Prenatal and Infant Health, Family Background, and Educational Attainment: Results from the 1966 Northern Finland Birth Cohort Study

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Abstract

We use data from the Northern Finland Birth Cohort 1966 Study to analyze the effects of prenatal and infant health on educational attainment at age 31. Recent research has paid attention to the effects of early experiences on human capital formation and there is an expanding literature on the effects of early health on later socioeconomic outcomes. Our main contribution comes from the definition and use of several clinically meaningful indicators of health and health behavior. We find that many of these factors are negatively associated with subsequent educational attainment. However, in many cases these associations disappear after controlling for socioeconomic, demographic, and attitudinal factors. Nevertheless, we find that maternal smoking during pregnancy and problems in neurological development detected in infancy have robust negative effects. We find weaker support for negative effects of higher pre-pregnancy BMI and anemia during pregnancy. These prenatal and infant health factors generally explain only a very small share (less than 5 percent) of the effects of maternal education and parental class on educational attainment. However, these factors, and maternal smoking in particular, explain 14 to 16 percent of the effects of unwed motherhood on educational attainment. This suggests that social differences in maternal smoking behavior can create intergenerational inequalities. We discuss these findings in the light of the recent research on childhood conditions and socioeconomic achievement.

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Negative relationships between social status and health have been found in numerous countries and across various health outcomes (e.g. Williams 1990; Williams and Collins 1995; Adler and Ostrove 1999; Marmot and Wilkinson 1999; Capriano, Link and Phelan 2008; WHO 2008). Many scholars suggest that the causation runs from social status—measured as education, incomes, or occupational standing—to the health of adults and children. An alternative strand of research has examined effects in the opposite direction, from health to socioeconomic outcomes. Some these studies have looked at the effects of early health conditions all the way from the prenatal period (cf., Conley, Strully and Bennett 2003; Currie, forthcoming).

The objective of this study was to contribute to this ongoing and growing field of study. We asked whether specific health conditions and behaviors *in utero* and during the first year of life are associated with educational attainment in early adulthood (at age 31). Recent research in economics has emphasized the important role of early years in the formation of human capital (Cunha et al. 2005; Heckman 2007). This study adds to this literature by evaluating the fetal and early childhood health correlates of future educational attainment, an issue that has been of recent interest and is of potential importance (Currie, forthcoming). A major contribution of our paper to the existing research is the use of well-specified and clinically meaningful measures of prenatal and infant health conditions. Much previous research on the role of childhood health has mainly used self-reported retrospective assessments (cf. Haas 2006; 2007; Smith 2007) or indicators such as birth weight (Conley and Bennett 2000; 2001; Conley, Scrully, and Bennett 2003; Behrman and Rosenzweig 2004; Black, Devereux and Salvanes 2007) that offer a broad assessment of early health. However, they are themselves affected by other, more proximate and clinically more meaningful health conditions that can have direct effects on later outcomes.

Secondly, we were interested in whether these health conditions help explain the family background gradients in educational attainment. Recently, there has been increasing interest in the role of childhood health in social mobility. This research has been motivated by findings of the effects of childhood health on socioeconomic attainment and research on the socioeconomic gradients in child health (cf. Case, Lubotsky and Paxson 2002; Eriksson, Bratsberg, Raaum 2005; Case, Fertig and Paxson 2005; Case and Paxson 2006; Palloni 2006; Palloni and Milesi 2006; Haas 2006; Salm and Schunk 2008; Currie, forthcoming). The results suggest that early health does play a role in the inheritance of social status, although the effects are by many estimates rather modest. Specifically, we are interested in the educational attainment differences by parental class, maternal education, and mother's marital status. Again, our study with its number of clinically meaningful health conditions during the fetal and early childhood periods contributes to this research by focusing on proximate health mechanisms that mediate the social background gradients in educational attainment. We also look at a broader range of family background variables than is usually done.

We use data from an ethnically homogeneous population of the full cohort of children born in the two most northern provinces of Finland in 1966. The Northern Finland Birth Cohort 1966 (NFBC66) study is an ongoing prospective cohort study. Approximately 12,000 children were originally recruited through their mothers in prenatal clinics and delivery rooms in hospitals. We have data on the educational attainment of 8,625 of these cohort members. The data include a rich selection of health data collected at different stages of the life-course through questionnaires, interviews, and registers, complemented with information on educational and occupational attainment, parental backgrounds, and living conditions.

In the next section, we provide a general overview of the evidence on the role of early health in socioeconomic attainment. We also discuss the evidence on the socioeconomic gradients of child health and its role in the intergenerational transmission of socioeconomic status. After that, we present our data and the variables. We also discuss the analytical approach. We then continue to our results. The last section concludes.

Background

Prenatal and infant health conditions and socioeconomic attainment

In this section, we introduce the literature on prenatal and infant health conditions and future socioeconomic outcomes. The review focuses on the general pathways from early health to later outcomes and presents some research findings, whereas the discussion on the specific health variables and evidence concerning their effects can be found below from the data and variables section of the paper. The discussion borrows heavily from a recent review of the literature by Janet Currie (forthcoming).

The idea of early life conditions determining later outcomes dates back to early research in lifespan psychology and life-course sociology (Mayer, forthcoming) and has been recently taken up in the economics of human capital development and in social mobility research. This literature builds on the premise that harmful conditions during the early "critical" periods of human development can have long-lasting and possibly irreversible effects. While much of the research has been interested in the social, economic, psychological, and environmental conditions of children and their families (Cunha et al. 2005; Heckman 2007), there has been a surge of analyses on the effects of childhood health on later outcomes.

Early health can affect later outcomes through different pathways. Possibly the most important one works through the effects of health conditions on cognitive skills (Currie, forthcoming). Some health insults may have direct implications for neurological development. Furthermore, ill health can affect children's interactions with the environment and their ability to benefit from stimuli. Another pathway works through non-cognitive traits (Farkas 2003; Palloni 2006; Palloni and Milesi 2006; Currie, forthcoming). For example, low birth weight (LBW) children or children whose mothers smoked during pregnancy have been found to have a higher rates of problem behaviors, personality disorders, and attention deficit hyperactive disorders (ADHD) (Wakschlag et al. 2002; Das Banerjee, Middleton and Faraone 2007; Currie, forthcoming). Currie (forthcoming) and Palloni (2006) have suggested that non-cognitive traits can be more important mediators of the effect of health on earnings and occupational attainment than on education. However, these traits may affect children's learning capabilities, and shape their future interests and possibilities to proceed to future levels of education (Farkas 2003). Poor childhood health may have adverse effects on adult socioeconomic outcomes also through its effects on health in adulthood (e.g. Haas 2006). Again, these effects are likely to be stronger on outcomes such as earnings and wealth than on educational attainment. Finally, by missing days in school, children with health problems may also fall behind their peers in the curriculum.

Currie (forthcoming) argued that fetal health deficiencies have particularly important effects on later outcomes. Poor fetal growth features prevalently in empirical research. In epidemiology, a famous example is the "Barker hypothesis" (e.g., Barker et al. 1989; 1990; Barker 2001), which links adult hypertension and cardiovascular disease to poor fetal growth.

Poor fetal growth (measured commonly by low birth weight (LBW)) can also decrease educational and income attainment. Several studies have reported clear negative effects of LBW on schooling outcomes in the United States (Conley and Bennett 2000; 2001; Behrman and Rosenzweig 2004) and elsewhere (Black, Devereux, and Salvanes 2007). These effects hold after controlling for various confounding factors, and are often, in fact, found to be stronger once common genetic and environmental factors have been accounted for.

Fetal effects go beyond compromised fetal growth. Fetal insults in the form of substance abuse, toxic exposure, and maternal disease have been found to have strong effects on various socioeconomic and other later life outcomes (cf. Currie, forthcoming). From the viewpoint of identifying causal effects, the most convincing evidence comes from studies on fetal exposure to exogenous health shocks such as in the influenza epidemic of 1918-9 (Almond 2006) or the radioactive fallout after the Chernobyl disaster (Almond, Edlund and Palme 2007). In both cases, the estimated effects of fetal insults were strong. These results provide evidence of the effects of fetal exposure to environmental hazards and maternal infections, but provide less clues to the effects of other (more common) conditions during pregnancy.

Health conditions and behavior after the prenatal period can also have long-term impacts. Several studies have found positive effects of breastfeeding on cognitive development (e.g. Caspi et al. 2007). Asthma, one of the most common chronic conditions among children, can also have negative long-term effects (Salm and Schunk 2008; Currie, forthcoming). Haas (2006) found that retrospectively assessed childhood health was a non-trivial predictor of educational attainment and other socioeconomic outcomes in adulthood.

Socioeconomic gradients in fetal and infant health

Most studies on the socioeconomic gradient of health focus on adults. Although socioeconomic gradients in child health have received less attention, many studies have found similar gradients as for adults so that child health improves by each improvement in parental socioeconomic position (for reviews, Chen, Matthews and Boyce 2002; Currie, forthcoming). Even though the strength of this gradient depends on the outcome, similar to the adult gradients, it is found across a number of health conditions. Similar to explanations of adult health gradients (Williams 1990; Williams and Collins 1995; Capriano, Link and Phelan 2008), socioeconomic differences in child health are often explained by differences in material conditions, behaviors, resources (including access to medical services), or psychosocial outcomes of social position. Previous research has also found that the gradient depends on developmental age so that for overall health, the gradient widens with the age of the child (for the United States: Case, Lubotsky and Paxson 2002; Canada: Currie and Stabile 2003; United Kingdom: Case, Lee and Paxson 2007). Concerning specific health conditions, the relationship between age and social disparities depends on the outcome (Chen, Martin, and Matthews 2006).

Relevant to our study, previous research has found socioeconomic inequalities in prenatal and neonatal health (e.g. Aber et al. 1997; Case and Paxson 2002; Arntzen et al. 2007; Nagahawatte and Goldenberg 2008; Currie, forthcoming). Differential access to and use of prenatal health services is an often-cited reason for these inequalities as appropriate care can improve various birth outcomes (Kiely et al. 1994). However, these differences cannot explain the full range of inequalities in birth outcomes (Case and Paxson 2002). Furthermore, such birth outcomes as preterm delivery do not seem to be affected by prenatal care (Nagahawatte and Goldenberg 2008). Apart from (American) socioeconomic inequalities in health care coverage, disadvantaged mothers may have weaker links to prenatal care services also because of negative experiences, lack of transportation, or mental health problems (ibid.).

Birth outcome inequalities are also shaped by social gradients in adult (maternal) physical and mental health. Prenatal health risk factors such as obesity and diabetes are more common among lower-status women (e.g., Connolly et al. 2000; McLaren 2007). The same applies to mental health conditions such as depression and stress (Nagahawatte and Goldenberg 2008). Furthermore, health related behaviors vary across social classes and contribute to explaining social disparities in fetal health and birth outcomes. Substance abuse has been a matter of specific focus (Case and Paxson 2002), and according to some results, differences in smoking during pregnancy can explain up to half of the socioeconomic differences in low birth weight (Meara 2001).

Rather little attention has been given to differences in child health by family structure. However, children living in single-parent families tend to have worse health than children living with two (married) parents (Dawson 1991; Montgomery, Kiely and Pappas 1996; Bramlett and Blumberg 2007; Bzostek and Beck 2008). Bramlett and Blumberg (2007) found health differences between children living with single mothers and married couples and Dawson (1991) found that children of divorce were had heightened risk of accidental injury while children living with single mothers had higher rates of asthma. Family structure can also affect birth outcomes. For example, it has been found that lone mother status is associated with lower birth weight (Pattenden, Dolk and Vrijheld 1999; Moser, Li and Powell 2003). The proposed reasons for these disparities in child health include lower socioeconomic status, stress, and weaker surveillance of children. Another explanation stresses selection to family structures by health-compromising traits. Mauldon (1990) studied the effects of divorce on child health and did not find support for an explanation stressing selection or reverse causation. Bzostek and Beck (2008) found in their study of health of pre-school children that selection explained a part, but not all, of the health advantage of children living with married biological parents. Family structure seems therefore to have at least some effects on child health.

Findings of socioeconomic gradients in child health and its long-term implications have raised interest in the role of early health in the intergenerational transmission of socioeconomic inequality. Palloni (2006) estimated that around 10 percent of the relationship between parents' and sons' social class is explained by childhood health (measured as LBW and number of limiting health conditions at ages 7 and 16) in Britain. Salm and Schunk (2008) argued that health conditions explained 18 percent of the gap in cognitive ability and no less than 65 percent of the gap in language ability between children with college- and less-educated mothers. In a different setting, Erikson, Bratsberg and Raaum (2005) estimated that around one fourth of the intergenerational earnings elasticity in Denmark could be explained by various health conditions in adulthood, some of which may have antecedent in childhood. Haas (2006) also found effects of socioeconomic background on childhood health and of childhood health on adulthood outcomes, although he did not present an estimate of the share of social background gradients that could be explained by early health. Similar results have been presented by Case, Fertig and Paxson (2005) who used British cohort data on such childhood conditions as heavy maternal smoking during pregnancy, the number of chronic conditions, and height at age 16.

Data and variables

The 1966 Northern Finland Birth Cohort Study

We use data from 1966 Northern Finland Birth Cohort Study (NFBC66), a prospective study of all children born in the two most northern provinces of Finland in 1966 and followed up to ages 1, 14-15, and 31 years (Koivusilta 1969; http://kelo.oulu.fi/NFBC/). The data were collected at the University of Oulu and participants were recruited through their mothers at their first visit to a prenatal clinic. The original sample size was 12,231 births (12,058 born alive). We excluded 163 multiple births. Of the remaining singleton births, information on educational attainment is available for 8,625 respondents, which form our sample.

The NFBC66 has data on health and social conditions during pregnancy, on birth outcomes, on child health around age 1, on health and social conditions and schooling outcomes in adolescence (at age 14-15), and on health, educational, and occupational outcomes at age 31. In addition to these data that cover the full sample, the NFBC66 has data from various studies on specified subpopulations. The data were collected by surveys to mothers, to the cohort members, and to medical clinic personnel, and from population and hospital registers.

For this study, we use survey and hospital register data from the prenatal and antenatal records, the first-year child health examinations, and population register based information for educational attainment at age 31.

Dependent variable: educational attainment at age 31

Our dependent variable is educational attainment at age 31, retrieved from national registers that were linked to the NFBC66. In Finland, students take nine (or ten) years of compulsory education, after which they choose either a vocational track or high school, the latter being the primary track to tertiary and higher secondary education.

We use a five-category classification of educational attainment: only nine years of compulsory education (lowest), additional vocational training (usually one or two years), a three-year academically oriented high school education, up to three years of additional (after vocational school or high-school) secondary-level schooling, and university education (highest).

Table 1

We present descriptives of the variables in Table 1. As discussed below and seen in Table 1, many of the variables had missing values. We used multiple imputations to deal with this problem. However, the descriptive information on the sample presented in Table 1 is based on the original, non-imputed, case numbers for each variable.

Health conditions

Preterm birth

Preterm birth, together with low birth weight, is a leading cause of infant mortality in industrialized countries. It is also associated with a number of child morbidity conditions (e.g. Blackmore, Rower, and Kiely 1994) and long-term outcomes, including health conditions, cognitive and behavioral outcomes, educational attainment, incomes, and benefit receipt (e.g., Bhutta et al. 2002; Moster, Lie, Markestad 2008).

We used the common definition of preterm births as those born before the 37th full gestational week. Gestational age was determined from the last menstrual period.

Low and heavy birth weight for gestational age

Low birth weight (< 2500 grams) is probably the most common early childhood health variable in socioeconomic research, and it has repeatedly been found to have adverse short-term and long-term effects (see discussion above). However, the commonly used measure of LBW confuses low birth weight due to early or premature birth with intrauterine growth retardation, which is a more serious risk factor. In fact, LBW was originally developed to determine prematurity (Ylppö 1919).

In this paper, we use a more proper measure of intrauterine growth retardation by linking birth weight to gestational age. We define low birth weight as below 2 standard deviations of the mean birth weight for gestational age, derived from Finnish fetal growth charts (Pihkala et al. 1989), calculated separately for boys and girls. It approximates the 3^{rd} percentile in our data, a commonly used cutoff point in modern pediatrics.

Excessive fetal growth (fetal macrosomia) can also have adverse effects on pregnancy and birth outcomes, including stillbirth, neonatal mortality, neonatal asphyxia, and meconium aspiration (Zhang et al. 2007). Some studies find a hump-shaped association between birth weight and developmental and educational outcomes, so that small and heavy babies have the worst outcomes (Malacova et al. 2008). To examine whether heavy weight for gestational age affects educational attainment in our data, we measure heavy for gestational age as above 2 standard deviations of the mean birth weight for gestational age, from Pihkala and associates' (1989) growth charts.

Inadequate weight gain during pregnancy

Inadequate weight gain during pregnancy reflects multiple adverse physiological conditions and is associated with undesired fetal outcomes, such as intrauterine growth retardation (Scholl et al. 1991; Susser 1991; Kiely et al. 1994; Olson 2008). The complete etiology of inadequate weight gain is unknown, although it is associated with smoking, stress, and diet.

We construct a measure of inadequate weight gain using three variables, weight at first visit to a prenatal clinic, the time of the first visit, and pre-pregnancy weight. We calculated the weight gain at the first visit and compared it to cutpoints for inadequate weight gain for gestation using information from Scholl et al. (1991: 424) to create a dummy variable for experience of inadequate weight gain during pregnancy.

Maternal smoking during pregnancy

Smoking during pregnancy has attracted wide attention for years, and research has shown clear associations between maternal smoking during pregnancy and several adverse health, cognitive, and behavioral outcomes (Floyd et al. 1993; Wakschlag et al. 2002; Huizink and Mulder 2006). More direct causal evidence of the negative impacts of nicotine exposure *in utero* on development is found from studies on animals (Slotkin 1998). The NFBC includes information on smoking behavior during pregnancy, and any changes in it. We use a simple dummy variable to indicate whether the mother smoked during pregnancy.

Hypertensive disorders

Hypertension during pregnancy and preeclampsia can limit the amount of blood the fetus gets and may result in adverse birth and longer-term outcomes. Many women have high blood pressure already before pregnancy. However, pregnancy induced hypertension is a more severe condition, especially if the mother has increased amounts of protein in the urea (preeclampsia). The reasons for preeclampsia are not known and it can be cured only by delivery.

We measure hypertensive disorders during pregnancy using a four-class variable, where women in the control group did not experience hypertensive disorders. Chronic hypertension was defined as systolic blood pressure above 145 mmHg and diastolic blood pressure above 90 mmHg through pregnancy and/or clinically defined hypertension before pregnancy. Pregnancy induced hypertension was defined as systolic/diastolic blood pressure of 145/90 mmHg respectively after the 20th week of pregnancy (but not before), and preeclampsia was defined as gestational hypertension with continuous protein in the urine (cf. Järvelin et al. 1997).

Anemia during pregnancy

Many women have or develop anemia or iron deficiency during pregnancy. Anemia during pregnancy is a risk factor for preterm delivery, low birth weight, and potentially for infant health, although much remains to be learned of its longer term consequences (Allen 2000). The NBFC66 includes measurements of hemoglobin levels at three stages during pregnancy. We include a measure of anemia during pregnancy following WHO guidelines, and define it as a hemoglobin concentration of less than 110 g/l at any stage of the pregnancy.

Mother's frame of mind during pregnancy

Maternal depression has received substantial interest in the literature (e.g. Orr and Miller 1995; Murray and Cooper 1997). The results show that maternal depression is associated with a risk of poor pregnancy outcomes, although the effects vary across social groups. Furthermore, by shaping mother-child interactions, (postpartum) depression may have negative effects on child development.

We do not have information on postpartum depression symptoms. We measure depression during pregnancy using a dummy variable based on a question on the mother's mood during pregnancy: the variable is unity if the mother felt depressed or very depressed.

First prenatal screening visit

As discussed above, prenatal care is associated with favorable perinatal outcomes, although less is known about the specifics of how and what kind of prenatal care is most effective (Nagahawatte and Goldenberg 2008). However, empirical research has in particular stressed the positive effects of early and continuous prenatal care (Kiely et al. 1994). NFBC66 has a variable on the gestational age of the first visit to a prenatal clinic.

Unfortunately, we do not know how often and regularly mothers visited prenatal clinics. Due to findings that stress the importance of early first visits to prenatal clinics, we use a dummy variable indicating whether the mother had her first visit during the first trimester of pregnancy

Mother's BMI before pregnancy

Obesity has become a public health concern across the globe due to its severe morbidity and mortality implications. Maternal obesity can have adverse effects on pregnancy and birth outcomes (Sebire et al. 2001; Hauger et al. 2008). We measure pre-pregnancy BMI of the mother using measures of mother's height and pre-pregnancy weight collected during the first visit to a prenatal clinic. We enter mother's BMI as a linear variable. Low BMI can also have adverse outcomes (Hauger et al. 2008). However, nonlinear specifications were not supported by our data.

Problems in neurological development: Convulsions during first 12 months and neurological abnormalities at 12 months

Early life is important for the development of the brain and problems in neurological development at this stage of life can have permanent negative effects. We use two variables to measure problems in neurological development: convulsions during the first year of life and neurological abnormalities detected during the first year checkup.

Seizures in childhood are most common during the neonatal period and they are associated with increased mortality and morbidity rates. They are also associated with adverse long-term outcomes, although the prognosis depends on the underlying cause and type of seizure. Furthermore, many antiepileptic drugs that have been used in treatment may themselves have deleterious effects on the developing brain (Silverstein et al. 2008).

In the NFBC66, mothers were asked by doctors during the first-year checkup whether the child had any febrile or non-febrile convulsions during her or his first year of life. Although the latter is a better indicator of problems in neurological development, we had to combine these two categories to achieve sufficient cell-sizes. We thus use a single dummy variable of convulsions during the first 12 months of the child. This combines the effect of the convulsions themselves and any possible effects of the medication used to treat them.

The NFBC66 also contains information on any neurological impairment detected by the doctor or nurse during the first-year checkup of the child. Again, low cell numbers forced us to combine the different categories to form a single dummy variable.

Chronic condition at 12 months

Chronic conditions have featured prevalently in the literature on child health. In the NFBC66, doctors and nurses filled in a question on any chronic conditions detected in the child at the one-year checkup. Due to limited cell numbers, we again combined these categories to form a dummy variable on any early chronic conditions.

Admitted to hospital during first 12 months

The first-year checkup data files contain variables on whether and how often the child was admitted to a hospital during the first twelve months of her/his life. As opposed to visits to a doctor, hospitalization indicates more severe and acute health conditions. Using this information, we constructed a dummy variable on hospitalization during the first year of life and use it as another proxy for health problems in early childhood.

Other relevant but excluded or unobserved variables

Although not commonplace, it is appropriate to briefly comment on some potentially relevant variables that were not included, either because these variables were not measured in the data or they were excluded for other reasons. Unfortunately, the data do not include information on breastfeeding, which has been shown to boost the IQ (e.g. Caspi et al. 2007). We also do not know head circumference at birth. The data include a measure of head circumference at 12 months, but since we lack an earlier measure, we cannot ascertain whether one's head circumference at 12 months is consistent with the growth charts. We also do not use measures of weight and height at 12 months as proxies for nutritional or other conditions that affect growth and development. Low birthweight babies may catch up during early months; additionally, genetic factors are important in early growth, and gene-induced growth that does not comply with growth percentiles during the first months can be erroneously interpreted as abnormal growth. We also do not have information on infections during pregnancy.

Family background: social class, maternal education and family structure

What constitutes class and how to measure it is a longstanding question in the social stratification literature. Small wonder, then, that the literature on socioeconomic differences in health has used a plethora of variables to measure socioeconomic standing, the most common ones being occupational class, education, SES, and income (cf. Capriano, Link, and Phelan 2008). Often these measures tap to similar positions and processes that can affect health. However, not all indicators work equally well in each case (e.g., Winkelby 1992) and some indicators may affect some outcomes more than others. For example, Case, Lubotsky and Paxson (2002) found that the family income gradient, but not the mother's education gradient, in child health widened by age of the child. Similarly, Desai and Alva (1998) found that in the developing world, mother's education proxies socioeconomic status, area of residence, and material conditions. They concluded that without proper controls, the effects of maternal education on child health can be interpreted improperly.

We use both parental class and maternal education measured during pregnancy or around birth as measures of socioeconomic background. After testing for correct specifications, we found that these factors affected somewhat different health indicators: class was a more important control for the effects of prenatal care visits and mother's frame of mind than mother's education, while mother's education was a more important control for body mass index and preterm births. For other variables, such as smoking during pregnancy and anemia, both variables worked equally well.

We include a dummy variable on whether the mother was married or not during pregnancy or at the time of birth. We use this as a proxy for family structure (single motherhood) around birth. Unwed motherhood, cohabitation, and fertility in consensual unions remained rare in 1966 (cf. Finnäs 1995), especially in the more provincial northern parts of the country.

Class background was measured using occupational information from both the mother and the father, using the "dominance" principle, according to which the family's class status is determined by the partner with the highest class status. Using the available information, we differentiate between five classes: higher and lower professional, skilled working class, farmers, and unskilled working class (reference group).

Due to educational reforms that affected the children in our sample but not their mothers, mother's education was determined through four categories: compulsory schooling or unfinished secondary school or less (reference group), completed vocational school, secondary schooling (high school), and high school matriculation and above (including academic education).

Control variables

As additional control variables we use age of the mother at birth, parity order, information on whether the pregnancy was wanted or not, and general attitudes of the mother toward self-provision.

Mother's age at delivery has effects on both birth outcomes and educational attainment: young and old mothers have higher risk pregnancies and age of the mother has a positive effect on subsequent education, both due to economic reasons and general maturity (e.g. Kalmijn and

Kraaykamp 2004). We enter mother's age at birth using three dummy variables: up to 18 years, 26 to 33 years, and 34 years and above, with 19 to 25 years as the reference category.

Parity order can affect both health outcomes and educational attainment. For example, the risk of LBW is higher in first pregnancies and parity can influence later educational outcomes (Kalmijn and Kraaykamp 2004). We measured parity as the order of live births. Our estimates of parity order do not differentiate parity order from effects of the number of siblings. However, since we are not interested in the parity effect *per se*, this does not pose a problem.

We also control for wantedness of the pregnancy using two dummy variables: one measuring whether the pregnancy was unwanted and the other measuring whether the mother had preferred the pregnancy later (wanted pregnancies being the reference category). In the late 1960s, abortions were still rather rare and regulated by a relatively strict law from 1950 (new law came effective in 1971) (Heino, Soimula and Gissler 2008). Unwanted pregnancies that were carried to term were thus likely to be more common. Unwanted pregnancies can affect pregnancy outcomes (for example, depression) and unwanted children often have lower educational outcomes (Piccinino et al. 1994; Myhrman et al. 1995; Pop-Eleches 2006).

Finally, we control for attitudes of the mother toward self-provision. The survey taken by mothers during pregnancy or around birth asked "Which alternative does the mother prefer", with the options "one has to continuously take steps to gain a better economic position", "one should be happy with one's conditions" and "society should help people more". We created dummy variables for the last two options. In the absence of better measures, this can tap into otherwise unmeasured attitudes and behaviors that affect child health and educational outcomes.

Missing values

Our data suffered from a rather large number of missing values. Out of the 8,625 cases, 4,198 (48.7 %) had at least one variable with missing values. This threatened to compromise the power of our analyses. If values are not missing at random (NMAR), our estimates may also be biased.

We used multiple imputation of missing values to handle this problem, with the *ice* (version 1.4.6) package in Stata (Royston 2004; 2005). For proper imputation and to minimize bias from possible NMAR patterns, we followed the multiple imputation procedures recommended by Van Buuren, Boshuizen and Knook (1999) with each outcome having separate prediction equations. These included the dependent and independent variables discussed above, additional measures hypothesized to affect the variable with missing values, and information on the data collection procedure which could result in the missing values. The new data were created using 5 imputations with 20 regression switching cycles within each imputation.

Method

Given the ordinal nature of our response variable ordered logit models are appropriate (e.g. Winship and Mare 1984). With these models, one assumes that the outcome (education) is a manifestation of an underlying latent variable, which could be interpreted as a propensity for educational attainment. As a result, interpretation of the coefficients is less straightforward than in binomial logit models, for example.

We first estimate two models, one with health conditions as the only independent variables and another one, which additionally includes the family background and the other control variables. Given our multiply imputed data, we used Stata's *mim* prefix that calculates corrected standard errors using the so-called "Rubin's rules" (Royston 2004; 2005).

In the second step, we estimate the share of the effects of the family background variables that can be explained by our health measures. Due to neglected heterogeneity (Winship and Mare 1984: 517; Wooldridge 2002: 470-472), estimates from logit models with and without certain control variables cannot be compared, unlike with OLS estimates. Because of this problem, adding variables which affect the outcome can change the estimates of the original variables even when the additional variables are not correlated with the original variables. In our case, we cannot compare the estimates for family background variables from a "gross" model (which does not include the health variables) and a "net" model (in which health variables are included). To assess whether the health variables act as mediators between family background and educational attainment, we estimated Y-standardized coefficients using Stata's *listcoef* command. These estimates are free of bias due to neglected heterogeneity and can be used to compare the estimates from different models (Long and Freese 2001: 74).

Results

Prenatal and infant health conditions and educational attainment

Table 2 presents our estimates of the effects of prenatal and infant health conditions on educational attainment from the ordered logit models. The first column presents estimates from a model that includes only the health variables. Several of them are associated with educational attainment. Prematurely born children with convulsions or with a detected neurological impairment attained less education 31 years later. Furthermore, several health conditions and behaviors during pregnancy (smoking, anemia, depression, lack of visits to prenatal clinics during the first trimester) are associated with lower educational attainment. Children with heavier mothers before pregnancy also tend to attain less education.

Table 2

Not all of our health variables are associated with later educational attainment, however. Maybe the most surprising finding is that low and high birth weight for gestational age (measures for intrauterine growth retardation and excessive fetal growth) do not show effects. Neither did we find bivariate associations between the birth weight variables and educational attainment, which could have suggested that the other health variables control for their effects. These results go against much previous research. However, similar results with the same data have been reported elsewhere. For example, Olsén, Myhrman and Rantakallio (1994) did not find an association between LBW and dropping out of education after compulsory schooling. It should be stressed that since birth weight data are from hospital records, measurement error is an unlikely reason for this result (which anyway would create downward bias). Another possibility points to omitted variables: some studies have found that sibling and twin fixed-effects models yield higher estimates of birth weight (Conley and Bennett 2000; Behrman and Rosenzweig 2004).

We also do not find associations between hypertensive disorders and educational outcomes, despite the many adverse birth outcomes related to pregnancy induced hypertension and preeclampsia. Neither do chronic illnesses or hospital admissions during the first year predict later educational attainment (the latter was negative and significant in bivariate models, not shown). In general, however, prenatal and infant health seems to correlate with adult educational attainment.

The model presented in the second column of Table 2 controls for family background (class, mother's education, and family structure), mother's age, parity order, wantedness of the pregnancy, and attitudes toward self-provision. The main finding is that these variables control for the effects of several health conditions. Only maternal smoking, convulsions during the first year, detected neurological impairments at twelve months, pre-pregnancy BMI, and anemia remain significantly (and negatively) associated with educational attainment. The latter two variables are significant only at the 10 percent level. The other variables do not remain significant after we entered the control variables. The effects of some variables, such as preterm birth and insufficient weight gain, become non-significant after controlling for parental socioeconomic background (not shown). Others, such as depression during pregnancy, depend more on whether the pregnancy was wanted or not. As for the effects of the control variables, later-born boys from lower socioeconomic backgrounds, whose mothers were young, unmarried, who had unwanted pregnancies, and who thought that one should be happy with one's conditions attained less education, on average.

These results suggest two conclusions. First, many of the health conditions hypothesized to have long-term human capital effects are only spuriously correlated with educational attainment in young adulthood. Second, many of these health factors are associated with some or all of our background variables. This brings us to our second question, that is, the extent to which prenatal and infant health conditions act as mediators between family background and educational attainment.

Family background gradients in early health and social mobility

Table 3 presents family background gradients of our health measures. Due to the multiply imputed nature of our data, the figures correspond only to one imputed dataset (created by the first imputation). We checked these associations against all imputations, however: while numerically the results differed, the associations and their statistical significances remained.

Table 3

Table 3 contains a lot of data. Summarizing the main results, we find social gradients in many, but not all health measures. Convulsions and neurological impairments are examples of health conditions without statistically significant social gradients. In other cases social disparities are larger. For example, unskilled working class women with little education were over twice as likely to feel depressed compared to academically educated women from the higher professional class. Lower status women were also less more likely to experience inadequate weight gain during pregnancy, had a higher likelihood of anemia, were more likely to smoke, were more likely to experience pregnancy-induced hypertension (although the pattern for preeclampsia is less clear), and were more likely to give birth prematurely. These patterns are consistent between class and maternal education. In other cases, such as low or heavy birth weight, hospitalization of the child, and chronic conditions at age 1, we find differences by class but not by maternal education.

Health differences in our sample are particularly clear between married and unmarried mothers. Smoking during pregnancy is a clear case: while one fifth of married mothers smoked during pregnancy, nearly half of unmarried mothers smoked. Unmarried mothers were also clearly less likely to visit a prenatal clinic during the first trimester of the pregnancy. These findings suggest that unmarried mothers who had children constituted a very selected group in late 1960s Northern Finland. Unmarried mothers also had higher rates of anemia, hypertensive disorders, preterm births, and their children were more likely to have low birth weights for gestational age. However, unmarried mothers had lower pre-pregnancy BMI levels, were less likely to have insufficient weight gain, and their children had less chronic conditions.

Do our health variables help in explaining the family background gradients in educational attainment? As discussed above, (ordered) logit estimates cannot be compared across models to give an impression of the share of effects that can be explained by inclusion of intervening variables. For this, we estimated Y-standardized coefficients using Stata's *listcoef* command (Long and Freese 1997). We estimated three models, one without the health variables, one with all health variables, and one with smoking as the only health variable. The latter was estimated because smoking during pregnancy was both associated with subsequent educational attainment of the child and showed clear disparities across family background measures unlike problems in neurological development, for example. By comparing the Y-standardized coefficient estimates from these two models, we calculated percentage shares of the effects of the family background variables (class, mother's education, and marital status) that can be explained by the health variables.

Figure 1

Figure 1 presents these shares. The black bar shows the share of family background differences explained by all health variables and the grey bar shows the share that is explained by maternal smoking during pregnancy. One result from Figure 1 is that prenatal and infant health does not explain socioeconomic background gradients in educational attainment. With the exception of the comparison between children from unskilled working class and farmer backgrounds, our health variables explain less than five percent of these gradients. Health conditions explain 8 percent of the difference in educational attainment between farmers' children and children with an unskilled working class background. Otherwise, health conditions are more important for explaining educational attainment differences by maternal education than by class background. However, in both cases prenatal and infant health explain only a negligible share of differences in educational attainment. Smoking alone is of varying importance. It accounts for most or all of the mediating effects of early health for differences between farmers and the unskilled working class and between mothers with up to incompleted versus completed secondary education. In other cases it is of less importance. Overall, these shares are smaller than the one estimated by Palloni (2006) for class background gradients in occupational attainment and particularly smaller than the estimates of Salm and Schunk (2008) for early educational achievement.

However, prenatal and infant health conditions explain a larger share (14 percent) of the educational attainment difference between children born to unmarried versus married mothers. As seen from the comparison of the black and the grey bar, smoking explains 16 percent of the difference in educational attainment: in other words, were it not for the slightly *better* conditions of unwed mothers in some factors that affect educational attainment, the educational gap between children born to unwed and married mothers would be larger. The strong role of maternal smoking in explaining this gap is not surprising given its clear association with subsequent educational attainment and the differences in smoking during pregnancy between unmarried and married mothers. As discussed above, unwed mothers in our sample are likely to form a selected group. Therefore, this result cannot be generalized to populations where the difference in smoking between married and unmarried mothers is smaller. Furthermore, smoking during pregnancy can proxy some unmeasured factors that influence both smoking and unwed motherhood in our sample. Nevertheless, the results suggest that social differences in maternal smoking can contribute to social background differences in educational attainment.

Discussion

Recent research has paid increasing attention to the role of early childhood experiences in human capital formation (e.g. Cunha et al. 2005; Heckman 2007). A more specific literature in this field has analyzed the effects of childhood health on later socioeconomic outcomes (Currie, forthcoming). Previous findings include negative effects of low birth weight and insults to fetal development and of global health and chronic health conditions.

Our paper contributes to this literature with estimates of several well-specified and clinically meaningful prenatal and infant health conditions on educational attainment in young adulthood. Much previous research can be criticized of focusing on too broad health measures (such as overall health or low birth weight), which provide limited insights to the effects of more proximate health conditions and behaviors, or of focusing on rare environmental health shocks (such as nuclear disasters). These choices are often determined by available data. Previous research can also be criticized of sometimes implicitly assuming that all fetal and early health conditions are of equal importance.

For our study, we used rich health data from a Finnish cohort study (Northern Finland Birth Cohort 1966) that has followed subjects from the womb to young adulthood (age 31).

These data enabled us to construct appropriate measures of several health conditions that feature in obstetric and pediatric research and practice. We analyzed the effects of pre-pregnancy body mass index, maternal anemia during pregnancy, maternal depression, maternal smoking during pregnancy, hypertensive disorders during pregnancy, visits to prenatal clinics, inadequate weight gain during pregnancy, preterm birth, intrauterine growth retardation and excessive fetal growth, problems in neurological development during infancy, and hospitalizations and chronic conditions during infancy.

We found that although many of our health variables were associated with subsequent educational attainment. Most of these effects disappeared when we controlled for social, demographic, and attitudinal variables. Only pre-pregnancy BMI, anemia during pregnancy, maternal smoking during pregnancy, and neurological development problems remained significantly (and negatively) associated with educational attainment. Of these, the two latter factors appeared particularly important. The effects of problems in neurological development (measured by convulsions and detected neurological impairment in infancy) remained robust across the models (when compared with Y-standardized coefficient estimates, not shown). These variables indicate developmental problems that can permanently hamper cognitive skill formation (cf. Haggers-Algra and Touwen 1992). The effects of maternal smoking also remained relatively stable across our models. This may of course still reflect selection bias as mothers who smoke can form a selected group according to other factors that also affect the educational outcomes of their children. Furthermore, as mothers who smoke during pregnancy are likely to continue smoking after pregnancy, we cannot distinguish between the effects of nicotine exposure *in utero* from maternal smoking later in the child's life. However, a large body of research shows negative associations between fetal nicotine exposure and child development and results from experimental animal studies suggest that these associations are at least partly causal (Slotkin 1998). Together our results suggest that fetal and infant conditions that have adverse effects on neurological and cognitive development can have the most adverse effects on educational outcomes.

We also analyzed whether our health variables are mediators between socioeconomic and demographic family background measures and educational attainment. This question has gained increasing interest following findings of negative effects of child health and social gradients in child health. Because different measures of socioeconomic status can have different effects on different health outcomes, we analyzed the mediating role of early health both for parental class and maternal education. Although we find that in general, early health conditions explain more of the relationship between maternal and filial education than between parental class and filial education, our health variables mostly explained a very small share of these associations. The main exception was the difference in filial educational attainment between farmers and the unskilled working class: in this case, prenatal and infant health explained 8 percent of the differences, still a small share. This result has implications for recent research that has increasingly been interested in the mediating role of childhood health in social mobility (Case and Paxson 2006; Palloni 2006; Palloni and Milesi 2006; Currie, forthcoming).

However, early health—and in particular, maternal smoking during pregnancy—explained 14 percent of the educational attainment differences between children born to unmarried compared to married mothers. While we acknowledge that the generalizability of this particular result is limited and likely to reflect the selected composition of unwed mothers in our sample, it does suggest that social differences in smoking during pregnancy can create intergenerational inequalities in educational and other outcomes (cf. Meara 2001). To the extent that the link between smoking during pregnancy and educational attainment is causal, the increasing social disparities in smoking (Graham 1996; Jarvis and Wardle 1999) may produce widening intergenerational inequalities.

Naturally, our study is not without limitations. First, we cannot control for unobserved factors. This can obviously bias our estimates and lead to misleading conclusions. Previous research that has used sibling or twin data has, for example, found that birth weight has a stronger effect when common genetic and environmental effects are taken into account (Conley and Bennett 2000; Rosenzweig and Behrman 2004). This may also explain why we do not find effects of low or heavy weight for gestational age (a better measure than low birth weight), contrary to previous findings.

Second, education may not be the socioeconomic outcome that is most affected by early health. Much research on the topic has looked at occupational outcomes or earnings. Early health may have effects on these outcomes that are independent of educational attainment. For example, childhood health can affect non-cognitive traits that affect labor market outcomes but not educational attainment (e.g. Palloni 2006; Palloni and Milesi 2006; Currie, forthcoming). Furthermore, if early health affects later health, which then affects labor market outcomes (Erikson, Bratsberg and Raaum 2005) but not educational attainment, the effects of prenatal and childhood health may be more important for labor market outcomes and these same factors may mediate more of the intergenerational associations between family background and labor market outcomes.

Despite these shortcomings, our study has implications for public health policies and future research. As to the former, our results show that maternal smoking during pregnancy (but also problems in neurological development) is not only a health issue, it can also have socioeconomic and social inequality implications. As for the latter, our results underline the importance of using clinically meaningful health variables that tap into proximate mechanisms that affect socioeconomic outcomes, whenever possible.

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Tables

Table 1. Descriptive data on the original non-imputed sample

	Mean / %	N cases
Health		
BMI of mother before pregnancy	23.1	7,872
Insufficient weight gain	39.1	7,592
Anemia during pregnancy (hemog. <110g/l)	17.3	7,286
Smoking during pregnancy	20.5	8,394
Hypertension: no (reference)	88.2	
Hypertension: chronic	2.0	
Hypertension: pregnancy induced	6.9	
Hypertension: preeclampsia	2.1	6,839
Visited prenatal clinic during 1st trimester	21.9	7,615
Depressed/very depressed	13.5	8,444
Preterm birth (<37 full gestational week)	4.7	8,334
Birth weight: small for gestational age	2.9	8,334
Birth weight: heavy for gestational age	1.0	8,334
Convulsions	1.2	7,854
Neurological impairment	1.4	7,847
Been in hospital	13.2	7,795
Chronic condition	7.0	7,823
Educational attainment: Compulsory (9 yrs.)	13.1	
Lower secondary, vocational (10-11 years)	31.0	
Higher secondary, high school (12 years)	19.1	
Lower tertiary	16.4	
Higher tertiary	10.3	8,610
Parental class: Unskilled working	18.2	
Farmer	18.4	
Skilled working (reference)	34.6	
Lower professional	20.0	
Higher professional	8.9	8,372
Marital status: unmarried	3.7	8,611
Mother's schooling: ≤ unfinished sec.	65.5	
Completed vocational	18.9	
Secondary (high school)	10.9	
University	4.9	8,491
Controls		
Female	52.2	8,625
Birth order	2.9	8,610
Age of mother	27.9	8,584
Unwanted pregnancy	24.3	8,440
Wanted later	11.7	8,440
Should be happy with conditions	15.0	8,193
Help wanted	9.1	8,193

Table 2. Ordered logit models for educational attainment using multiply imputed data

	Model 1		Model 2	
	b	s.e.	*b*	s.e.
Mother BMI before pregnancy	-0.041	0.006**	-0.012	0.007†
Anemia	-0.246	0.052**	-0.103	0.055†
Depressed/very depressed	-0.327	0.057**	-0.027	0.063
Smoking during pregnancy	-0.374	0.050**	-0.308	0.051**
Hypertension: no	Ref.		Ref.	
Hypertension: chronic	-0.100	0.138	-0.053	0.133
Hypertension: preg. induced	0.075	0.079	0.121	0.081
Hypertension: preeclampsia	0.101	0.153	0.041	0.146
Prenatal clinic visit, 1st trimester	0.220	0.051**	0.067	0.051
Inadequate weight gain	-0.136	0.043**	-0.057	0.043
Preterm birth	-0.234	0.097**	-0.109	0.097
Low weight for gestational age	0.104	0.118	-0.098	0.121
High weight for gestational age	-0.056	0.206	-0.109	0.212
Convulsions	-0.389	0.195*	-0.433	0.199*
Neurological impairment	-0.625	0.176**	-0.661	0.176**
Been in hospital	-0.042	0.062	0.031	0.062
Chronic condition	0.007	0.082	-0.003	0.087
Class background				
Unskilled working			Ref.	
Farmer			0.390	0.069**
Skilled working			0.410	0.059**
Lower professional			0.646	0.070**
Higher professional			1.115	0.097**
Mother's education				
Unfinished secondary or less			Ref.	
Completed vocational			0.390	0.053**
Secondary school (high school)			0.700	0.070**
Matriculation and above			1.263	0.112**
Family structure				
Married			Ref.	
Unmarried			-0.291	0.116**
Controls				
Girl			0.478	0.040**
Mother's age: ≤ 18 years			-0.278	0.125*
Mother's age: 19-25 years			Ref.	
Mother's age: 26-33 years			0.177	0.049**
Mother's age: ≥ 34 years			0.558	0.071**
Parity order			-0.155	0.013**
Attitude: hard work			Ref.	
Attitude: happy with conditions			-0.199	0.057**
Attitude: society should help			-0.066	0.070
Wanted pregnancy			Ref.	
Unwanted pregnancy			-0.139	0.050**
Pregnancy preferred later			-0.187	0.077*
Imputations	5		5	
Minimum observations	8625		8625	
Minimum dof	49.3		79.6	

** $p<0.001$, * $p<0.05$, † $p<0.1$

Table 3. Social gradients in prenatal and infant health, % unless otherwise mentioned

	Parental class					Mother's education				Marital status	
	Unskill. working	Farmer	Skilled working	Lower prof.	Higher prof.	≤ unfin. Second.	Comp. vocat.	Second.	Matric. +	Married	Not married
BMI (mean)	23.3	24.5	22.7	23.0	22.7	23.5	23.1	22.3	22.1	23.2	22.2**
Anemia	20.7	21.5	15.3	14.7	13.7**	18.6	15.3	12.8	12.7**	16.8	26.4**
Depressed	20.0	15.6	12.6	9.5	8.2**	15.4	11.1	8.5	7.0**	12.3	44.4**
Smoke pregnant	24.8	10.0	25.4	20.1	14.8**	22.0	16.9	21.6	14.4**	19.5	46.4**
Hypertension: chronic	2.8	5.4	2.5	2.7	1.4	3.6	2.3	1.2	1.9	3.1	(1.3)
Hypertension: pregnancy-induced	8.3	8.5	6.9	6.6	6.2	7.9	6.2	6.7	4.6	7.3	7.0
Hypertension: Preeclampsia	1.8	1.6	2.8	2.6	2.1**	2.0	2.9	3.4	1.9**	2.3	3.8†
First prenatal visit, 1st trimester	17.1	14.4	23.0	24.2	30.3**	19.5	22.8	26.3	28.2**	21.8	7.0**
Inad. weight gain	42.8	44.0	33.4	32.3	28.5**	38.6	35.0	29.0	29.5**	36.7	28.5**
Preterm birth	5.9	5.0	5.2	3.7	3.6*	5.5	3.8	3.9	2.9**	4.7	10.2**
Low weight for GA	3.5	2.5	3.1	2.3	1.9†	2.9	2.8	2.3	2.6	2.7	4.8*
Heavy weight for GA	1.5	1.3	0.7	0.7	(0.5)*	1.1	0.8	(0.7)	(0.2)	0.9	(1.6)
Convulsions	1.3	1.1	1.4	1.5	(1.0)	1.2	1.5	1.7	(0.7)	1.3	(1.9)
Neurological impairment	1.4	1.4	1.1	1.7	1.3	1.3	1.5	1.2	(1.7)	1.4	(1.3)
Been in hospital	15.3	13.5	13.4	13.4	10.2*	14.0	12.7	12.3	11.8	13.3	17.5*
Chronic condition	6.5	5.7	7.6	7.6	8.2†	7.1	6.2	8.5	8.2	7.2	4.4†

( ) Cell size < 10; ** p<0.001, * p<0.05, † p<0.1

Figure 1. Percentages of family background gradients in educational attainment explained by prenatal and infant health