BADS, including each of the independent variables plus one of the health variables. We did this for each health variable.

4. In most instances, poor health had a significant impact on poor school outcomes.

5. Although the magnitudes are small for any individual child, they could become costly to health systems or school districts if they have large numbers of children who were low birthweight.

6. We excluded hospitalizations due to accidents, injuries or poisonings.

7. Specifically, we ran the regressions with three dichotomous variables: low birthweight only, low SES only, or both. In these estimations, we excluded the relevant SES variable (the dichotomous poverty variable or the continuous mother's education variable). Mother's education is the more exogenous of the two indicators, since most women do not return to school. Thus, this variable indicates the education level at the time the child was born. Poverty may be somewhat endogenous to the system. For example, research by Corman and Kaestner (1992) found that mothers with children in poor health are more likely to become single, and therefore poor.

8. Because of the potential endogeneity of some of the SES variables, discussed above, there may, in fact, be more interactions.

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Table I
Means of Variables
(Standard Deviation)

Variables	Description	All Children		Children Not in Special Education	
		Ages 6-10	Ages 11-15	Ages 6-10	Ages 11-15
Dichotomous Dependent Variables					
REPEAT1	Respondent reports child repeated a grade	.110 (.313)	.194 (.396)	.094 (.292)	.168 (.374)
REPEAT2	Respondent reports child repeated a grade or (Age - grade) > = 7	.121 (.326)	.212 (.409)	.105 (.307)	.185 (.389)
SCHOOLPERF	Respondent rates child's school performance below average	.048 (.214)	.089 (.285)	.030 (.171)	.069 (.253)
SPECED1	Child is in any form of special education	0.65 (.247)	.077 (.266)		
SPECED2	Child is in special education for learning, emotional or developmental disability	.055 (.228)	.071 (.257)		
SUSPEND	Respondent reports child has been suspended from school at least once	.017 (.129)	.093 (.291)	.016 (.124)	.083 (.276)
BEHAVIOR1	Behavior checklist - at least one item coded "often true"	.328 (.470)	.328 (.469)	.309 (.462)	.303 (.460)
BEHAVIOR2	Behavior checklist - at least two items coded	.133 (.339)	.137 (.344)	.116 (.321)	.116 (.321)
EMOPROBS	Child has had emotional or behavioral problems	.127 (.333)	.173 (.379)	.111 (.314)	.148 (.356)
HEALTH1	Nine question health survey - at least one question coded "mostly true"	.425 (.494)	.374 (.484)	.413 (.492)	.357 (.479)
HEALTH2	Nine question health survey - at least two questions coded "mostly true"	.223 (.416)	.194 (.395)	.210 (.407)	.179 (.384)
HEALTH3	Nine question health survey - at least three questions coded "mostly true"	.097 (.295)	.083 (.276)	.087 (.282)	.072 (.259)

HEALTH4	Child's health rated worse than "very good"	.187 (.390)	.206 (.404)	.184 (.388)	.198 (.399)
HEALTH5	Child's health rated worse than "good"	.021 (.144)	.024 (.152)	.019 (.136)	.020 (.141)
LIMITS	Child is limited in some range of activities	.068 (.251)	.079 (.270)	.040 (.196)	.048 (.214)
CHRONHLTH	Child has at least one chronic health condition	.207 (.405)	.200 (.400)	.193 (.395)	.183 (.386)
SERIOUSHLTH	Child had at least one serious illness in past year	.294 (.456)	.267 (.442)	.290 (.454)	.260 (.439)
Continuous Dependent Variables					
NSUSPEND	Number of times suspended from school	.042 (.669)	.213 (1.216)	.033 (.488)	.178 (1.123)
NBEHAVIOR1	Number of times "often true" on behavior index	.513 (.874)	.543 (.966)	.469 (.834)	.477 (.880)
NBEHAVIOR2	Number of times "sometimes true" on behavior index	1.993 (1.371)	1.950 (1.382)	1.937 (1.347)	1.886 (1.365)
NILLABSC	Number of absences from school due to illness	3.726 (4.978)	3.856 (6.285)	3.643 (4.843)	3.722 (5.942)
NBEDDAYS	Number of bed days due to illness	2.696 (4.947)	3.030 (8.318)	2.633 (4.824)	2.939 (8.173)
NCHRONICH	Number of chronic conditions	.249 (.543)	.261 (.606)	.227 (.511)	.232 (.566)
NSERIOUSH	Number of serious illnesses in past 12 months	.405 (.741)	.367 (.702)	.397 (.733)	.355 (.689)
HOSPCHRONIC	Number of nights in hospital for chronic condition in past 12 months	.033 (.876)	.043 (.727)	.032 (.894)	.042 (.734)
HOSPSERIOUS	Number of nights in hospital for serious illness in past 12 months	.066 (1.729)	.077 (2.203)	.066 (1.776)	.075 (2.280)
HOSP-ALL	Number of nights in hospital for either illness in past 12 months	.121 (2.109)	.137 (2.510)	.122 (2.159)	.134 (2.572)
Independent Variables					
MALE	Dichotomous - one for male	.499 (.500)	.516 (.500)	.049 (.500)	.503 (.500)

AGE	Child's age	7.945 (1.424)	13.068 (1.420)	7.916 (1.429)	13.068 (1.420)
POOR	Dichotomous - one if below poverty level	.164 (.370)	.143 (.350)	.158 (.365)	.138 (.345)
TEENMOM	Dichotomous - one if mother was teen-aged when child was born	.206 (.405)	.219 (.414)	.203 (.402)	.217 (.412)
INCOME	Income	27,138 (19,755)	28,665 (20,315)	27,267 (19,740)	28,835. (20,310)
BLACK	Dichotomous - one if black	.169 (.375)	.174 (.379)	.170 (.376)	.175 (.380)
NE	Dichotomous - one if lives in Northeast	.188 (.391)	.183 (.386)	.191 (.393)	.181 (.385)
SOUTH	Dichotomous - one if lives in South	.345 (.475)	.348 (.476)	.344 (.475)	.350 (.477)
WEST	Dichotomous - one if lives in West	.199 (.399)	.204 (.403)	.199 (.400)	.206 (.404)
CITY	Dichotomous - one if lives in metropolitan area	.752 (.432)	.761 (.427)	.751 (.433)	.761 (.427)
SUBURB	Dichotomous - one if lives in suburb of metropolitan are	.449 (.497)	.469 (.499)	.445 (.497)	.466 (.500)
TWOPAR	Dichotomous - one if both parents live in household	.593 (.491)	.559 (.497)	.601 (.490)	.569 (.495)
LOWBW	Dichotomous - one if born less than 2500 grams	.079 (.270)	.074 (.261)	.076 (.266)	.071 (.256)
MOMED	Mother's Education	12.657 (2.563)	12.407 (2.674)	12.680 (2.571)	12.432 (2.675)
SIBS	Number of siblings	1.134 (1.000)	1.154 (1.048)	1.135 (1.005)	1.154 (1.045)
Observations		3868	3865	3640	3583

Table 2
The Effect of Low Birthweight on Childhood Outcomes
Logit Results

Dependent Variable Name	All Children 6-10				All Children 11-15			
	Logit Coeff.	S.E.	OLS-Type Coeff.	Obs.	Logit Coeff.	S.E.	OLS-Type Coeff.	Obs.
REPEAT1	.2641	.192	.0259	3271	.2990*	.159	.0468	3424
REPEAT2	.2427	.186	.0258	3291	.4516***	.152	.0755	3427
SCHOOLPERF	.9488***	.240	.0432	3262	.2456	.213	.0200	3394
SPECED1	.3620	.269	.0188	3243	.4520**	.229	.0298	3340
SPECED2	.4636*	.241	.0282	3243	.5504**	.216	.0389	3340
SUSPEND	-.9844	.615	-.0164	3290	.1119	.212	.0095	3434
BEHAVIOR1	-.0224	.136	-.0049	3569	.2831**	.136	.0624	3495
BEHAVIOR2	-.1062	.185	-.0122	3569	.0199	.183	.0023	3495
EMOPROBS	-.2104	.224	-.0234	3274	.1579	.186	.0226	3121
HEALTH1	.3898***	.129	.0953	3516	.5248***	.134	.1228	3451
HEALTH2	.4561***	.142	.0326	3516	.7175***	.146	.1120	3451
HEALTH3	.4138**	.192	.0361	3516	.9456***	.181	.0720	3451
HEALTH4	.1926	.153	.0293	3549	.2515*	.153	.0411	3478
HEALTH5	.7165**	.316	.0148	3549	-.0525	.391	-.0012	3478
LIMITS	.5354**	.211	.0338	3577	.7543***	.188	.0548	3499
CHRONHLTH	.2139	.153	.0351	3577	.1877	.159	.0301	3499
SERIOUSHLTH	.2263	.139	.0470	3577	.3981***	.142	.0779	3499

Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Table 3
The Effect of Low Birthweight on Childhood Outcomes
Logit Results

Dependent Variable Name	Children Ages 6-10 Not in Special Education				Children Ages 11-15 Not in Special Education			
	Logit Coeff.	S.E.	OLS-Type Coeff.	Obs.	Logit Coeff.	S.E.	OLS-Type Coeff.	Obs.
REPEAT1	.2154	.213	.0184	3065	.4107**	.173	.0575	3169
REPEAT2	.2037	.205	.0192	3085	.5572***	.165	.0842	3171
SCHOOLPERF	.8542***	.301	.0249	3055	.1163	.262	.0075	3142
SUSPEND	-.8154	.619	-.0125	3082	.0601	.237	.0046	3179
BEHAVIOR1	-.0220	.144	-.0047	3360	.2264	.146	.0478	3236
BEHAVIOR2	-.1275	.205	-.0131	3360	-.0165	.208	-.0017	3236
EMOPROBS	-.2104	.241	-.0207	3187	.0397	.208	.0050	3019
HEALTH1	.3259**	.135	.0790	3312	.5264***	.142	.1209	3194
HEALTH2	.3666**	.152	.0608	3312	.7524***	.157	.1106	3194
HEALTH3	.5012**	.204	.0399	3312	.9085***	.203	.0609	3194
HEALTH4	.1897	.160	.0285	3341	.2200	.165	.0350	3219
HEALTH5	.6861*	.353	.0127	3341	.0292	.450	.0006	3219
LIMITS	.4139	.284	.0159	3367	.7746***	.239	.0354	3240
CHRONHLTH	.1874	.164	.0292	3367	.1298	.176	.0194	3240
SERIOUSHLTH	.2642*	.145	.0544	3367	.3756**	.153	.0723	3240

Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Table 4
Full Logit Results: Dependent Variable - Repeat 2

	All Children		Children Not in Special Education	
	Ages 6-10	Ages 11-15	Ages 6-10	Ages 11-15
Variables	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)
INTERCEPT	-3.18*** (.51)	-.412 (.50)	-3.19*** (.55)	-.701 (.55)
MALE	.476*** (.11)	.776*** (.09)	.425*** (.12)	.762*** (.10)
AGE	.315*** (.04)	.011 (.03)	.299*** (.05)	.018 (.03)
POOR	.202 (.16)	.323*** (.13)	.163 (.17)	.362*** (.14)
TEENMOM	.304** (.13)	.340*** (.10)	.405*** (.14)	.373*** (.11)
INCOME	-1.0 E-5** (4.4 E-6)	-6.16 E-6** (3.1 E-6)	-1.1 E-5** (4.9 E-6)	-7.09 E-6** (3.49 E-6)
BLACK	.188 (.15)	.118 (.12)	.190 (.16)	.175 (.13)
NE	-.159 (.18)	.011 (.14)	.064 (.19)	-.013 (.16)
SOUTH	.034 (.14)	.376*** (.11)	.020 (.16)	.450*** (.12)
WEST	-.055 (.17)	-.138 (.14)	.090 (.18)	-.044 (.15)
CITY	-.128 (.15)	-.081 (.12)	-.135 (.17)	-.089 (.14)
SUBURB	.219 (.14)	.077 (.11)	.174 (.15)	.008 (.12)
TWOPAR	-.388*** (.12)	-.551*** (.10)	-.369*** (.14)	-.526*** (.11)
LOWBW	.243 (.19)	.452*** (.15)	.204 (.20)	.557*** (.16)
MOMED	-.115*** (.02)	-.120*** (.02)	-.114*** (.03)	-.122*** (.02)
SIBS	.036 (.05)	.100** (.04)	.028 (.06)	.123*** (.04)
OBSERVATIONS	3291	3427	3085	3171

Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Table 5
OLS Regression Results: All Children

Dependent Variable Name	All Children Ages 6-10			All Children Ages 11-15		
	Coeff.	S.E.	Obs.	Coeff.	S.E.	Obs.
NSUSPEND	-.059	.046	3290	.037	.082	3434
NBEHAVIOR1	-.015	.143	3312	.047	.177	3167
NBEHAVIOR2	-.672**	.295	3312	.109	.308	3167
NILLABSC	.857***	.329	3255	.634	.423	3395
NBEDDAYS	.531*	.319	3542	.184	.559	3479
NCHRONICH	.087**	.034	3577	.088**	.040	3499
NSERIOUSH	.107**	.047	3577	.120***	.046	3499
HOSP-CHRONIC	.056	.061	3137	-.024	.052	3214
HOSP-SERIOUS	.408***	.114	3567	-.037	.151	3490
HOSP-ALL	.507***	.151	2972	-.093	.182	3017

Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Table 6
OLS Regression Results: Children Not in Special Education

Dependent Variable Name	Children Ages 6-10 Not in Special Education			Children Ages 11-15 Not in Special Education		
	Coeff.	S.E.	Obs.	Coeff.	S.E.	Obs.
NSUSPEND	-.037	.035	3082	-.044	.081	3179
NBEHAVIOR1	-.043	.142	3119	-.047	.161	3236
NBEHAVIOR2	-.737**	.301	3119	.032	.321	3236
NILLABSC	.621*	.335	3047	.858**	.422	3144
NBEDDAYS	.497	.324	3334	.408	.587	3221
NCHRONICH	.060*	.033	3367	.082**	.040	3240
NSERIOUSH	.104**	.048	3367	.115**	.047	3240
HOSP-CHRONIC	.047	.065	2986	-.015	.055	3006
HOSP-SERIOUS	.426***	.122	3358	-.029	.166	3232
HOSP-ALL	.531***	.159	2831	-.079	.196	2823

Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Table 7
Full OLS Regression Results: Dependent Variable - NILLABSC

	All Children		Children Not in Special Education	
	Ages 6-10	Ages 11-15	Ages 6-10	Ages 11-15
Variable	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)	Coeff. (S.E.)
INTERCEPT	5.63*** (.78)	2.36** (1.2)	5.56*** (.78)	3.04** (1.2)
MALE	-.219 (.17)	-.491** (.22)	-.247 (.17)	-.655*** (.21)
AGE	-.138** (.06)	.146* (.08)	-.148** (.06)	.103 (.08)
POVERTY	.261 (.27)	1.95*** (.36)	.020 (.28)	1.57*** (.36)
TEENMOM	.789*** (.23)	-.109 (.28)	.72*** (.23)	-.186 (.28)
INCOME	5.06 E-6 (5.45 E-6)	2.82 E-6 (6.56 E-6)	6.95 E-6 (5.46 E-6)	8.19 E-7 (6.42 E-6)
BLACK	-1.15*** (.26)	-1.92*** (.32)	-1.00*** (.26)	-1.72*** (.31)
NE	.307 (.27)	.096 (.34)	.400 (.27)	.135 (.33)
SOUTH	.212 (.23)	-.641** (.28)	.208 (.23)	-.668** (.28)
WEST	.171 (.26)	-.139 (.32)	.219 (.26)	-.209 (.31)
CITY	.294 (.24)	.079 (.32)	.187 (.24)	.234 (.31)
SUBURB	-.045 (.22)	.062 (.27)	-.132 (.22)	-.073 (.27)
TWOPAR	.199 (.20)	-.484** (.24)	.226 (.20)	-.465* (.24)
LOWBW	.857*** (.33)	.634 (.42)	.621* (.34)	.858** (.42)
MOMED	-.054 (.04)	.055 (.05)	-.040 (.04)	.033 (.05)
SIBS	-.312*** (.09)	-.221** (.11)	-.272*** (.09)	-.190* (.11)
N	3255	3395	3047	3144
F	4.386***	6.190***	3.390***	5.362***
R-Square	.02	.03	.02	.03

Note: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level