Pre-Analysis Plan for the Intergenerational Analyses in

"WEALTH, HEALTH AND CHILD DEVELOPMENT: EVIDENCE FROM ADMINISTRATIVE DATA ON SWEDISH LOTTERY PLAYERS"

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Background

In this document we pre-specify some of the analyses that will be conducted in a paper provisionally entitled "Wealth, Health and Child Development: Evidence from Administrative Data on Swedish Lottery Players". The paper, once complete, will report estimates of the causal impact of wealth on health and childhood development. These estimates will be obtained by exploiting the randomized assignment of about a billion dollars in lottery prize money to a large sample of Swedes who have been matched to population-wide registers.

The final paper will have been written in two stages.

In stage one (Cesarini et al. 2014), which was completed before the preparation and online publication of this document, we looked exclusively at the effect of lottery wealth on players' own health. The health outcomes in these analyses were not pre-specified before we ran our first outcome regressions (though we will include in the final paper a full disclosure of other outcome variables that were examined).

Upon completion of stage one, we decided to augment the original paper with estimates of the intergenerational wealth effect on health and child development. Because there may be little overlap between the health problems that commonly afflict children and those afflicting adults, we felt that it may not be appropriate to look at the same health outcomes that were examined in stage one. The literature on child development also emphasizes the adverse impacts that early child health can have on subsequent human capital accumulation; we therefore decided to include some measures of scholastic, cognitive and non-cognitive achievement.

To avoid concerns about data-mining and specification searching, we decided to pre-specify our intergenerational analyses in this publicly available analysis plan before generating any matched datasets with child outcomes and parental lottery wealth. Specifying these analyses before testing any of our main hypotheses is intended to help make transparent the distinction between planned and exploratory ("post hoc") analyses in the final paper. Here, we specify our list of primary outcome variables. We also describe some important aspects of the planned intergenerational analyses, including sample selection criteria and the reduced form equation to be estimated.

The document is structured as follows. In Section 1, we give a brief overview of the literature on family income and children's outcomes. In Section 2, we report the results of our exploratory analyses. In Section 3, we provide and motivate our list of proposed outcomes. We conclude with a description of the most important sample selection criteria and the basic estimating equation that will be used in the intergenerational analyses.

1. Previous Literature

Children who grow up in relatively poor households tend to have worse early health outcomes than do children who grow up in wealthier households (Currie 2009). At birth, infants born to poor mothers tend to have lower gestational ages and lower birth weights. In adolescence, children in poorer households are at greater risk of a number of health conditions, including depression, anxiety, ADHD, asthma and respiratory allergies. They are also at greater risk of incurring injuries that require medical attention. Markers of childhood "health capital" are in turn predictive of subsequent cognitive and psychological development, human capital outcomes and the risk of exhibiting behavioral problems (Currie 2009; Smith 2009).

Currently, little is known about the processes that generate the correlation between child health and markers for socioeconomic status (such as parental income, occupation or educational attainment). For policymakers interested in promoting child health or the development of skills that are rewarded in the labor market, it is important to have credible estimates of the causal impact of household wealth on child health. Credible estimates can also help researchers better formulate and calibrate models of child development and intergenerational transmission. Currie (Currie 2009, p. 87) emphasizes the critical importance of opening the "black box" of the family in order to better understand *why* better family backgrounds are associated with better outcomes.

A number of mechanisms have been proposed linking parental socioeconomic status to child health outcomes. Psychologists point to evidence that low income is often associated with maternal stress, depression and feelings of inefficacy, and argue that low income adversely impacts child outcomes through its deleterious effects on parenting quality practices (Conger et al. 1994; Elder 1974). In the standard framework that economists often use to analyze the relationship between parental characteristics and child health outcomes, child health is a stock (in the sense of Grossman 1972) that is responsive to investments by parents who are altruistic toward their children. In such a framework, wealth impacts child health primarily by allowing parents to (i) spend time on non-market activities that promote child health and (ii) purchase larger quantities of health inputs (Currie 2009). Examples of health inputs are the quality of nutritional intake and housing in an area without environmental hazards.

It is well understood that an observed positive relationship between health and parental income may be spurious and reflect the omission of parental characteristics correlated with SES (Mayer 1997). On the other hand, measurement error in parents' long-run economic status may bias the estimated effect of parental income toward zero. The net effect of these two biases is unclear. As a result, conventional estimates obtained from simple regressions of child outcomes on parental income may deliver misleading conclusions about the magnitude of the effect of income (and other parental characteristics) on child health outcomes. A body of quasi-experimental research is now emerging that tries to address the identification challenge by capitalizing on natural variation arising from quasi-experiments. One set of papers uses policy changes to study the causal impact of maternal education on child health and educational outcomes (Carneiro, Meghir, and Parey 2012; Chevalier and O'Sullivan 2007; McCrary and Royer 2011).

Most of the quasi-experimental studies that have examined income are best interpreted as providing estimates of the causal impact of a policy package in which wealth and other policy variables are exogenously manipulated. For example, Akee et al. (2010) compare the children of American Indian parents – who were eligible for regular cash disbursements after the opening of a casino on their tribe's land – to children of non-American Indian households (whose parents were ineligible for disbursements). They show that the opening of the casino improved child outcomes in the domains of mental health, crime and educational attainment. As they make clear (2010, p. 103), what they estimate is probably best interpreted as the effect of a conditional cash transfer, not a pure income effect. Indian American individuals between 18 and 21 were only eligible for the payment conditional on graduating high school; the opening of the casino thus sharply increased incentives to graduate from high school. Research exploiting regional and temporal variation in Canadian child tax benefits finds evidence of modest improvements to test scores and some mental and physical health outcomes (Milligan and Stabile 2011).

Some studies have also used data from the negative income tax experiments (NITs), conducted in the 1970s, to try to learn about the causal impact of welfare to work programs on child health. In these experiments, marginal taxes and basic income guarantees were varied experimentally (Currie 1997; Widerquist 2005). Evaluations find little evidence of an impact on child health, though there are hints that the additional income improved nutritional quality (O'Connor and Madden 1979) and reduced the risks of having babies with low birth weight (Kehrer and Wolin 1979). Because these findings did not show up robustly across study sites (Duncan et al. 1998), and a substantial fraction of the NIT subjects were lost to follow-up (Hall 1975; Hausman and Wise 1979; Widerquist 2005) it is not possible to draw any strong conclusions from these experiments.

Despite an abundance of observational research, the literature attempting to establish causality is still in its infancy and much uncertainty remains about both the nature and the magnitude of the causal impact of household wealth on child outcomes. Currie characterizes the existing literature attempting to establish causal pathways as "filled with holes" (Currie 2009, p. 99).

Considerable uncertainty also remains about the extent to which the marginal return to wealth varies across families with different characteristics. Previous research has highlighted a number of dimensions along which one might predict heterogeneous effects.

A first, highly influential set of theories originating in epidemiology, suggest that infancy and early childhood are critical periods of physiological development (see the review in Almond & Currie 2011). This research has inspired an economic literature on the technology of capacity formation, according to which there exist important complementarities between the early childhood health stock and the return to later child investments (Heckman 2007). Second, several papers test the intuitive notion that the marginal return to household wealth is diminishing, perhaps because poorer families are more likely to face binding credit constraints, a pattern consistent with the theoretical models in the spirit of Becker and Tomes (1976). A third commonly studied source of heterogeneity is child sex. For example, randomized interventions that exogenously vary one aspect of socioeconomic status, area of residence, find positive impacts on the mental health of girls in treated families but not on boys (Ludwig et al. 2013).

2. Data and Exploratory Analyses

In this section, we report the results from the exploratory analyses that we conducted to help guide us in determining our final list of pre-specified outcomes (described in Section 3). We study outcomes in the domains of health, school achievement, cognitive achievement and non-cognitive ("socio-emotional") skills. A priori, it seems likely that the types of health problems that afflict children are quite different from those afflicting adults. An important goal of the analyses is therefore to better understand what health conditions afflict children of different ages.

All analyses are based on population-based register data. For the health outcomes, we rely primarily on summary statistics available from the National Board of Education and Welfare. For school performance, we use a representative sample of 50,000 Swedes drawn from the 2000 population. We identified all 33,489 biological children born between 1981 and 2010 to members of this representative sample.

Our health variables are derived using information available in the *Medical Birth Register*, the *Patient Register*, the *Conscription Register* and the *Prescribed Drug Register*. Our variables on school achievement and skill formation are derived from the *Ninth Grade Register,* the *Register with National Tests of Swedish, English and Mathematics*, and the *Conscription Register*.

Finally, we consider a number of proxy variables for parental investment in children based on the *Medical Birth Register* and *LISA* database provided by Statistics Sweden.

Health

<u>Medical Birth Register</u>

The *Medical Birth Register* contains information about all infants born since 1973. The data are all collected from medical records in prenatal, delivery and neonatal care.

Two common indicators of infant health are birth weight and prematurity (or "preterm births"). The convention is to classify newborns with birth weights below 2,500 grams as low birth weight (ICD 10, Chapter XVI) and as preterm if their estimated gestational age is below 37 weeks (Morken, Källen, Hagberg, & Jacobsson, 2005). Figure 1 shows, for the period 1973-2009, the average birth weight of Swedish babies (left panel, scale on right y-axis), the fraction of infants with low birth weight (left panel, scale on left y-axis) and the fraction born prematurely (right panel). There are no dramatic trends over time: approximately 4.5% of babies are low birth weight and 6% are preterm. To benchmark these numbers, the corresponding figures in US Non-Hispanic Whites were 7% and 11% in 2012 (Martin et al. 2013).

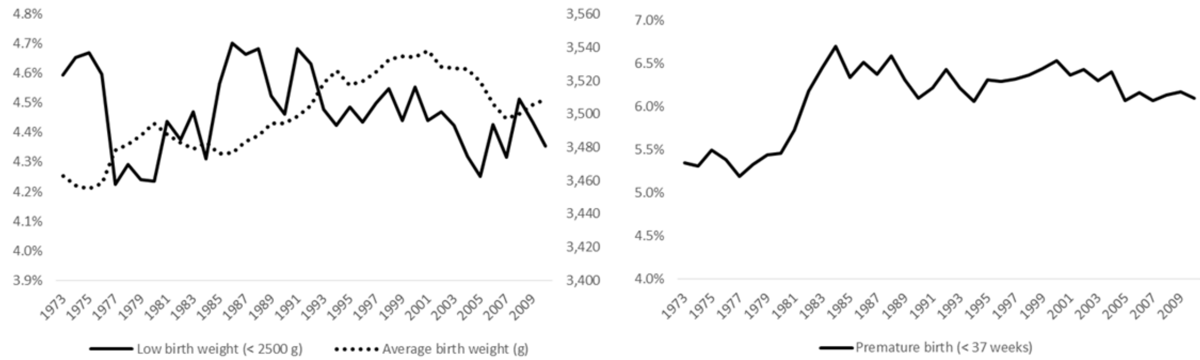

Figure 1. Birth Weight and Preterm Births (All Children Born 1973-2010)

Notes: The left panel shows the fraction of infants at low birth weight (<2,500 grams) and the average birth weight (N = 3,865,630). The right panel shows the fraction of infants born preterm (N = 3,868,436). An infant is classified as born preterm if the estimated gestational age below 37 weeks. Figure is based on data on all babies born in Sweden 1973-2009. Source: Medical Birth Register.

Patient Register

The *Patient Register* covers all Swedish hospitalizations involving overnight stays at a hospital. The coverage of the register is complete beginning in 1987. For each hospital visit resulting in an overnight stay, the register contains information about the date of arrival and discharge, diagnoses at discharge and any surgical procedures undertaken. We restrict attention to hospitalization events resulting in an overnight stay because it is typically only individuals with relatively severe health conditions who stay overnight – the measured outcomes are therefore more likely to pick up differences across individuals in their health statuses (as opposed to differences in the propensity to seek care).

Children. We used data on all hospitalizations of children aged 19 or below that took place from 1998 to 2010. Figure 2 shows the total number of hospitalizations by cause (inferred from the ICD classifications) in children stratified into four age groups. To interpret the aggregate figures, a useful rule-of-thumb is that each yearly cohort comprises approximately 100,000 people. Among children, the two most common diagnoses during this period are injury, poisoning and other injuries due to external causes (16.8 percent of all hospitalizations) and diseases of the respiratory system (14.6 percent of all hospitalizations). Hospitalizations due to mental and behavioral disorders are rarely observed in children below the age of 15, but reasonably common thereafter (14.6 percent of all hospitalizations in children aged 15-19). Because respiratory disease and injuries feature prominently in the literature on child health, we verified that the total number of hospitalizations have remained fairly constant over time (analyses not shown).

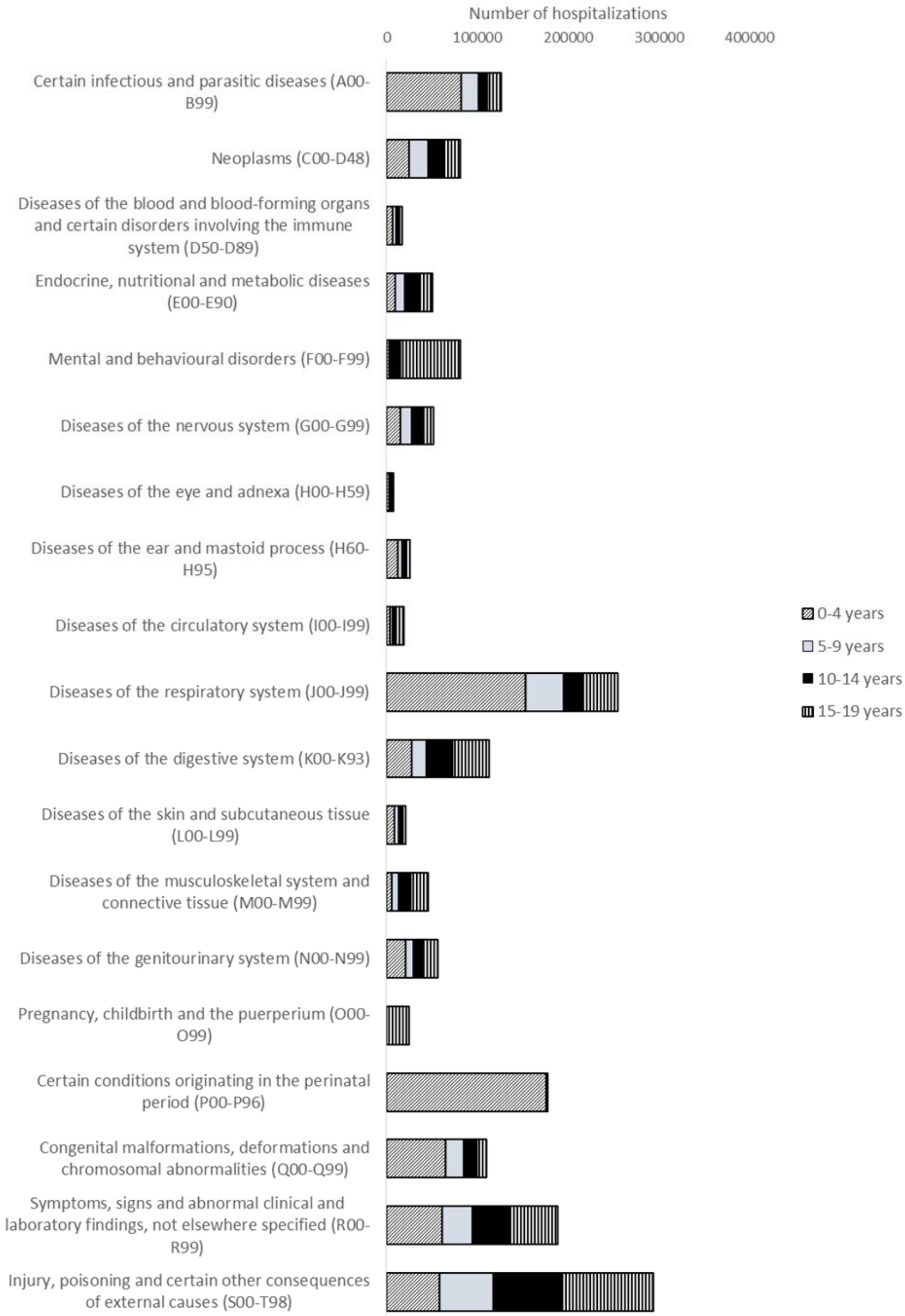

Figure 2. Cause-Specific Hospitalizations: Individuals Aged 0-19

Notes: Hospitalizations are classified using the main diagnosis code. Figure is based on all hospitalizations 1998-2010. Source: Patient Register, Swedish National Board of Health and Welfare.

Young Adults. Because we can observe the children of some of our lottery winners up to 25 years after the wealth shock, we also looked at patterns of hospitalizations in young adults (aged 20-39). Hospitalization due to pregnancy, child birth and puerperium is by far the most common cause of hospitalization in this age group (44.7 percent of all hospitalizations). Since pregnancy and child birth is unlikely to convey much information about underlying health status, we omit these hospitalizations from our subsequent exploratory analyses. Figure 3, which is based on the total population aged 20-39, shows, the total number of hospitalizations due to causes other than pregnancy and childbirth. The most common cause of hospitalization in this age group is mental and behavioral disorders (20.1 percent of all hospitalizations not related to pregnancy and childbirth) and external causes (15.7 percent). Figure 3 also shows that causes of hospitalizations appear to change relatively little with age between 20 and 39.

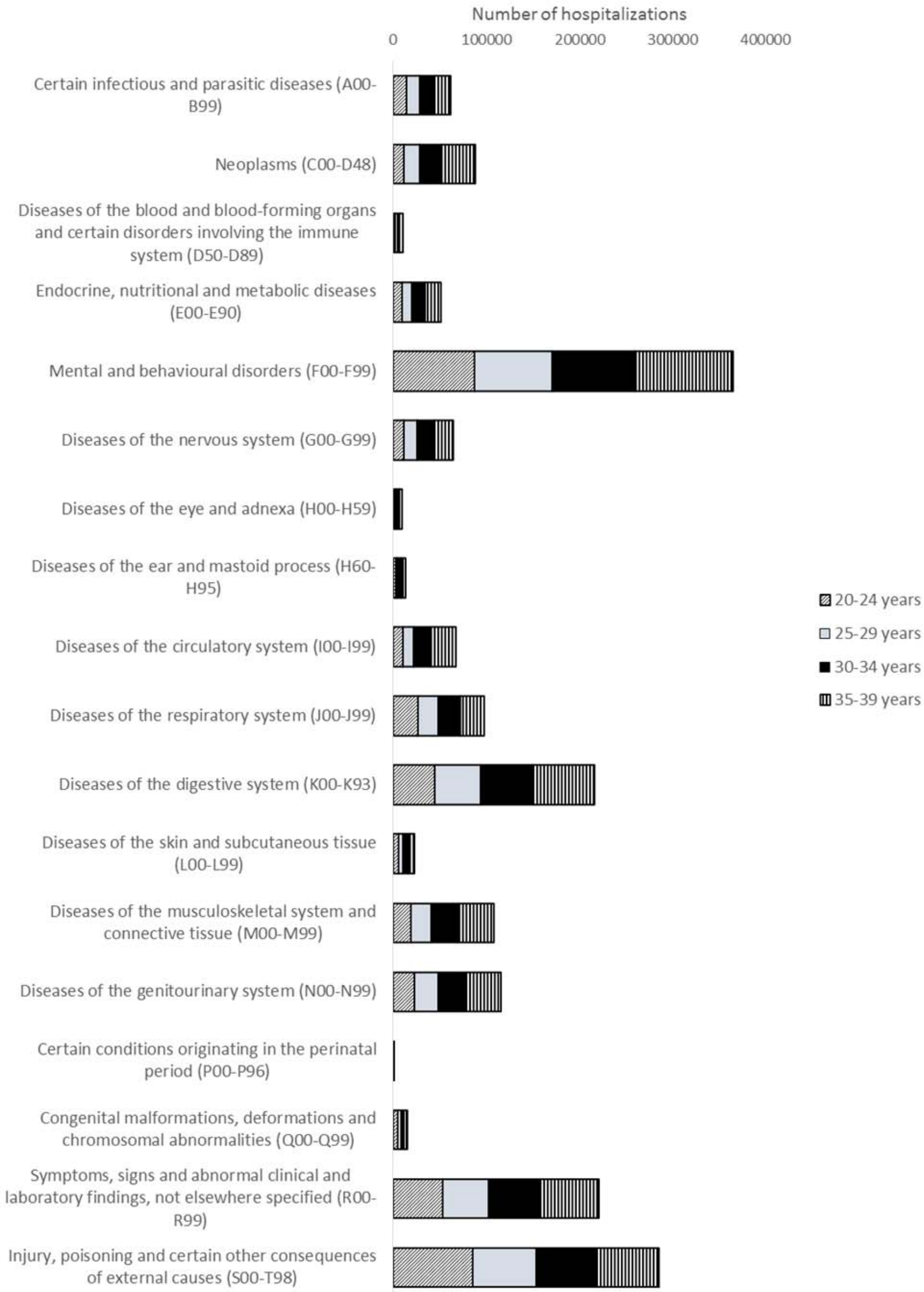

Figure 3. Cause-Specific Hospitalizations: Individuals Aged 20-39

Notes: Hospitalizations are classified using the main diagnosis code. Figure is based on all hospitalizations 1998-2010. Source: Patient Register, Swedish National Board of Health and Welfare.

Conscription Register (Health Variables)

The *Conscription Register* contains information about a wide range of characteristics of men around the age of 18. For example, the conscription data contains high-quality and objectively measured information on body mass index (BMI). Conscription was mandatory for all Swedish men until 2010, but exemptions were granted more and more liberally over time (1985-2010).

Prescribed Drug Register

The *Prescribed Drug Register* contains information on all prescription drugs collected from Swedish pharmacies during the period 2006-2010. For each drug, the register contains the date of purchase, the drug's Anatomical Therapeutic Chemical Classification System (ATC) code, and the total number of defined daily doses (DDD) purchased. A DDD is an estimate of the average maintenance dose per day for a drug when it is used for its main indication.

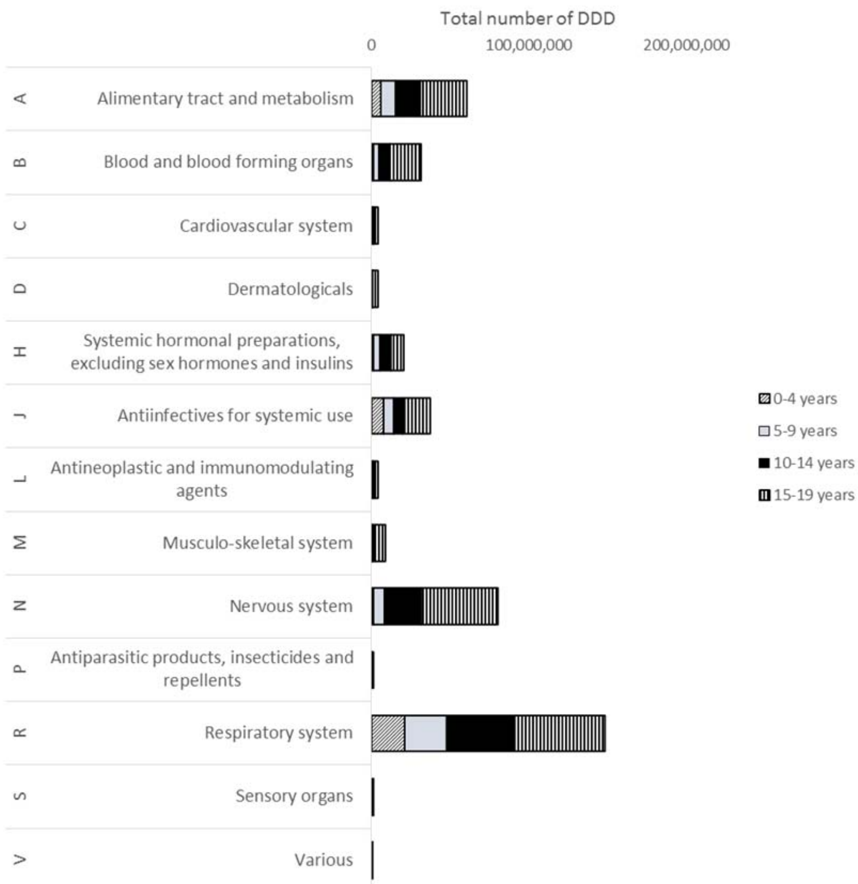

Figure 4. Consumption of Prescription Drugs 2006-2010: Individuals Aged <20

Notes: Total consumption measured in defined daily doses (DDDs) summing the years 2006-2010. ATC category G has been excluded. Source: Prescribed Drug Register, Swedish National Board of Health and Welfare.

Children. Figure 4 shows disaggregated drug consumption in 2006-2010, again for children in four different age strata. The disaggregation is performed at the first-digit level of the ATC classification. We report for all categories except for ATC category G ("Genito-Urinary System and Sex Hormones"). We exclude category G drugs because the high consumption of contraceptive pills (G03) in women aged 15 or above would otherwise dominate the figure.

It is clear from the figure that the prescription drug consumption patterns of children vary by age. Among children up to 10 years, the by far most commonly prescribed type of drugs are in category R (drugs for the respiratory system). Among older children, we observe that in addition to respiratory drugs, drugs in category N (neurological drugs) account for a substantial portion of the drugs prescribed.

Given that mental and respiratory health feature prominently in the literature on health and child development, Figures 5 and 6 contain a more detailed breakdown of drugs in these categories. Figure 5 shows that the most commonly prescribed types of respiratory drugs are R01 and R06, which mainly consist of drugs used to treat asthma, and drugs used to treat allergies (so called antihistamines, R06). These drugs are consumed in meaningful quantities by children of all ages.

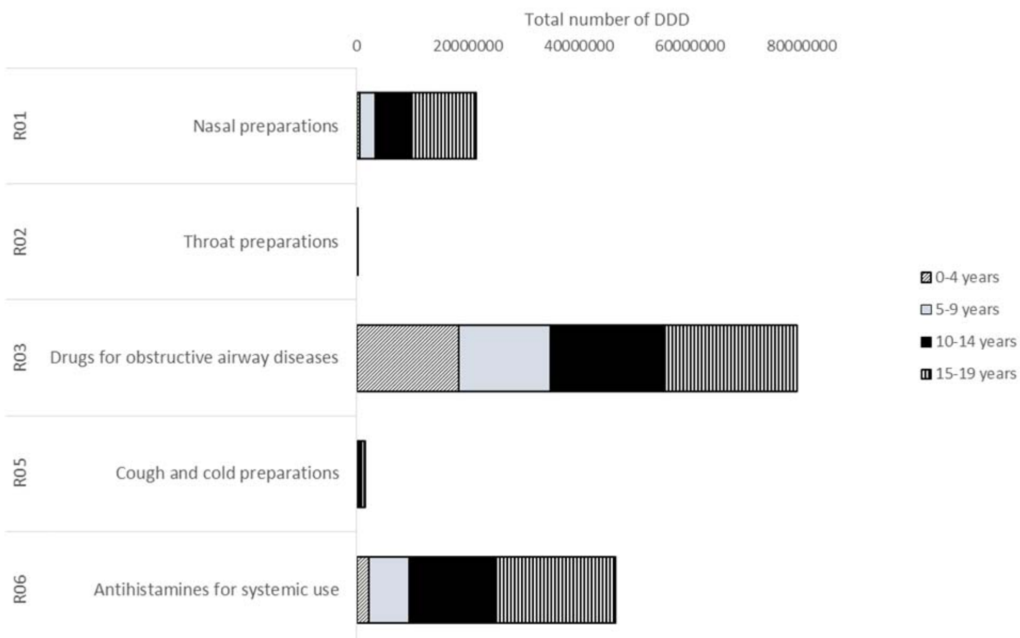

Figure 5. Disaggregated Consumption of Respiratory Drugs (R): Individuals Aged <20

Notes: ATC Category R07 is excluded because no drugs in this category were consumed.

Figure 6 shows that prescriptions of drugs in category N vary by child age. It is very rare for children below the age of 10 to be prescribed any neurological drugs, but drug consumption increases steadily with age. Among children aged 10 and above, hypnotics and sedatives (N05C), antidepressants (N06A) and ADHD drugs (N06BA) are quite common, and account for around 75% of total neurological drug consumption. It is also clear from Figure 6 that the drugs included in the “mental health” index (N05 and N06A) we used for adults in the first stage are primarily prescribed to children who have reached the age of 15.

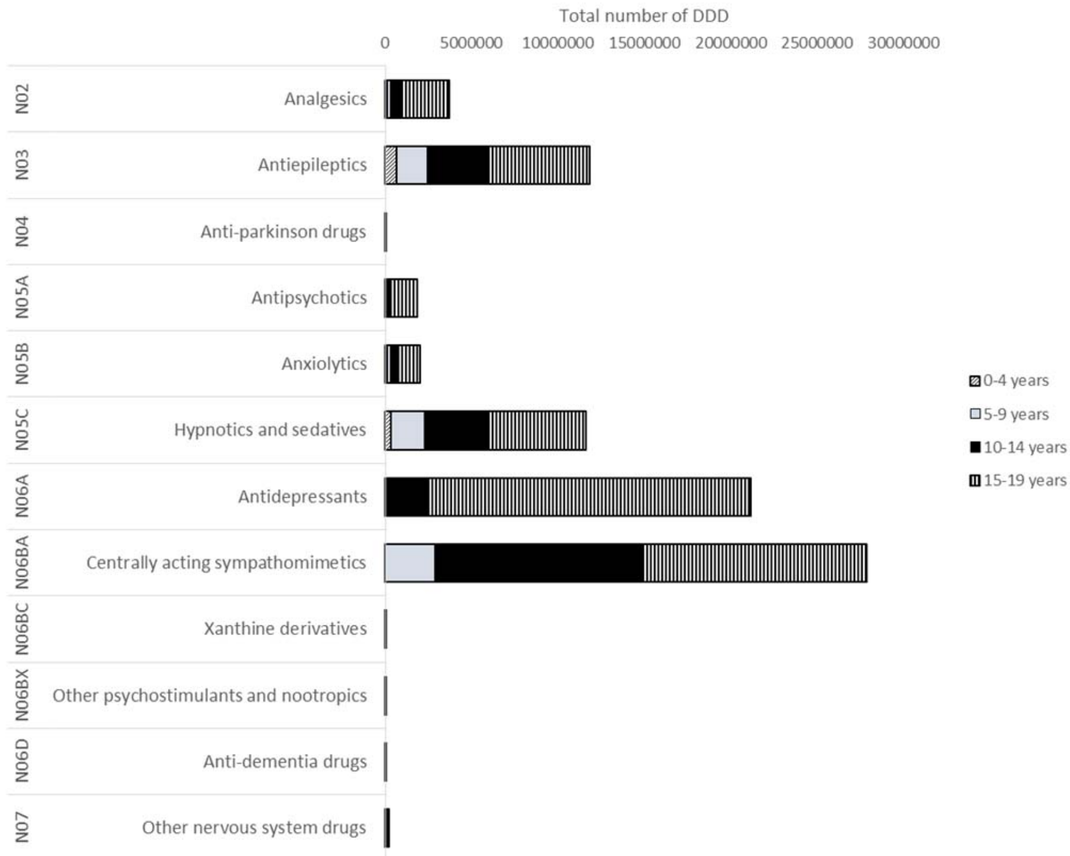

Figure 6. Disaggregated Consumption of Neurological Drugs (N): Individuals Aged <20

Notes: Category N01 has been excluded because drugs in this category were not consumed.

Young Adults. Finally, Figure 7 displays drug consumption among young adults age 20 to 39 (again excluding category G). The overall consumption patterns are quite similar to those of observed for children aged 15-19. Neurological drugs are by far the most commonly consumed drugs.

One important interpretational caveat to bear in mind when studying the consumption of prescription drugs is that what is being measured is the total quantity of prescribed drugs purchased. An observed difference between poor and rich households may not only reflect differences in underlying health, but also differences in health utilization or preferences for preventive care.

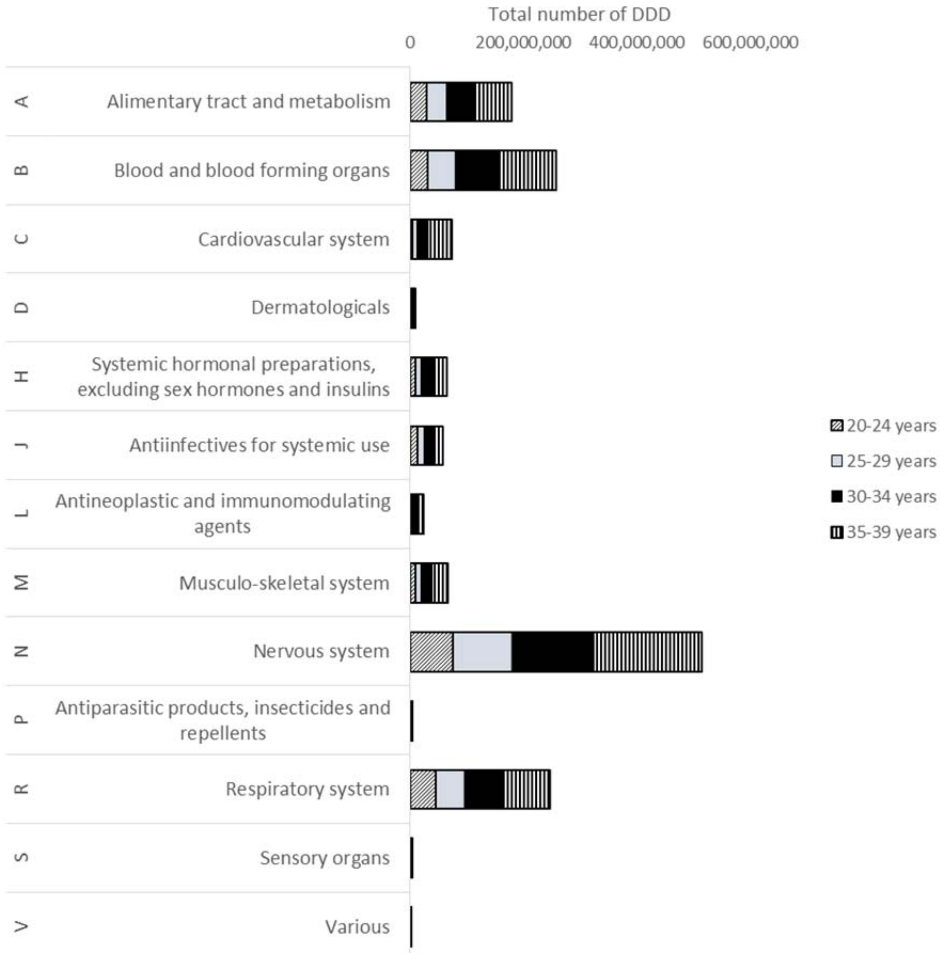

Figure 7. Consumption of Prescription Drugs 2006-2010: Individuals Aged 20-39

Notes: ATC category G has been excluded from the figure.

School Achievement and Skills

Ninth Grade Register

The *Ninth Grade Register* contains information about the performance of students in their ninth and last year of compulsory school. These data are available annually from 1988. The grading is on a 5-point scale between 1988 and 1997 and on a 4-point scale thereafter.

Sweden has nine years of compulsory schooling and children typically enter school in the year they turn seven. For most of our study period, the schools are the responsibility of the municipalities. Schools are required to follow a national curriculum and a government body – the Swedish National Agency of Education – is charged with overseeing that the curriculum is followed. Since 1994, charter schools are also allowed – these receive a fixed amount of funding per student and are not allowed to charge fees for instruction. Because of the national curriculum, these schools are limited in their ability to change what material is covered in the courses.

In our representative sample, approximately 94% of the children are observed in the *Ninth Grade Register* before their 18th birthday (and virtually always at the age of 15 or 16). For these children, we observe the full range of courses taken, their final grade in each subject, and a measure of their overall GPA. We set the GPA variable to missing if the child does not appear in the register.

National Tests in Swedish, English and Mathematics

Since 2003 all students in ninth grade take a series of standardized national tests in Swedish, English and Mathematics. The purpose of the tests is to facilitate comparisons across schools and geographic areas, and thus assist teachers in setting grades. The national tests are constructed by the Swedish National Agency for Education in collaboration with the higher education system. The tests are graded by each student's teacher based on guidelines provided by the Swedish National Agency for Education. The test results are graded using the same 4-point scale (Fail, Pass, Pass with Distinction, Excellent) used for the final grades toward the end of the period. Teachers are urged to use the results from the national tests into account when assigning students their final grade, but the test grade implies no restrictions for the final grade.

Conscription Register (Cognitive and Non-Cognitive Skills)

Besides undergoing a comprehensive health screening, conscripts also complete a battery of tests measuring psychological characteristics.

At military enlistment, each potential conscript takes a test of cognitive ability. Based on the performance on this test, each conscript is assigned a score on a 1 to 9 stanine scale (a discrete approximation to a normal distribution with mean 5 and standard deviation 2). For a detailed evaluation of the test's psychometric properties, see Carlstedt (2000).

To assess "non-cognitive" skills, conscripts are also interviewed by a certified military psychologist. The purpose of the interview, which lasts around 25 minutes, is to evaluate the conscript's ability to deal with wartime stress. The character traits considered beneficial by the enlistment agency include willingness to assume responsibility, independence, outgoing character, persistence, emotional stability, and power of initiative. Each conscript is assigned a score on a stanine score by the psychologist. The enlistment psychologists' evaluation of conscripts has been shown to a level of predictive power that exceeds that of conventional personality measures for a range of labor market outcomes (Lindqvist and Vestman 2011).

Income Gradients

We used our representative sample to explore the relationship between household income and a range of child outcome variables. Unfortunately, we did not have access to the cognitive and non-cognitive skills variables when this analysis plan was posted, and we are therefore unable to report gradients for these two variables.

For each child, we constructed a family income variable based on the sum of the biological parents' average disposable incomes in the three years prior to the child's year of birth (we take a three-year average to reduce the role of transitory variance arising from year-to-year fluctuations). We drop 2,595 children for whom we could not observe both biological parents' incomes. We divided the children into one of three mutually exclusive parental income groups: low income (income below the 25th percentile), medium income (25th to 75th percentile) and high income (above the 75th percentile). The percentile rankings were done separately by birth year. To convey a sense of the typical income levels in the three groups, the 25th and 75th percentiles of the 1995 income distribution are 202,400 and 272,700 SEK.

Table 1 reports summary statistics for a range of child health outcomes across the three income groups.

We observe a gradient with respect to both birth weight and prematurity: the risk of premature birth is about 15 percent higher in low-income groups than medium- and high-income groups.

To examine the gradients for hospitalizations, we computed the total number of times a child was hospitalized by age 9 and age 18. We looked at the total number of hospitalizations, hospitalizations due to respiratory disease and hospitalizations due to external causes. If a child is not observed from birth until the age of 9 or 18, we impute the data for the years with missing data. Table 1 shows that all hospitalization variables exhibit a gradient with respect to household income. Children in the bottom income quartile experience 20 percent more hospitalization events than children in the top income quartile. The relationship is strongest for hospitalizations due to respiratory disease (30%). We also observe a gradient with respect to BMI at conscription: children in the low-income group are 72% more likely than children in the high-income group to satisfy the clinical definition of obesity.[1]

The table also reports the gradients for four drug prescription variables: mental health (ATC code N05 and N06A), ADHD (ATC code N06BA), asthma and allergy (ATC codes R01, R03 and R06) and total consumption net of consumption of drugs in the previous three categories and contraceptive pills (ATC code G03). We observe a moderate socioeconomic gradient with respect to both mental health and ADHD drugs. For example, low-income children consume twice as much ADHD medication as high-income children. We observe no gradient for either total consumption or consumption of allergy and asthma drugs. The absence of a gradient for these two variables may reflect differences across income groups in health utilization and

[1] The BMI gradients should be interpreted with some caution since they are based on a modest sample of conscripts. We currently only have access to conscription data until 2003. At the time this plan was posted, our request to supplement these data with data for later years and information about cognitive and socio-emotional skills.

prevention. For example, Currie (2009) shows that poor children are only slightly more likely to have asthma than rich children, but much more likely to suffer from asthmatic attacks because they are not properly managing their disease.

Table 1. Parental Income and Child Health

	Low Income (<25 pctile)			Medium Income (25-75 pctile)			High Income (>75 pctile)		
	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
Infant Health									
Birth Weight (g)	3,492	569	7,571	3,538	584	15,194	3,546	585	7,555
1 if Birth Weight <2500 g	0.041	0.199	7,571	0.040	0.195	15,194	0.037	0.190	7,555
Gestation Length (in days)	277.7	13.6	7,570	278.4	13.3	15,230	278.5	13.6	7,573
1 if Gestation Length < 37 weeks	0.064	0.244	7,570	0.056	0.229	15,230	0.058	0.233	7,573
Hospitalizations									
# By Age 9: Total	1.212	3.537	6,653	1.068	3.338	13,357	0.965	4.109	6,718
# By Age 18: Total	1.877	5.284	7,239	1.651	4.750	14,523	1.494	4.971	7,294
# By Age 9: Respiratory	0.273	1.003	6,653	0.247	0.974	13,357	0.212	0.956	6,718
# By Age 18: Respiratory	0.380	1.605	7,239	0.335	1.478	14,523	0.289	1.525	7,294
# By Age 9: External	0.118	0.578	6,653	0.105	0.447	13,357	0.103	0.431	6,718
# By Age 18: External	0.221	0.975	7,239	0.196	0.723	14,523	0.191	0.683	7,294
Physical Health									
BMI	22.88	3.99	359	22.83	3.61	755	22.38	3.32	408
1 if Overweight (BMI>25)	0.21	0.41	359	0.19	0.39	755	0.18	0.39	408
1 if Obese (BMI>30)	0.05	0.22	359	0.04	0.20	755	0.03	0.17	408
Drug Utilization									
Allergy & Asthma	66.3	331.8	7,737	71.6	298.6	15,447	69.7	274.4	7,710
ADHD	19.3	180.1	6,221	11.4	135.6	12,417	10.9	139.2	6,195
Mental Health	95.3	581.4	4,077	89.6	644.7	8,137	80.2	451.3	4,059
Total (net of above)	133.0	755.1	7,737	125.8	679.6	15,447	137.2	688.8	7,710

Notes: Average health outcomes by parental income group among biological children born between 1981 and 2010 to a representative sample of 50,000 Swedes taken in year 2000. Parental income is measured by the sum of the biological parents' disposable three years prior to birth. See the main text for the definitions of the outcome variables.

Finally, Table 2 reports gradients for scholastic achievement. As a measure of scholastic achievement, we standardize the child's ninth grade GPA so that it has mean zero and standard deviation 1 in the representative sample. We perform the standardization separately by graduating cohort. As is clear from Table 2, there is a substantial gradient with respect to family income: children in low-income households have GPAs that are approximately 0.47 population standard deviation below children in high-income households. The difference in grades from the three national tests between low and high income households is of similar magnitude, around 0.4 standard deviation.

Table 2. Parental Income and School Achievement

	Low Income (<25 pctile)			Medium Income (25-75 pctile)			High Income (>75 pctile)		
	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
Scholastic Achievement									
GPA	-0.176	1.021	3,409	-0.011	0.950	6,902	0.297	0.951	3,460
Math test score	-0.098	0.973	1,644	-0.053	0.964	3,481	0.294	1.045	1,748
Swedish test score	-0.098	1.002	1,307	-0.041	0.975	2,740	0.279	1.000	1,386
English test score	-0.143	0.986	1,318	-0.049	0.978	2,748	0.275	1.000	1,379

Notes: Average child outcomes by parental income group among biological children born between 1981 and 2010 to a representative sample of 50,000 Swedes taken in year 2000. Parental income is measured by the sum of the biological parents' disposable three years prior to birth. See the main text for the definitions of the outcome variables.

3. Proposed Analyses

In this section, we describe the planned intergenerational analyses. We first describe (without specifying all details) the basic sample selection procedure that will be used to determine our final estimation samples. We then provide a list of pre-specified outcomes that will be examined in our intergenerational analyses. For each outcome, we report and motivate any variable-specific sample restrictions that will be imposed. These restrictions are imposed either because the variable does not vary in a meaningful way in children in certain age ranges or because the variable is not available for children in certain cohorts. We conclude this section by proposing some heterogeneity analyses.

Sample Selection

Pre- and Post-Lottery Children

In our analyses of the lottery players' children, we make a conceptual distinction between pre-lottery children (children born or conceived by the time of the lottery) and post-lottery children (children conceived after the lottery).[2] With the exception of the infant health variables, our final estimation sample will be restricted to the pre-lottery children who were at most 18 years old (or a subset of these children) at the time of the lottery. In our analyses of infant health, our estimation sample comprises all post-lottery born to female winners in our sample.

[2] We define a child as conceived by the time of the lottery if the child was born within three quarters of the lottery win.

Constructing Cells

Though we plan to closely follow the approach from the first stage of the project on winners' own health, we cannot rely on exactly the same sample selection procedure in the proposed intergenerational analyses. The reason is that the unit of observation in the intergenerational analyses is often the child of a lottery player. As in the adult health analyses, our basic strategy is to identify cells within which wealth is randomly assigned and then control for cell fixed effects. We make two primary changes in how we construct the cells.

A first is that in order to be assigned to the same cell, we require players to have an identical number of pre-lottery children. We impose this restriction because it ensures that children in the same cell face the same distribution of treatments, irrespective of whether we think of the treatment as the wealth shock per family or the wealth shock per child. We also drop an observation if both parents won in the same draw (such children are extremely rare in the data and the restriction is made purely out of convenience).

Our second change is that we exclude odds-prize winners from our basic specification. The typical odds-prize cell contains a small number of individuals because it is difficult to identify suitable controls. Our additional requirement that players have an identical number of pre-lottery children in the month of win would compound the problem of finding suitable controls, leaving us with few usable cells. We therefore omit odds-prize winners altogether.

Estimation

Our final estimating equation is given by,

$$Y_{ij,t} = \alpha_t \times P_{i,0} + \boldsymbol{X}_i \times \boldsymbol{\beta} + \boldsymbol{Z}_{i,-1} \times \boldsymbol{\gamma} + \boldsymbol{C}_{ij,-1} \times \boldsymbol{\delta} + \varepsilon_{ij,t}$$

In this equation, $Y_{ij,t}$ is the outcome of lottery winner i's child j measured t years after i won the lottery. $P_{i,0}$ is the prize awarded to individual i at time t = 0 (deflated by a consumer price index equal to 1 in the year 2010), and X_i is a set of indicator variables for the lottery cells within which the prize money is (conditionally) independent of potential outcomes. In our baseline specification we estimate this equation with the prize variable defined as the wealth shock per family. We will also include a number of parental controls $Z_{i,-1}$ as well as child-specific controls $C_{ij,-1}$, all of which are determined prior to the parent winning the lottery. In our child outcome regressions, we control for the pre-win baseline characteristics of the winning biological parent (defined exactly as in the adult health regressions).

It may be feasible to improve the precision of our estimates by including controls beyond those listed above. For example, some children may have older siblings for whom the outcome (e.g. school grades at 15) is observed before the lottery. If a substantial share of the variance in a child outcome is explained by factors that siblings share, then controlling for the sibling's predetermined outcome is likely to reduce the standard errors. Parental characteristics and predetermined child characteristics may similarly have substantial explanatory power for some of our outcomes. We make no attempt to fully pre-specify such additional controls, primarily because determining the appropriate vector of additional controls for each outcome would require a very comprehensive set of analyses that is difficult to complete without access to the final dataset.

Robustness Analyses

The coefficient estimates are subject to some interpretational caveats. A first, major, issue is whether wealth impacts fertility. For the pre-lottery children, the presence of a fertility response would not invalidate the interpretation of our estimated coefficient as a causal effect of wealth on the outcomes of the pre-lottery children, but it would change the structural interpretation of our results. For example, a positive impact on fertility would dilute the amount of resources remaining for each pre-lottery child. Quantifying the relative importance of quantity and quality adjustments not only helps us interpret our coefficients, but it is also in and of itself a question of substantive economic interest (Becker and Tomes 1976). We will directly test for an endogenous fertility responses and also report results of robustness analyses in which we restrict the sample to parents who have reached an age at which fertility rates are very low or zero.

For the post-lottery children studied in the infant health regressions, endogenous fertility responses will bias the estimates if winning the wealth shock changes the composition of women who have babies. Suppose, for example, that lottery wealth only induces women from disadvantaged backgrounds to have more children and that women from disadvantaged backgrounds have babies who weigh less, on average. Then our estimates would not have a simple interpretation as an average treatment effect of wealth on birth weight, since the women in the control group now have different characteristics from the women in the treated group. We will directly test the hypothesis that there are interactions between lottery wealth and predetermined characteristics in the determination of post-lottery fertility. The presence of such interactions would suggest that an observed effect on infant health outcomes could be driven entirely through changes in birth composition.

As a third robustness check, we also estimate the effect of wealth on the pre-lottery children's to outcomes scaling the prize variable by the number of pre-birth children. This alternative specification is intended to explore the sensitivity of our results to other alternative assumptions about the child health production function.

Pre-Specifying Child Outcomes

Table 3 and 4 summarizes our list of pre-specified outcome variables. Column (1) shows the year in which we observe the outcome and Column (2) the age at which the outcome is measured. Column (3) reports any restrictions on the child's age at the time of the lottery that we impose in order for the child to be in the estimation sample and Column (4) shows the birth years of the cohorts that are included for each measure. As we discuss below, the sample restrictions are imposed either because data are not available in some years or because the outcome does not exhibit meaningful variation in children of certain ages.

Health Outcomes of Post-Lottery Children

Infant Health Variables from Medical Birth Register

Our list of pre-specified outcomes contains three measures of infant health: birth weight (in grams), an indicator variable for low birth weight (below 2,500 grams), and an indicator variable for preterm births (gestation length below 37 weeks). The cutoffs used to define the indicator variables for birth weight (i.e. ICD 10, Chapter XVI) and preterm births (Morken, Källen, Hagberg, & Jacobsson, 2005) are standard. Babies born with a low birth weight or prematurely are known to be at greater risk of adverse health outcomes, and inhibited cognitive development (Almond and Currie 2011).

Health Outcomes of Pre-Lottery Children

Hospitalization Data from the Patient Register

We examine hospitalizations in three difference categories: respiratory disease, external causes, and an omnibus category that includes hospitalizations due to all causes except pregnancy. We focus on respiratory disease and external causes because these are the most common causes of hospitalization in children (see our previous discussion and the review in Currie 2009).

Because the distribution of hospitalization spell lengths is highly skewed, the variables on our final list of outcomes are all binary. For each of our three causes, we define an indicator variables equal to 1 if the individual was hospitalized due to that cause in at least one of the 2 and 5 years following the lottery. For the total hospitalization category, we additionally define an additional set of indicator variables equal to 1 if the individual was hospitalized for at least seven days (due to any cause except pregnancy) in at least one of the 2 or 5 years following the lottery.

For hospitalizations due to external causes and respiratory disease, we restrict the sample to children aged 18 or below during the entire time window for which the variable is defined. For example, when studying respiratory disease in children over the two-year horizon, the sample is restricted to children who were at most 16 years of age in the year of the lottery event. For the omnibus category, we make no such restrictions.

BMI Variables from the Conscription Register

Our list of pre-specified outcomes includes three different BMI measures from the *Conscription Register*: BMI measured on a continuous scale, and indicator variables for having a BMI above 25 and 30, the standard cutoffs used to define “overweight” and “obesity”. High BMI is known to be strongly associated with a long range of adverse health outcomes including heart disease and diabetes (Reilly et al. 2003), as well as earnings (Sargent and Blanchflower 1994).[3]

Variables from Drug Prescription Register

Drug prescription data are available from 2006 to 2010. Our list of pre-specified outcomes includes the following outcomes derived from this register:

- Asthma & Allergy (ATC codes R01, R03 and R06)
- Mental Health (ATC codes N05 and N06A).
- ADHD (ATC codes N06BA)
- Total (net of above three categories and ATC code G03)

Each variable is computed as the average of total yearly consumption (measured as the sum of daily doses prescribed). The average is taken over all post-lottery years in which the child's age falls in the age range. For Mental Health, we exclude years in which the child had not yet turned 15. For ADHD, we include children aged 6-18. In both cases, these cutoffs were chosen based on the exploratory analyses which showed strong age-related patterns of consumption. For asthma and allergy, we only keep observations from years in which the child was 18 years of age or below. Finally, we only keep an observation if the average is computed from at least 3 yearly observations. The last restriction means that lotteries that occurred in 2008 or later are not included.

As discussed by Currie (Currie 2009), respiratory and mental health problems are the most commonly observed chronic conditions in children. Both are related to socioeconomic status and predictive of later outcomes. For example, childhood asthma is associated with a doubling of the odds of behavior problems (Bussing et al. 1995) and children with an ADHD diagnoses score about 0.3 standard deviations lower on achievement tests (Currie and Stabile 2006). We aggregate asthma and allergy medication into a single category but study ADHD and Mental Health separately.

[3] Data from the Conscription Register are available until 2010. Conscription is only compulsory for men and takes place around the age of 18, so our estimation sample is de facto restricted to sons born in the window 1968-1992. Because exemptions from military service were granted more liberally towards the end of our sample period, it is possible that lottery wealth could impact the probability of undergoing conscription. If there is evidence that lottery wealth impacts the probability of appearing in the conscript data, we will limit our analyses to the earlier cohorts of draftees.

Table 3. Outcome Variables and Sample Restrictions: Child Health

	(1) Outcome Years	(2) Age at which Outcome is Measured	(3) Age at Lottery Win	(4) Included Cohorts by Birth Year	(5) Additional Restrictions
Children Born after Lottery Win					
Infant Health					
Birth Weight	1987-2010	At birth	-	1987-2010	
1 if Birth Weight <2500 grams	1987-2010	At Birth	-	1987-2010	
1 if Gestation Length < 37 weeks	1987-2010	At Birth	-	1987-2010	
Children Born before Lottery Win					
Hospitalizations					
Hospitalized within 2 years	1987-2010	0-20	0-18	1969-2008	
Hospitalized within 5 years	1987-2010	0-23	0-18	1969-2005	
Hospitalized 1 week within 2 years	1987-2010	0-20	0-18	1969-2008	
Hospitalized 1 week within 5 years	1987-2010	0-23	0-18	1969-2005	
Hospitalized for Respiratory Disease within 2 years	1987-2010	0-18	0-16	1971-2008	
Hospitalized for Respiratory Disease within 5 years	1987-2010	0-18	0-13	1974-2005	
Hospitalized due to External Causes within 2 years	1987-2010	0-18	0-16	1971-2008	
Hospitalized due to External Causes within 5 years	1987-2010	0-18	0-13	1974-2005	
BMI at Conscription					
BMI	1987-2010	Men age ~18	0-17	1968-1992	
1 if Overweight (BMI > 25)	1987-2010	Men age ~18	0-17	1968-1992	
1 if Obese (BMI > 30)	1987-2010	Men age ~18	0-17	1968-1992	
Prescribed Drug Consumption (Yearly average DDD)					
Total (net of contraceptives)	2006-2010	0+	0-18	1968-2007	≥ 3 yearly obs.
Mental Health (N05 & N06A)	2006-2010	15+	0-18	1968-1992	≥ 3 yearly obs.
Allergy & Asthma (R01, R03 & R06)	2006-2010	0-18	0-15	1990-2007	≥ 3 yearly obs.
ADHD (N06BA)	2006-2010	6-18	0-15	1990-2001	≥ 3 yearly obs.

Notes: This table summarizes our proposed list of health outcomes. Columns (1) and (2) list the year/age at which the health outcome is measured. Column (3) lists the additional restrictions on age at the time of the lottery win. Column (4) lists potential cohorts that can be included for each outcome variable and Column (5) lists any additional sample restrictions.

Skill Formation and School Achievement of Pre-Lottery Children

Cognitive and Non-Cognitive Skills from Conscription Register

We use the register variables to define one cognitive skills variable and one variable measuring non-cognitive skills.

To measure cognitive skills, we normalize the conscript's stanine cognitive test score so the resulting variable has mean zero and standard deviation one. The exact test from which the stanine score is derived have changed on three occasions (in 1980, 1994 and 2000) and the mapping from the result on the test score to the stanine score has also changed for a given test (Grönqvist and Lindqvist 2014; Lindqvist and Vestman 2011). We therefore perform the normalization separately by draft cohort using data on the population of conscripts.

To measure non-cognitive skills, we again normalize the stanine score assigned to the conscript by the military psychologist. The score is normalized using a procedure analogous to the one used to generate the cognitive skills variable.

GPA from the Ninth Grade Register

To minimize multiple-hypotheses problems, the only school performance variable we include on our list of pre-specified outcomes is the child's ninth-grade GPA, computed by Statistics Sweden. The GPA variable is a good measure of overall academic performance. If a student appears in the register but one or several grades are incomplete, the GPA is computed setting these grades to the lowest possible grade.

To construct the final GPA variable, we compute the percentile ranking in a representative sample of Swedes graduating in that year and convolute this percentile ranking with the inverse of the standard normal distribution. The resulting variable is by construction standard normal in the population, and its mean and standard deviation in our sample of children is informative about the mean and variance in our population of winners compares to a representative sample. We perform the normalization separately by year because it is known that the Swedish school system has had grade inflation during our period of study, especially in the later years (Vlachos 2010).

We set the GPA variable to missing for the approximately 6% of students who cannot be identified in the register.

National Tests in Swedish, English and Mathematics

As an additional measure of performance in school, we use the standardized national tests in Swedish; English and Mathematics students take in ninth grade. The national tests are constructed by the Swedish National Agency for Education in collaboration with the higher education system. The tests are graded by each student's teacher based on guidelines provided by the Swedish National Agency for Education. The test results are graded using the same scale

(Fail, Pass, Pass with Distinction, Excellent) used for the final grades. Teachers are instructed (but not formally required) to take into account the test performance when assigning students their final grade. In our analysis, we normalize the grades from the three tests separately for each test and year.

Table 4. Outcome Variables and Sample Restrictions: Child Human Capital

	(1) Outcome years	(2) Age at which outcome is measured	(3) Age at Lottery Win	(4) Included Cohorts by Birth Year
Children Born before Lottery Win				
Skills at Conscription				
Cognitive skill	1987-2010	Men age ~18	0-17	1968-1992
Non-Cognitive skill	1987-2010	Men age ~18	0-17	1968-1992
Performance in school				
Grade point average in ninth grade	1988-2010	15-16	0-14	1972-1995
National test in Swedish	2003-2010	15-16	0-14	1988-1995
National test in English	2003-2010	15-16	0-14	1988-1995
National test in Mathematics	2003-2010	15-16	0-14	1988-1995

Notes: This table summarizes our proposed list of human capital and behavioral outcomes. Columns (1) and (2) list the year/age at which the health outcome is measured. Column (3) lists the additional restrictions on age at the time of the lottery win. Column (4) lists potential cohorts that can be included for each outcome variable.

Heterogeneity Analyses

To test for heterogeneous effects, we propose four separate heterogeneity analyses in which we split the sample along the following dimensions: (1) household disposable income below or above the 25th percentile (2) child's age below or above 9 at the time of the win (3) boys and girls (4) mother or father won. In all cases, these subpopulations are selected because of previous theoretical or empirical research – reviewed in Section 1 – suggesting that effects should vary across these groups.

Exploring Possible Mechanisms

Why might income impact child outcomes? An economic literature that goes back to Becker and Tomes (1994) emphasizes that one channel through which income can influence child outcomes is through parental investments. These investments could take the form of parental time and the purchase of human-capital-augmenting market goods, such as school quality and medical care. Psychologists studying the relationship between income and children's outcomes have pointed to evidence that low incomes are often associated with maternal stress and depression (Bradley and Corwyn 2002). They therefore postulate that income, by reducing stress, may affect child outcomes through its impact on parenting and maternal lifestyles (Bradley and Corwyn 2002; Conger et al. 1994; Elder 1974).

Few variables are available in the register data that can be unambiguously interpreted as measures of parental investments, but we plan to examine the impact of wealth on a number of variables that can be plausibly be interpreted as proxies for parental investment behaviors. Even absent any direct evidence of an impact of wealth on child outcomes, it is interesting to ask if the proxies for parental investment behaviors respond to the wealth shocks in the direction predicted by existing theories. Below, we describe our five pre-specified measures of parental investments: asset transfers, maternal smoking, parental mental health, parental leave, and local school quality. For each outcome, we specify, to the extent possible, how the final estimation sample will be determined and whether we examine parents jointly, separately or mothers only.

<u>Asset Transfers</u>

A direct measure of parental investments is asset transfers to children. For the years 1999-2007, the Swedish Wealth Registry contains detailed information on individual net wealth. Up to 2005 there was a 30 percent gift tax, whereas gifts below 10,000 SEK were tax exempt. Winning parents are therefore likely to spread out gifts to their children over several years. We therefore focus on the child's net worth five years after the lottery event as our measure of asset transfers. In these regressions, our unit of analysis is a pre-lottery child and we estimate a single effect in a pooled sample of winning mothers and fathers.

<u>Maternal Smoking</u>

Another popular hypothesis in the literature is that income impacts child development in part through improvements in maternal health behaviors (Bradley and Corwyn 2002). To test this hypothesis, we use data on maternal smoking during pregnancy from the *Medical Birth Register*. We construct a dummy variable equal to 1 in case the mother reported smoking a non-zero amount of cigarettes per day when registered at the maternity clinic. Validation of this self-reported measure has shown that it underestimates actual smoking behavior, but that it is nevertheless fairly accurate. For example, only about 6 percent of those that reported that they did not smoke were likely to be smokers based on serum samples (Lindqvist et al 2002).

The unit of analysis in these regressions is a post-lottery child and we restrict the sample to children of female winners. Our default is to include the full set of post-lottery children born to female lottery winners. However, it may be necessary to further restrict the sample if there is evidence of an endogenous fertility response to winning the lottery. We focus on the children of female winners since it seemed plausible, a priori, that the effect of lottery wealth on own smoking would be appreciably stronger than the effect on spouse's smoking.

Parental Mental Health

Another mechanism frequently highlighted in the literature is improved parenting due to better mental health. As in our previous analyses, we construct a mental health index by studying the consumption of drugs in ATC categories N05 ("psycholeptics") and N06A ("antidepressants"). We define mental as the sum of defined daily doses of mental health drugs prescribed between 2006 and 2010.

In our analyses of parental mental health, the unit of analyses is a lottery winner. Therefore, we employ the specification as in the adult health analyses, but restrict the sample to parents with at least one pre-birth child. Because much of the existing literature focuses on maternal mental health (Bradley and Corwyn 2002), we do not pool female and male winners, but rather report one set of estimates for mothers and one for fathers. We restrict the sample to winners who satisfy three conditions: (1) they were alive in 2010, (2) they had at least one pre-lottery child aged 18 or below in 2010, and (3) they won their prize in 2005 or earlier.

Parental Leave

Wealth could also improve child outcomes by allowing parents to spend more time with their children. Our proxy for time spent with children is the number of days of parental leave claimed by the parent. One advantage with this measure compared to for example labor earnings is that access to publicly subsidized childcare is restricted while being on parental leave, implying that parents on parental leave are likely to spend more time with their children.

Parents of a newborn Swedish child are entitled to a certain number of transferrable months of paid leave and a certain number of non-transferrable months of paid leave. The transferrable months – 10 for most of our study period – can be allocated between the two parents as they see fit. The non-transferrable months – one month per parent between 1994 and 2001 and two thereafter – are individual. During paid leave, a parent is entitled to compensation equal to approximately 80% of their monthly salary up to a ceiling (roughly corresponding to the average monthly salary). With the exception of the years 1994 and 1995, parents can in addition claim a low benefit (which is independent of income) for an additional three months. Parental leave must be claimed before a child turns 8. About 85% of the total parental leave is claimed before the child turns three. As of 2009, mothers claim 78% of days with parental leave benefits.

Beginning in 1993, the registers contain information about the total number of days of parental leave claimed by each individual.

Since our exploratory analyses showed that the vast majority of days with parental leave benefits are claimed when children are very young, we restrict attention to post-lottery children in our analysis of parental leave. The unit of analysis is a post-lottery child. For each post-lottery child, we compute the total number of parental leave days claimed by the winning parent in the years that the child was 0-3 years old. A limitation of the register data is that we only observe the total amount of parental leave claimed by a parent, not the child for which the benefits were claimed.

To avoid misclassification or double counting, we therefore restrict our analyses to post-lottery children without siblings 0-3 years younger in age. As in all other analyses of post-lottery children, it may prove necessary to further restrict the sample if there is evidence of an endogenous fertility response to winning the lottery in some subsamples.

School Quality

A final plausible causal pathway from household wealth to child outcomes runs via school quality. Swedish schools are not allowed to charge fees, but region of residence is a major determinant of admission (for a review, see Grönqvist & Vlachos 2008). To test for this possibility, we use our grade 9 GPA data to construct a measure of average school quality.

For most children, we define this variable as the average GPA, normalized by year, in the child's graduating school in the year of graduation. In our data, 2% of graduating children graduate from a school with where we observe fewer than 20 children in the graduation year. For such children, we define the school quality variable as a ten-year average. A small number of children also graduate from schools that are not required to assign grades because they rely on special pedagogical strategies. For such children, we instead impute average grades using information about national test scores in mathematics, English and Swedish (whenever available) and conscription test scores (cognitive and non-cognitive skills, whenever available).

Table 5. Outcome Variables and Sample Restrictions: Parental Investment and Behavior

	(1) Outcome year	(2) Age at which outcome is measured	(3) Age at Lottery Win	(4) Included Cohorts by Birth Year	(5) Additional restrictions
<u>Children Born after Lottery Win</u>					
Mother's gross days of parental leave	1993-2010	0-3	-	1993-2007	Children with 0-3 year younger siblings excluded.
Father's gross days of parental leave	1993-2010	0-3	-	1993-2007	Children with 0-3 year younger siblings excluded.
Mother smokes during pregnancy	1987-2010	During pregnancy	-	1987-2010	
<u>Children Born before Lottery Win</u>					
Net wealth 5 years after winning	1999-2007	5-23	0-18	1976-2002	
School quality	1988-2010	7-16	0-15	1972-2003	
<u>Parent' Mental Health</u>					
Father's mental health (N05 & N06A)	2006-2010	-	-	-	Father alive in 2010, won before 2006 and at least one child ≤18 years of age in 2010.
Mother's mental health (N05 & N06A)	2006-2010	-	-	-	Mother alive in 2010, won before 2006 and at least one child ≤18 years of age in 2010.

Notes: This table summarizes our proposed list of outcome variables of parental child investments. Columns (1) and (2) list the year/age at which the health outcome is measured. Column (3) lists the additional restrictions on age at the time of the lottery win. Column (4) lists potential cohorts that can be included for each outcome variable and Column (5) lists any additional sample restrictions.

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