# “Understanding the Relationship Between Child Health and Long-Term Socioeconomic Status”

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## Introduction

Many studies have identified a connection between poor health and low socioeconomic status (SES). Several recent studies have shown that SES-related gaps in health are present at birth, and that these gaps in health at birth have long term consequences for children's development. We also know that SES-related gaps in maternal reports of child health status tend to grow with child age in both the United States and Canada (Case, Lubotsky and Paxson (2002); Currie and Stabile, (2003)). And poor children receive more insults to their health than richer children, including more injuries, chronic conditions and acute conditions (see for example, Newacheck (1994), Newacheck and Halfon (1998), Currie and Lin (2007), Case, Lubotsky and Paxson (2002)).

Previous research has not addressed the questions of how insults to child health after birth affect long-term outcomes, whether health at birth matters primarily because it predicts future health or through some other mechanism, whether health insults matter more at some key ages than at other times, how insults cumulate, or whether the effects of health insults vary with socioeconomic status.

This study provides a first look at these questions using a unique administrative data set from the Canadian province of Manitoba's public health insurance system. The data combines health information from birth records, emergency room visits, hospitalizations, and outpatient visits with information from other provincial registers about educational and young adult socio-economic outcomes including: grade 12 standardized language arts and math achievement, on time high school completion, and welfare participation. This health and outcome information is much more complete, and in many ways more accurate, than what is typically available in survey data. The Canadian data is also useful because it sheds light on the consequences of disparities in health in a setting that abstracts from differences in access to insurance coverage.

We follow 51,000 children born in the Canadian province of Manitoba between 1979 and 1985, until 2006, when they are young adults. In contrast, Case, Lubotsky and Paxson use cross-sectional data, Currie and Stabile (2003) use a four year panel, and authors who use longitudinal data sets such as the British cohort data sets have much less detailed, and less continuous measures of health status than we have.

A growing body of research suggests that adverse conditions in early childhood may have particularly negative long term effects. James Heckman has hypothesized that this is because “skill begets skill,” so that children who suffer early disadvantages may fall behind and never catch up (Cuhna and Heckman, 2007). On the other hand, to the extent that children are resilient and recover after health insults, one might expect more recent insults to have greater effects on current outcomes. If both mechanisms are at work, then one might expect to find that both health insults in early childhood and recent health shocks have particularly negative effects on young adult outcomes. We will show that for many types of health shocks, this is indeed the case.

Our results show that early health insults have significant effects on future adult outcomes. Mental health problems are particularly important for children at all levels of socioeconomic status. Injuries are also an important source of future disparities particularly among children of lower SES. While there is strong evidence, consistent with other studies, that early health affects future health, the evidence also suggests that early health matters even conditional on future health. We conclude that differences in health in childhood are a significant source of socioeconomic disparities in adulthood.

## 2. Background

There is a great deal of evidence that socioeconomic status is related to health more generally (see Adler and Ostrove (1999), Marmot and Wilkinson (1999), and Cutler and Lleras-Muney (2006) for reviews) and that low socioeconomic status in childhood is related to poorer future adult health. Elo and Preston (1992) summarize some of this literature, and show that cohorts who suffered high death rates in childhood also tend to show high death rates in adulthood, in part because of the direct effects of childhood health conditions on future morbidity. Currie and Madrian (1999) summarize the literature showing that health problems in adulthood reduce labor supply and wages.

Most of the literature about the effects of children's health has focused on linking a specific health insult to a specific later outcome. Because it is widely available, the most commonly examined insult is low birth weight (LBW, birth weight less than 2500 grams). For example Linnet et al. (2006) use Danish registry data to show that children who were premature, or low birthweight and/or whose mothers smoked in pregnancy, had a much higher risk of Attention Deficit Hyperactivity Disorder (ADHD).

A large literature has established that low birth weight babies have lower average scores on a variety of tests of intellectual and social development (see for example, Breslau et al. 1994, Brooks-Gunn, Klebanov, and Duncan, 1996). Currie and Hyson (1999) show that low birth weight children from the 1958 British birth cohort study (all of the children born in Great Britain in one week in 1958) have lower test scores, educational attainments, wages, and probabilities of being employed as of age 33, even conditional on many measures of family background and circumstances. Case, Fertig, and Paxson (2005) extend this research by showing that the same is true at age 42, and for adults who suffered chronic conditions as children.

In one of the few studies to look at other health measures, Luo and Waite (2005) use data from the Health and Retirement Survey, a national survey of older adults, and find that the effect of a retrospective measure of childhood SES on future health, education, and income is attenuated by the inclusion of child health measures, suggesting that child health may explain some of the impact of low childhood SES on future outcomes. But it is possible that these correlations are due to other characteristics of households that are associated both with poor child health and poorer outcomes.

More recently, several studies have used sibling designs and/or large-scale administrative data sets to examine the relationship between low birth weight and future outcomes in models that control more fully for family background characteristics by comparing siblings. In these studies the "control" for the low birth weight child is the child's non-low birth weight sibling. For example, using data from the Panel Study of Income Dynamics, Conley and Bennett (2000) find that low birth weight reduces the probability of high school graduation, while Johnson and Schoeni (2007) find that low birth weight is strongly related to poorer adult health and lowers adult annual earnings by 17.5 percent. Oreopoulos, Stabile, Roos, and Walld (2007) use the Manitoba data used in this study and find results consistent with the U.S. studies: children with birth weight between 1,500 to 2,500 grams were 8.2 percent less likely to reach grade 12 by age 17 than siblings who weighed over 3,500 grams and these children also spent 1 month longer on welfare than their siblings who weighed over 3,500 grams.

Smith (2007) is unusual in that he applies the sibling comparison design to a measure of the health of older children. He investigates the relationship between child health and future outcomes using data from the 1999 Panel Study of Income Dynamics. The 25 to 47 year old adult children of PSID respondents were asked a retrospective question about the state of their health when they were less than or equal to 16 years old: Whether it was excellent, very good, good, fair or poor? In models with sibling fixed effects, Smith finds significant negative effects of poor overall health status in childhood on earnings.1

There has been little work applying these methods to other specific health conditions besides low birth weight. The literature does, however suggest that some classes of child health problems are likely to be of particular importance in explaining future child outcomes because of their prevalence and documented negative correlations with child outcomes:

1) Mental Health: The MECA Study (Methodology for Epidemiology of Mental Disorders in Children and Adolescents) cited in the 1999 U.S. Surgeon General's Report on Mental Health finds that approximately one in five children and adolescents in the U.S. exhibit some impairment from a mental or behavioral disorders, 11 percent have significant functional impairments, and 5 percent suffer extreme functional impairment. (Shaffer et al., 1996; U.S. DHHS, 1999). Using retrospective questions about onset, Kessler et al. (1995) find that those with early onset psychiatric problems were less likely to have graduated from high school. Using large-scale national surveys of children from both the U.S. and Canada, Currie and Stabile (2006, 2007) show that mental health conditions in childhood are associated with lower future test scores and schooling attainments, and that the effects are quite similar in Canada and the U.S. Duncan et al. (2006) report similar results.

2) Injuries are the leading cause of death among children over one year of age in developed countries, notwithstanding a dramatic reduction in deaths due to injuries in the past 30 years

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Salm and Schunk (2008) use data from an administrative data set in a German city to show that 6 year old children with health problems also have lower test scores, but it is somewhat difficult to interpret this contemporaneous relationship as causal.

(Glied, 2001). Yet we have little information about the burden of morbidity caused by injuries among surviving children (Bonnie et al, 1999).

3) Asthma is the leading cause of school absence and pediatric hospitalizations in children, and one of the most common chronic conditions of childhood (U.S. Environmental Protection Agency, 2006). However, we do not find evidence that asthma in childhood is strongly or consistently related to poorer adult outcomes once we control for other characteristics of households.

4) There are many other serious health problems that can afflict children, but even in a data set of

The registry contains information on 96 percent of all children born in Manitoba over the sample period and tracks 99 percent of the original sample conditional on remaining in the province until June of their 18th year.3 We restrict our sample to families with more than one child born between 1979 and 1987 (excluding 1983 as we are unable to match this cohort to educational information). We track outcomes for these children through to 2007. We restrict our sample to children with siblings also born in the period of interest as our identification strategy (discussed in more detail below) relies on sibling comparisons. Previous work using these data (Oreopoulos et al, 2008) has shown that the sibling cohort and entire cohort of Manitoba births over this period are quite similar. Further details on the construction of the data set are available in the data appendix.

irth weight, congenital anomalies and perinatal problems are obtained from hospital records. These measures are important conceptually as a summary measures of health at birth. That is, we wish to investigate the effects of health shocks after birth, so it is necessary to control for the continuing effects of health at birth.4 It is also of interest to ask whether the documented effects of health at birth matter primarily because they affect future health, or through some other mechanism.

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correlation between individual-level income and median income in the enumeration area is about .44 (Roos et al, 2005).

3 The registry data do suffer from attrition when families move out of the province and can no longer be tracked. Approximately 20 percent of the sample leaves the province between the birth of the child and their 18th year. Previous studies (Oreopoulos, Stabile, Roos and Walld) find that there does not appear to be a correlation between children being in poor health and the families leaving the province. There is also a small amount of attrition from children who die, but children who died before age eight were much less healthy at birth and most of these deaths (~3/4) occur within the first year of life.

4 Congenital problems may continue to generate diagnoses as the child ages. We have not eliminated complications due to congenital anomalies from our measures of child health status.

Table 1 shows that there is a relatively large difference in the incidence of low birth weight by socioeconomic status:  14% of the entire sample have a congenital anomaly or perinatal problem compared to 41% of the low SES sample!  For low birthweight, the comparable figures are 4.3% of the entire sample and 5% in the bottom two income quintiles.

Since birth weight is recorded in other data sets, it is possible to compare the SES-gradient in low birth weight in these data to that found in a national survey where SES can be measured using household income, the Canadian National Longitudinal Survey of Youth (NLSCY).   In the NLSCY the incidence of low birth weight is 6 percent overall compared to 6.7 percent for the bottom 40% of family incomes suggesting that the SES gradient in our sample is not very different from that found using family level income information.[5]

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5  Note that the sample used for our study includes only families with siblings and is taken over a different set of years than the NLSCY so the two numbers are not directly comparable. However, the difference between the entire sample and the bottom two income quartiles in each case is informative in that the gap is similar in size across samples.  Also, although the NLSCY has better income data, it has worse birth weight data since that information is collected retrospectively from mothers.

We use the ADG codes to construct six health measures. First, the Johns Hopkins software classifies some ADGs as major and some as minor for each age group, and we look at the number of these major ADGs. It is important to note that "major injuries" are not included as a major ADG for the three youngest age groups, though they are included for the oldest group. In order to construct a more consistent measure, we use a slightly amended measure of major ADGs that excludes injuries for all age groups. In addition to major injuries, the Johns Hopkins measure excludes asthma and many mental health conditions. Since these are all very prevalent threats to child health, we also estimate models using binary measures of whether a child had an ADG code for a mental health problem, a major injury, asthma, and a consistent set of other major health problems excluding mental health, asthma, and injuries.6

In each case the measure is constructed to cover a specific age range starting from the date of birth of the child. So, for example, we define a child as having a major injury between ages 0 and 3 if the child has a diagnosis of a major injury at any point between their birth and their 4th birthdays. We construct similar measures for the age ranges 4-8, 9-13, and 14-18. We chose these age ranges to correspond to important stages of childhood: The preschool years, early elementary school, early adolescence, and the late teen years.

The data appendix shows the mapping between our measures and the most common

6 AGDs for mental health problems include 23, 24, and 25. The ADG for major injury is 22 and for asthma is 6. The remaining "major" ADG codes are 3, 9, 11, 12, 13, 18, and 32. When we look at the number of major ADGs we follow the Johns Hopkins designation and use these later codes plus ADG 25. Johns Hopkins also adds ADG 22 for the oldest age group, but for consistency we exclude this from all age groups.

ICD9 codes in each category. For example, Appendix Table 3 shows a breakdown of the most common ICD9 codes for the children we classify as having a mental health problem in each age group. The table shows that there is both continuity and change in the types of problems faced by children as they grow older. Conduct disorders and hyperactivity are important problems at all ages, while for younger children, developmental delays are more important and for older children, neuroses start to become prominent. Similar mappings for our other health measures and for congential anomalies and perinatal problems are reported in Appendix Tables 4-6.

percent of the sample have a code for a major injury during ages 0-3, rising to 40 percent by ages 14-18. Approximately 6 percent of our sample has a mental health diagnosis between ages 0 and 3 rising steadily to 25 percent by ages 14-18. The fraction with asthma rises from 6.7% at the youngest ages to about 12% for the older age categories. As discussed above, the "other" category captures orthopedic, ear, nose throat and eye problems, cancers, and a variety of other acute major illnesses. Rates in our sample range from approximately 16 percent of the sample for ages 0-3 to 20 percent by ages 14-18.

Figure 2 explores the question of whether there are differences in the incidence of health shocks after birth by socioeconomic status. The underlying data are shown in Table 1. As discussed above, most previous analyses including Currie and Stabile (2003) (which uses Canadian data) find that poor children receive more health insults than richer children. However, we look at whether poor children were more likely than rich children to receive medical attention for a range of major health problems over a four year interval, and Figure 2 shows that SES gradients in these measures are relatively small in Manitoba. Low SES children have a larger number of major ADGs or major health conditions (consistently defined) at ages 0-3 and 14-18. In between, the differences are very slight. For injuries, there is a consistent gradient favoring higher income children. For mental health, lower SES children have more problems in their late teens, but are similar to other children at younger ages. For asthma, the gradient is reversed (higher income children have more diagnoses) which is consistent with previous evidence based on survey data (e.g. Case, Lubotsky and Paxson (2002), Currie and Stabile (2003)). For other conditions, there is little difference, except at the youngest ages.

It is possible that the relatively small gradients reflect differences in the propensity of higher and lower income families to seek diagnoses and treatment (Billings et al. 1993, Dafny and Gruber, 2005). That is, if poor people have more illnesses but are less likely to seek treatment for them, then one might see approximately equal numbers of medical contacts for rich and poor children. However, previous work with these data shows that with medical care free in Manitoba, low-income people have more contact with physicians and spend more days in hospital, although higher income people are more likely to see specialists (Roos et al., 2005; Roos and Mustard, 1997).

We think it more likely that the flat gradients by SES are a result of the fact that we focus on major health conditions, and use four year windows. Even if lower income people are less likely to seek care overall, they are likely, when faced with a major health problem and free care, to show up in the system at least once in four years. Moreover, as described further below, we focus most of our analysis on comparisons between siblings with and without specific health conditions. These sibling comparisons control for any systematic differences between families in tendencies to seek care.

Table 2 explores the pattern of health shocks over time for the children in our sample. For each of the major health problems examined we report what fraction of the sample experienced this health problem in any or each of the four age groups examined. So, for example, 0000 denotes that a child did not have a record of a particular health problem in any of the age ranges. In the case of mental health, 63 percent of our sample had no indication of a problem in any of the four age groups. The pattern 0001 denotes having mental health problem recorded in only the last age category, ages 14-18. The table suggests that, as expected, the largest group for all the health measures used is not having a health problem in any of the age ranges, as many children are healthy.

However, it is also the case that some share of sample experienced a health problem in one, two, three or all of the age ranges examined. It is therefore not the case that the same children are unhealthy in each age range, or that once a child has an administrative record of a health condition, he or she will have an administrative record for that condition at all ages going forward.

Of course, we are only able to observe whether the child interacted with the health care system and not whether they actually experienced the problem. However, it is reasonable to expect that over a four year period a child who is experiencing a severe health condition, or being treated for that condition, would need to interact with the health care system at some time. Thus, the variation in our data over time periods suggests that some children without initial health conditions develop health problems, and other children with health conditions recover from them. Such variation is key if we are to be able to use the data to examine the impact of health conditions at different ages.

Table 3 describes the young adult outcomes explored in our paper. The outcome variables are created by linking the health care registry information to administrative data on education, and social assistance.7 We link education enrollment records with the provincial registry to determine whether a student has attained Grade 12 by age 17. This measure is available for all nine birth cohorts used. Not attaining grade 12 by this age could indicate that a student entered school late, has been held back in a grade at least once, or has dropped out. Hence, we also looked at whether the child was in school at age 17, but did not find significant effects of early health on this measure. Therefore, it seems that "grade 12 by age 17" mostly captures the effect of starting school late or of being delayed. Our measure is correlated with the overall risk of ending up with a low level of education, and shows clear signs of a gradient by SES which suggests that our measure of SES is capturing real differences between groups. For the entire sample of siblings, 69 percent have reached grade 12 by age 17, while for the lower SES sample, the figure is 53 percent.

We also have information from provincial language arts standards tests taken in grade 12. These tests contribute 30 percent to the students' final course grade. Individuals pass the

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These data are available only for Manitoba residents. The analysis of the effects of health on these longer-term outcomes, therefore, is conditional on both survival and on remaining a resident in the province. This issue is discussed further in the data appendix.

language arts test by scoring 50 percent or more on a comprehensive exam.[8] The score on the test is normalized to have a mean of zero and a standard deviation of one for the entire population of students in Manitoba. Within each birth cohort, approximately 35 percent of test scores are missing and we have imputed scores for these children based on the reasons for the failure to write the test, as discussed further in the data appendix. Table 3 shows that the overall normalized average score is close to zero, while for the low SES sample it is -.34, about a third of a standard deviation lower.

Students in the province can select into one of several math tracks. While the courses offered differ by year and school, they always include courses that would prepare the student for college level mathematics. In each year we classify courses into college versus non-college mathematics based on the difficulty of the course and the course material. The number of college preparatory math courses available increased over our sample period, and as a result the number of student in college preparatory courses also increased. In our empirical analysis we include year fixed-effects to account for some of this difference.[9] We calculate that 22 percent of the whole sample took college-preparatory math courses, compared to 15 percent of the low SES sample.

Finally, the sample of Manitoba residents is matched to monthly social assistance records (the provincial welfare program) up to 2007. Our youngest birth cohort can only be followed for 1.25 years after the age of 18. While the older cohorts can be tracked for longer, in order to avoid censoring issues we define our social assistance exposure window to be a consistent 1.25 years

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8 The test focuses on reading comprehension, exploring and expanding on ideas from texts, the management of ideas and information, and writing and editing skills.

9 To further ensure that our results are not overly sensitive to the fact that the number of courses increases, we use information on the grade obtained in the course and assign students with a grade of 80% or better to college-level math. Results using this specification are quite similar to the results using just the course assignment and we present our results using only the course assignment here.

for each cohort (or 70 weeks). Using this exposure window, 6 percent of our sample has ever been on social assistance and the average number of weeks on social assistance is 2.1.

Note that our last age group, 14-18, encompasses the ages when some of our outcomes are measured. This, combined with the fact that some people might delay seeking treatment for conditions first noted at say age 16, leads us to consider the health measures for 14-18 as roughly contemporaneous with the outcomes we are examining. Hence, we have measures of earlier health and contemporaneous health, and can examine the effect of early health shocks conditional on current health.

The administrative and registry records provide information on the characteristics of the mother at the birth of the child, and on the number of children in the family. The number of children in a family and the birth order of the children are determined at a fixed point in time. We use 2004 as the fixed point to determine family size and the birth order of the child. This year, several years after the final birth cohort used in the analysis (1987), was chosen in order to try and ensure that families are past the childbearing phase.

## 2. Econometric Approach

There are several questions that we wish to address: 1) What is the impact of poor health in childhood on young adult health, educational and labor market outcomes? 2) Do health shocks at some ages have a larger impact than health shocks at others? And 3) Does the lingering effect of health at birth operate through health at older ages or through some other mechanism? To facilitate comparison to other research that does not use sibling comparisons, we first estimate models of the form:

(1) $OUTCOME = a + b_1X + b_2HEALTH_0 + b_3HEALTH_{0-3} + b_4HEALTH_{4-8} + b_5HEALTH_{9-13} + b_6HEALTH_{14-18} + e$,

where OUTCOME is one of the young adult outcomes described above, X is a vector of controls including marital status, sex of the child, and mother's age at birth, and dummy variables for birth order of the child, and year of birth indicators, $HEALTH_0$ are measures of health at birth and $\{HEALTH_{0-3}, HEALTH_{4-8}, HEALTH_{9-13}, HEALTH_{14-18}\}$ is a vector of age specific health shocks. We use a number of different measures of health, as described above. These models show the correlations between young adult outcomes and an individual's health history, but they may be biased by omitted characteristics of families, including characteristics that affect both the health of children in the family and the propensity of the family to seek medical care.

Our main models are of the following form:

(2) $OUTCOME_{ya} = a + b_1X + b_2HEALTH_0 + b_3HEALTH_{0-3} + b_4HEALTH_{4-8} + b_5HEALTH_{9-13} + b_6HEALTH_{14-18} + MOTHER + e$,

where MOTHER is an indicator for each mother in the data. The inclusion of mother fixed effects will help us to control for many unobserved family background characteristics that may be correlated with the propensity to use medical care, true health status, and with young adult outcomes. We estimate all of our models using linear probability models for dichotomous outcomes both for ease of interpretation, and for ease of including fixed effects. We have verified that in models without mother fixed effects, logits give very similar estimates.

This model will allow us to examine the significance of the time pattern of health insults. For example, if children largely recover from initial health shocks over time, then one would expect measures taken in the teen years to be more highly related to young adult outcomes than measures taken in early childhood. On the other hand, if "skill begets skill" then it may be the case that shocks at early ages cause children to stay on a lower trajectory than they would otherwise have obtained. If there is some truth to both viewpoints, then it might be the case that the pattern of coefficients estimated is U-shaped, with shocks at both very young ages and contemporaneous shocks having strong effects. .

Finally, we estimate models separately for children of lower socioeconomic status. Although we have shown that the SES-related differences in the incidence of health conditions are not large in Manitoba, it is possible that the *impacts* of health conditions are larger for children of lower SES, perhaps because their families lack the resources to compensate for negative health shocks.

In order for the models that include family fixed effects to be informative there must be variation within families in both the health problems children experience and the outcomes observed later in life. To explore the extent of this variation we report the average difference in each outcome for families with children who have different health measures in each age group. The results are reported in Table 4.

The first column reports the number of siblings with different health measures at each age. So, for example, there were 9945 children who had a different value for having had a major injury between ages 0 and 3 than their sibling. The remaining columns report the average difference in outcomes for those siblings who had differences in the health measure. In each case the difference is reported as the outcome for the child with the worse health measure minus the outcome for the child with the better health outcome. Interestingly most of these differences are in the expected direction – that is the child with worse health experienced a worse outcome later in life – and many mean differences are statistically significant. This suggests that there is indeed sufficient within-family variation to estimate the models described above.

**4. Results**

The first two panels of Table 5 shows estimates of the effects of birth weight from models that did not include the other health measures discussed above. The purpose is to replicate results in the literature showing long-term negative effects of low birth weight. The first panel shows estimates similar to model (1) (i.e. they do not include indicators for each mother). These estimates show negative effects of lower birth weight on all of our outcomes. Moreover, the effects are monotonic: The lower the birth weight of the surviving infant, the more likely the young adult is to be on social assistance, the less likely they are to have been in grade 12 by age 17, the lower the probability that they take college math, and the lower their literacy score.

The second panel shows that including mother fixed effects (so that lower birth weight siblings are compared to their own siblings of higher birth weight) reduces, but does not entirely eliminate these effects. Children of lower birth weight are still more likely to end up on social assistance, and are less likely to have reached grade 12 by age 17. Children in the lowest birth weight category also have lower literacy scores. However, other effects on cognitive test scores are of only marginal statistical significance. The contrast between the two panels of Table 5 shows the importance of adequately controlling for family background when examining the effects of ill health. In the remaining tables, we focus on models that include the mother fixed effects.

The third panel in Table 5 includes an additional control for whether the child has an ICD9 code for a congenital anomaly or perinatal problem in the first year of life that would also be considered part of a major ADG code. Including an indicator for an ADG specifically related to a congenital anomaly from birth allows us to more fully capture the health of the child at birth beyond simply looking at birth weight. Having a congenital anomaly or perinatal problem is positively associated with being on social assistance and length of time on social assistance and is negatively correlated with reaching grade 12 by age 17 and with math and reading achievement. These effects are independent of birth weight, which continues to have a significant effect on the outcomes we examine. In the rest of the models we present we will therefore include controls for both birth weight and congenital anomalies to more fully control for health at birth.

Table 6 shows estimates from models that include the number of major conditions (as defined by the Johns Hopkins algorithm (but excluding major injuries for the oldest group) for each age group. As shown in Figure 3, the coefficients on the number of ADGs show a U-shaped pattern for almost every outcome, the sole exception being whether the child is in grade 12 by age 17. As discussed above, the health measure for age 14-18 can be thought of as roughly contemporaneous with the outcomes, so it is not surprising that health measured at this age has a large effect. It is however, quite surprising that the effect of health shocks at 0-3 is larger than the effect of health shocks in middle childhood.

Moreover, it is important to keep in mind that the coefficient on health at 0-3 measures the effect of an additional health shock conditional on health at 14-18, the time that the outcome is measured, and conditional on the effect of low birth weight. Thus, it can be thought of as the effect of an additional health shock at 0-3, given health at birth, and in addition to any direct effect of health at age 0-3 on future health. These results are supportive of the idea that the preschool years are a "critical period" in which poor health can set the stage for future problems.

The addition of ADGs reduces the effect of low birth weight on future receipt of social assistance. In fact, the only birth weight effects that remain statistically significant are for birth weight between 1000 and 1500 grams. However, the effects of low birth weight on "grade 12 by age 17" remain monotonic and almost as large as in Table 5. A similar pattern emerges for congenital anomalies. The direct effects of congenital anomalies become insignificant for all outcomes except math reading scores. These results suggest that some, but not all of the negative effect of low birth weight and poor infant health for future outcomes comes through negative effects on future health.

As discussed above, the Johns Hopkins definition of a major ADG excludes several of the most common health insults of early childhood, including asthma, many mental health diagnoses, and major injuries (for all but the oldest children). Hence, in Table 7 we estimate models that include indicators for major injuries, mental health problems, asthma, and the remaining "other" major ADGs. The variables of interest here are indicators for whether the child had a diagnosis in any of these categories in the relevant age range.

The coefficients on Table 7 shows that each major category of health shock presents a unique profile in terms of the pattern of coefficients by age. Injuries at age 0-3 increase the number of weeks on social assistance, and reduce the probability that a child will be in grade 12 by age 17. But for college math and literacy, only injuries at later ages (9-13 and 14-18) are statistically significant.

Perhaps surprisingly, asthma does not have very consistent effects, though asthma at ages 4-8 is estimated to increase both the probability of being on social assistance and the number of weeks on social assistance.  Hence, in Figure 4 we graph the estimated coefficients from Table 7 for major injuries, mental health problems, and other health problems, but exclude asthma.

Figure 4 shows that mental health problems have very large, and statistically significant effects at all ages on all outcomes, that are much greater than those of other diagnoses.  For example, a diagnosis of a mental health problem at any of the four ages increases the number of weeks on social assistance by between 1.5 and 2 weeks (on a mean of about 2 weeks out of the possible 70 week window).  Mental health problems also reduce the probability of being in grade 12 by age 17 by 5 to 9 percentage points, and, depending on the age, they reduce the probability of taking college math by 3 to 4 percentage points as well as reducing the literacy score by between 7 and 17 points.  Mental health conditions diagnosed at ages 9 to 13 seem to generally have the largest effects on academic outcomes, while mental health conditions diagnosed at ages 4 to 8 have the largest effects on weeks of social assistance.

Injuries and the "other" category tend to show the same U-shaped pattern discussed above with respect to the number of ADGs in Table 6.  In the case of social assistance, having a major injury at 0-3 has a larger effect than major injuries later on, while contact with the medical system for another major health condition at age 0-3 has almost as large an effect as having such a diagnosis at ages 14-18.  For literacy, having a medical contact for another major diagnosis at age 0-3 actually has a larger effect than having such a contact at ages 14-18.

These estimates imply that early health shocks have an effect on future outcomes, independent of their effects on future health problems.  For example, having a contact with the medical system because of a mental health problem at age 3 affects outcomes independent of the fact that people with a contact at age 3 are more likely to also have had contacts at later ages.

The effects are largest for mental health problems, though, given their prevalence, major injuries also constitute a serious threat to children's future well being.

Table 8 replicates the analysis in Table 7 for children from households in the bottom two quintiles of our SES measure. The most striking difference between the two tables is that the consequences of major injuries are much greater for poorer children. Figures 5 through 7 compare the pattern of age effects for the two groups. Figure 5 shows that mental health problems have larger negative effects on lower SES children in terms of weeks of social assistance, but they have lower effects on college math and literacy scores.

The most striking figure is Figure 6 which shows that major injuries have consistently much larger effects on children from lower SES backgrounds. The differences are large: For example, a major injury at age 0-3 increases weeks on social assistance by .259 weeks overall, but by .664 weeks in the lower SES sample, on a baseline of 2 weeks for overall sample and 3.5 weeks on the lower SES sample. Similarly, literacy scores are reduced by 0 vs. .026 points on baselines of 0 and .34, respectively. Given the overall prevalence of major injuries at age 0 to 3 of 31.9 percent, these estimates imply that injuries at this age raise the mean number of weeks on social assistance by .1 weeks overall, and by .2 weeks (out of 70) in the lower SES population.

Figure 7 shows that the effects of other health problems vary by outcome but that poor health in the three younger age groups tends to have smaller effects on outcomes for the lower SES groups.

## 6. Concluding Remarks

Our study makes use of some of the most comprehensive health information available for children. Linkages with administrative level education and social assistance information allow us to follow the children for a lengthy period of time – far longer than typical longitudinal surveys. Family linkages offer a powerful way to control for differences between families that may be related both to health insults and long term outcomes.

Large numbers of children suffer from health problems in childhood. Previous research across a number of countries has shown that there is a strong link between socioeconomic status and poor health. Further, children in poor health are more likely to be sickly as adults. But it has not been clear whether health problems in early childhood had any effect over and above their effects on future health. The paucity of data on health in early childhood has severely limited research in this area.

Our research offers several striking conclusions. First, some but not all of the previously documented effect of health at birth on future outcomes works through the effects on later health. Second, early health shocks as a group have effects on young adult outcomes that are comparable to the effects of health problems in young adulthood. Early health shocks matter even when current health and health at birth are controlled. If this is true in Canada where every child has access to health care, it is also likely to be the case in the U.S. where the effects of health shocks may be exacerbated in some cases by lack of access to care.

Third, and turning to specific health problems, we find that injuries are the most common childhood health problem, and that injuries in early childhood often have long-term effects on educational attainments and receipt of social assistance. These effects are especially large for children from poorer families. Although they are less prevalent than major injuries, mental health problems have the largest effects, and mental health problems at all ages are associated with more negative outcomes in young adulthood.

## References


Adler, Nancy, and Joan Ostrove. “Socioeconomic Status and Health: What we Know and What we Don't,” Socioeconomic Status and Health in Industrialized Nations. Annals of the New York Academy of Sciences 896, 1999:3-15.

Almond, Douglas. “Is the 1918 Influenza Pandemic Over? Long-term Effects of In Utero Influenza Exposure in the Post-1940 U.S. Population,” Journal of Political Economy, 114, August 2006: 672-712.

Almond, Douglas and Bhashkar Mazumder. “The 1918 Influenza Pandemic and Subsequent Healht Outcomes: An Analysis of SIPP Data,” American Economic Review: Papers and Proceedings, 95, 2005: 258-262.

Baillargeon, R., Tremblay, R., Willms, J.D., “The Prevalence of Physical Aggression in Canadian Children: A Multi-Group Latent Class Analysis of Data from the First Collection Cycle (1994-1995) of the NLSCY,” Human Resources Development Canada, Applied Research Branch, December 1999.

Baker, Michael, Mark Stabile and Catherine Deri. “What Do Self-Reported, Objective Measures of Health Measure?” 2004, *Journal of Human Resources*, 39(4), pp.1067-1093.

Barker, David. 1998. In utero programming of chronic disease. Clinical Science 95:115-28.

Begley, Charles, Carl Slater, Martha Engel, and Thomas Reynolds. “Avoidable Hospitalizations and Socio-Economic Status in Galveston County, Texas,” Journal of Community Health, 19, 1994:377-387.

Behrman, Jere, Robert Pollak, and Paul Taubman. “Parental Preferences and Provision for Progeny,” Journal of Political Economy, 90 #1, 1982: 52-73.

Behrman, Jere, Robert Pollak and Paul Taubman. “Family Resources, Family Size, and Access to Financing for College Education,” Journal of Political Economy, 97 #2, 1989: 398-419.

Behrman, Jere and Mark Rosenzweig. “Returns to Birthweight,” Review of Economics and Statistics, 86 #2, 2004: 586-601.

Billings, John, Lisa Zeitel, Joanne Lukomnik, Timothy Carey, Arthur Black and Laurie Newman, “Impact of Socioeconomic Status on Hospital Use in New York City,” Health Affairs, 12, 1993: 162-173.

Bonnie, R. J., C. E. Fulco, C. T. Liverman (eds.), Reducing the Burden of Injury, (Washington D.C.: Institute of Medicine) 1999.

Brooks-Gunn, Jeanne, Klebanov, Patricia, and Greg Duncan. 1996. Ethnic differences in children's intelligence test scores: role of economic deprivation, home environment, and maternal characteristics.

Cutler, David and Adriana Lleras-Muney. "Education and Health: Evaluating Theories and Evidence," NBER Working Paper # 12352, June 2006.

Duncan, G., Dowsett, C. Claessens, A., Magnuson, K. Hustonb, A. Klebanov, P., Pagani, L. Feinstein, L. Engel, M. Brooks-Gunn, J., Sexton, H. Duckworth, K. and C. Japel "School Readiness and Later Achievement," Northwestern University Working Paper, 2006.

Elo, Irma T. and Samuel H. Preston. "Effects of Early Life Conditions on Adult Mortality: A Review," Population Index, 58, 1992: 186-212.

Fransoo, Randall. "How Helath Status at Birth and Through Childhood Affects Progress and Performance in School: A Population Based Study," Ph.D thesis, Department of Community Health Sciences, Faculty of Medicine, University of Manitoba, August 2007.

Glied, Sherry. "The Value of Reductions in Child Injury Mortality in the U.S.," in David Cutler and Ernst Berndt (eds) Medical Care Output and Productivity (Chicago: University of Chicago Press for NBER) 2001.

Gregg, Paul and Steven Machin. "Child Development and Success or Failure in the Youth Labour Market," Center for Economic Performance, London School of Economics Discussion Paper 0397, July 1998.

Kessler, Ronald, Cindy Foster, William Saunders, and Paul Stang. "Social Consequences of Psychiatric Disorders, I: Educational Attainment," American Journal of Psychiatry, 152, 1995, 1026-32.

Luo, Ye and Linda J. Waite. "The Impact of childhood and Adult SES on Physical, Mental and Cognitive Well-Being on Later Life," Journals of Gerontology: Social Sciences. 60B #2, 2005, S93-101.

Marmot, Michael, and Wilkinson, Richard (eds.). 1999. *Social Determinants of Health.* Oxford, UK: Oxford University Press.

McLeod, Jane D. and Karen Kaiser. "Childhood Emotional and Behavioral Problems and Educational Attainment," American Sociological Review, 69, October 2004, 636-658.

Mustard, C., Derksen, S., Berthelot. J.M. Wolfson, M, Roos, L., and K.C. Carriere, "Socio-Economic Gradients in Mortality and the Use of Health Care Services at Different Stages in the Life Course" Manitoba Centre for Health Policy Report, December 1995.

Mustard, C., Derksen, S., Berthelot, J.M., Wolfson, M. "Assessing ecologic proxies for household income: a comparison of household and neighbourhood level income measures in the study of population health status," Health and Place 5:2 (1999) 157-171.

Newacheck, Paul. "Poverty and Childhood Chronic Illness," Archives of Pediatric and Adolescent Medicine, 148 (1994): 1143-1149.

Newacheck, Paul and Neil Halfon, "Prevalence and Impact of Disabling Chronic Conditions in Childhood," American Journal of Public Health, 88 no. 4 (1988): 610-617.

Oreopoulos, Philip, Mark Stabile, Roos, L., and Walld, R., "The Short, Medium, and Long Term Effects of Poor Infant Health," forthcoming, *Journal of Human Resources*.

Powe, N.R., J. Weiner, B. Starfield, M.E. Stuart, A. Baker, D. Steinwachs. "Systemwide Performance in a Medicaid Program: Profiling the Care of Patients with Chronic Illness," medical Care, 1998, 34(8):798-810.

Reid, R.J., MacWilliam, L., Verhulst, L, Roos, N.P., Aitkinson, M. "Performance of the ACG Case-Mix System in Two Canadian Provinces" Medical Care 2001 39(1): 86-99.

Reid, R.J., Roos N.P., MacWilliam, L., Frohlich, N., Black, C., "Assessing Population Health Care Needs Using A Claims Based ACG Morbidity Measure: A Validation Exercise in the Province of Manitoba," Health Services Research 2002, 37(5): 1345-63.

Roos N.P., and C.A.Mustard, "Variation in Health and Health Care Use by Socioeconomic Status in Winnipeg, Canada: Does the System Work Well? Yes and No," Milbank Quarterly, 1997,75(1):80-111.

Roos, LL., Walld, R., Uhanova, J. and R. Bond, "Physician visits, hospitalizations, and socioeconomic status: ambulatory care sensitive conditions in a Canadian setting," Health Services Research 40:4 (August 2005), 1167-1185.

Roos LL., and JP Nicol, "A research registry: uses, development, and accuracy," J Clin Epidemiology 52:1 (1999), 39-47.

Salm, Martin and Daniel Schunk. "The Role of Childhood Health for the Intergenerational Transmission of Human Capital: Evidence from Administrative Data," University of Mannheim, May 2008.

Shaffer, D., P. Fisher, M.K. Dulcan, M. Davies, J. Piacentini et al. "The NIMH Diagnostic Interview Schedule for Children Version 2.3 (DISC-2.3): Description, acceptability, prevalence rates, and performance in the MECA Study. Methods for the Epidemiology of Child and Adolescent Mental Disorders Study," Journal of the American Academy of Child and Adolescent Psychiatry, 35, 1996, 865-877.

Starfield, Barbara, S. Shapiro, J. Weiss, K. Liang, K. Ra, D. Paige, and X. Wang. 1991. Race, family income and low birth weight. American Journal of Epidemiology 134:1167-74.

The Johns Hopkins University Bloomberg School of Public Health, Health Services Research & Development Center. *The Johns Hopkins ACG® Case-Mix System Version 6.0 Release Notes.* (Editor in Chief: Jonathan P. Weiner). The Johns Hopkins University. April, 2003.

U.S. Centers for Disease Control. Preventing Chronic Diseases: Investing Wisely in Health, Preventing Dental Caries (Washington D.C.: U.S. Department of Health and Human Services) April 6, 2004.

U.S. Department of Health and Human Services. Mental Health: A Report to the Surgeon General (Rockville MD: U.S. Dept. Of Health and Human Services) (1999).

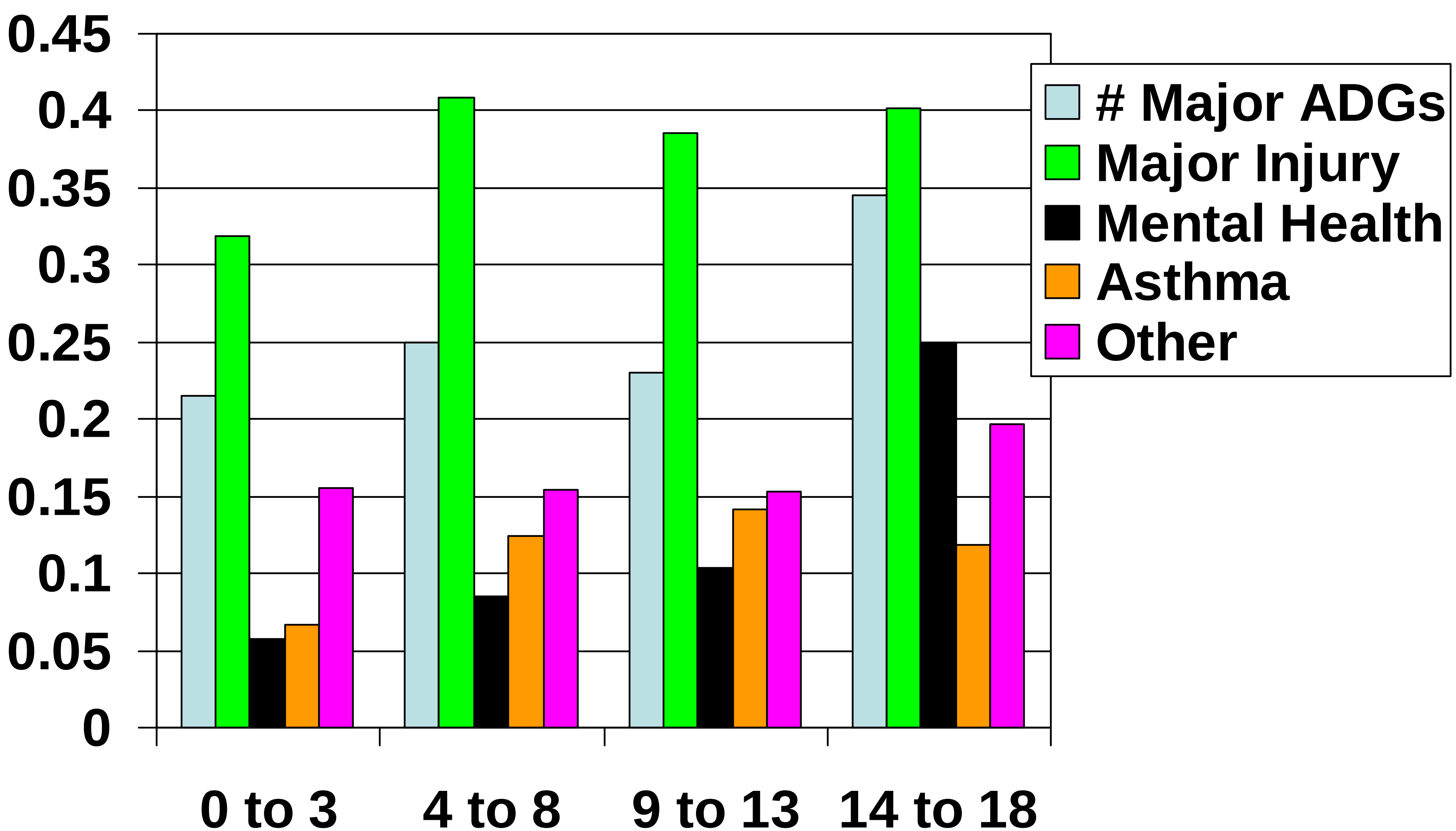
U.S. Environmental Protection Agency, Indoor Environments Division Office of Air and Radiation, "Asthma Facts," EPA 402-F-04-019 (2006).

Weiner, J. A. Dobson, S. Maxwell, K. Coleman, B. Starfield, G. Anderson. "Risk-Adjusted Medicare Capitation Rats Using Ambulatory and Inpatient Diagnoses," Health Care Financing Review, 1996, 17(3): 77-99.

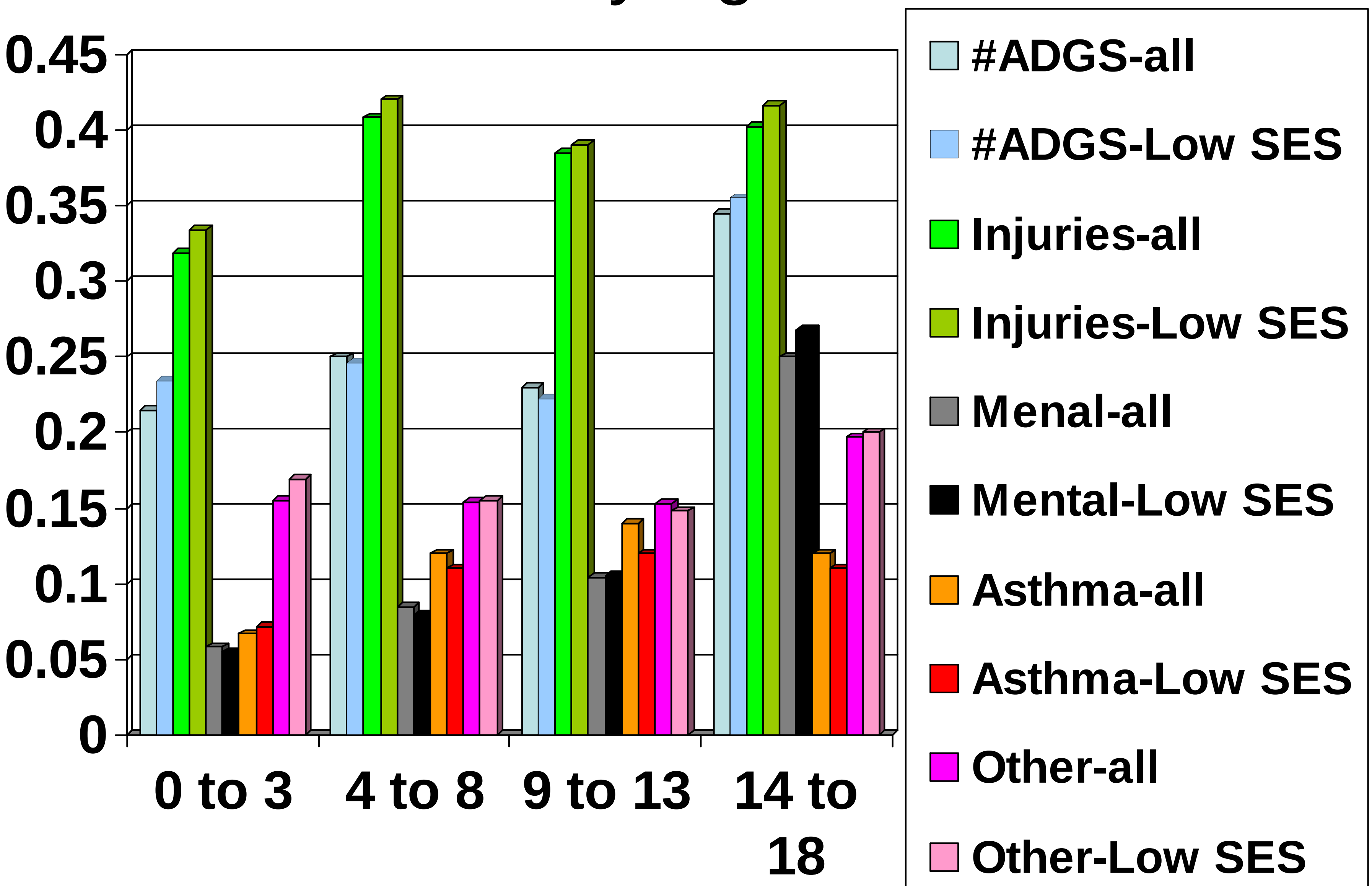
Weiner, J. B. Starfield, R.N. Lieberman. "Johns Hopkins Ambulatory Care Groups (ACGs): A Case Mix System for UR, QA, and Capitation Adjustment," HMO Pratice, 1992, 6(1): 13-19.

Weiner, J. B. Starfield, D. Steinwachs, L Mumford. "Development and Application of a Population-Oriented Measure of Ambulatory Care Case-Mix," Medical Care, 1991, 29(5):452-72.

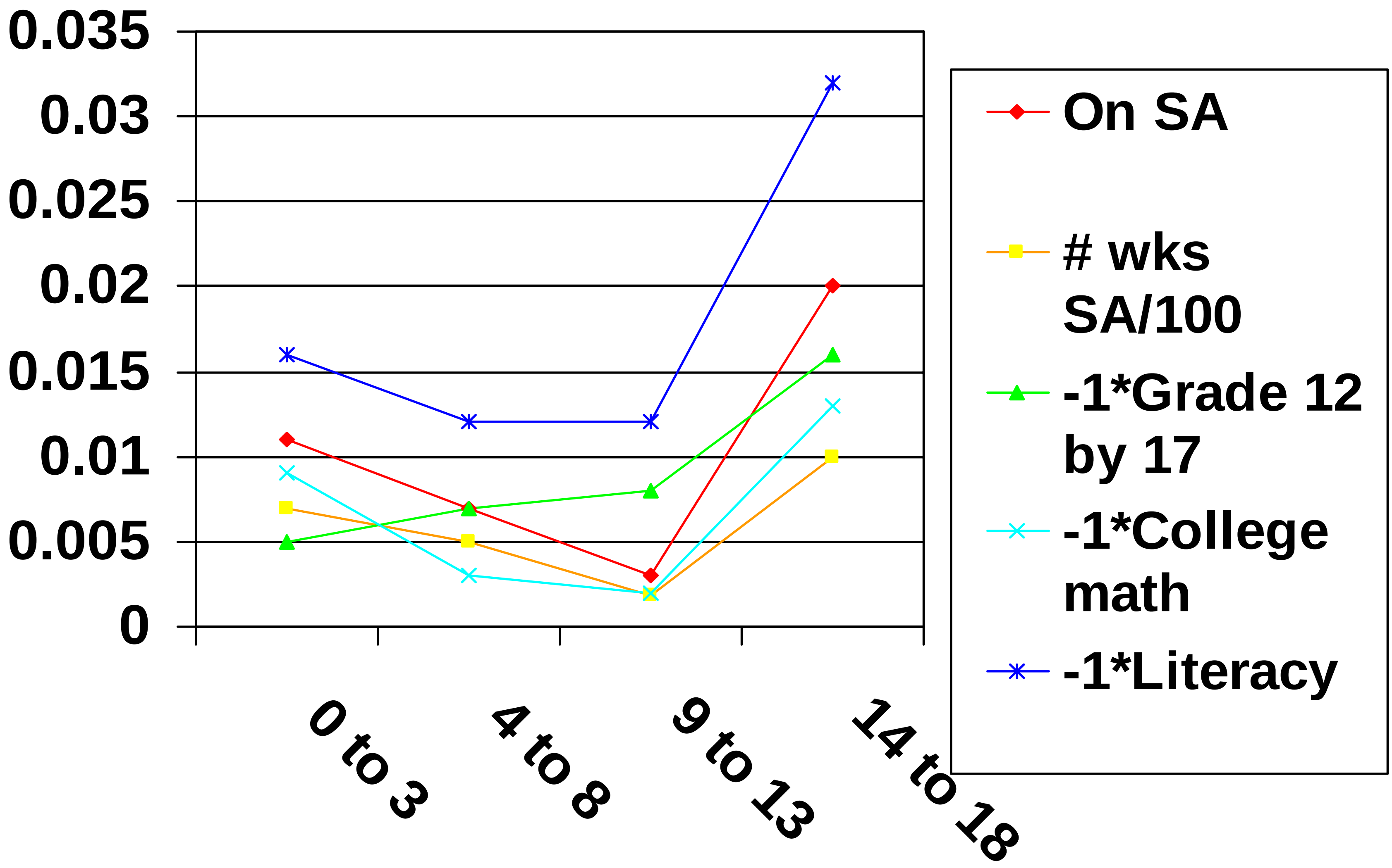
## Figure 1: # of Major ADGs and Incidence of Major Health Problems, by Age



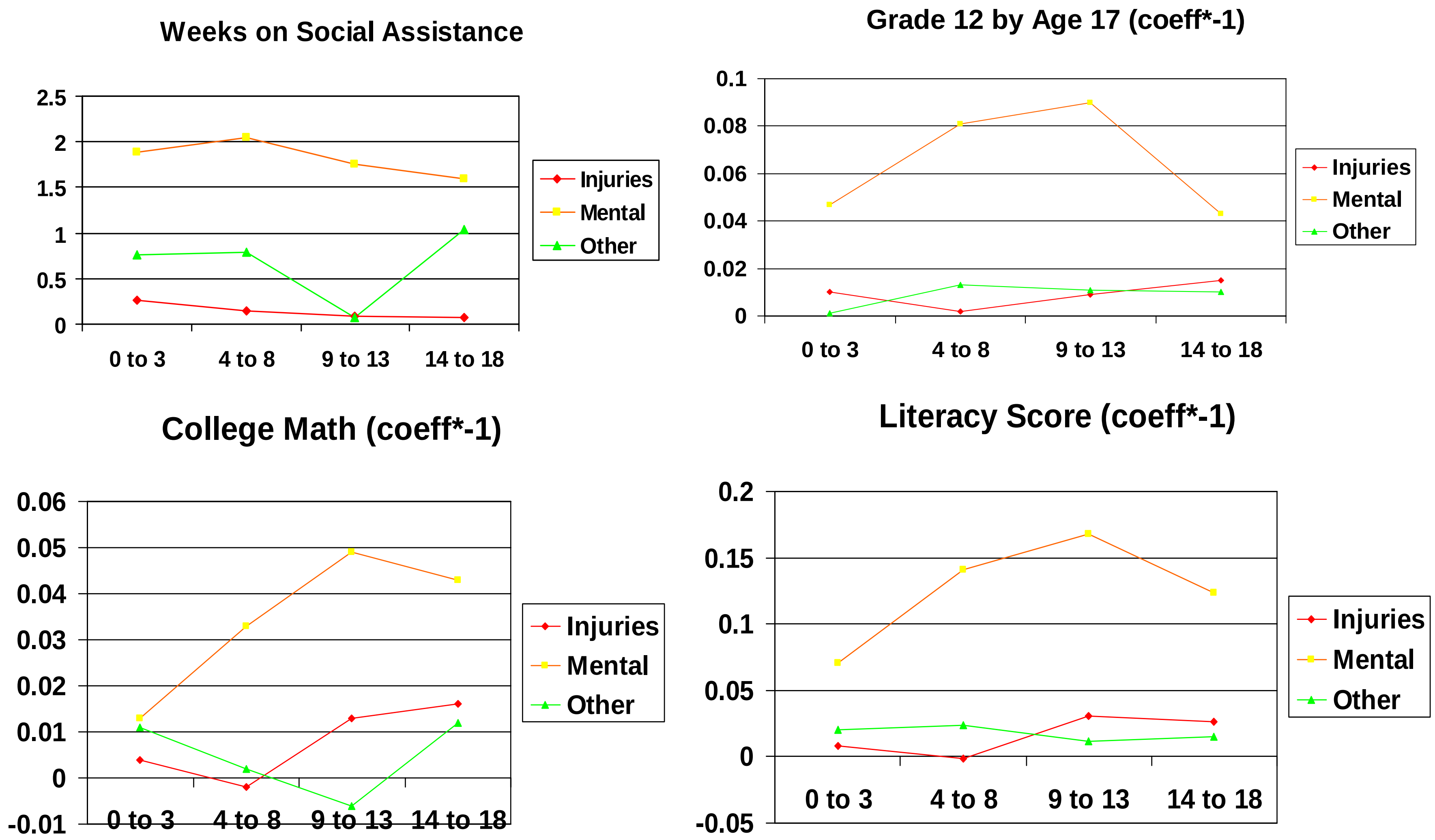
# Figure 2: SES and Health Problems, by Age



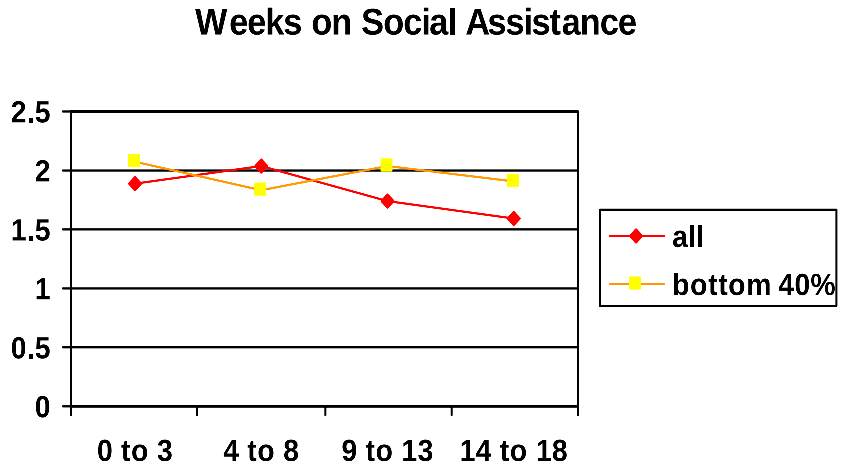
# Figure 3: Coefficients on #ADGs at each age, by Outcome

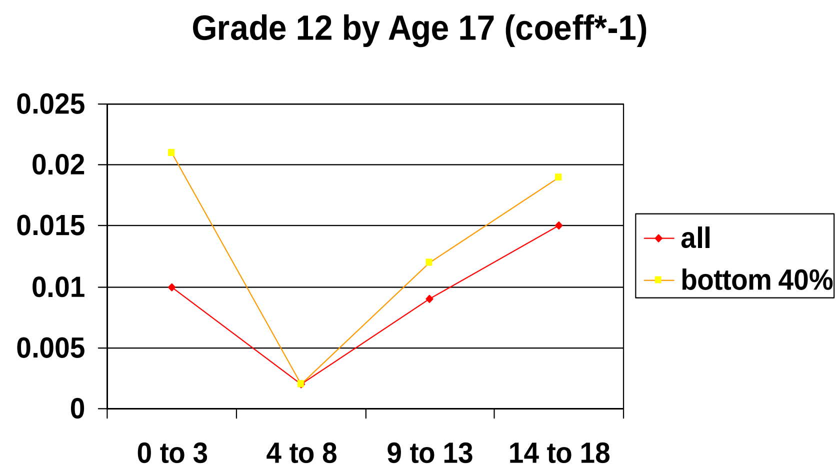


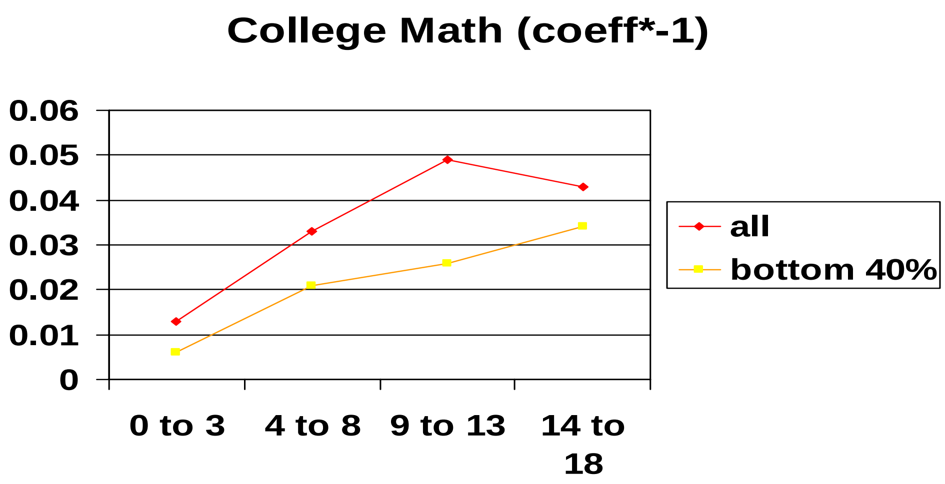
# Figure 4: Effects of Major Injury, Mental Health, and Other, by Age

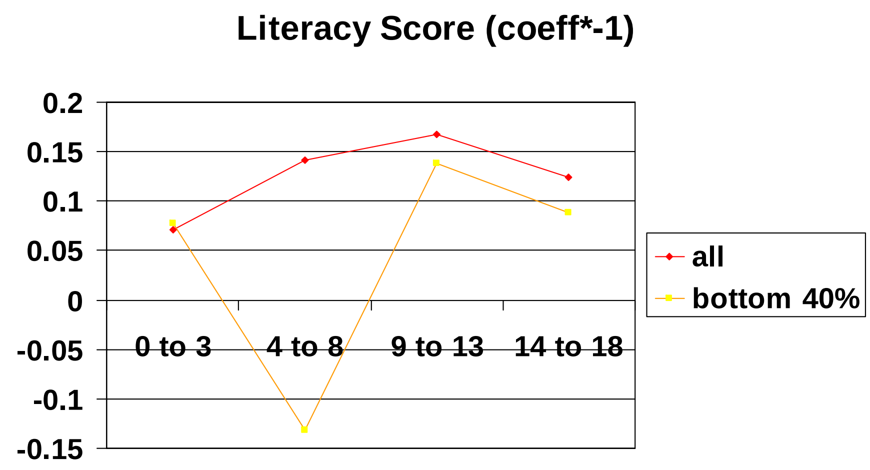


# Figure 5: Effects of Mental Health at Various Ages, all vs. bottom 40%

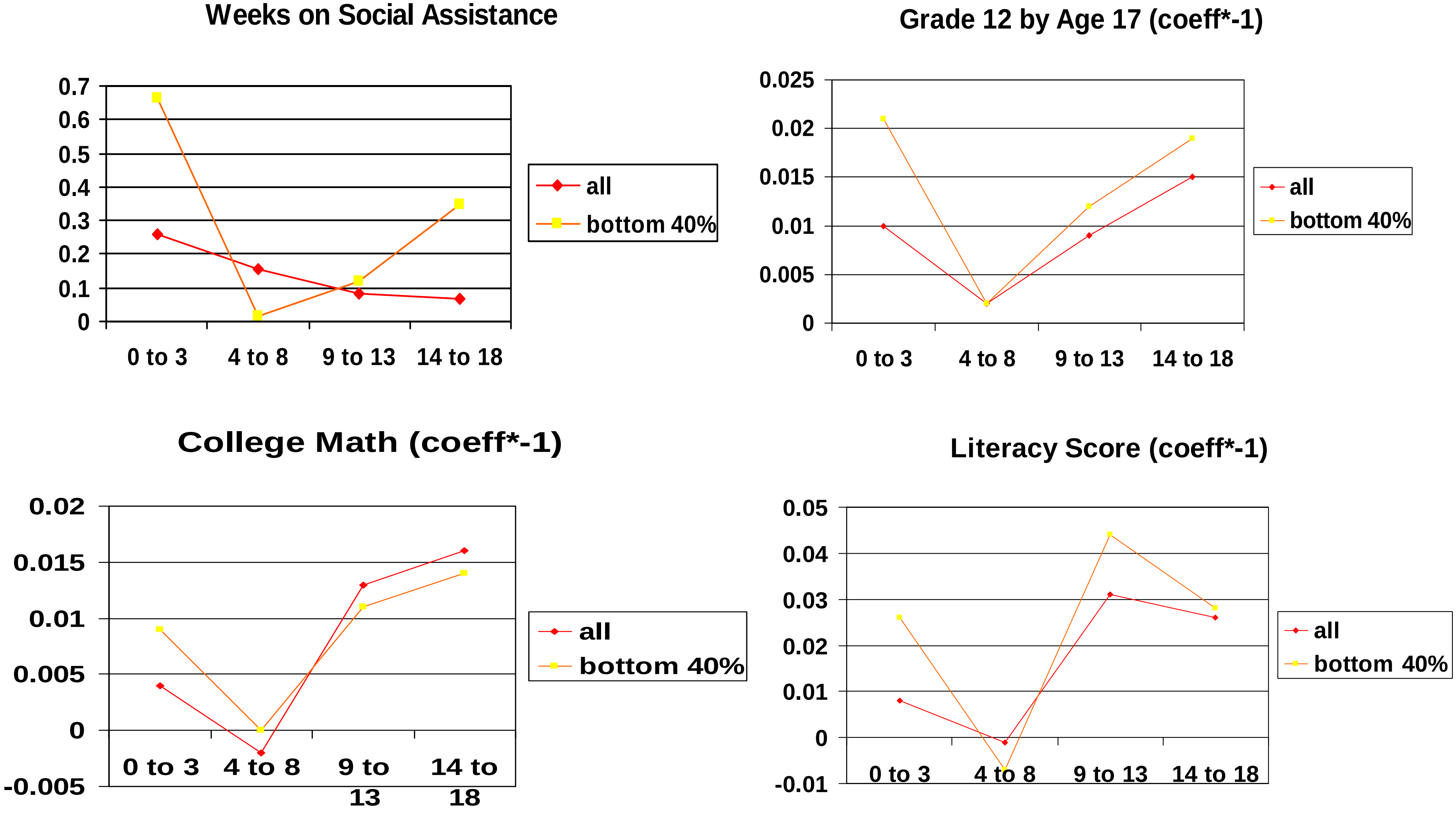


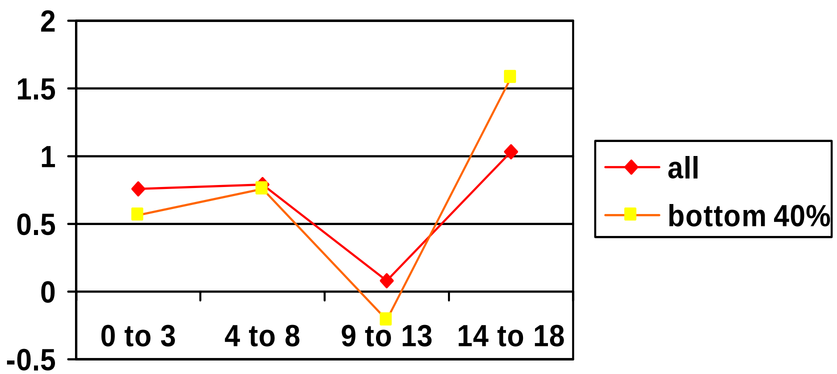



# Figure 6: Effects of Major Injury at Various Ages, all vs. bottom 40%

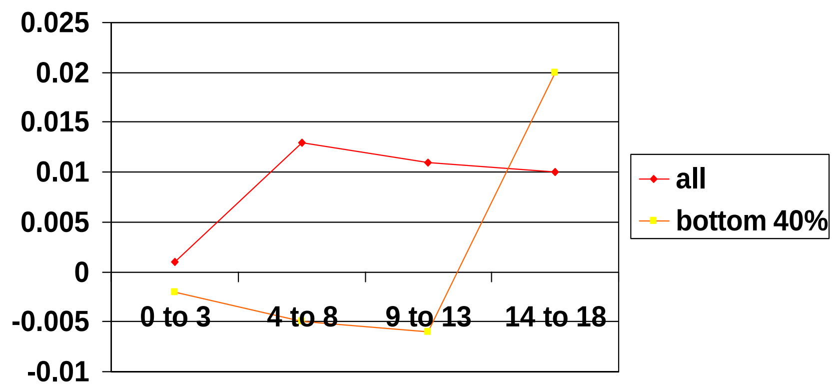


# Figure 7: Effects of Other Health Problems at Various Ages, all vs. bottom 40%

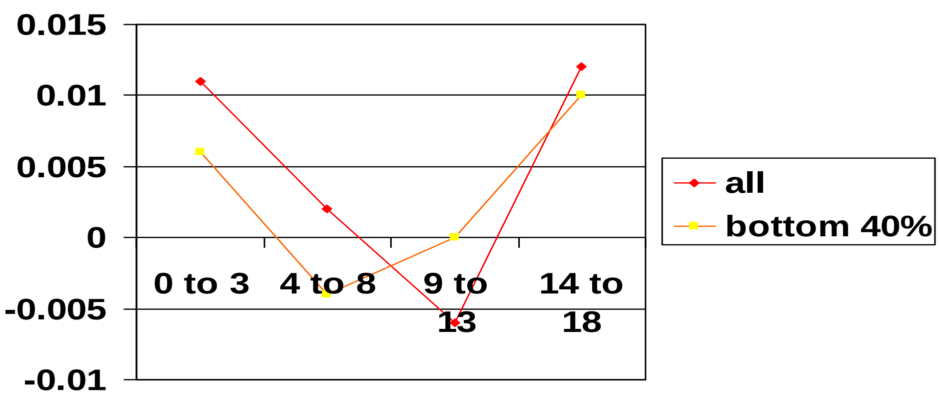
Weeks on Social Assistance




Grade 12 by Age 17 (coeff*-1)




College Math (coeff*-1)




Literacy Score (coeff*-1)

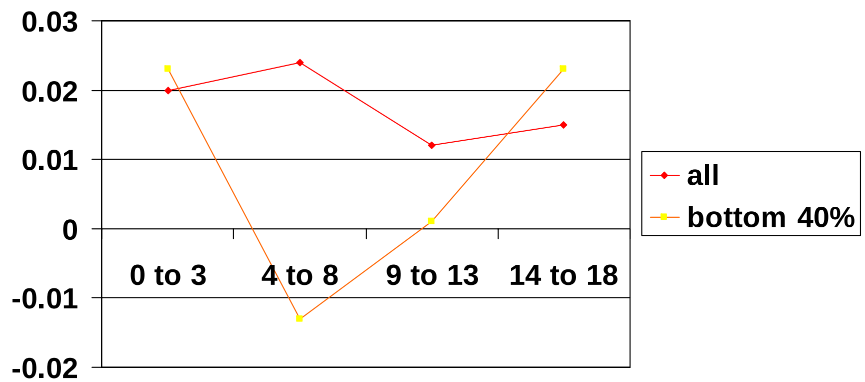


**Table 1: Means of Health Variables at Various Ages**

| **Health at Birth** | **Full Sample** | **Bottom 40%** |
|---|---|---|
| Birth weight < 1000 grams | 0.001 | 0.001 |
| | [0.027] | [0.034] |
| Birth weigth >=1000,<1500 | 0.003 | 0.004 |
| | [0.058] | [0.061] |
| Birth weight >=1500, <2500 | 0.043 | 0.050 |
| | [0.203] | [0.218] |
| Birth weight >=2500< 3500 | 0.476 | 0.480 |
| | [0.499] | [0.500] |
| Birth weight>3500 | 0.477 | 0.466 |
| | [0.499] | [0.499] |
| Congenital Anomolies/Perinatal Problems | 0.137 | 0.410 |
| | [0.344] | [0.492] |

| **Health After Birth** | **0 to 3** | **4 to 8** | **9 to 13** | **14 to 18** | **0 to 3 Bottom 40%** | **4 to 8 Bottom 40%** | **9 to 13 Bottom 40%** | **14 to 18 Bottom 40%** |
|---|---|---|---|---|---|---|---|---|
| Asthma | 0.067 | 0.124 | 0.142 | 0.118 | 0.072 | 0.113 | 0.125 | 0.105 |
| Mental Health Problem | 0.058 | 0.085 | 0.104 | 0.250 | 0.055 | 0.079 | 0.105 | 0.268 |
| Major Injury | 0.319 | 0.408 | 0.385 | 0.402 | 0.334 | 0.419 | 0.391 | 0.416 |
| Other Major Health Problems | 0.155 | 0.154 | 0.153 | 0.285 | 0.169 | ,155 | 0.148 | 0.200 |
| Any of the above | 0.461 | 0.576 | 0.566 | 0.641 | 0.478 | 0.575 | 0.556 | 0.648 |
| Total ADGs | 8.062 | 9.349 | 8.106 | 8.671 | 8.341 | 8.928 | 7.777 | 8.474 |
| | [6.006] | [5.545] | [5.525] | [6.186] | [6.117] | [5.626] | [5.606] | [6.390] |
| Maximum Total # ADGs | 43 | 48 | 48 | 69 | 40 | 43 | 45 | 51 |
| Number of Major ADGs | 0.215 | 0.250 | 0.23 | 0.345 | 0.234 | 0.246 | 0.222 | 0.355 |
| | [0.613] | [0.745] | [.664] | [.829] | [0.634] | [0.733] | [0.643] | [0.826] |
| Maximum # Major ADGs | 12 | 12 | 11 | 14 | 10 | 12 | 9 | 12 |
| Number of Observations | 50732 | | | | 19793 | | | |

Notes: Standard deviations of continuous variables in brackets. The number of major conditions is the same of as the number of major ADGs except for the oldest group, where it excludes major injuries in order to make the categorization consistent across age groups.
The Johns Hopkins definition of major conditions excludes asthma and some mental health conditions as well as injuries.

**Table 2 Pattern of Health Conditions Across Age Groups**

| Age Pattern | Mental | Asthma | Major Injury | Other Major Health Problem | Major Condition* |
|---|---|---|---|---|---|
| 0000 | 62.98 | 72.75 | 20.16 | 53.72 | 51.95 |
| 0001 | 17.11 | 4.24 | 9.08 | 10.73 | 12.02 |
| 0010 | 3.67 | 4.75 | 7.56 | 6.39 | 6.29 |
| 0011 | 3.48 | 2.53 | 6.01 | 2.57 | 2.99 |
| 0100 | 3.52 | 4.06 | 8.67 | 6.85 | 6.64 |
| 0101 | 1.32 | 0.57 | 5.51 | 1.55 | 1.79 |
| 0110 | 0.92 | 2.00 | 5.37 | 1.66 | 1.63 |
| 0111 | 1.23 | 2.39 | 5.70 | 1.00 | 1.10 |
| 1000 | 2.73 | 2.66 | 6.76 | 7.80 | 7.47 |
| 1001 | 0.94 | 0.22 | 3.49 | 1.71 | 1.95 |
| 1010 | 0.32 | 0.27 | 3.29 | 1.12 | 1.14 |
| 1011 | 0.28 | 0.22 | 2.89 | 0.51 | 0.58 |
| 1100 | 0.60 | 1.02 | 4.57 | 1.86 | 1.79 |
| 1101 | 0.31 | 0.24 | 3.27 | 0.52 | 0.60 |
| 1110 | 0.21 | 0.72 | 3.38 | 0.83 | 0.81 |
| 1111 | 0.38 | 1.37 | 4.31 | 1.19 | 1.28 |

Notes: Reported numbers are percentages.
Patterns reflect the inidence of having an ADG code for a particular condition in each of the age cateogries 0-3, 4-8, 9-13, and 14-18
E.g. 0000 denotes have no ADG for any of the 4 age cateogries, 0001 denotes having and ADG between ages 14-18 only
* Major condition includes ADGs 3, 9, 11, 12, 13, 18, 25, and 32, that is, it is the same as the Johns Hopkins definition except that it excludes major injury for all age groups (rather than including it only for the oldest children). It does not include asthma and only includes the most major mental health conditions.

**Table 3: Outcome Variables**

| | All | Bottom 40% |
|---|---|---|
| In grade 12 by age 17 | 0.69 | 0.53 |
| Took college level math | 0.22 | 0.15 |
| Language arts score | -0.02 | -0.34 |
| | [1.01] | [1.00] |
| Ever on Social Assistance | 0.057 | 0.095 |
| # Weeks on Social Assistance | 2.131 | 3.504 |
| | [10.180] | [12.794] |
| Number of Observations | 50732 | 19793 |

Notes: Standard deviations in brackets. The maximum weeks on social assistance that is possible in our sample is 70.

**Table 4: Mean Differences Between Sibling Pairs with Divergent Health Measures**

| | # Sib pairs w diff | Diff in on SA | Diff in #wks SA | Diff in grade 12 by 17 | Diff College Math | Diff in Literacy |
|---|---|---|---|---|---|---|
| Congenital Anomalies | 5276 | 0.01 | 0.642 | -0.014 | -0.017 | -0.044 |
| & Perinatal Problems | | [0.004] | [0.187] | [0.006] | [0.006] | [0.013] |
| # Major ADGs 0-3 | 6185 | 0.018 | 1.16 | -0.012 | -0.006 | -0.054 |
| | | [0.004] | [0.183] | [0.006] | [0.006] | [0.012] |
| # Major ADGs 4-8 | 6294 | 0.021 | 1.37 | -0.027 | -0.012 | -0.044 |
| | | [0.004] | [0.178] | [0.006] | [0.006] | [0.012] |
| # Major ADGs 9-13 | 6362 | 0.018 | 0.952 | -0.025 | -0.006 | -0.043 |
| | | [0.004] | [0.180] | [0.006] | [0.006] | [0.012] |
| # Major ADGs 14-18 | 8209 | 0.037 | 1.83 | -0.024 | -0.024 | -0.032 |
| | | [0.003] | [0.158] | [0.005] | [0.005] | [0.011 |
| Major Injury 0-3 | 9945 | -0.001 | 0.119 | -0.014 | 0.014 | -0.053 |
| | | [0.003] | [0.122] | [0.005] | [0.005] | [0.010] |
| Major Injury 4-8 | 10963 | -0.002 | 0.048 | -0.016 | -0.002 | -0.046 |
| | | [0.003] | [0.118] | [0.004] | [0.003] | [0.009] |
| Major Injury 9-13 | 10874 | 0.000 | -0.049 | -0.024 | -0.021 | -0.077 |
| | | [0.003] | [0.120] | [0.004] | [0.004] | [0.009] |
| Major Injury 14-18 | 11104 | 0.004 | 0.039 | -0.033 | -0.025 | -0.083 |
| | | [0.003] | [0.120] | [0.004] | [0.004] | [0.009] |
| Mental 0-3 | 2484 | 0.035 | 2.140 | -0.067 | -0.010 | -0.140 |
| | | [0.007] | [0.344] | [0.010] | [0.009] | [0.020] |
| Mental 4-8 | 3436 | 0.041 | 2.300 | -0.117 | -0.052 | -0.235 |
| | | [0.006] | [0.290] | [0.009] | [0.008] | [0.017] |
| Mental 9-13 | 4055 | 0.048 | 2.210 | -0.120 | -0.066 | -0.251 |
| | | [0.005] | [0.264] | [0.008] | [0.007] | [0.016] |
| Mental 14-18 | 8152 | 0.050 | 2.120 | -0.042 | -0.044 | -0.098 |
| | | [0.004] | [0.161] | [0.005] | [0.005] | [0.011] |
| Asthma 0-3 | 2767 | -0.010 | -0.630 | -0.015 | 0.010 | -0.102 |
| | | [0.005] | [0.240] | [0.009] | [0.009] | [0.018] |
| Asthma 4-8 | 4418 | 0.001 | 0.087 | -0.002 | 0.002 | -0.041 |
| | | [0.004] | [0.174] | [0.007] | [0.007] | [0.015] |
| Asthma 9-13 | 5227 | -0.006 | -0.228 | -0.003 | -0.015 | -0.028 |
| | | [0.004] | [0.168] | [0.006] | [0.007] | [0.014] |
| Asthma 14-18 | 4628 | 0.009 | 0.383 | -0.008 | -0.021 | -0.015 |
| | | [0.004] | [0.190] | [0.007] | [0.007] | [0.015] |
| Other Major 0-3 | 6163 | 0.016 | 1.090 | -0.011 | -0.006 | -0.053 |
| | | [0.004] | [0.182] | ]0.006] | [0.006] | [0.012] |
| Other Major 4-8 | 6232 | 0.017 | 1.120 | -0.022 | -0.010 | -0.039 |
| | | [0.004] | [0.174] | [0.006] | [0.006] | [0.012] |
| Other Major 9-13 | 6214 | 0.011 | 0.590 | -0.018 | -0.003 | -0.031 |
| | | [0.004] | [0.176] | [0.006] | [0.006] | [0.012] |
| Other Major 14-18 | 7626 | 0.026 | 1.420 | -0.010 | -0.017 | -0.003 |
| | | [0.003] | [0.158] | [0.005] | [0.005] | [0.011] |

Notes: Standard Errors in brackets. Table shows the average over the differences between sibs with a health condition and sibs without a health condition, for all sibling pairs where there is a difference in the specified health condition.

**Table 5: Effects of Birth Weight on Future Outcomes**

| | On Social Assistance | # Wks SA | Grade 12 by 17 | College Math | Literacy Score |
|---|---|---|---|---|---|
| **Ordinary Least Squares Estimates** | | | | | |
| Birth weight<=1000 grams | 0.087 | 4.150 | -0.276 | -0.163 | -0.040 |
| | [0.036] | [1.610] | [0.066] | [0.064] | [0.144] |
| 1000<Birth weight<=1500 | 0.086 | 5.144 | -0.076 | -0.064 | -0.018 |
| | [0.017] | [0.757] | [0.031] | [0.030] | [0.068] |
| 1500<Birth weight<=2000 | 0.027 | 1.196 | -0.064 | -0.031 | -0.125 |
| | [0.005] | [0.222] | [0.009] | [0.009] | [0.020] |
| 2500<Birth weight<=3500 | 0.006 | 0.285 | -0.020 | -0.016 | -0.056 |
| | [0.002] | [0.091] | [0.004] | [0.004] | [0.008] |
| R-squared | 0.069 | 0.052 | 0.236 | 0.080 | 0.231 |
| **Sibling Fixed Effects Estimates** | | | | | |
| Birth weight<=1000 grams | 0.008 | 1.500 | -0.267 | -0.119 | -0.387 |
| | [0.046] | [2.089] | [0.076] | [0.078] | [0.160] |
| 1000<Birth weight<=1500 | 0.057 | 3.093 | -0.076 | 0.015 | -0.071 |
| | [0.023] | [1.023] | [0.037] | [0.038] | [0.078] |
| 1500<Birth weight<=2000 | 0.014 | 0.668 | -0.052 | -0.021 | -0.043 |
| | [0.007] | [0.322] | [0.012] | [0.012] | [0.025] |
| 2500<Birth weight<=3500 | 0.000 | 0.181 | -0.019 | -0.007 | -0.022 |
| | [0.003] | [0.134] | [0.005] | [0.005] | [0.010] |
| R-squared | 0.605 | 0.579 | 0.729 | 0.646 | 0.751 |
| **Sibling Fixed Effects Estimates, including Congenital/Perinatal Problems** | | | | | |
| Congential/Perinatal prob. | 0.011 | 0.646 | -0.011 | -0.025 | -0.026 |
| | [.004] | [0.169] | [0.006] | [.006] | [0.013] |
| Birth weight<=1000 grams | 0.000 | 1.057 | -0.259 | -0.102 | -0.369 |
| | [0.046] | [2.091] | [0.076] | [0.078] | [0.160] |
| 1000<Birth weight<=1500 | 0.050 | 2.678 | -0.069 | 0.031 | -0.054 |
| | [0.023] | [1.028] | [0.038] | [0.038] | [0.079] |
| 1500<Birth weight<=2000 | 0.010 | 0.440 | -0.049 | -0.012 | -0.034 |
| | [0.007] | [0.327] | [0.012] | [0.012] | [0.025] |
| 2500<Birth weight<=3500 | 0.000 | 0.163 | -0.018 | -0.007 | -0.021 |
| | [0.004] | [0.134] | [.005] | [.005] | [0.010] |
| R-squared | 0.600 | 0.579 | 0.729 | 0.646 | 0.751 |
| # Observations | 50732 | | | | |

Note: Standard errors in brackets.

Notes: Models include all of the controls listed in Appendix Table 1.  Standard errors in brackets.

**Table 6: Sibling Fixed Effects Estimates of Number of Major Conditions on Future Outcomes**

| | On Social Assistance | # Wks SA | Grade 12 by Age 17 | College Math | Literacy Score |
|---|---|---|---|---|---|
| # Major ADGs 0-3 | 0.011 | 0.685 | -0.005 | -0.009 | -0.016 |
| | [0.002] | [0.082] | [0.003] | [0.003] | [0.006] |
| # Major ADGs 4-8 | 0.007 | 0.527 | -0.007 | -0.003 | -0.012 |
| | [0.002] | [0.086] | [0.003] | [0.003] | [0.007] |
| # Major ADGs 9-13 | 0.003 | 0.186 | -0.008 | 0.002 | -0.012 |
| | [0.002] | [0.095] | [0.004] | [0.004] | [0.007] |
| # Major ADGs 14-18 | 0.020 | 1.048 | -0.016 | -0.013 | -0.032 |
| | [0.002] | [0.070] | [0.003] | [0.003] | [0.005] |
| Congenital Conditions or | 0.002 | 0.038 | -0.005 | -0.018 | -0.011 |
| Perinatal Problems | [0.004] | [0.174] | [0.006] | [0.007] | [0.013] |
| Birth weight<=1000 grams | -0.033 | -1.074 | -0.240 | -0.077 | -0.317 |
| | [0.046] | [2.078] | [0.077] | [0.078] | [0.16101.9(-1.074)-3501.9(-0.240)7Sfs(Birth weight<=5040)40.050 16 |

[0.203] -1.202] [0.382] [0.382] [0.79101.9(-1.074)-3501.9(-0.240)5Sfs(Birth w

[0.007] [0-327] [0.027] [0.027] [0.205]

0.927 -0.107 -0.016 -0.092 Birth weight<35040

[0.003] [01303] [0.005] [0.005] [0.105]

Noate: HeuremMajorcConditionsis the same as the JohonsHopkionsdefinditio except that 7
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**Table 7: Sibling Fixed Effects Regressions of Outcomes on Past Health Shocks**

| | On Social Assistance | # Wks SA | Grade 12 by Age 17 | College Math | Literacy Score |
|---|---|---|---|---|---|
| Major Injury 0-3 | 0.003 | 0.259 | -0.010 | -0.004 | -0.008 |
| | [0.003] | [0.125] | [0.005] | [0.005] | [0.010] |
| Major Injury 4-8 | 0.000 | 0.153 | -0.002 | 0.002 | 0.001 |
| | [0.003] | [0.114] | [0.004] | [0.004] | [0.009] |
| Major Injury 9-13 | 0.002 | 0.082 | -0.009 | -0.013 | -0.031 |
| | [0.003] | [0.115] | [0.004] | [0.004] | [0.009] |
| Major Injury 14-18 | 0.005 | 0.069 | -0.015 | -0.016 | -0.026 |
| | [0.003] | [0.115] | [0.004] | [0.004] | [0.009] |
| Mental 0-3 | 0.032 | 1.884 | -0.047 | -0.013 | -0.071 |
| | [0.005] | [0.242] | [0.009] | [0.009] | [0.019] |
| Mental 4-8 | 0.034 | 2.045 | -0.081 | -0.033 | -0.141 |
| | [0.005] | [0.208] | [0.008] | [0.008] | [0.016] |
| Mental 9-13 | 0.040 | 1.749 | -0.090 | -0.049 | -0.168 |
| | [0.004] | [0.191] | [0.007] | [0.007] | [0.015] |
| Mental 14-18 | 0.039 | 1.600 | -0.043 | -0.043 | -0.124 |
| | [0.003] | [0.135] | [0.005] | [0.005] | [0.010] |
| Asthma 0-3 | -0.004 | -0.436 | -0.007 | 0.001 | -0.029 |
| | [0.005] | [0.236] | [0.009] | [0.009] | [0.018] |
| Asthma 4-8 | 0.008 | 0.434 | 0.008 | 0.007 | 0.017 |
| | [0.004] | [0.195] | [0.007] | [0.007] | [0.015] |
| Asthma 9-13 | -0.008 | -0.319 | 0.008 | -0.011 | 0.010 |
| | [0.004] | [0.184] | [0.007] | [0.007] | [0.014] |
| Asthma 14-18 | 0.007 | 0.290 | -0.009 | -0.013 | -0.021 |
| | [0.004] | [0.191] | [0.007] | [0.007] | [0.015] |
| Other Major 0-3 | 0.011 | 0.765 | -0.001 | -0.011 | -0.020 |
| | [0.003] | [0.161] | [0.006] | [0.006] | [0.012] |
| Other Major 4-8 | 0.011 | 0.788 | -0.013 | -0.002 | -0.024 |
| | [0.003] | [0.154] | [0.006] | [0.006] | [0.012] |
| Other Major 9-13 | 0.001 | 0.078 | -0.011 | 0.006 | -0.012 |
| | [0.003] | [0.154] | [0.006] | [0.006] | [0.012] |
| Other Major 14-18 | 0.017 | 1.033 | -0.010 | -0.012 | -0.015 |
| | [0.003] | [0.138] | [0.005] | [0.005] | [0.011] |
| Congenital or Perinatal | 0.006 | 0.307 | -0.007 | -0.021 | -0.015 |
| Problems | [0.004] | [0.174] | [0.006] | [0.007] | [0.013] |
| Birth weight<=1000 grams | -0.021 | -0.137 | -0.236 | -0.088 | -0.316 |
| | [0.046] | [2.070] | [0.076] | [0.077] | [0.159] |
| 1000<Birth weight<=1500 | 0.051 | 2.611 | -0.075 | 0.028 | -0.064 |
| | [0.023] | [1.019] | [0.037] | [0.038] | [0.078] |
| 1500<Birth weight<=2000 | 0.008 | 0.274 | -0.047 | -0.011 | -0.028 |
| | [0.007] | [0.324] | [0.012] | [0.012] | [0.025] |
| 2500<Birth weight<=3500 | -0.001 | 0.106 | -0.017 | -0.006 | -0.018 |
| | [0.003] | [0.133] | [0.005] | [0.005] | [0.010] |
| R-squared | 0.608 | 0.589 | 0.734 | 0.649 | 0.755 |
| # fixed effects | 22797 | | | | |
| # Obs. | 50732 | | | | |

Notes: "Other Major" includes all of the major ADGs included in the Johns Hopkins measure except for ADG 25, with is included in the mental health conditions category. The JH measure does not include injuries (except for the oldest children) or asthma. Only congenital or perinatal problems that are considered major are included. Standard errors in brackets.

**Table 8: Sibling Fixed Effects Regressions of Outcomes on Past Health Shocks**
**Bottom 40% Only**

| | On Social Assistance | # Wks SA | Grade 12 by Age 17 | College Math | Literacy Score |
|---|---|---|---|---|---|
| Major Injury 0-3 | 0.011 | .664 | -.021 | -.009 | -.026 |
| | (.005) | (.238) | (.008) | (.006) | (.014) |
| Major Injury 4-8 | -.003 | .013 | -.002 | .000 | .007 |
| | (.005) | (.219) | (.007) | (.006) | (.013) |
| Major Injury 9-13 | .003 | .119 | -.012 | -.011 | -.044 |
| | (.005) | (.222) | (.007) | (.006) | (.013) |
| Major Injury 14-18 | .010 | .348 | -.019 | -.014 | -.028 |
| | (.005) | (.220) | (.007) | (.006) | (.013) |
| Mental 0-3 | 0.049 | 2.08 | -.050 | -.006 | -.078 |
| | (.011) | (.477) | (.015) | (.013) | (.029) |
| Mental 4-8 | .024 | 1.84 | -.086 | -.021 | .132 |
| | (.009) | (.411) | (.013) | (.011) | (.025) |
| Mental 9-13 | .046 | 2.03 | -.091 | -.026 | -.138 |
| | (.008) | (.362) | (.011) | (.010) | (.022) |
| Mental 14-18 | .047 | 1.91 | -.043 | -.034 | -.089 |
| | (.006) | (.252) | (.008) | (.007) | (.007) |
| Asthma 0-3 | -.014 | -.769 | .006 | -.007 | -.003 |
| | (.010) | (.442) | (.014) | (.012) | (.026) |
| Asthma 4-8 | .012 | .638 | .007 | -.007 | .005 |
| | (.009) | (.391) | (.012) | (.010) | (.024) |
| Asthma 9-13 | -.007 | -.151 | .018 | (.011) | .020 |
| | (.009) | (.378) | (.012) | (.010) | (.023) |
| Asthma 14-18 | .013 | .494 | -.009 | -.024 | -.008 |
| | (.009) | (.388) | (.012) | (.010) | (.023) |
| Other Major 0-3 | .007 | .569 | .002 | -.006 | -.023 |
| | (.007) | (.303) | (.010) | (.008) | (.018) |
| Other Major 4-8 | .008 | .764 | .005 | .004 | .013 |
| | (.007) | (.295) | (.009) | (.008) | (.018) |
| Other Major 9-13 | -.005 | -.203 | .006 | .000 | -.001 |
| | (.007) | (.298) | (.009) | (.008) | (.018) |
| Other Major 14-18 | .025 | 1.58 | -.020 | -.010 | -.023 |
| | (.006) | (.264) | (.008) | (.007) | (.016) |
| Congenital or Perinatal | .007 | .429 | -.008 | -.025 | -.021 |
| Problems | (.007) | (.325) | (.010) | (.009) | (.019) |
| Birth weight<=1000 grams | -.028 | .014 | -.126 | -.086 | -.164 |
| | (.074) | (3.25) | (.103) | (.087) | (.195) |
| 1000<Birth weight<=1500 | .008 | -1.25 | -.069 | .063 | .031 |
| | (.041) | (1.81) | (.057) | (.048) | (.108) |
| 1500<Birth weight<=2000 | .004 | -.102 | -.045 | -.013 | -.035 |
| | (.013) | (.581) | (.018) | (.016) | (.035) |
| 2500<Birth weight<=3500 | .002 | .238 | -.019 | -.003 | -.022 |
| | (.006) | (.257) | (.008) | (.007) | (.015) |
| R-squared | 0.627 | .616 | .748 | .648 | .775 |
| # fixed effects | 8730 | 8731 | 8732 | 8734 | 8735 |
| # Obs. | 19793 | 19794 | 19795 | 19797 | 19798 |

Notes: See Table 7.

**APPENDIX**

We use the ADG codes to construct the health measures used in the analysis.  We construct binary measures of whether a child had an ADG code for a mental health problem, a major injury, asthma, or a set of other major health problems. In each case the measure is constructed to cover a specific age range for the child defined by the date of birth for the child (rather than by calendar years). So, for example, we define a child as having asthma between ages 1 and 4 if the child has an ADG code of asthma (ADG code 6) at any point during the years between the child's $1^{st}$ and $5^{th}$ birthdays. We construct this measure for the age ranges 0-3, 4-8, 9-13 and 14-18.

**Appendix Table 1: Means of Control Variables Used in Analysis**

| | All | Low SES |
|---|---|---|

**Time Limited: Major,**

**Likely to Recur: Progressive,**

**Chronic Medical: Unstable,**

**Chronic Specialty: Stable – Orthopedic,**

**Chronic Specialty: Stable – Ear, Nose, Throat,**

**Chronic Specialty: Unstable – Eye,**

**Psychosocial: Recurrent or Persistent, Unstable,**

*31. Prevention / Administration (not used in this study),*
*V20.2Routine Infant or Child Health Check, V72.3Gynecological Examination*
**Malignancy (Cancer),**

*33. Pregnancy,*
*V22.2 Pregnant State, 650.0 Delivery in a Completely Normal Case*
*34. Dental,*
*521.0 Dental Caries, 523.1 Chronic Gingivitis*

**Appendix Table 3: Top 10 ICD9 Codes for Mental Conditions in Each Age Group**

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| | **0-3 Year Olds** | | |
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**Top 10 ICD9 Codes for Major Injuries in Each Age Group**

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**Top 10 ICD9 Codes for Other Conditions in Each Age Group**

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## Top 10 ICD9 Codes for Congenital Anomalies between Birth and Age 1

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