

Child Health and Young Adult Outcomes

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Abstract

Previous research has shown a strong connection between birth weight and future child outcomes. We focus on how insults to child health after birth are related to child outcomes. We address this question using a unique data set based on public health insurance records for 50,000 children born between 1979 and 1987 in the Canadian province of Manitoba. These children are followed until 2006, and their records are linked to provincial registries with outcomes data. We compare children to their own siblings born an average of 3 years apart. We find that conditional on health at birth, health problems in early childhood are significant predictors of young adult outcomes. Early physical health problems are linked to outcomes primarily because they predict later health. Early mental health problems have additional predictive power even conditional on future health.

Introduction

A large literature has established that low birth weight babies are more likely to suffer various deficits, including lower average educational attainment. But prior research has not asked how poor child health *after* birth affects long-term outcomes? We provide a first look at this question using a unique administrative data set based on public health insurance records from the Canadian province of Manitoba. The data combines information from birth records, hospitalizations, and ambulatory physician visits with information from other provincial registers about educational outcomes and use of social assistance. The information about health and outcomes is much more complete, and in many ways more accurate, than what is typically available in survey data. And because Canada has universal public health insurance, this study sheds light on the consequences of disparities in child health in a setting that abstracts from differences in access to insurance coverage.

We follow 50,000 children and their siblings who were born in Manitoba between 1979 and 1987, until 2006, when they are young adults. We compare siblings with different childhood health problems conditional on health at birth. We are able to compare the impacts of health problems at different ages, and to examine the consequences of different types of health problems including asthma, major injuries, externalizing mental health conditions, and other major conditions.

Our results suggest that many physical health problems in early life are significant predictors of future adult outcomes. But this is largely because poor health in childhood predicts poor health in young adulthood. Short-term health events generally have little long-run impact. Mental health problems are a different story--we find that diagnoses of Attention Deficit Hyperactivity Disorder or Conduct disorder at school entry are significant predictors of

future outcomes whether or not future health problems occur. We conclude that poor health in childhood may be a significant source of socioeconomic disparities in adulthood.

2. Background

There is a large literature linking low birth weight to 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)). Several recent studies use sibling comparisons to assess the relationship between low birth weight and future outcomes (Conley and Bennett, 2000; Johnson and Schoeni, 2007; Lawlor et al., 2006; Black, Devereux, and Salvanes, 2005; Royer, 2005; Currie and Moretti, 2007). Oreopoulos, Stabile, Roos, and Walld (2008) examine the Manitoba data used in this study and, consistent with the other studies, find that siblings of lower birth weight have worse outcomes. They did not however, have any data on health after birth.

In fact, very few studies have examined the effect of child health after birth on future outcomes.¹ Case, Fertig, and Paxson (2005) use data from the 1958 British birth cohort study and show that children who suffered chronic conditions as children had lower educational attainment, wages, and employment probabilities than other children.

Smith (2007) examines the long-term effects of child health using a retrospective health measure using data from the Panel Study of Income Dynamics. In 1999, the 25 to 47 year old adult children of PSID respondents were asked whether their health when they were less than 16

¹ Salm and Schunk (2008) use administrative data from a German city and show that 6 year old children with health problems also have lower test scores, but they are not able to track the children over time.

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.

Case and Paxson (2006) treat adult height as an indicator of childhood health, and show that much of the wage premium associated with adult height can be explained by children's cognitive test scores. They interpret their results as evidence that early child health affects cognition, which in turn affects earnings.

Our study improves on this literature in several ways. First, we have a continuous measure of health which is taken from medical records and covers the child's entire life. This is an improvement over retrospective measures, or the snap shots that are available in the British Cohort Study. Second, we are able to compare children to their own siblings, in order to control for fixed aspects of family background that may affect both health during childhood and future outcomes.

3. Data

Our main source of data is records that are routinely collected through the administration of Manitoba's public health insurance system. These records include enrollment files, physician claims, and hospital claims for every person in Manitoba. These data are matched to administrative records on educational attainment and social-assistance (welfare) take-up and use.

The registry contains information on 96% of all children born in Manitoba over the sample period and tracks 99% of the original sample conditional on remaining in the province until June of their 18th year.² We restrict our sample to families with more than one child born

² Approximately 20% of the sample leaves the province between the birth of the child and their 18th year. Oreopoulos et al. (2008) find that there is no correlation between poor child health and the family leaving the province. There is also a small amount of attrition from children who die.

between 1979 and 1987 (excluding 1983 as we are unable to match this cohort to educational information). We track outcomes for these children through 2006. Oreopoulos et al. (2008) show that the sibling cohort and entire cohort of Manitoba births over this period are quite similar. We also exclude children who ever have a diagnosis of mental retardation. Further details on the construction of the data set are available in the data appendix.

Because the data set includes all hospitalizations and ambulatory visits, there are a very large number of potential health measures. Birth weight, congenital anomalies and perinatal problems are obtained from hospital records and are used as measures of health at birth.³

In order to collapse the other available health measures in an objective and arms-length way, we use Adjusted Clinical Group software developed by researchers at Johns Hopkins University (The Johns Hopkins University, 2003).⁴ The software is designed to measure

Children who died before age eight were much less healthy at birth and most of these deaths occurred within the first year of life. Excluding these children did not affect our results.

³ Perinatal refers to the period from birth to 22 weeks. We count only those congenital and perinatal problems that are considered “major” health conditions by the ADG system. Appendix Table 4 in the Data Appendix lists these conditions. Congenital problems may continue to generate diagnoses as the child ages. For example, we code a 10 year old may have visits related to a congenital heart defect. We treat this as a congenital problem rather than as a new health condition.

⁴ The ADG system has been extensively validated in the U.S. (Weiner, Starfield, Steinwachs et al., 1991; Weiner, Starfield, and Lieberman, 1992; Powe, Weiner, Starfield et al., 1998; Wiener, Dobson, Maxwell et al., 1996). The Manitoba Center for Health Policy has also evaluated the

morbidity by creating constellations of diagnoses. Medical providers indicate diagnoses using International Classification of Disease codes (ICD9 or ICD10 codes depending on the year). The software groups 14,000 ICD codes into 32 groups (called Aggregated Diagnostic Groups or ADGs).⁵ Individuals are assigned an ADG code if they have been diagnosed with any of the ICD codes in the group in either an outpatient or hospital visit over the past year.⁶

We use the ADG codes to construct several health measures. First, the software classifies some ADGs as major and some as minor for each age group, and we start by looking at their definition of major diagnoses for children. However, this definition excludes several diagnoses that are highly prevalent among children, and which are thought to have important effects: While the Johns Hopkins definition of major conditions includes acute, unstable mental health conditions such as psychosis, it excludes “stable” mental health conditions such as Attention Deficit Hyper Activity Disorder (ADHD) and Conduct disorders, two of the most

application of the ACG software to the Manitoba administrative data (Reid et al., 1999). See the data appendix for further details.

⁵ Groups are created on the basis of 5 criterion: 1) Duration of the Condition (acute, recurrent, or chronic), 2) severity of the condition (e.g. minor and stable versus major and unstable), 3) diagnostic certainty (symptoms focusing on diagnostic evaluation versus documented disease focusing on treatment), 4) etiology of the condition (infectious, injury, or other), and 5) specialty care involved (medical, surgical, obstetric, etc.)

⁶ Further information about the most common ICD codes in the ADGs we use is available in the Data Appendix.

common mental health conditions among children. Also excluded are asthma and major injuries.⁷

These are potentially significant exclusions. Using large-scale national surveys of children from both the U.S. and Canada, Currie and Stabile (2006, forthcoming) show that mental health conditions in childhood are associated with lower future test scores and schooling attainments in both countries. Externalizing disorders such as ADHD and conduct disorders were found to have the largest effects on future outcomes.⁸

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

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). The available evidence suggests however, that when properly managed asthma may have little impact on children's functioning or academic achievements so it is not clear that asthma in childhood should be expected to have consistent effects on young adult outcomes (Annett et al. 2000; Gutstadt et al., 1989).

⁷ "Major injuries" are not included as a major ADG for 0 to 17 year olds, but they are included for 18 year olds. In order to construct a more consistent measure, we use the same definition of major conditions for 18 year olds as we do for younger children. Further details are in the data appendix.

⁸ Duncan et al. (2006) report similar findings.

In view of these literatures, we examine the effects of asthma, major injuries, two specific stable mental health problems (ADHD and conduct disorders), as well as the number of major health conditions as classified by the ADG software. 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 birth and their 4th birthday. We construct similar measures for the age ranges 4 to 8, 9 to 13, and 14 to 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.

Table 1 shows the means of our measures for each age range. Because the first age range is one year smaller than the others, the estimates are pro-rated so that they all apply to a 5 year interval. The fraction of children with a medical contact for asthma ranges from 8% among 0 to 3 year olds, to 14.4% among 9 to 13 year olds. These numbers compare very closely with the best available evidence of asthma prevalence for the U.S., which suggest that 13.1% of 0 to 17 year old children have ever been told by a doctor that they have asthma (Bloom and Cohen, 2007).

Major injuries are clearly the most common reason for seeking medical attention, with around 40% of children having at least one visit for a major injury over each age interval. U.S. data suggest that in 2000, 11.9% of children less than 10 and 17.9% of children 10 to 19 received medical attention for an injury, which suggests that over a 4 or 5 year period, a rate of 40% is not unreasonable.

In comparison, contacts for externalizing mental health problems are not nearly as common: 3 to 4% of children receive a medical contact for ADHD or conduct disorders over

each period. U.S. rates of ADHD prevalence are higher than this. For example, Froehlich et al. (2007) report that 8.7% of 8 to 15 year old children in the National Health Interview Survey have been told by a doctor that they have ADHD. But there is evidence that Canadian rates of mental health diagnosis are lower than in the U.S. Currie and Stabile (forthcoming) found that 9.3% of children in the U.S. National Longitudinal Survey of Youth were being treated for mental health conditions compared to 4.5% in a similar Canadian survey. This disparity in the rates suggests that Canadian children who are diagnosed may display more severe behavior problems than treated children in the U.S., a comparison which should be born in mind when interpreting the results below.

About 15% of children 0 to 13 have other major conditions. Although it is relatively common to have a medical contact for a major health problem, most individual health problems have low prevalence. For example, the 629 children who had a medical contact related to hearing loss when they were 0 to 3 represent only 1.2% of the sample. This is the main reason that we group these major health conditions together. Still, 40 to 50% of young children categorized as having a major condition have hearing or vision problems, and it would not be surprising if these problems had effects on learning.

The average number of major health conditions is a little over .2 for children 0 to 13 (vs. .335 for 14 to 18 year olds) which suggests that most children with a major health condition have only one such condition. There are however a small number of children who have multiple conditions, with the maximum being 10 to 12 for 0 to 13 year olds (14 for 14 to 18 year olds). Finally, the table shows the effects of limiting our attention to major conditions. While the average number of major conditions identified is far less than 1, the average child has an average of 5 different major *and* minor conditions diagnosed over a five year period.

Table 2 explores the temporal pattern of health problems for the children in our sample. For example, a child is assigned the pattern 0000 if he or she did not have a diagnosis for a particular health condition in any age range. The fractions ever diagnosed with asthma, ADHD/conduct disorder or major injuries are 28.31, 10.18, and 82.06 respectively, while 47.36% ever have a major condition. Relatively small numbers of children have a diagnosis related to the same condition in each period. However, 5.58% of sample children have a major injury in every period.

The variation in our data over time periods suggests that in each period, some children without initial health conditions develop them, and other children with health conditions recover from them. Such variation is the key if we are to be able to use the data to examine the impact of health conditions at different ages.

The outcome variables we examine are created by linking the health care registry information to administrative data on education, and social assistance. We use education enrollment records to determine whether a student has attained Grade 12 by age 17. This measure is available for all birth cohorts. Overall, about 70% of children are in grade 12 by age 17. 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.

We also have information from provincial language arts standards tests taken in grade 12. These tests contribute 30% to the students' final course grade. Individuals pass the language arts test by scoring 50% or more on a comprehensive exam. 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, some 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.

Students in the province can select into one of several math tracks. In each year we classify high school courses into college versus non-college preparatory mathematics based on the difficulty of the course and the course material.⁹ We calculate that 22% of the sample took college-preparatory math courses.

Finally, the sample of Manitoba residents is matched to monthly social assistance records (the provincial welfare program). Residents become age-eligible to participate in welfare in their own right (rather than as a dependent child) on their 18th birthday. 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, we define our social assistance exposure window to be a consistent 1.25 years for each cohort (or 70 weeks). Using this exposure window, 6% of our sample went on social assistance in the 70 weeks after they became eligible on their 18th birthday.

The administrative records provide limited information on the characteristics of the mother at the birth of the child, and on the number of children in the family. We control for mother's marital status, age, child gender, child birth order, the number of children in the family, and the child's birth year. We use 2004 as the fixed point to determine family size and the birth order of the child. This year, many years after the final birth cohort used in the analysis (1987),

⁹The number of college preparatory math courses available increased over our sample period.

The inclusion of year fixed-effects will help to account for this trend. We also estimated alternative models using a binary variable equal to one if a student obtained a grade of 80% or more on their math courses. Results using this specification are quite similar.

was chosen in order to try to ensure that families were past the childbearing phase. Unfortunately, there is no information about the family's income or the mother's education.

4. Conceptual Framework

A growing body of research suggests that adverse conditions in early childhood may have particularly negative long term effects. Cunha and Heckman (2007) hypothesize that this is because health human capital is complementary to skills and "skill begets skill," so that children who suffer early disadvantages may fall behind and never catch up. On the other hand, to the extent that children are resilient and recover, one might expect more recent health conditions to have greater impacts 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 problems have particularly negative impacts on young adult outcomes.

This section presents a barebones model that captures these ideas and shows that early health shocks may have either larger or smaller effects than later ones, even in the simplest models:

$$(1) Y_t = aH_t^\alpha C_t^\beta$$

$$(2) c_t = b_0 + b_1c_{t-1} + b_2h_{t-1}$$

$$(3) h_t = \gamma h_{t-1} + u_t$$

where Y_t is a young adult outcome, H_t is contemporaneous health, C_t is contemporaneous cognitive ability, and h_t and c_t are log health and log cognitive ability, respectively. We assume that outcomes are produced using inputs of health and cognitive ability, and that cognitive ability depends on ability last period and also on health last period. Finally, health depends on health last period, and is subject to random problems, u_t . Note that in principal cognitive ability can also be subject to random shocks, but including them would only complicate this illustrative

model. Moreover, we cannot observe shocks to cognitive ability, but only shocks to health in our data.

Solving the model recursively yields an equation of the form:

$$(4) \log(Y_t) = \delta + \delta_1 c_{t-4} + \delta_2 h_{t-4} + \delta_3 u_t + \delta_4 u_{t-1} + \delta_5 u_{t-2} + \delta_6 u_{t-3}$$

where, $(\delta_1 c_{t-4} + \delta_2 h_{t-4})$ represents both cognitive and health endowments at birth (both will be assumed to be captured by our measures of health at birth in combination with the sibling fixed effects), u_t is a contemporaneous health problem, and u_{t-3} is a health problem in the first 3 years of life. The coefficients δ_3 to δ_6 are given by:

$$\delta_3 = \alpha, \delta_4 = \alpha\gamma + \beta b_2, \delta_5 = \gamma\delta_4 + \beta b_2 b_1, \delta_6 = \gamma\delta_5 + \beta b_2 b_1^2.$$

The model yields several interesting special cases:

Case 1. $b_2 = 0$ so that cognition does not depend on health. If $\gamma < 1$ then health depreciates, and the effects of health problems die out over time. In this case, more recent health problems always have a larger effect than problems further in the past.

Case 2: $b_2 > 0$ and $\gamma = 1$. Now early health problems matter more than later health problems. The reason is that early health problems affect the development of cognitive ability through multiple periods.

Case 3. if $b_2 > 0$ and $\gamma < 1$ then it is possible to generate many interesting patterns. For example, if $\alpha = \beta = .5$; $b_1 = 1.5$; $b_2 = .2$; $\gamma = .7$, then $\delta_3 = .5$, $\delta_4 = .45$, $\delta_5 = .47$, $\delta_6 = .56$ so that health problems in the first years of life and contemporaneous health problems matter most.

Hence, the impact of health shocks may be bigger or smaller for health shocks further in the past depending on which of the two mechanisms highlighted above dominates: On the one hand, if early health problems affect early cognitive ability, then future cognitive ability and early health problems have cumulative effects. However, people tend to recover from health

problems over time, so that the main effect of the health problem per se diminishes with time.

The takeaway message is that the overall pattern of effects on outcomes is an empirical matter.

The empirical analogue of (4) is given by:

$$(5) \text{ OUTCOME} = a + b_1X + b_2\text{HEALTH}_0 + b_3\text{HEALTH}_{0-3} + b_4\text{HEALTH}_{4-8} + b_5\text{HEALTH}_{9-13} + b_6\text{HEALTH}_{14-18} + e,$$

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, dummy variables for birth order of the child, family size, and year of birth indicators, HEALTH₀ are measures of health at birth and {HEALTH₀₋₃, HEALTH₄₋₈, HEALTH₉₋₁₃, HEALTH₁₄₋₁₈} is a vector of age specific health problems. We use a number of different measures of health, as described above.

Estimation of (5) could be biased by omitted characteristics of families, including characteristics that affect young adult outcomes, the health of children in the family and the propensity of the family to seek medical care.

Hence, our main focus is on models of the following form:

$$(6) \text{ OUTCOME}_{ya} = a + b_1X + b_2\text{HEALTH}_0 + b_3\text{HEALTH}_{0-3} + b_4\text{HEALTH}_{4-8} + b_5\text{HEALTH}_{9-13} + b_6\text{HEALTH}_{14-18} + \text{MOTHER} + e,$$

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, health status, and with young adult outcomes. The fact that we observe families over a relatively short period of time is helpful, as siblings will be less likely to be exposed to different environments over a short time than over a long time. The mean difference in age between two siblings is only 3 years, and 74% of children

are born less than 4 years apart. 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.

5. Estimation Results

In order for 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 3.

The first column of Table 3 reports the number of siblings with different health measures at each age. So, for example, there were 3177 pairs of siblings with differences in whether they were ever treated for asthma between age 0 to 3. The remaining columns report the average difference in outcomes for these pairs. 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. Many of the mean differences reported in Table 3 are significantly different than zero. They are all of the anticipated sign except for the case of asthma at age 0 to 3 which is negatively related to future welfare utilization. Thus, this initial exploration of the data shows that there is a good deal of variation in health between siblings, and that siblings in worse health generally suffer worse outcomes. However, these simple comparisons do not control for health at birth, multiple health problems, or health problems at different ages. Hence, we turn to estimation of equation (6).

Table 4 shows estimates of a model similar to (6) except that we include only measures of health at birth and health at 0 to 3. There has been a good deal of popular discussion of the

idea that the earliest ages are a uniquely vulnerable period, so it is of interest to see if health conditions at these ages are associated with long term outcomes.

Table 4 shows that, consistent with other studies, health at birth has significant effects on all four of our outcomes. Turning to health after birth, we find, perhaps surprisingly, that asthma at 0-3 is not predictive of adverse outcomes, while major injury is significant only in the regression for grade 12 by 17. The most powerful and consistent predictors of poor outcomes are mental health problems and the number of other major health conditions.

Perhaps surprisingly, there is no association between asthma and future outcomes. However, relative to their own healthy siblings, children with an early diagnosis of ADHD or conduct disorders are 1.6 percentage points more likely to end up on welfare immediately after becoming eligible (on a baseline of 5.5%). They are also 4.4% less likely to be in grade 12 by age 17. An additional major condition increases the probability of being on welfare by 18%, reduces the probability of being in grade 12 by age 17 by 1%, reduces the probability of taking college preparatory math by 3%, and reduces the literacy score by .15 of a standard deviation. Hence, poor mental health at 0-3 and other major conditions are associated with significantly poorer outcomes.

But how much of the effect of early health conditions is due to the fact that they are predictive of later health conditions, and how much operates through another channel? Table 5 takes up this question by showing estimates from a model of the form (6) which includes health conditions in all four age ranges. Table 5 suggests the following conclusions:

1. A diagnosis of ADHD and/or conduct disorder at school entry (4-8) or later is associated with much more negative outcomes. Controlling for such diagnoses at ages 4 and

above greatly attenuates the estimated effect of mental health diagnoses at 0-3, presumably because it is difficult to accurately diagnose mental health problems at such a young age.

2. The number of other major conditions at 0-3 and 4-8 remains predictive of social assistance use even when later diagnoses of major conditions are controlled. However, when diagnoses at 14-18 are included in the model, diagnoses at 0-3 and 4-8 are no longer significantly associated with future school outcomes.¹⁰

3. Health at birth remains a significant predictor of young adult welfare use and schooling attainment even when many intervening health measures are included in the model.

4. On average, major injuries in childhood do not have lingering effects on educational attainment or welfare use, though major injuries in adolescence place teens at higher risk of poor outcomes.

5. Asthma in early childhood is not predictive of diminished future educational outcomes or receipt of social assistance in young adulthood, though there are some weak associations between adolescent asthma and outcomes and asthma at 14-18 has a significant effect on future social assistance use.

One difficulty with the interpretation of equation (6) is that conditions that occur early can persist over more periods than ones that appear late in our observational window. An alternative way to look at the data is to compare the effects of health conditions which apparently lasted for only one period. The largest single category in Table 2 is children who never have a given condition. The next largest groups are children who had a condition only once. We might then compare children who have a given condition at age 0 to 3 and then recover, to those who

¹⁰ The same is true if we include health measures at 0-3, 4-8, and 9-13 only. That is, only the latest measure is predictive of schooling outcomes.

have the same condition at a different age. Table 6 includes indicators for having a condition only at 0-3, having it only at 4-8, having it only at 9-13, and having it only at 14-18. A fifth indicator is added for children who have a condition over multiple periods. The left out group for each condition is children who never had the condition.

Table 6 confirms that for physical health problems, it is problems that occur late in adolescents or which last for multiple periods that have effects on schooling and welfare participation. Children who sustain health problems early in life and then recover do not appear to suffer lasting effects on these outcomes. Again, mental health proves an exception. ADHD or conduct disorders at 4-8 are associated with poorer outcomes even if the children have no other contacts for mental health problems, although the effects are largest for mental health problems that persist over multiple age ranges.

6. Extensions

While the ADG system is a well established way to construct health measures from underlying ICD9/ICD10 codes, some arbitrariness in grouping diagnoses and in classifying diagnoses as major or minor is inevitable. One obvious extension involves breaking down the injury category, since it is so large. We have tried to estimate the effect of serious head injuries (skull fractures and intracranial injuries including concussion) since there is a literature positing long term effects of such injuries (Hawley et al, 2008). However, although 4 to 7% of children have such injuries in each age group, we did not find any statistically significant effects. It is possible that to do so may require larger samples.

Our findings with regard to ADHD/conduct disorders beg the question of how other mental illnesses affect child outcomes. We have repeated our analyses with a somewhat broader measure of mental health conditions defined using all of the conditions included in ADG 24

“Recurrent or Persistent, Stable Psychosocial conditions” the category that includes both ADHD and conduct disorder. This exercise produced similar though somewhat larger estimates of the effects of mental health conditions.

In our administrative data we have no information about measures of socioeconomic status (SES) such as parent’s income or education. 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). Hence, it would be of great interest to break down our results by SES.

We constructed a measure of socioeconomic status (SES) using income measured at the enumeration area level (an area similar to a U.S. Census tract from the 1986 Canadian Census). Our outcome measures vary with this measure. However, our estimation results were inconclusive. If we divide our sample by SES, the point estimates of the effects of health problems tend to be larger for the lower SES group, but we cannot reject the null hypothesis that the effects are similar for high and low SES groups.

6. Discussion

The strengths of our study include: a large sample; coverage of the population from birth to follow-up; a long follow up period; and the use of objective health measures rather than self-reports or retrospective measures. The fact that we observe multiple children from the same family is an additional strength because sibling comparisons enable us to control statistically for

many unobserved characteristics of families that could be related to health and propensity to seek care.

Still several issues arise when using family fixed effects models. First, there may be characteristics of the individual child that are correlated with health conditions and also with future outcomes. While we cannot control for all such factors, it is important to note that we have unusually thorough controls for health at birth, and that the degree of serial correlation in many of our outcomes (such as injuries) is modest.

Second, parents may treat siblings differently, and illness could cause parents to behave differently towards the sick child, if for example, illness changes parental perceptions about the marginal return to investments in children. If parents favor the stronger child, then the estimated effect of health problems will reflect not only physiological effects, but also the result of the parent's smaller investments in the sick child. If on the other hand, parents of children with health problems invest in order to compensate disadvantaged children, then sibling fixed effects will tend to understate the true physiological effect of health. Such bias could go either way. Rosenzweig and Zhang (2006) argue that in China, parents favor the stronger child, perhaps because many Chinese still expect to be supported by their children in old age. In the U.S., the available evidence suggests that investments are usually compensatory (Behrman, Pollak, and Taubman, 1982, 1989; Ashenfelter and Rouse, 1998; Ermish and Francesconi, 2000, McGarry 1999; McGarry and Schoeni 1995, 1997) so that sibling comparisons are likely to yield underestimates of the true physiological effects of health. We believe that Canada is more similar to the U.S. than to China, so that our estimates may tend to understate the effects of health problems.

Third, health conditions of one sibling may have an impact on the other sibling. To the extent that the household is disrupted by a child's illness, we might expect both children to be negatively affected in which case our sibling comparisons will also tend to underestimate the effects of health conditions.

Fourth, sibling fixed effects models may exacerbate the effects of measurement error. This last point highlights a strength of our analysis in that our measures of health are much more accurate than those used in previous studies, and less likely to be subject to bias due to self/parental reports, forgetting, etc.

Still, several limitations are implicit in our reliance on administrative health records. First, the outcomes that can be examined are limited by the availability of administrative data sets that can be merged to the health records. It would be very interesting to be able to measure adult earnings or employment status, but this information is currently unavailable.

Second, what can we observe is whether a child had any interaction with the health care system for a specific ADG over a four-year interval. It is always difficult to construct measures of underlying health from data about utilization of care. There are two reasons to believe, however, that the measures we construct are good proxies for underlying health status: First, these children are all fully insured. It is reasonable to expect that a seriously ill child who is fully insured will interact with the health care system at least once, and in fact, over 98% of our sample children have a contact with the medical system in each period. Hence, the use of data from a country with universal health insurance mitigates the concern about access to care (and hence about the relationship between health and utilization). Second, our measure is not affected by the number of visits, as long as the child sees the doctor at least once.

Our Canadian setting provides a data set that would be virtually impossible to replicate in a U.S. setting. It would be difficult to find a U.S. insurer that had comprehensive data on a similarly sized sample of children from birth to young adulthood. And as argued above, universal access to care makes it defensible for us to approximate underlying health status with data based on health care utilization. Still, readers may wonder whether our results can be generalized to a U.S. setting? We believe that if health problems have long term impacts in the Canadian setting, then they are likely to have even greater impacts in the U.S. where access to care is an issue for many children. More specifically, it is possible for example, that asthma could have more deleterious effects in the U.S., given large numbers of children with inadequate access to preventive care.

7. Conclusions

Our research offers several striking conclusions. First, both poor health at birth and early mental health problems are associated with poorer long term outcomes, even conditional on future health outcomes. Second, physical health problems in early childhood are associated with poorer long-term outcomes, but this appears to be because they predict poorer future health. Unless they persist over time, even serious early health problems have little association with future schooling attainment or reliance on welfare. This is true of major injuries as well as illness. Finally, it is notable that we find very little effect of childhood asthma on the outcomes we examine.

Our overall conclusion is that health problems in early childhood may be significant determinants of adult socioeconomic status, even in a country like Canada where all children

have access to health insurance. Hence, prevention and better care for children who have early health problems could make a significant difference to their life prospects.

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Table 1: Means of Health Variables at Various Ages

	Age 0 to 3	Age 4 to 8	Age 9 to 13	Age 14 to 18
Diagnoses related to:				
Any major condition	0.154	0.148	0.153	0.219
ADHD/Conduct disorder	0.033	0.037	0.038	0.030
Asthma	0.081	0.125	0.144	0.120
Major Injury	0.412	0.412	0.386	0.404
Congenital/Perinatal Problem	0.156	0.016	0.012	0.013
Any of the above	0.599	0.563	0.544	0.642
Number of Major diagnoses	0.208	0.228	0.216	0.335
	[0.580]	[0.691]	[0.628]	[0.806]
Maximum # major diagnoses	11	12	10	14
Number Total diagnoses major and minor	10.500	10.320	9.45	10.01
	[5.28]	[5.72]	[5.76]	[6.48]
Number of Observations	50404			

Notes: Standard deviations of continuous variables in brackets.

Sample is drawn from administrative records from the province of Manitoba and includes children born between the years 1979 and 1987 excluding 1983.

Table 2: Pattern of Health Conditions Across Age Groups

Age Pattern	Major Condition	ADHD/ Conduct Disorder	Asthma	Major Injury
0000	52.64	89.82	71.69	17.94
0001	12.02	1.37	4.29	7.97
0010	6.28	1.67	4.70	6.47
0011	2.99	0.70	2.46	5.00
0100	6.46	1.99	4.03	7.62
0101	1.72	0.12	0.54	4.70
0110	1.54	0.50	1.95	4.47
0111	0.97	0.51	2.26	4.59
1000	7.45	2.46	3.45	8.73
1001	2.05	0.07	0.30	4.52
1010	1.15	0.12	0.35	4.31
1011	0.6	0.06	0.30	3.85
1100	1.77	0.35	1.07	5.70
1101	0.63	0.02	0.27	4.23
1110	0.79	0.10	0.79	4.32
1111	0.93	0.13	1.55	5.58

Notes: Reported numbers are percentages of children with diagnoses. N=50404.

Patterns reflect whether the child had a diagnostic code for a particular condition in each of the age categories 0-3, 4-8, 9-13, 14-18.

E.g. 0000 denotes have no diagnoses for any of the 4 age categories, while 0001 denotes having a diagnosis between ages 14-18 only, 1100 denotes having a diagnosis at ages 0-3 and ages 4-8 but not 9-13 and 14-18.

Table 3: Mean Differences Between Sibling Pairs with Divergent Health Measures

	# Sib pairs w diff	Diff in on SA	Diff in grade 12 by 17	Diff College Math	Diff in Literacy
Major Conditions, Age 0-3	6103	0.011** [0.004]	-0.005 [0.006]	-0.012** [0.006]	-0.021* [0.012]
Age 4 to 8	5986	0.014** [0.004]	-0.020** [0.006]	-0.015** [0.006]	-0.035** [0.012]
Age 9 to 13	6147	0.011** [0.004]	-0.019** [0.006]	-0.009 [0.006]	-0.038** [0.012]
Age 14 to 18	8103	0.035** [0.003]	-0.020** [0.005]	-0.023** [0.005]	-0.029** [0.011]
ADHD/Conduct Disorder, Age 0-3	1438	0.011 [0.008]	-0.052** [0.013]	-0.018 [0.012]	-0.084** [0.026]
Age 4 to 8	1619	0.029** [.009]	-0.144** [0.013]	-0.062** [0.011]	-0.322** [0.025]
Age 9 to 13	1650	0.038** [0.008]	-0.208** [0.013]	-0.094** [0.010]	-0.463** [0.024]
Age 14 to 18	1332	0.070** [0.011]	-0.215** [0.015]	-0.117** [0.011]	-0.468** [0.026]
Asthma, Age 0-3	3177	-0.010** [0.005]	-0.016** [0.008]	0.005 [0.008]	-0.088** [0.017]
Age 4 to 8	4427	0.000 [0.004]	-0.004 [0.007]	0.003 [0.007]	-0.041** [0.015]
Age 9 to 13	5217	-0.005 [0.004]	-0.004 [0.006]	-0.015** [0.007]	-0.028** [0.014]
Age 14 to 18	4675	0.010** [0.004]	-0.01 [0.007]	-0.018** [0.007]	-0.017 [0.014]
Major Injury, Age 0-3	10789	0.002 [0.002]	-0.016** [0.004]	-0.005 [0.004]	-0.041** [0.010]
Age 4 to 8	10928	-0.003 [0.003]	-0.016** [0.004]	-0.006 [0.004]	-0.045** [0.009]
Age 9 to 13	10798	-0.001 [0.003]	-0.025** [0.004]	-0.021** [0.004]	-0.077** [0.009]
Age 14 to 18	11055	0.004 [0.003]	-0.033** [0.004]	-0.026** [0.004]	-0.082** [0.009]
Congenital Anomalies & Perinatal Problems, Age 0-3	5868	0.004 [0.004]	-0.009 [0.006]	-0.014** 0.006	-0.031** [0.012]
Age 4 to 8	755	0.033** [0.011]	-0.058** [0.016]	-0.01 [0.016]	-0.091** [0.033]
Age 9 to 13	585	0.042** [0.012]	-0.045** [0.019]	0.003 [0.018]	-0.113** [0.040]
Age 14-18	606	0.033** [0.013]	-0.032* [0.018]	-0.01 [0.017]	-0.093** [0.039]
Mean of Outcome:		0.055	0.691	0.214	-0.014

Notes: Standard Errors in brackets. Column 1 reports the number of sibling pairs with differences in health measures at each age. The remaining columns report the average difference in outcomes for the pairs where there is a difference in the specified health condition. * denotes statistical significance at the 10% level. ** denotes significance at the 5% level.

Table 4: Regressions of Outcomes on Health Problems at Age 0-3, Birth Weight, and Congenital or Perinatal Problems.

	On Social Assistance	Grade 12 by Age 17	College Math	Literacy Score
# Major Conditions, Age 0-3	0.010** [0.002]	-0.006** [0.003]	-0.007** [0.003]	-0.015** [0.006]
ADHD/Conduct, Age 0-3	0.016** [0.007]	-0.044** [0.012]	-0.011 [0.012]	-0.058** [0.025]
Asthma, Age 0-3	-0.004 [0.005]	-0.003 [0.008]	0.005 [0.008]	-0.019 [0.017]
Major Injury, Age 0-3	0.004 [0.003]	-0.008** [0.004]	-0.002 [0.004]	-0.01 [0.009]
Birth weight<=1000 grams	-0.026 [0.047]	-0.263** [0.079]	-0.099 [0.080]	-0.348** [0.167]
1000<Birth weight<=1500	0.038* [0.023]	-0.061 [0.038]	0.038 [0.039]	-0.035 [0.081]
1500<Birth weight<=2500	0.011 [0.007]	-0.046** [0.012]	-0.007 [0.012]	-0.025 [0.025]
2500<Birth weight<=3500	-0.001 [0.003]	-0.018** [0.005]	-0.007 [0.005]	-0.021** [0.010]
# Congenital/Perinatal 0-3	0.004 [0.002]	-0.006 [0.004]	-0.011** [0.004]	-0.015** [0.007]
R-squared	0.609	0.731	0.648	0.752
Mean of Outcome:	0.055	0.691	0.214	-0.014
# fixed effects	22692			
# Obs.	50404			

Notes: Standard errors in brackets. Each column reports the results of a regression (or linear probability model) for the outcome listed in that column. On Social Assistance, Reaching Grade 12 by Age 1, and Taking College Math are 0/1 variables. The literacy score is normalized (0,1). In addition to the controls listed, all regressions also include mother fixed effects and controls for marital status, sex of the child, mother's age at birth, dummy variables for birth order of the child, family size, and year of birth indicators. * denotes statistical significance at the 10% level. ** denotes

Table 5: Regressions of Outcomes on Childhood Health Conditions at Various Ages a

	On Social Assistance	Grade 12 by Age 17	College Math	Literacy Score
# Major Conditions, Age 0-3	0.006** [.002]	-0.001 [0.003]	-0.004 [0.003]	-0.004 [0.006]
# Major Conditions, Age 4-8	0.005** [.002]	-0.005 [0.003]	-0.004 [0.003]	-0.009 [0.007]
# Major Conditions, Age 9-13	0.000 [.002]	-0.004 [0.004]	0.001 [0.004]	-0.005 [0.008]
# Major Conditions, Age 14-18	0.017** [.002]	-0.012** [0.003]	-0.010** [0.003]	-0.025** [0.006]
ADHD/Conduct, Age 0-3	0.010 [.007]	-0.028** [0.012]	-0.002 [0.012]	-0.025 [0.024]
ADHD/Conduct, Age 4-8	0.021** [0.007]	-0.071** [0.011]	-0.024** [0.012]	-0.145** [0.024]
ADHD/Conduct, Age 9-13	0.024** [0.007]	-0.121** [0.012]	-0.053** [0.012]	-0.234** [0.025]
ADHD/Conduct, Age 14-18	0.060** [0.008]	-0.132** [0.013]	-0.075** [0.013]	-0.268** [0.027]
Asthma, Age 0-3	-0.005 [.005]	-0.004 [0.008]	0.007 [0.008]	-0.021 [0.017]
Asthma, Age 4-8	0.007* [0.004]	0.007 [0.007]	0.007 [0.007]	0.018 [0.015]
Asthma, Age 9-13	-0.007* [0.004]	0.008 [0.007]	-0.013* [0.007]	0.011 [0.014]
Asthma, Age 14-18	0.008** [0.004]	-0.012 [0.007]	-0.011 [0.007]	-0.028* [0.015]
Major Injury, Age 0-3	0.004** [0.002]	-0.006 [0.004]	-0.002 [0.004]	-0.006 [0.009]
Major Injury, Age 4-8	0.000 [0.002]	-0.002 [0.004]	-0.001 [0.004]	0.002 [0.009]
Major Injury, Age 9-13	0.001 [0.003]	-0.011** [0.004]	-0.013** [0.004]	-0.033** [0.009]
Major Injury, Age 14-18	0.005** [0.002]	-0.015** [0.004]	-0.018** [.004]	-0.027** [0.009]
Birth weight<=1000 grams	-0.019 [.047]	-0.262** [.078]	-0.102 [.080]	-0.347** [.165]
1000<Birth weight<=1500	0.046** [.022]	-0.069* [.038]	0.036 [.039]	-0.051 [.080]
1500<Birth weight<=2500	0.011 [.007]	-0.044** [.012]	-0.006 [.012]	-0.022 [.025]
2500<Birth weight<=3500	-0.002 [.003]	-0.016** [.005]	-0.006 [.005]	-0.017* [.010]
# Congenital/Perinatal 0-3	0.001 [.002]	-0.003 [.004]	-0.012** [.004]	-0.009 [.008]
R-squared	0.614	0.736	0.65	0.756
Mean of Outcome:	0.055	0.691	0.214	-0.014
# fixed effects	22692			
# Obs.	50404			

Notes: Standard errors in brackets. Each column reports the results of a regression (or linear probability model) for the outcome listed in that column. On Social Assistance, Reaching Grade 12 by Age 1, and Taking College Math are 0/1 variables. The literacy score is normalized (0,1). In addition to the controls listed, all regressions also include mother fixed effects and controls for marital status, sex of the child, mother's age at birth, dummy variables for birth order of the child, family size, and year of birth indicators. * denotes statistical significance at the 10% level. ** denotes significance at the 5% level.

Table 6: Health Problems in Single Periods vs. Multiple Periods

	On Social Assistance	Grade 12 by Age 17	College Math	Literacy Score
# Major Conditions, only ages 0-3	0.002 [0.005]	0.000 [0.008]	-0.006 [0.008]	-0.01 [0.016]
only ages 4-8	-0.001 [0.005]	0.001 [0.008]	-0.008 [0.008]	-0.004 [0.025]
only ages 9-13	0.000 [0.005]	-0.004 [0.008]	-0.001 [0.008]	-0.009 [0.017]
only ages 14-18	0.031** [0.004]	-0.021** [0.006]	-0.018** [0.006]	-0.042** [0.013]
multiple periods	0.022** [0.004]	-0.022** [0.006]	-0.020** [0.006]	-0.053** [0.013]
ADHD/Conduct, only ages 0-3	0.008 [0.008]	-0.041** [0.013]	-0.003 [0.013]	-0.039 [0.027]
only ages 4-8	0.01 [0.009]	-0.084** [0.014]	-0.027* [0.015]	-0.161** [0.030]
only ages 9-13	0.027** [0.009]	-0.144** [0.015]	-0.072** [0.016]	-0.303** [0.033]
only ages 14-18	0.057** [0.010]	-0.180** [0.017]	-0.106** [0.017]	-0.369** [0.036]
multiple periods	0.082** [0.008]	-0.213** [0.013]	-0.100** [0.013]	-0.424** [0.028]
Asthma, only ages 0-3	-0.01 [0.007]	-0.002 [0.011]	0.012 [0.011]	-0.023 [0.023]
only ages 4-8	-0.001 [0.006]	0.007 [0.010]	0.007 [0.011]	0.016 [0.022]
only ages 9-13	-0.003 [0.006]	0.013 [0.009]	-0.011 [0.010]	0.026 [0.020]
only ages 14-18	0.009 [0.006]	-0.020** [0.010]	-0.001 [0.010]	-0.024 [0.020]
multiple periods	0.004 [0.004]	-0.001 [0.007]	-0.011 [0.007]	-0.015 [0.015]
Major Injury, only ages 0-3	0.002 [0.005]	-0.012 [0.008]	-0.01 [0.008]	-0.021 [0.017]
only ages 4-8	-0.003 [0.005]	0.000 [0.008]	0.006 [0.008]	0.031* [0.018]
only ages 9-13	0.002 [0.005]	-0.004 [0.009]	0.000 [0.009]	-0.012 [0.019]
only ages 14-18	0.006 [0.005]	-0.010 [0.008]	-0.020** [0.008]	-0.028* [0.017]
multiple periods	0.006 [0.004]	-0.018** [0.006]	-0.022** [0.001]	-0.041** [0.012]
Birth weight<=1000 grams	-0.012 [0.047]	-0.265** [0.078]	-0.109 [0.080]	-0.357** [0.165]
1000<Birth weight<=1500	0.048** [0.022]	-0.071* [0.038]	0.033 [0.039]	-0.053 [0.080]
1500<Birth weight<=2500	0.012* [0.007]	-0.044** [0.012]	-0.005 [0.012]	-0.021 [0.025]
2500<Birth weight<=3500	-0.001 [0.003]	-0.016** [0.005]	-0.006 [0.005]	0.018* [0.010]
# Congenital/Perinatal 0-3	0.002 [0.004]	-0.004 [0.016]	-0.017** [0.006]	-0.008 [0.013]

R-squared	0.613	0.735	0.65	0.756
# fixed effects	22692			
# Obs.	50404			

Notes: Standard errors in brackets. Each column reports the results of a regression (or linear probability model) for the outcome listed in that column. On Social Assistance, Reaching Grade 12 by Age 1, and Taking College Math are 0/1 variables. The literacy score is normalized (0,1). In addition to the controls listed, all regressions also include mother fixed effects and controls for marital status, sex of the child, mother's age at birth, dummy variables for birth order of the child, family size, and year of birth indicators. * denotes statistical significance at the 10% level. ** denotes significance at the 5% level.

DATA APPENDIX:

The province of Manitoba was chosen for this study because of the unique ability to link the sources of data used in this paper. With a population of 1.17 million, Manitoba has the 5th largest population among Canada's provinces and territories. Within Canada, Manitoba has generally ranked in the mid-range of a series of indicators of health status, socioeconomics, and health care expenditures.

The data used in this study come from a number of sources. The birth data originate from Manitoba Health hospital records. The registry contains information on all births in Manitoba since 1970. Siblings are linked to mothers using hospital birth record information. The registry data allow us to specify the mother in all cases. Fathers are specified in 85 percent of cases. When an individual turns eighteen years old, he or she receives his or her own family identification number. On marriage, a female receives the identification number of her husband. Both the mother's identification number (an encrypted Personal Health Identification Number) and the family identification number are used to define siblings¹. Several checks on this algorithm as applied to the nine years of birth cohorts (looking at missing data, the number of children designated as having the same mother and father, and complicated blended families) have indicated it to be highly accurate.

Information on the provincial language arts test is taken from education enrollment records and linked to the provincial registry. Taken in grade 12, these tests

¹ Siblings are noted as "full siblings" if they are children of the same mother (as noted on the birth record) and the same man is noted on the research registry (using the child's family identification number) as 'family head' at the time of the child's birth. Slightly over 85 percent of those identified as siblings (from having the same mother) meet the criterion set out above.

contribute 30 percent to the students' final course grade. Individuals pass the language arts test by scoring 50 percent or more on a comprehensive exam. The test focuses on reading comprehension, exploring and expanding on ideas from texts, the management of ideas and information, and writing and editing skills. For each birth cohort, we record the test score in 5 percentage point categories (13 in total, with a residual 14th for students scoring between 0 and 35 percent) in the year that most students write the test. Within each birth cohort, approximately 40% of test scores are missing. We impute scores for missing students based on the reason for missing information (ranking them below the lowest scoring category among those who wrote the test).

The missing data categories, listed from highest to lowest rank are: absent (about 1 percent of each birth cohort sample); In grade 12 but not tested (about 8 percent); In grade 11 or lower (about 19 percent), Not enrolled (about 2 percent), and Withdrawn from School (about 10 percent). For the entire sample, we therefore have 19 test score categories. Following methods discussed by Mosteller and Tukey (1977) and Willms (1986), we compute a standardized score for each individual by assuming an underlying logit distribution, which is divided into pieces according to the percentage of cohort members in each category. Scores are calculated separately for each birth cohort because of small changes in the categories available and in the percentage distribution each year. In a typical year, the highest scorers are given an index score of 2.96, while those withdrawn from school are given a score of -1.84. The logit transform produces an index with an overall mean of zero and a standard deviation of one. The ordering on this index is closely correlated with the student's eventual graduation status.

We remove children who ever had a diagnosis of mental retardation from the sample. This includes ICD9's 317 to 319 and ICD10's F70-F79.

Appendix Table 1 shows means of the “control variables” that are available in our administrative data. Note that while we start with approximately the same number of children in each birth cohort, the focus on comparing siblings means that in our sibling sample, children in the middle cohorts are more likely to be retained in the sample (because they are more likely to have a sibling in the sample).

In order to collapse the number of health measures to a manageable number in an objective and arms-length way, we use Adjusted Clinical Group (ACG) software developed by researchers at Johns Hopkins University (The Johns Hopkins University, 2003). The ACG is designed to measure morbidity by clustering individuals by their age, gender, and constellations of diagnoses. Medical providers indicate diagnoses using what are called International Classification of Disease 9th or 10th edition (ICD9 or ICD10) codes. This software groups 14,000 ICD9 codes into 32 groups (called Aggregated Diagnostic Groups or ADGs) on the basis of 5 criteria: 1) duration of the condition (acute, recurrent, or chronic), 2) severity of the condition (e.g. minor and stable versus major and unstable), 3) diagnostic certainty (symptoms focusing on diagnostic evaluation versus documented disease focusing on treatment), 4) etiology of the condition (infectious, injury, or other), and 5) specialty care involved (medical, surgical, obstetric, etc.) Individuals are assigned an ADG code if they have been diagnosed with any of the ICD9/10 codes in the group in either a physician or hospital visit over the past year. A person can have from zero to 32 ADGs. The system further classifies diagnoses as “major” or “minor”, a distinction we take advantage of in our study.

The ADG system has been extensively validated in the U.S. (Weiner, Starfield, Steinwachs et al., 1991; Weiner, Starfield, and Lieberman, 1992; Powe, Weiner, Starfield et al., 1998; Wiener, Dobson, Maxwell et al., 1996). The Manitoba Center for Health Policy has also evaluated the application of the ACG software to the Manitoba administrative data (Reid et al., 1999). They found, for example, that the diagnostic codes used in Manitoba worked well with the ACG software, and that the fraction of people with no valid code in a given year (18%) was similar to that expected on the basis of previous analyses of Manitoba data. (People have no valid code if they did not see a doctor at all during the reference period). About 16% of the population had 4 or more ADG codes in a year. The system also generated a distribution of relative expenditures similar to that seen in other data sets (Minnesota Medicaid recipients, and a large U.S. HMO), suggesting that relative expenditures for different types of illness are not very different in Canada and the United States. Finally, the MCHP study verified that areas with high rates of premature mortality also had higher morbidity as measured by the ACG system.

We use the ADG codes to construct the health measures used in the analysis. 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 sum the number of major condition codes recorded in each year between ages 0 and 3 to get a measure of the number of major conditions in that age range. We construct this measure for the age ranges 0-3, 4-8, 9-13 and 14-18.

Major conditions are defined using ADG codes 3, 9, 11, 12, 13, 18, 25 and 32. These codes capture most of the chronic and acute major illnesses faced by children

including orthopedic, ear, nose throat and eye problems, cancers, and a variety of other acute major illnesses.

The definition of a “major ADG” comes directly from the John Hopkins software and depends on the age of the child. For children ages 0-17 it includes ADGs 3,9,11,12,13,18, 25 and 32 and for children ages 18 and older it includes 3, 4, 9, 11, 16, 22, 25, 32. For the sake of defining a consistent measure across age groups, we re-define the major ADG group using the 0-17 definition for all ages in the sample.

ICD9 codes have been used for both physician claims and hospital separation abstracts through March 31, 2004. These will have generated the ADG scores for all nine birth cohorts up through age 14. Beginning April 1, 2005, ICD10 coding was adopted for hospital separation abstracts. Because of this, a relatively small number of ICD10 diagnoses (N=447) on abstracts from the 1985-1987 birth cohorts were also used in categorizing major conditions.

Appendix Table 2 shows the most prevalent ICD9 codes generating major conditions for each age group. While the most common serious conditions change as children age, hearing and vision problems are important in each age group. Appendix Table 3 shows the most prevalent ICD9 codes generating major injuries. While the most common serious conditions change as children age, “open wound of the head” and “certain adverse conditions, not elsewhere classified” are important categories at all ages.

Appendix Table 4 shows the most prevalent ICD9 codes for congenital problems and perinatal problems (ICD9 740 to 779). By definition, these conditions occur at birth or slightly thereafter. However, children with serious congenital/perinatal problems continue to have contacts with the medical system that are related to these diagnoses.

Hence, one can sum the number of contacts having to do with congenital/perinatal problems at each age. In our regression models, we control for the number of contacts related to congenital/perinatal problems at each age group.

The health measures are generated from physician visits and hospital separation abstracts. Emergency department and hospital outpatient visits are not uniformly included in the data sets. Some of these visits are captured as (physician) ambulatory visits. An earlier analysis using 1 year of Winnipeg data found that 4.9 percent of ambulatory care was provided by emergency departments and outpatient clinics and that residents of lower income neighborhoods were disproportionately likely to receive such care.^{i ii} In our records, 2.5 percent of physician claims are for emergency room visits, and 1.6 percent of hospital claims over the period 1979-2004 are for outpatient visits. This comparison suggests that about 1 percent of visits could be missing.

Our analysis is based on ADGs and numbers of ADGs rather than on numbers of visits. Hence, if a child with a missing visit had another contact for a diagnosis in the same ADG within a four year period (e.g. a follow up visit), that child's condition would be included in our analysis. Nevertheless, in order to gauge the potential importance of missing visit records, we conducted the comparison shown in Appendix Table 5. This table shows the number of ADGs for each age group calculated first using the entire sample of visits available, and then excluding the ER and outpatient records that we do have. Clearly, this exclusion makes very little difference to the average number of ADGs. It also had no effect on the maximum number of ADGs observed, so we have chosen to conduct our analysis using the entire sample of visit records.

Finally, we have examined the number of children who do not have any medical

contacts in each 4 year period. It is extremely small, only .63 of a percent in the 0-3 and 4-8 age ranges, rising to 1.24 and 1.29 in the 9-13 and 14-18 age ranges. Only 10 children lack visits over the whole 0-18 interval. These may be due to data entry errors, including children who left the province, but whose exit was not recorded. In any case, it is not the case that large numbers of children will lack diagnoses because they lack any access to medical care.

Appendix Table 1: Control Variables Used in Analysis

	Mean	Standard Deviation
Birth weight 0-999 grams	.001	
Birth weight 1000-1499 grams	.003	
Birth weight 1500-2499 grams	.043	
Birth weight 2500-3499 grams	.476	
Congenital/Perinatal 0-3	.156	
# Congenital/Perinatal 0-3	.222	.587
Congenital/Perinatal 4-8	.016	
# Congenital/Perinatal 4-8	.027	.263
Congenital/Perinatal 9-13	.012	
# Congenital/Perinatal 9-13	.019	.209
Congenital/Perinatal 14-18	.013	
# Congenital/Perinatal 14-18	.019	.208
Mother married at birth	.843	
Mother<20 at birth	.073	
Mother>=20, <25 at birth	.298	
Mother>=25,<35 at birth	.581	
Mother 35+ at birth	.048	
Child Male	.514	
Child first born	.308	
Child 2 nd born	.377	
Child 3 rd born	.191	
Child 4 th born	.072	
Child 5 th born or higher	.052	
# children in family=2	.294	
# children in family=3	.342	
# children in family=4	.180	
# children in family=5	.184	
Birth year 1979	.076	
Birth year 1980	.100	
Birth year 1981	.119	
Birth year 1982	.154	
Birth year 1984	.171	
Birth year 1985	.139	
Birth year 1986	.118	
Birth year 1987	.123	
# Observations	50404	

Appendix Table 2: Top 10 ICD9 Codes for Children with Major Conditions, by Age Group

0-3 Year Olds (Total Number of Diagnoses=10061)			
ICD9	Description of condition	#Cases	%Cases
378	Strabismus, Other disorder binocular eye	1647	15.57
373	Inflammation of eyelids	1219	12.12
389	Hearing Loss	1060	10.54
579	Intestinal malabsorption	454	4.51
530	Diseases of esophagus	341	3.39
385	Other disorder middle ear and mastoid	233	2.32
560	Intestinal obstruction w/o hernia	232	2.31
518	Other diseases of lung	194	1.47
514	Pulmonary congestion - hypostasis	142	1.41
707	Chronic ulcers of skin	142	1.43
4-8 Year Olds (Total Number of Diagnoses=9429)			
389	Hearing loss	2334	24.75
378	Strabismus, other disorder binocular eye	1323	14.03
373	Inflammation of eyelids	1216	12.90
385	Other disorder middle ear and mastoid	266	2.82
541	Acute appendicitis	217	2.30
540	Appendicitis, unqualified	182	1.93
707	Chronic ulcer of skin	146	1.55
259	Other endocrine disorder	117	1.24
540.9	Acute appendicitis w/o peritonitis	115	1.22
448	Disease of capillaries	112	1.19
9-13 year olds (Total Number of Diagnoses= 10084)			
373	Inflammation of eyelids	1431	14.09
389	Hearing loss	872	8.65
378	Strabismus, other disorder binocular eye	791	7.84
717	Internal derangement of knee	736	7.30
540	Acute appendicitis	476	4.72
718	Other derangement of joint	430	4.26
541	Appendicitis, unqualified	338	3.35
5409	Acute appendicitis w/o peritonitis	279	2.77
259	Other endocrine disorders	265	2.63
905	Late effect musculoskeletal & connective tissue injury	186	1.84
14-18 year olds (Total Number of Diagnoses=16646)			
717	Internal derangement of knee	1557	9.35
373	Inflammation of eyelids	1548	9.30
718	Other derangement of joint	839	5.04
296	Affective psychoses	776	4.66
530	Diseases of esophagus	639	3.84
540	Acute appendicitis	535	3.21
389	Hearing loss	486	2.92
541	Appendicitis, unqualified	421	2.53
303	Alcohol dependence syndrome	393	2.36
370	Keratitis	356	2.14

Appendix Table 3: Top 10 ICD9 Codes for Children with Major Injuries, by Age Group

0-3 Year Olds (Total Number of Diagnoses=31583)			
ICD9	Description of condition	#Cases	%Cases
873	Other open wound of head	8483	26.86
995	Certain adverse effects, not elsewhere classified	3184	10.08
854	Intracranial injury other unspecified nature	2814	8.91
883	Open wound of finger(s)	1478	4.68
977	Poison-other/unspecified drugs/medicinal	1134	3.59
879	Open wound other unspecified site except limbs	936	2.96
892	Open wound foot except toe(s) alone	799	2.53
850	Concussion	659	2.09
882	Open wound of hand except finger(s)	575	1.82
360	Disorders of the globe-eye, adnexa	535	1.69
4-8 Year Olds (Total Number of Diagnoses= 31508)			
873	Other open wound of head	8103	25.72
995	Certain adverse effects, not elsewhere classified	3199	10.15
854	Intracranial injury other unspecified nature	1886	5.99
892	Open wound foot except toe(s) alone	1639	5.20
883	Open wound of finger(s)	1580	5.01
891	Open wound knee, lower leg and ankle	1315	4.17
879	Open wound other unspecified site except limbs	1213	3.85
882	Open wound of hand except finger(s)	868	2.75
930	Foreign body on external eye	6.43	2.04
850	Concussion	653	2.07
9-13 year olds (Total Number of Diagnoses=30384)			
873	Other open wound of head	3419	11.25
995	Certain adverse effects, not elsewhere classified	2642	8.70
844	Sprains and strains of knee and leg	1978	6.51
883	Open wound of finger(s)	1875	6.17
891	Open wound knee, lower leg and ankle	1861	6.12
892	Open wound foot except toe(s) alone	1311	4.31
854	Intracranial injury other unspecified nature	1208	3.98
814	Fracture of carpal bones	1106	3.64
815	Fracture of metacarpal bones	1014	3.34
882	Open wound of hand except finger(s)	977	3.22
14-18 year olds (Total Number of Diagnoses=35232)			
844	Sprains and strains of knee and leg	2915	8.27
995	Certain adverse effects, not elsewhere classified	2721	7.72
873	Other open wound of head	2708	7.69
883	Open wound of finger(s)	2513	7.13
882	Open wound of hand except finger(s)	1452	4.12
815	Fracture of metacarpal bones	1335	3.79
850	Concussion	1145	3.25
814	Fracture of carpal bones	915	2.60
891	Open wound knee, lower leg and ankle	907	2.57
824	Fracture of ankle	891	2.53

Appendix Table 4: Top 10 ICD9 Codes for Congenital Anomalies at Each Age
(includes only congenital/perinatal anomalies that are also major pediatric ADGs)

0-3 Year Olds (Total Number of Diagnoses=11469)			
ICD9	Description of condition	#Cases	%Cases
7686	Mild/moderate birth asphyxia	1724	15.03
7742	Neonatal Jaundice-preterm delivery	980	8.54
770.6	Transitory tachypnea newborn-wet lung	965	8.41
770.1	Meconium aspiration syndrome	770	6.71
769	Respiratory distress syndrome	694	6.05
7756	Neonatal hypoglycemia	571	4.98
7685	Severe birth asphyxia	504	4.39
746	Other congenital anomalies of heart	459	4.00
745	Bulbus cordis and other anomalies of cardiac septum closure	391	3.41
775	Endocrine/metabolic disorder fetus/newborn	383	3.34
4-8 Year Olds (Total Number of Diagnoses=1071)			
746	Other congenital anomalies of heart	420	39.22
745	Bulbus cordis and other anomalies of cardiac septum closure	179	16.71
747	Other congenital anomalies of circulatory systems	90	8.40
749	Cleft palate and cleft lip	79	7.38
751	Other congenital anomaly of digestive system	55	5.14
7455	Ostium secundum type atrial septal defect	27	2.52
741	Spina bifida	19	1.77
75689	Other congenital musculoskeletal anomalies	11	1.03
** cells with fewer than 10 people not reported **			
9-13 year olds (Total Number of Diagnoses=730)			
746	Other congenital anomalies of heart	386	52.88
745	Bulbus cordis and other anomalies of cardiac septum closure	104	14.25
749	Cleft palate and cleft lip	47	6.44
747	Other congenital anomalies of circulatory systems	45	6.16
741	Spina bifida	23	3.15
751	Other congenital anomaly of digestive system	15	2.05
7455	Ostium secundum type atrial septal defect	11	1.51
** cells with fewer than 10 people not reported **			
14-18 year olds (Total Number of Diagnoses=724)			
746	Other congenital anomalies of heart	395	54.56
745	Bulbus cordis and other anomalies of cardiac septum closure	87	12.02
747	Other congenital anomalies of circulatory systems	57	7.87
749	Cleft palate and cleft lip	44	6.08
741	Spina bifida	25	3.45
751	Other congenital anomaly of digestive system	19	2.62
** cells with fewer than 10 people not reported **			

Appendix Table 5: Comparison of Frequencies/Counts With/Without Emergency Room Visits

	With	Without
# Major ADGs 0-3	0.260	0.260
	[0.726]	[0.726]
# Major ADGs 4-8	0.228	0.227
	[0.691]	[0.691]
# Major ADGs 9-13	0.216	0.213
	[0.628]	[0.625]
# Major ADGs 14-18	0.335	0.322
	[0.806]	[0.791]

Notes: Standard errors in brackets.

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