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Birth Order and Child Health

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Birth Order and Child Health[1]

by

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Abstract

Previous research has shown that birth order affects outcomes such as educational achievements, IQ and earnings. The mechanisms behind these effects are, however, still largely unknown. In this paper, we examine birth-order effects on health, and whether health at young age could be a transmission channel for birth-order effects observed later in life. Our results show that firstborns have worse health at birth. This disadvantage is reversed in early age and later-born siblings are more likely to be hospitalized for injuries and avoidable conditions, which could be related to less parental attention. In adolescence and as young adults, younger siblings are more likely to be of poor mental health and to be admitted to hospital for alcohol induced health conditions. We also critically test for reverse causality by estimating fertility responses to the health of existing children. We conclude that the effects on health are not severely biased; however, the large negative birth-order effects on infant mortality are partly due to endogenous fertility responses. Overall our results suggest that birth order effects are due to differential parental investment because parents' time and resources are limited.

Keywords: Birth order, child health, parental behavior, endogenous fertility
JEL-codes: J13; J24; I12

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1 Introduction

Health status during childhood is an important predictor for outcomes later in life such as educational attainment, labor market outcomes and adult health.[4] Poor health is strongly correlated with socioeconomic background and is transmitted across generations, which may be due to persistent factors such as genetics, family investments or institutions.[5] However, long-term outcomes do not only differ systematically between families but also within families, holding many of these persistent factors constant. A vast number of studies in various research disciplines have shown that younger siblings have lower educational achievements, IQ and earnings than their older siblings.[6] The mechanisms behind these effects are still debated and previous empirical research has struggled to identify the channels. Our objective is to study how health develops through childhood and, by studying different sorts of health conditions, to shed some light on the mechanisms giving rise to the negative birth-order effect on later life outcomes.

What can we learn from studying birth-order effects? It can be difficult to think of policy implications of birth order since it is impossible to alter, and is not in the hands of policy makers. However, there is a random assignment of elementary abilities since, at conception, a child gets a half of each parent’s genes. This gene setup does not differ systematically between siblings and birth order and thus we can interpret the effects of birth order causally. In other words, differences by birth order should depend on pre- and postnatal influences rather than pre-determined conditions, which also opens up for policy interventions.[7] Learning about what is important in the family environment for children’s long-term outcomes is crucial beyond our understanding of birth-order effects.

[4] See, for example, Currie et al. (2010) and Case et al. (2005). Currie et al. (2010) compare Canadian siblings and find that the physical health status in early childhood is a strong predictor for young adult outcomes, mainly because it is a strong predictor for later health. Mental health problems, however, have an independent effect on future outcomes. Case et al. (2005) also find negative effects of poor childhood health on educational attainment, health and social status as an adult. For a review article on socioeconomic status and child health, see Currie (2009).

[5] See Smith (1999) for an overview of the health gradient and, for example, Lindahl et al. (2015) on the nature and nurture decomposition of mortality and health, and Mörk et al. (2014) on family background and child health.

[6] For example, Behrman and Taubman (1986) find birth-order effects on schooling and earnings among young US adults, Black et al. (2005) find birth-order effects on education, adult earnings, and teenage childbearing using a rich data set on the Norwegian population. Barclay (2015b) uses conscription data from Sweden and find birth-order effects on IQ and Black et al. (2015) find birth-order effects on personality traits

[7] The policy implications will depend on the findings. If the results show that it is investments and time alone with parents as young that are important, this could, for example, indicate that day care for older siblings is important while parents are on parental leave with the youngest child.

Previous evidence on child health and birth order shows that firstborn children are disadvantaged at birth with lower birth weight and worse health (see, for example, Brenoe and Molitor, 2015; Modin, 2002; Swamy et al., 2012). However, the health disadvantage of firstborn children seems to be reversed in adulthood. Later-born siblings have a higher mortality risk both in working age and older age (Modin, 2002; Barclay and Kolk, 2015). The research on birth-order effects on childhood health after birth is limited. Moreover, the existing studies use small samples and are unable to control for unobserved differences across families. Using data from the National Longitudinal Survey of Youth 1997, Argys et al. (2006) find that later-born siblings are more likely to engage in risky behavior such as smoking, drinking alcohol and marijuana usage. There is some evidence that later-born children in large families run a greater risk of experiencing accidents in early childhood (Nixon and Pearn, 1978; Bijur, Golding and Kurzon, 1988). A weakness with the studies of birth-order effects on experiences of accidents is that they do not control for family size and may thus suffer from selection problems since large families may be inherently different from smaller families. To avoid this issue, we use a large register dataset from Sweden and estimate the effect of birth order using a family-fixed effects specification. Thus, we identify the birth-order effects by comparing siblings within the same family, thereby controlling for family-level unobserved characteristics and observable characteristics such as family size.

Several hypotheses about the mechanisms through which the birth-order effect works have been suggested, including the resource dilution hypothesis (Blake, 1989), strategic parental behavior (Hotz and Pantano, 2015), sibling influences (Zajonc, 1976) and birth endowments. However, there is limited empirical evidence on which underlying mechanisms are most important for explaining the birth-order effects. By making use of our comprehensive data, which includes detailed information on medical diagnoses, we shed some light on the mechanisms behind the observed birth-order effects.

Our results lend support to the idea that firstborns are disadvantaged at birth for biological reasons. Firstborn children are more likely to be hospitalized for perinatal conditions and congenital malformations in early childhood. We also find that lower birth-order children are more likely to die during infancy. One possible explanation is that the womb becomes more effective at nurturing the fetus for each new pregnancy, in particular between the first and second pregnancy (Khong et al. 2003). The disadvantage of older siblings is, however, reversed as the child grows older. In adolescence, the second sibling is 14 percent more likely to be hospitalized and the third sibling is 20 percent more likely to be admitted to hospital, as compared to the firstborn child. The causes for hospitalization suggest that later-born siblings are involved in more risky behavior and have a less healthy life style during adolescence. In particular, later-born siblings are more likely to be admitted to hospital for diagnoses related to poor mental health, alcohol consumption, self-harm and injuries. Our results suggest that part of the explanation is that parents do not look after younger siblings to the same extent, perhaps due to time and other resource constraints since there are positive birth-order effects on injuries and avoidable conditions, which are conditions that should not be the cause for hospitalization if taken care of properly, for example diarrhea, anemia and asthma.

The gene-set up at conception across siblings is random, implying that by comparing siblings within the same family, we can estimate causal effects of birth order on health. However, if parents base subsequent fertility decisions on the health of already born children, the estimates may be biased. Negative associations between children’s outcomes and birth order could be an effect of endogenous fertility decisions if parents refrain from having more children when a particularly demanding child is born. This response is often referred to as optimal stopping. Studies on birth-order effects generally ignore this problem of possible reverse causality since it is difficult to identify random variation in the ‘quality’ of children that is observable by parents at an early age when fertility decisions are generally made. We test for this directly by studying whether early ill-health or death of born children affects the probability of having another child. Our results show that having an unhealthy child decreases the probability of having another child and if the family has another child, the spacing between the children increases. In contrast, if the child dies, it increases the probability that the parents have another child and decreases the spacing between pregnancies. This would imply that the sibling order of the last child born into the family is related to the health of already born children. To remedy this endogeneity problem, we remove the last born child in all families and re-estimate the effect of birth-order on health and mortality. Although the sample size is significantly smaller, the estimated effects of birth order on health remain very similar.

Re-estimating the birth-order effects on mortality on this sample reduces the original estimates on infant mortality by 30-40 percent. However, there is still a clear birth-order effect on infant mortality suggesting that lower birth-order children are disadvantaged at birth as compared to higher birth-order children.

Our results support the hypothesis that birth-order effects are due to lower investment in children with a higher birth order. Younger siblings are more likely to be hospitalized for avoidable conditions, injuries and risky behavior such as excess alcohol consumption. This is in line with the dilution hypothesis presented in Blake (1989) and the finding in Price (2008) that parents spend more time with earlier-born than later-born siblings. It could also be that the family environment changes with older siblings in the family and more time and attention is needed to achieve the same 'investment' in the child. The parents' endogenous fertility response to the health and death of previous children lends further support to the hypothesis that parents are resource constrained.

The rest of the paper is organized as follows. Section 2 reviews previous empirical research and suggested hypotheses explaining the differential outcomes of children with different birth order. In Section 3 we describe the empirical strategy and in Section 4 the data used in the study. We present the results on birth order and health in Section 5 and our findings on optimal stopping in Section 6. Section 7 investigates potential heterogeneity, and finally Section 8 concludes the paper.

2 Related literature and mechanisms

2.1 Health and birth order

Previous research has shown that firstborn children have worse health at birth than their later-born siblings. The causes of the better health status of later-born siblings at birth are investigated by Brenoe and Molitor (2015) using Danish registry data. They find that firstborns are disadvantaged at birth, measured by a number of different birth outcomes, as compared to later-born siblings and that this is unlikely to depend on the behavior of the mother. For example, they find that women are less likely to go to check-ups etc. for later-born siblings, which suggests that mothers take greater care during pregnancies with the firstborn child. Hence, the observed birth-order effects are not driven by the behavior of the mother and they conclude that there are biological differences depending on birth order, which could be caused by changes in the womb, as found by Khong et al. (2003).[8][9] However, these changes cannot explain the reverse birth-order pattern that is found on educational outcomes later in life. Rather, controlling for endowments at birth increases the birth-order effects on outcomes later in adulthood; this is also noted in Black et al. (2011).

Modin (2002) studies the mortality risk over the life cycle for a sample of individuals born in Sweden in 1915-1929. She shows that the mortality risk is u-shaped at infancy; it is highest for firstborn children and children with birth-order five and higher. At all other ages, she documents a positive correlation between birth order and mortality risk. However, Modin is not able to control for family size and to the extent that parents who have larger families are different, the correlation between birth order and health without controlling for family size may falsely attribute these differences to birth order. Barclay and Kolk (2015) find an increased risk of death and poor health in adulthood for higher birth-order siblings also when controlling for family size. Using Swedish registry data, they document a higher mortality risk between the ages 30 and 69 for individuals with a higher birth order, in particular for mortality due to cancers of the respiratory system and to external causes. Using Norwegian data, Black et al. (2015) study self-reported health and find birth-order effects in different directions depending on the type of health problem. They find that later-born siblings are more likely to smoke and have poorer self-reported physical and mental health in their 40's. Firstborns are, on the other hand, more likely to be overweight, obese and have high blood pressure. In contrast to the last result, Barclay and Myrskylä (2014) find, when studying the physical fitness among 18 year old men in Sweden, a monotonic negative effect of birth order which could suggest that later-born siblings take less care of their health.

As discussed in the introduction, less is known about birth order and health in childhood and adolescence. Previous studies tend to support the idea that higher birth-order siblings engage in more risky behavior such as smoking and that this behavior begins in early age. Argys et al. (2006) use data from the US (NLSY79) and study risky behavior such as smoking, drinking alcohol and marijuana usage at age 12-16. They find a positive correlation between this type of risky behavior and having an older

[8] Their results suggest that pregnancy results in permanent changes in the spiral arteries which play a vital role in supplying nutrients to the placenta and fetus. This could explain why the birth weight increases with parity, particularly between the first and second born.

[9] Studies of different mammals have shown that primiparous females are less successful in rearing a calf than females with earlier births. However, it is not clear whether there are biological reasons for this pattern or whether it is due to lack of rearing experience (see e.g Ibanze et al. 2013)

sibling. Another study finds that birth order affects delinquency behavior both among individuals in Florida and Denmark; Breining et al. (2017) show that second-born siblings have more disciplinary problems at school and are more likely to enter the criminal system than firstborns. Two small sample studies, which could not control for family size, have found that younger siblings are more likely to experience accidents (Bijur et al., 1988, Nixon and Pearn, 1978).

2.2 Mechanisms

Our study is also closely related to the literature studying the mechanisms behind the documented pattern that higher birth-order children have lower cognitive and non-cognitive skills, lower educational attainment and lower earnings. Theoretically, birth-order effects could emerge through several different channels. Broadly, we could divide these different channels into two categories: biological differences, and differences in the environment where the children grow up. The first category, which is related to health at birth, does not receive any support in the previous literature. As discussed earlier, firstborn children are more likely to have worse health at birth than their younger siblings, not better. The finding that the explanation is not biological is also supported by the evidence found in Barclay (2015a). He finds that the effects of the sibling order of adopted children are associated with differences in educational attainment. Compared to results from families with biological children, he finds that the birth-order effects are slightly stronger in families with adopted children. This strongly indicates that the birth-order effects are driven by intra-family social dynamics rather than by biological differences.

The post-birth differences in family environment could be due to many factors such as, for example, parental time and investment and changes in the family environment due to the presence of children of different ages. The dilution hypothesis (Blake, 1989), which could be traced back to Becker and Tomes' (1976) influential article on the quantity and quality of children, argues that birth-order effects could be explained by parental time and financial constraints. The firstborn child will not have to share parental time with any siblings, at least not during the first period in life. Since parental time is limited, eventual consecutive children will get less parental quality time during the first years. However, related to this, parents might become better parents over time which could possibly mitigate the parental dilution effect or even reverse the total effect. Using US data on time usage, Price (2008) finds that parents do, on average, spend an equal amount of time with each child at every point in time. Thus, aggregating over the whole childhood, parents spend less time with each additional child. The differences are especially large between first and later-born siblings in the time spent with their parents in early childhood.[10] A recent study by Black et al. (2016) estimates the effect of parental resources by studying the effect of having a disabled sibling and concludes that the negative sibling spillover is partly due to lower parental time exposure and financial resources. A couple of studies have tried to test whether earlier birth-order differences in investments can explain later outcomes. Monfardini and See (2012) find that the relationship between birth order and education remains significant and negative even when controlling for maternity time with the child. Lehmann et al. (2016) explore in utero and early childhood investments in health, education and maternal emotion/verbal responsiveness during the child's first year. However, controlling for variations in early childhood factors, the birth-order effects are robust. Using data from the National Longitudinal Survey of Youth, Children and Young Adults (NLSY-C) 1979 in a structural framework, Pavan (2015) finds that the differences in parental investments account for more than one-half of the gap in cognitive skills among siblings. A somewhat different mechanism is explored in Hotz and Pantano (2015). In a model of strategic parenting, they find that it may be optimal for parents to be stricter with earlier-born children. Using the NLSY-C, they find some support for their model as earlier-born children are subject to more rules and monitoring by parents than later-born children. That first-borns are supervised more than their siblings is also found by Avrett et al. (2011). In an evolutionary perspective, it may be beneficial to invest in a child with higher potential returns. Stanton et al. (2014) find when studying maternal investment among chimpanzees that primiparous mothers invest more in their infant than multiparous mothers. However, since firstborns have worse health at birth, the investment in firstborns appears to be compensatory since the probability of survival did not differ by birth order.

Related to the dilution hypothesis is the confluence model with the idea that the intellectual development of a child depends on the average intellectual environment

[10] Price does not have siblings in his data, instead he uses a matching strategy to compare a firstborn child to a second-born child. He does not have any information on completed fertility and the time use data is only for one parent.

which can be considered as the average of all members in the family (Zajonc, 1976). When the first child is born, the intellectual environment is relatively high, but it will decrease quickly as the family grows since intellectual growth is a function of age. Zajonc (1976) also finds support for the no one to teach hypothesis, stating that the youngest child (and an only child) will not get the chance to teach younger siblings, which could be important for learning. The idea that older siblings in the family change the family environment, which has detrimental effects on later-born children, may also be applicable to the health outcomes studied in this paper. Older siblings may create a more hazardous family environment by introducing toys or activities which are suitable for older children. Another plausible mechanism is that later-born children are, on average, more exposed to family disruptions such as divorces, or experience the loss of a parent at younger ages. Family disruptions could have a negative effect on educational attainment. Björklund et al. (2007) observe this negative relationship between parental separation and children's educational attainment using both Swedish and US data. However, performing a sibling-difference estimation, this relationship is no longer significant, indicating that the negative relationship is due to selection rather than causation.

As discussed in the introduction, the birth-order pattern may also be explained by parents' fertility decisions; if parents have a child who is difficult to rear, this might influence their decision not to have another child and give rise to a non-causal correlation between birth order and child outcomes. Pavan (2015) uses a structural approach and estimates an achievement production function which accounts for selection bias due to endogenous fertility decisions of mothers. Using US data from the National Longitudinal Survey of Youth, Children and Young Adults, he finds that optimal stopping, where parents stop having children after getting a difficult child, cannot explain the birth-order effects.

3 Empirical strategy

To estimate causal effects of birth order on health, we would like to have a random assignment of birth order. This is in fact the case within families, since a child receives a random half of each parent’s genes at conception. Thus, by controlling for family fixed effects and, thereby, exploiting only the variation in health between siblings, we will capture the prenatal and postnatal birth-order effects on health.[11] However, since there are trends in our health measures over time, we also need to control for birth cohorts. This creates an unbalance in family background by birth order because higher birth-order children in a cohort do, on average, have older mothers and mothers with larger families have their first child at a younger age. This may bias the estimated effect of birth order. To reduce the bias, we control for the mother's age at birth. As a consequence, we are identifying the effect of birth-order from unequal spacing of children. If unequal spacing is due to some other family characteristics, the estimate may still be biased.[12] More specifically, we will estimate the effect of birth-order on children's health using the following model:

$$H_{if} = \alpha + \sum_{b=2}^{k} \beta_b \, (Birth\ Order)_{if} + \gamma X_i + \delta_f + \varepsilon_{if},$$

where *H* is health status, *i* denotes the individual child and *f* denotes family. β_b captures the birth-order effect (where k = 2, 3, 4 or >4 is the birth order) relative to the firstborn child. We control for other individual-specific characteristics in X_i, including mother's age at birth (third-order polynomial), father's characteristics and indicators for the child's sex and birth cohort. δ_f are family fixed effects capturing all time-invariant characteristics of the family.[13] The child's birth order is set by the number of births of the mother.[14]

By including a fixed family effect, we are identifying the effect of birth order on families where at least one child has been sick or, in the case when we are studying mortality, on families where at least one child has died. A concern may be that families with a sick or dead child are different from other families, implying that the results are not generalizable to the whole population. This may be a problem, especially for very rare events such as child mortality. We will discuss this issue when presenting the results on mortality and investigate the question of heterogenous effects in Section 7.

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[11] This is true for siblings with the same mother and father. For siblings with different fathers there will could be birth order effects in gene-composition if there the fathers of later born siblings are systematically different from fathers of later born siblings.

[12] See Black et al. 2015 for a further discussion of the empirical challenges when estimating birth-order effects.

[13] Appendices A1 and A4 display the results from estimations of the model with and without family fixed effects and separately for each parity. In specifications without family- fixed effects, we add control variables for: mother's age at first birth, family size, birth cohort of the mother, and the mother's educational attainment.

[14] In our definition, siblings have the same mother but may have different fathers.

A potential threat to the identification when studying birth-order effects is that the effects may be due to reverse causality, i.e., in our setting, this implies that the child's health affects parents' fertility decision. A negative (positive) health effect of birth order may arise if parents stop having children after a particularly unhealthy (healthy) child. For example, suppose that an unhealthy child requires more time from time constrained parents. In that case, families with an unhealthy child will postpone or perhaps even refrain from having another child, thus giving rise to negative birth-order effects on health. In the extreme case, the child may be of such poor health that it dies. In that case, parents are not time constrained and may decide to have another child which may give rise to a pattern where higher birth-order children are less likely to die. Van den Berg et al. (2016) study the impact of child deaths due to unintentional accidents on parental outcomes and find an increased probability that mothers have another child two to four years after the death of the child. Thus, endogenous fertility decisions may give rise to spurious negative birth-order effects if the child is unhealthy and positive birth-order effects if the child dies.

These hypotheses are difficult to test since the health status of a child is to large extent associated with parental characteristics. Although there is some randomness to the health status of the child, it is difficult to think of any exogenous factor – unrelated to parental characteristics and other factors determining preferences for family size – which affects the child's health that we can use to estimate the causal effects of the child health of previous children on family size. Instead, we make use of our rich data with detailed information on parental background characteristics and study whether the probability of having another child is affected by the initial health status of previous children when controlling for a battery of parental characteristics and characteristics of already born children. Thus, we estimate the following model:

$$P(another\ child)_f = \alpha + \sum_{b=1}^{3} \beta_b Health_{if} + \sum_{b=1}^{3} \mu_b \boldsymbol{Z}_{if} + \gamma \boldsymbol{X}_f + \varepsilon_f,$$

where f denotes family and i individual child. $Health_{if}$ is the health status of already born children, β_b captures the effect of the health of the firstborn, second-born and third-born child. **Z** includes indicators of sex and cohort year of the born children, **X** includes family-specific factors which might affect the probability of having another child (educational attainment, mother's age at first birth (third-order polynomial), both parents birth cohorts, the residential region of the parents the year before first birth, whether any of them have a foreign background and their incomes before the first birth) and ε_f is the error term. The model is estimated separately for the decision to have one or more children, two or more children, three or more children and four or more children. When studying the decision to have one or more children, we include all families with one or more children and estimate the effect of the health status of the first child at age 0–2 on having another child. For the decision to have two or more children, we estimate the effect of the health status of the first child at age 0–4 and the second child at age 0–2 on the probability of having another child in the population of families with two or more children. Finally, we estimate the effect of the health status of the first child at age 0–6, the second born at age 0–4 and the health status of the third child at age 0–2 on the probability of having four or more children on the population of families with three or more children. The idea is to analyze whether parents base their decision to have another child on whether they had a previous "bad draw" or a previous "good draw". To capture the health status, which should be of relevance for subsequent fertility decisions, we measure the health of the youngest child at age 0–2, the health of the second youngest at age 0–4 and the health of the oldest child at age 0–6, assuming there to be about two years between each sibling.[15] If there is a correlation between the error term and the health of the previous child, the estimated β will be biased. Thus, the identification of the effect hinges on whether we manage to control for all factors which affect both the probability of having another child and the health of previous children.

4 Data

Our data set merges information from several administrative registers covering the universe of all children born in Sweden 1968-2005. Children and parents are linked through the *Multigenerational Register* which includes information on family relations starting in 1932. To this, we add information from different administrative registers to follow children from birth to age 24 and their parents. Health status will be measured with administrative register data on hospitalization and mortality. Data on hospitalization comes from the *Swedish National Inpatient Register* which contains

[15] In our sample, the median spacing between the first and the second child is 29 months, between the second and the third 39 months and between the third and the fourth 34 months.

information on hospital admissions 1987–2011. It includes administrative information on the date of admission, the number of days in hospital, and discharge diagnosis classified according to the International Classification of Diseases (ICD). Information on mortality comes from the *National Cause of Death Register* which contains the date of death and the main underlying cause of death coded according to ICD. Information on parental characteristics comes from the *Longitudinal Integration Database for Health Insurance and Labour Market Studies (LISA)* which integrates data from population, tax, and social insurance registers.

4.1 Health measures

Health is measured by hospital admissions and mortality observed in the registry data. A benefit of using register data is that it covers the whole population and thus, does not suffer from non-representativeness, which is often a problem in surveys when participation is voluntary. The first measure that we use is an indicator of whether the child has been admitted to hospital. The potential problem with using hospitalizations as a measure of health is that it might capture health consumption rather than the underlying health status. This should be a minor problem in our setting for three reasons. First, as all individuals in Sweden are covered by the public health care insurance and healthcare is free of charge for children, family financial resources do not directly affect the usage of the health care system.[16] Second, it is unlikely that admittance to hospital is determined by parental preferences since patients are only allowed to stay overnight in hospital if the medical staff consider it necessary. As shown by Appendix A3, the birth-order effects that we observed are confirmed when studying longer hospital stays; thus, it is unlikely that our estimates are influenced by the parents' preferences for hospital care. Third, since we compare siblings within a family, we are controlling for all in-variant family factors which affect the health care consumption of all children in the family, such as the parents' inclination to consume healthcare and the average health status among the children. Our second health measure is mortality. The benefit of studying mortality as a health outcome is that it is an objective and unambiguous measure. However, studying mortality among young individuals might be less informative, since death is a very rare event in childhood (especially after infancy)

[16] In-patient care is free for children up to age 18. At ages 19–24, the fee varies across counties. In some counties, in-patient care is free up to the age of 24 but most counties charge a fee ranging from 80 to 100 SEK (8–10 Euros) per night after the age of 20.

and therefore captures very little health disparities. Here, we study the association between birth order and mortality in infancy and up to age 24.[17]

Figure 1 shows infant mortality rates and Figure 2 hospitalization rates for different age categories. The figures show a downward trend in adverse health events among young children. Infant mortality has decreased during the whole period as well as hospitalizations among the younger age categories. For the older age categorizes, hospitalization rates have been rather stable over the period 1987–2011. It is clear from these pictures that there are strong time trends in our measures of health and it is important to take the trends into account. There are also large differences between age categories. The youngest (age 0–6) and the oldest (age 19–24) are most likely to be admitted to hospital.[18] The least likely to end up in hospital are children 7–12 years old.

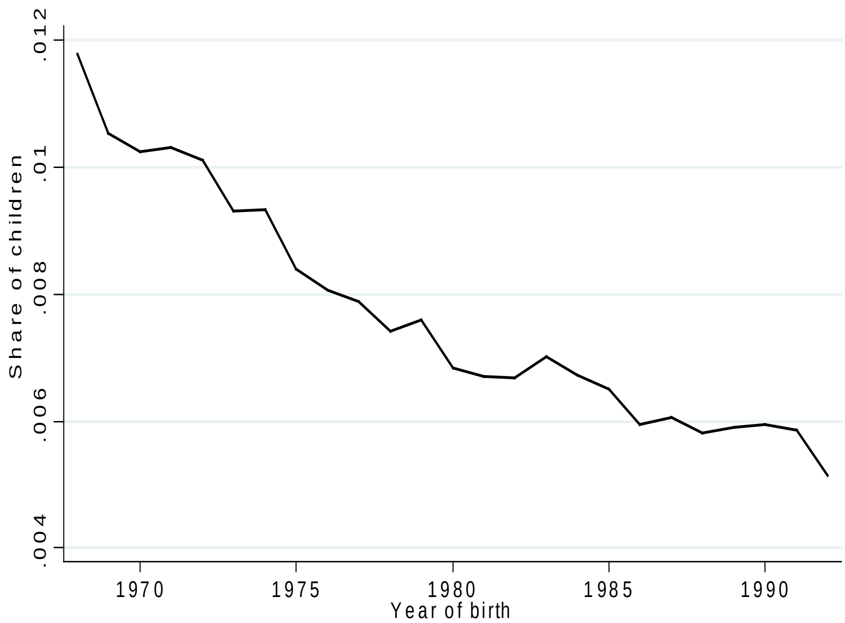

Figure 1 Infant mortality, year 1968-1992[19]

[17] The regulations regarding how to categorize children that die during pregnancy or at birth have not changed over the time period covered in this study. A child should be registered at the Swedish Tax Agency if he or she was born in Sweden or has a mother that is registered as a Swedish resident. All live births, and in utero deaths beyond week 28 of gestation, are defined as children. If gestation is unknown, the child should be at least 35 centimeters. In utero deaths decreased over the years 1973–1985, but have since then been constant at 3–4 deaths per 1,000 births. The regulations changed in 2008 (cohorts born after 2005 are not included in our study) to 22 weeks of gestation (Socialstyrelsen, 2009).
[18] The time series for age 0–6 stops in 2009 because the cohort born 2009 is the youngest cohort in the data.
[19] We lack data on those individuals that died in the same year as they were born after year 1992.

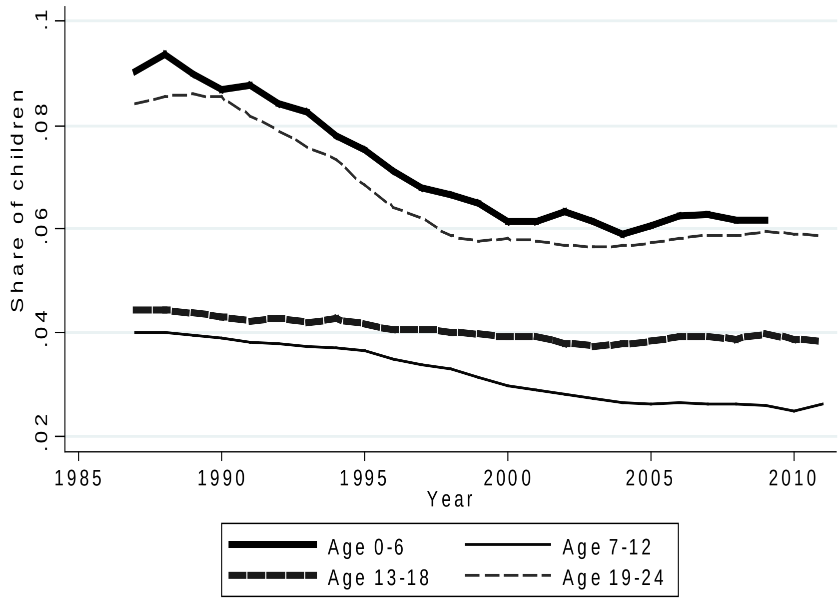

Figure 2 Hospitalization by age category, year 1987–2011

Our objective is to study how health develops through childhood and, by studying different sorts of health problems, to shed some light on the mechanisms leading to the negative birth-order effect on later life outcomes. As general measures of health we study whether a child has been admitted to in-patient care. To measure health at birth, we study in-patient care in early childhood (age 0–6) for diagnoses related to congenital malformations and perinatal conditions which originate from conditions in utero or at birth. It is not straightforward to define causes for hospitalization due to parental behavior during childhood. We will primarily focus on two measures: Our first measure is in-patient care due to injuries and being poisoned. The motivation is that hospitalization for injuries and poison in early childhood should be related to how closely the child is looked after. Our second measure is in-patient care for 'avoidable' conditions. These are conditions that would not have been a cause for hospitalization if the child had had access to timely and effective primary care.[20] This measure is commonly used as an indicator of the quality of, or access to, primary care, but a higher

[20] Avoidable conditions, or as also called in the literature, ambulatory care-sensitive conditions, include conditions where appropriate primary care may prevent the onset of, control an acute episode of, or manage a chronic condition or illness. Avoidable conditions can be divided into three categories: conditions that can be prevented through vaccination; selected chronic conditions that can be managed by pharmaceuticals, patient education and lifestyle; acute conditions for which hospitalization is commonly avoidable with antibiotics or other medical intervention. The concept is frequently used when evaluating the quality of primary care as well as in research. For example, Billings et al. (1993) study the association between socioeconomic status and hospitalization rates due to avoidable conditions among communities in the US. We use the definition for children suggested by the Public Health Information Development Unit in Australia which is based on a comprehensive review of the literature (Page et al. 2007). A complete list of the diagnoses can be found in Appendix Table A 7.

incidence of hospitalization due to avoidable health conditions could also be due to parents not seeking care in time.[21] Avoidable hospitalization includes conditions such as anemia, asthma, diabetes and chronic obstructive pulmonary disease.

We also study in-patient care related to diseases of the respiratory system since previous research has shown that diseases of the respiratory system are related to later in life outcomes such as school performance and labor market success (Case et al., 2005), and it is also the most common cause for hospitalization in early childhood. As the child grows older, both the family environment and the child's own behavior will affect the causes for being admitted to hospital. To investigate when potential health differences between siblings appear, we study the age intervals 0–6, 7–12, 13–18 and 19–24. For adolescents and young adults, we study in-patient care for injuries and poisoning, self-harm, mental health conditions and conditions caused by excess consumption of alcohol. As a test that there is nothing inherently different between younger and older siblings, we study in-patient care due to cancer since cancer among children and adolescents can be considered to be random and not affected by parental or child behavior.[22] A shortcoming with using cancer as a test of our identification strategy is that it is a rare condition among children.[23]

4.2 Sample restrictions

Our main sample consists of children who were born in 1968–2005 and who have parents that we observe in the data. Since our outcome measures are limited to certain years, we cannot observe all children at every age. Hospitalization measures are observed for 1987–2011 and information about which particular cohorts are included when studying health at certain ages is displayed in Table 2.[24] We exclude families with only one child since we cannot estimate birth-order effects within families for these children. We also exclude families with multiple births (twins, triplets etc.), since their circumstances differ compared to siblings born as singleton births. For example, the pre-natal circumstances are likely to differ and earlier born siblings do not have any

[21] The last point being closest to what we study as we are using family fixed effects. Access to health care (in terms of distance, family connections etc) and quality of primary care should be the same for all siblings within a family.
[22] In contrast to cancer among adults, research has shown that most childhood cancers do not have any outside causes. There is a genetic component for some types of childhood cancer but as the genetic set-up among siblings is random, this should not give rise to any birth-order effects. See the discussion of the causes of childhood cancer on the American Cancer Society' webpage. http://www.cancer.org.
[23] See Appendix Table A 7 for a complete list of all ICD-codes included in each condition category.
[24] Grades at 9th grade (age 16) are observed for cohorts born 1972–1994.

time alone with the parents. Furthermore, we make the restriction that all children must have been born in Sweden to limit the risk that the children have experienced very different circumstances in the first years of life. For the same reason, we exclude families that have adopted a child, or given a child up for adoption. Lastly, in our main sample, we have complete families, meaning that we restrict our sample to families with completed fertility, imposing the restriction that mothers are at least 45 years old in 2009.[25]

4.3 Summary statistics

The demographic characteristics of our sample are displayed in Table1. Families in our sample, which consist of families with two, three, four or more children do, on average, have 2.8 children. Children were, on average, born in 1982, their mothers were born in 1953 and their fathers were almost three years older than their mothers. Mothers have on average slightly higher education than fathers.

[25] 2009 is the year in which our sample is drawn from the Multigenerational register. The Multigenerational register is continuously updated by Statistic Sweden and the variables birth order and number of children are collected, and created, within the register. Since the register has a very good coverage from 1932 onwards, we can be confident that we are capturing all siblings at the beginning of our sample period but additional restrictions have to be made regarding mother's age to be confident that we have complete families also at the end of the period.

Table 1 Demographic variables

	Mean	SD
Number of children	2.810	(1.031)
Birth order 1	0.373	(0.484)
Birth order 2	0.396	(0.489)
Birth order 3	0.166	(0.372)
Birth order 4	0.046	(0.209)
Birth order >=5	0.019	(0.137)
Female	0.485	(0.500)
Year of birth, child	1981.833	(8.204)
Month of birth, child	6.234	(3.366)
Year of birth, mother	1953.331	(6.878)
Year of birth, father	1950.727	(7.753)
Years of education, mother	12.069	(2.408)
Years of education, father	11.731	(2.586)
Obs.	2106531	

Table 2 shows that hospitalization is most common among the youngest children (aged 0–6): about 37 percent have been admitted to hospital at least once. The lowest admission rates are found among children aged 7–12, thereafter the rates are increasing with age. Table 2 also displays which diagnoses that are most common by age category and will guide us in deciding which outcomes to study at what age. Hospitalizations related to perinatal and congenital malformations are by far most common among the youngest children. Almost all cases occur within the first year of life, 7.9 percent of all 0–1 year olds are admitted to hospital with this diagnosis. In contrast, hospitalization for mental health conditions and conditions related to self-harm and alcohol are most common in adolescence and among young adults.

Table 2 Hospitalizations and medical conditions by age, standard deviations in parenthesis

	Age 0–6	Age 7–12	Age 13–18	Age 19–24
Hospitalization	0.368	0.164	0.188	0.199
	(0.482)	(0.370)	(0.391)	(0.400)
Perinatal & Congenital malformation	0.087	0.011	0.007	0.005
	(0.282)	(0.104)	(0.084)	(0.069)
Respiratory & Eye/Ear	0.150	0.037	0.032	0.029
	(0.357)	(0.190)	(0.176)	(0.168)
Injury and poison	0.058	0.049	0.065	0.062
	(0.233)	(0.216)	(0.247)	(0.240)
Avoidable conditions	0.072	0.015	0.015	0.015
	(0.258)	(0.121)	(0.121)	(0.121)
Mental health	0.006	0.004	0.020	0.024
	(0.078)	(0.063)	(0.141)	(0.153)
Self-harm	0.000	0.000	0.006	0.008
	(0.021)	(0.015)	(0.080)	(0.090)
Alcohol	0.000	0.000	0.011	0.008
	(0.020)	(0.014)	(0.105)	(0.091)
Cancer	0.004	0.003	0.004	0.005
	(0.062)	(0.054)	(0.062)	(0.069)
Obs.	644,589	1,155,264	1,474,603	1,463,458

5 The effect of birth order on health

In this section, we present the results from the first model where birth order is modeled to affect health. First, we present the results on the probability of being admitted to hospital and for the different diagnoses discussed in Section 4.

5.1 Hospitalization

Table 3 and Table 4 present the results of regressing health measured as hospitalization for different diagnoses on birth order, family-fixed effects, and a set of additional controls, which are discussed in Section 3. Table 3 contains the results for children aged 0–6. Column (1) displays the results for ever being hospitalized for any condition. The risk decreases by 1.3 percentage points (3.5 percent) for the second-born child and by 1.5 percentage points (4.1 percent) for the third-born child relative to the firstborn child. No statistically significant difference is found for children with a higher birth order. Columns (2) – (5) report the results for the diagnoses discussed in the previous section, and a clearer pattern emerges across diagnoses. A strong negative effect of being firstborn is found on perinatal conditions and the risk of being born with congenital malformations. Second-born children are 4.1 percentage points less likely to be hospitalized, which corresponds to a 47 percent reduction given the mean of 8.7 percent. For the remaining conditions, there is a positive relationship between birth order and being admitted to hospital. These effects are also increasing over birth order. For conditions related to the respiratory system and eyes and ears, which is the most common diagnoses category, 15 percent of all children aged 0–6 in our sample have been hospitalized for any of these conditions and the risk is 2.4 percentage points (16 percent) higher among second-born children than among their older sibling. The effect is twice as large for a sibling order higher than 4. Second-born children are 1 percentage point more likely to end up in hospital for conditions related to injuries and siblings with birth order 5 or higher are 2.5 percentage points more likely, which corresponds to 17 and 43 percent, respectively. For avoidable conditions, the effects range from 0.9 to 2.3 percentage points (16 and 40 percent). For cancer, which is rare in this age category, we find no birth-order effects.

To see how the effects on different conditions develop, we estimate the birth-order effects as infants (age 0–1) and at age 0–3. The results presented in Appendix Table A 2 show that the effect on perinatal conditions is apparent among infants whereas the birth-order effect on admittance to hospital for injuries appears later. This pattern is expected as perinatal conditions are due to conditions before or at birth and injuries are due to factors in the family environment after birth.

In Panel B, the results for children aged 7–12 are displayed. No birth-order effect is present for all-cause hospitalization or for perinatal conditions and congenital malformations. However, an interesting pattern is present in column (3), showing that children with a higher birth order have a lower probability of being hospitalized than their older siblings for conditions related to the respiratory system and eyes and ears. These conditions might be caused by infections transmitted from younger siblings since they are most prevalent among young children, a child aged 0–6 is almost five times as likely to be hospitalized for these conditions as compared to children aged 7–12. Thus, lower-parity siblings with younger siblings are more likely to be exposed to infections when they are 7–12 years old than later-born siblings who will not have any small children in the household when they are in the same ages. The birth-order effect for injuries is positive and only slightly smaller than what is found at age 0–6, second-born children are 12 percent more likely to be injured and fourth-born children have a 29 percent higher risk as compared to their oldest sibling. The results for avoidable conditions reveal a weak negative and mainly statistically insignificant relation, and the birth-order effects on cancer are zero also in this age category.

In sum, the overall risk of being admitted to hospital across birth order is somewhat lower for second- and third-born children than for firstborns in the youngest age category. However, the overall admission rates conceal underlying systematic differences across birth order in health. Inspecting the effects on the probability of receiving different conditions, our results show that younger siblings have better health at birth compared to firstborn children. Later-born siblings are, however, more likely to be hospitalized for other conditions that could be related to parental investments and the family environment.

Table 3 Birth-order effects on hospitalization and diagnoses for age categories 0–6 and 7–12

	(1) Hospitalization	(2) Perinatal & congenital mal.	(3) Respiratory & eye/ear	(4) Injury and poisoning	(5) Avoidable diagnoses	(6) Cancer
Panel A: Age 0–6						
Birth order 2	-0.013***	-0.041***	0.024***	0.010***	0.009***	-0.001
	(0.004)	(0.002)	(0.003)	(0.002)	(0.002)	(0.000)
Birth order 3	-0.015**	-0.047***	0.034***	0.016***	0.016***	-0.001
	(0.007)	(0.004)	(0.005)	(0.004)	(0.004)	(0.001)
Birth order 4	-0.007	-0.047***	0.043***	0.018***	0.023***	-0.002
	(0.010)	(0.006)	(0.008)	(0.005)	(0.006)	(0.001)
Birth order >4	0.003	-0.043***	0.052***	0.025***	0.023***	-0.001
	(0.015)	(0.009)	(0.011)	(0.008)	(0.008)	(0.002)
Obs.	644,589	644,589	644,589	644,589	644,589	644,589
R-sq.	0.618	0.608	0.615	0.572	0.597	0.573
Mean	0.368	0.087	0.150	0.058	0.072	0.004
N clusters	360,806	360,806	360,806	360,806	360,806	360,806
Panel B: Age 7–12						
Birth order 2	0.001	-0.001	-0.005***	0.006***	-0.001**	-0.000
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
Birth order 3	0.001	-0.000	-0.008***	0.010***	-0.002	-0.000
	(0.003)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Birth order 4	0.001	-0.000	-0.009***	0.014***	-0.002	-0.000
	(0.005)	(0.002)	(0.003)	(0.003)	(0.002)	(0.001)
Birth order >4	-0.002	0.000	-0.011***	0.012**	-0.003	0.001
	(0.008)	(0.002)	(0.004)	(0.005)	(0.003)	(0.001)
Obs.	1,155,264	1,155,264	1,155,264	1,155,264	1,155,264	1,155,264
R-sq.	0.534	0.522	0.530	0.509	0.526	0.509
Mean	0.164	0.011	0.037	0.049	0.015	0.003
N clusters	578,318	578,318	578,318	578,318	578,318	578,318

Notes: Results from linear probability models with family fixed effects. The omitted category is firstborn child. Standard errors are clustered by family. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression and all regressions include controls for mother's age at birth, and indicators for child's birth cohort and gender. For siblings with different fathers, indicators for father's cohort and educational attainment are included.

Table 4, Panel A, shows the effect of sibling order on hospitalization and diagnoses for children aged 13–18. Across all outcomes, we find strong, positive birth-order effects. The risk of being hospitalized for any condition is 9 percent higher for second-born children as compared to firstborn, and the risk increases over birth order and is 21 percent higher for fifth- or higher order born siblings. Focusing on mental ill-health, and conditions related to self-harm and alcohol consumption, we find monotonically increasing effects of birth order. The size of these effects ranges from 15 percent for mental health for second-born children to 77 percent for diagnoses related to self-harm for fifth or higher birth-order born children. If we relate these effects to the socioeconomic gradient in hospitalization, we find that the effects are sizeable; Mörk et al. (2014) show that children with parents with incomes in the lowest percentile are 40 percent more likely to end up in hospital than children from families with the highest incomes, for injuries the gradient is 33 percent and for mental health conditions about 70 percent. The effect on cancer is again zero in adolescence and young adulthood, indicating that this condition affects children of different birth-order with equal likelihood.

A very similar pattern is found in Panel B which displays the results for young adults aged 19–24; however, the birth-order pattern for mental health and conditions related to self-harm is significantly less pronounced. Since there are strong effects on alcohol related conditions, it is possible that some of the other outcomes are related to alcohol consumption. In particular injuries, poor mental health and self-harm might be correlated with conditions related to alcohol. In the Appendix, Table A 4, we test this by deducting any hospital stay related to these conditions if the same individual has also been hospitalized for conditions related to alcohol in the same age span. We find a lower effect on hospitalization for mental health conditions suggesting a connection between mental health and alcohol problems and self-harm and alcohol problems for the older age category. The other results remain the same.

The results by family size, with and without family fixed effects, are reported in the Appendix, Table A 1. Overall, the findings that we report are rather robust across specifications. The birth-order effects, from the estimation with fixed family effects, do not seem to vary with parity, implying that we can pool all families regardless of size. In specifications without family fixed effects, there is a clear negative birth-order effect on hospitalization for the youngest ages which is not robust to the inclusion of a family fixed effect (see the results in Table A 1, panel A and B). The reference category is always the firstborn child.

Table 4 Birth-order effects on hospitalization and diagnoses for age categories 13–18 and 19–21

	(1) Hospital-ization	(2) Resp eye/ear	(3) Injury & poisoning	(4) Avoid-able	(5) Mental health	(6) Self-harm	(7) Alcohol	(8) Cancer
Panel A: Age 13–18								
Birth order 2	0.017***	0.005***	0.007***	0.002***	0.003***	0.002***	0.004***	0.000
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
Birth order 3	0.025***	0.008***	0.010***	0.004***	0.005***	0.002***	0.005***	0.000
	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Birth order 4	0.035***	0.011***	0.017***	0.005***	0.007***	0.004***	0.008***	0.000
	(0.005)	(0.002)	(0.003)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
Birth order >4	0.040***	0.008**	0.012**	0.006**	0.011***	0.005**	0.008***	0.001
	(0.008)	(0.004)	(0.005)	(0.002)	(0.003)	(0.002)	(0.002)	(0.001)
Obs.	1,474,603	1,474,603	1,474,603	1,474,603	1,474,603	1,474,603	1,474,603	1,474,603
R-sq	0.525	0.512	0.508	0.519	0.500	0.485	0.487	0.510
Mean	0.188	0.032	0.065	0.015	0.020	0.006	0.011	0.004
N clusters	737,256	737,256	737,256	737,256	737,256	737,256	737,256	737,256
Panel B: Age 19–21								
Birth order 2	0.017***	0.003***	0.007***	0.002***	0.001	0.001**	0.001***	0.000
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
Birth order 3	0.026***	0.005***	0.009***	0.003***	0.000	0.001	0.002**	0.000
	(0.003)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Birth order 4	0.031***	0.006**	0.011***	0.004**	0.003	0.002	0.003*	0.001
	(0.006)	(0.002)	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Birth order >4	0.028***	0.007*	0.012**	0.006**	0.000	-0.000	0.003	0.001
	(0.009)	(0.004)	(0.005)	(0.003)	(0.004)	(0.002)	(0.002)	(0.001)
Obs.	1463458	1463458	1463458	1463458	1463458	1463458	1463458	1463458
R-sq.	.5054218	.4896683	.493885	.4827051	.5132974	.4930366	.4950307	.4850051
Mean	.1993791	.0289868	.0615337	.0147753	.023903	.0082305	.0083829	.0047907
N clusters	709,654	709,654	709,654	709,654	709,654	709,654	709,654	709,654

Notes: Results from linear probability models with family fixed effects. The omitted category is firstborn child. Standard errors are clustered by family. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression and all regressions include controls for mother's age at birth, and indicators for child's birth cohort and gender. For siblings with different fathers, indicators for father's cohort and educational attainment are included.

5.2 Mortality

Next, we study the association between birth order and mortality at different ages. The results presented in Table 3 and Table 4 showed that firstborn children are more likely to be hospitalized for conditions originating in utero or at birth, whereas later-born children are more likely to be hospitalized in adolescence and as young adults. The results for mortality in Table 5 show a similar pattern. The results in the first column show that firstborn children are more likely to die before the age of one than later-born siblings and the effect is large relative to the average mortality rate: the second-born child has a 0.11 percentage point lower probability of dying and the third child a 0.33 percentage point lower probability as compared to the firstborn child. In contrast to the previous results on hospitalization due to perinatal conditions and congenital malformations, the mortality risk decreases monotonically with birth order.

Compared to the mean mortality rates in the population, the effects of birth order are huge. The large effect is partly due to the low incidence since a small number of deaths constitute a large change in the share of dead. The number of observations in the analytical sample, with a dead child in the family, when estimating the effect of birth order on infant mortality is only 32,000. The mean mortality rate in this sample is, of course, much higher, 0.33, than in the total population. If we instead post the question, how much lower is the likelihood of a second born dying as an infant as compared to a firstborn in the population of families with at least one dead child, the effect is 3.3 percent. In Section 7, we will have a closer look at whether families with at least one dead child are different in terms of observable characteristics.

Columns 2–5 show the effect of birth order on mortality in each age category. At age 1–6, later-born children still have a significantly lower mortality risk than their firstborn sibling. At ages 7–18, there is no birth-order effect on mortality. For the oldest age group, the results indicate a reversed pattern, later-born siblings have an increased mortality risk as compared to their firstborn sibling. The overall findings in this section confirm our results on hospitalizations: lower birth-order children have worse health at birth, but this change during their upbringing and firstborn children have better health than their younger siblings at older ages.

Table 5 Birth-order effects on mortality

	(1) Infant mortality	(2) Age 1–6	(3) Age 7–12	(4) Age 13–18	(5) Age 19–24
Birth order 2	-0.011***	-0.001***	0.000	0.000	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Birth order 3	-0.033***	-0.003***	0.000	0.000	0.001*
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Birth order 4	-0.052***	-0.006***	0.000	0.001	0.001*
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
Birth order >4	-0.068***	-0.007***	0.001	0.001	0.001
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Obs.	1,608,555	1,608,555	1,608,555	1,608,555	1,608,555
R-sq.	0.392	0.414	0.441	0.452	0.458
Mean	0.007	0.002	0.001	0.001	0.003
N clusters	739518	739518	739518	739518	739518

Notes: Results from linear probability models with family fixed effects. The omitted category is firstborn child. Standard errors are clustered by family. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression and all regressions include controls for mother's age at birth, and indicators for child's birth cohort and gender. For siblings with different fathers, indicators for father's cohort and educational attainment are included.

The results by family size, with and without family fixed effects, can be found in the Appendix, Table A 5. The effects on mortality are several times larger in the family fixed effects models, suggesting that they are picking up some additional variation that we cannot control for with our rich set of other background characteristics. We will discuss this further in the next section where we investigate endogenous fertility decisions.

6 Optimal stopping

As discussed in the empirical strategy section, if families stop having children when they have a child with poor health, children with a higher birth order will be less healthy, given the family size. Thus, an endogenous fertility response could explain the birth-order effects on health. Likewise, if parents respond to the death of a child by having another child, this will have the effect that a higher birth order will be correlated with lower mortality rates. To investigate whether families base their fertility decision on the health of previous children, we study if the health of previous children affects the probability of having another child, controlling for a range of factors which could affect family size (e.g., parental education and birth cohorts, income before first birth, parental age at first birth and residential region before first birth).

The first two columns of Table 6 show the effects of the firstborn child's health on the probability of having a second child. The result in the first column indicates that the early health status of the firstborn child, measured as in-patient care in the first two years of life, reduces the probability of the family having another child by 3.2 percentage points or, relative to the mean probability, by 3.9 percent. Hospitalizations for perinatal conditions decrease the probability by 4.0 percentage points. The results displayed in Columns 4 to 5 show the effect of first- and second-born children's health, on the probability of having a third child. As for the decision to have one or two children, the health of the last child affects whether the family chooses to have another child. However, the effect is smaller in magnitude; the probability that a two-child family decides to have a third child is 1.5 percent lower if the second child has been receiving in-patient care during its first year of life. In contrast, admittance to hospital of previous children does not seem to affect the probability that families with three children decide to have a fourth child.

Next we study whether a child's death affects the probability of having another child. The third column in Table 6 shows that when a mother has lost a child, the probability that she has another child increases by 0.1 percentage points, or 12 percent. The effect of a child's death in infancy is larger for the probability of having a third or a fourth child. The result in Column 6 shows that the probability of having a third child increases by 0.385 percentage points if the first child dies and 0.483 percentage points if the second child dies, which implies an increase of 89 and 115 percent, respectively. The probability of having a fourth child, if the third child has died in infancy, increases by over 300 percent. Thus, the results strongly indicate that the endogenous fertility response of a child's death could give rise to negative birth-order effects on mortality, i.e. lower birth-order children are more likely to die.

If parents respond to the health or death of previous children by changing their subsequent fertility decisions, the spacing between siblings may also be affected by the health or death of earlier-born siblings. As we can see in Table 7, the spacing of siblings is correlated with the health and death of earlier-born children. The results presented in Column 1 show that if the firstborn child is admitted to hospital during its first year of life, that increases the spacing between the first and the second child by 1.2 months. If the child is admitted to hospital with congenital malfunction or perinatal conditions, the spacing increases by 1 month (Column 2). In contrast, if the first child dies as an infant, the spacing to the next child decreases by 7.6 months (Column 3). The spacing between higher-order siblings is not correlated with the health of earlier-born children (Columns 4, 5, 7 and 8). However, as seen in Columns 6 and 9, the death of an earlier-born child reduces the spacing between later-born siblings. The spacing between the second and third birth is reduced by 19.3 months if the second child dies.

Table 6 Probability of having another child, given the health of older sibling(s)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Probability to have >1 child			Probability to have >2 children			Probability to have >3 children		
Firstborn child									
Hospitalization	-0.032***			-0.004*			0.000		
	(0.00187)			(0.00228)			(0.00188)		
Cong. mal & perinatal		-0.040***			-0.004			0.001	
		(0.00279)			(0.00345)			(0.00289)	
Dead			0.102***			0.375***			-0.006
			(0.0116)			(0.0145)			(0.0101)
Second born child									
Hospitalization				-0.006**			-0.003		
				(0.00248)			(0.00191)		
Cong. mal & perinatal					-0.013***			0.002	
					(0.00418)			(0.00367)	
Dead						0.483***			0.031**
						(0.0161)			(0.0156)
Third born child									
Hospitalization							0.000		
							(0.00223)		
Cong. mal & perinatal								-0.001	
								(0.00363)	
Dead									0.348***
									(0.0709)
Obs.	212,549	212,549	250,358	154,878	154,878	187,217	34,682	34,682	45,369
R-sq.	0.245	0.244	0.242	0.121	0.121	0.138	0.117	0.117	0.122
Mean	0.840	0.840	0.840	0.421	0.421	0.421	0.100	0.100	0.100

Notes: Results from linear probability models. Robust standard errors. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression. Columns (1) – (3) include all family sizes, Columns (4) – (6) include all families with 2 or more children, and Columns (7) – (9) include all families with more than 3 children. The sample consists of cohorts born 1987-2005. All regressions include controls for mother's age at first birth, parental birth cohorts, educational attainments, incomes and region before first birth, and indicators for foreign background and previous children's birth cohort, mother's age at birth and gender.

Table 7 Spacing between children, given the health of older sibling(s)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Months spacing between first and second child			Months spacing between second and third child			Months spacing between third and fourth child		
Firstborn child									
Hospitalization	1.199***			0.445			-1.000		
	(0.116)			(0.302)			(0.949)		
Cong. mal & perinatal		1.022***			-0.130			0.689	
		(0.173)			(0.468)			(1.497)	
Dead			-7.623***			-12.498***			0.561
			(0.612)			(0.914)			(2.600)
Second born child									
Hospitalization				0.316			1.324		
				(0.327)			(1.044)		
Cong. mal & perinatal					0.223			3.406*	
					(0.596)			(1.970)	
Dead						-19.337***			-9.510***
						(0.884)			(2.181)
Third born child									
Hospitalization							0.529		
							(1.095)		
Cong. mal & perinatal								-2.429	
								(1.893)	
Dead									-15.696***
									(3.092)
Obs.	156,065	156,065	187,807	39,936	39,936	52,771	5,575	5,575	8,139
R-sq.	0.062	0.061	0.066	0.110	0.110	0.108	0.283	0.284	0.236
Mean	35.338	35.338	43.464	47.771	47.771	46.843	44.089	44.089	44.537

Notes: Results from linear probability models. Robust standard errors. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression. Columns (1) – (3) include all family sizes, Columns (4) – (6) include all families with 2 or more children, and Columns (7) – (9) include all families with more than 3 children. The sample consists of cohorts born 1987–2005. All regressions include controls for mother's age at first birth, parental birth cohorts, educational attainments, incomes and region before first birth, and indicators for foreign background and previous children's birth cohort, mother's age at birth and gender**.**

Admittedly, the models estimated in this section may suffer from bias due to selection, since the identification strategy hinges on the strong assumption that we are able to control for all factors that determine both fertility and the health of the child. However, given the large battery of control variables and the consistency of the results, the analysis provides suggestive evidence that the health of born children affects subsequent fertility decisions. Moreover, under the reasonable assumption that both hospitalization and mortality measure child health we should expect both health proxies to be negatively correlated with family size, if the result in Table 6 is caused by large families being healthier. Since the death of a child in the family has the opposite effect on the probability of having another child, the results suggests that the effect of child health on subsequent fertility decision is not due to systematic differences in child health in large compared to small families.

The results suggest that parents are resource constrained and having a child with poor health, which may require more time from the parents, reduces the probability of having another child for a given family size preference. If parents have a firstborn with poor health, but decide to have another child, they are more likely to postpone that birth. On the other hand, if the child dies, resources are freed and parents are more likely to have another child. The spacing between the births is then shorter than average spacing. Assuming that parents who have a child with poor health have fewer children than planned and parents who experience the death of a child have more children than planned, the sibling order of the last child is not independent of the health or death of already born children and the estimated birth order effects are biased. To remedy this problem, we remove the last born child in every family and re-estimate the effects of sibling order on child health and mortality. If the effects are much smaller, it would be an indication that the effects of birth order found in Section 5 are largely due to endogenous fertility responses.

Table 8 presents the estimated birth-order effects on infant mortality and health at age 0–6 and age 13–18. The results in panel A, column 1, show large birth-order effects on infant mortality also in the restricted sample. However, the estimates are smaller than the results, for the full sample, presented in Table 5. The second child has a 118 percent lower probability of dying and the third born a 300 percent lower probability as compared to the firstborn. The estimated effects using the whole sample presented in

Table 5 was a 167 percent lower risk for the second born and a 501 percent lower risk for the third born. The reduced effect indicates that endogenous fertility responses can explain at least part of the birth-order effect on infant mortality.

Panel A, columns 3 to 6, presents the estimated effects of birth order on the probability of all-cause and cause-specific hospitalization. The estimates are remarkably similar to the birth-order effects estimated on the full sample. Restricting the sample by removing all last born children reduced the number of observations from over a million to 167,876, implying that we lose precision. For less common conditions, such as injuries and avoidable conditions, the estimates are no longer statistically significant although the estimates are of a similar magnitude to those estimated on the full sample. The lower panel displays the results from estimating the effect of birth order on different causes of hospitalization at the age of 13–18. These estimated effects are virtually exactly the same as those estimated on the full sample presented in Table 4. The results for the categories 7–12 and 19–24 are displayed in Table A 6 in the Appendix. For age category 7–12, the results remain the same, while for age category 19–24, the effects on the rare conditions such as mental health, self-harm and alcohol-related conditions lose statistical significance.

Table 8 Birth-order effects on infant mortality and health at the age of 0–6 and 13–18, restricted sample

	(1) Infant mortality	(2) Hospital-ization	(3) Perinatal cong. mal	(4) Resp eye/ear	(5) Injury	(6) Avoidable	(7)
Panel A: Infant mortality and hospitalization different causes age 0–6							
Birth order 2	-0.015***	-0.004	-0.039***	0.026***	0.011***	0.006	
	(0.001)	(0.008)	(0.005)	(0.006)	(0.004)	(0.004)	
Birth order 3	-0.038***	-0.001	-0.044***	0.044***	0.014*	0.012	
	(0.002)	(0.016)	(0.009)	(0.012)	(0.008)	(0.009)	
Birth order 4	-0.056***	0.002	-0.044***	0.050***	0.015	0.016	
	(0.003)	(0.024)	(0.014)	(0.018)	(0.013)	(0.014)	
Birth order >4	-0.074***	0.022	-0.053***	0.058**	0.023	0.014	
	(0.004)	(0.034)	(0.020)	(0.026)	(0.018)	(0.019)	
Obs.	593,322	167,876	167,876	167,876	167,876	167,876	
R-sq.	0.440	0.664	0.646	0.664	0.626	0.650	
Mean	0.013	0.379	0.082	0.157	0.062	0.072	
N clusters	278469	102,215	102,215	102,215	102,215	102,215	
Panel B: Hospitalization different causes age 13–18							
	Hospital-ization	Resp eye/ear	Injury	Avoidable	Mental	Self-harm	Alcohol
Birth order 2	0.016***	0.005***	0.007***	0.003***	0.003***	0.002**	0.003***
	(0.003)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Birth order 3	0.025***	0.007**	0.010**	0.004**	0.006***	0.002	0.005**
	(0.006)	(0.003)	(0.004)	(0.002)	(0.002)	(0.001)	(0.002)
Birth order 4	0.038***	0.013***	0.019***	0.008***	0.009**	0.005**	0.008***
	(0.009)	(0.004)	(0.006)	(0.003)	(0.004)	(0.002)	(0.003)
Birth order >4	0.035***	0.010	0.009	0.007	0.006	0.004	0.004
	(0.014)	(0.006)	(0.009)	(0.004)	(0.006)	(0.003)	(0.004)
Obs.	518,861	518,861	518,861	518,861	518,861	518,861	518,861
R-sq.	0.530	0.517	0.513	0.521	0.502	0.490	0.490
Mean	0.197	0.034	0.069	0.016	0.022	0.007	0.013
N clusters	260,991	260,991	260,991	260,991	260,991	260,991	260,991

Notes: Results from linear probability models with family fixed effects. The omitted category is firstborn child. Standard errors are clustered by family. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression and all regressions include controls for mother's age at birth, and indicators for child's birth cohort and gender. For siblings with different fathers, indicators for father's cohort and educational attainment are included.

In this section, we have made a novel attempt to answer the long standing question on optimal stopping and reverse causality. We have estimated the effects on fertility, given the health status of previous children. The results are in line with the hypothesis that family resources are important, not only as a direct explanation to birth-order effects, but also indirectly by affecting fertility decisions. The care of a sick child is likely to be demanding, financially and emotionally, but also in terms of time. Mortality is considered the most severe health outcome. However, considering families' resource constraint, and preference for children, the early loss of a child will free resources and hence, the fertility response will be different. The endogenous fertility response is important, not only for our study but also for the interpretation of birth-order effects found in other studies.

7 Heterogeneity

We have shown results suggesting that firstborns are at disadvantage at birth but as the child grows older, later-born children run a greater risk of being admitted to hospital. Our results suggest that this may be due to different access to parental resources. To further investigate the mechanisms, we study whether the effects differ depending on family resources in the form of parental educational attainment.[26] We also investigate whether the effects differ depending on the gender of the child.

Another reason why it is interesting to study heterogeneous effects with respect to family background is that, as discussed in Section 3, if families on which we estimate the birth-order effect are different from the population at large, the estimated effects may not be externally valid. Since we use a fixed effects approach the effects are estimated on families which at least one child has been admitted to hospital, or in the estimations of mortality, at least one child died. The concern is that families with a sick or a dead child is different from other families. Table 9 displays characteristics of families which are included, and not included, in the analytical sample for the estimation on a particular outcome. The first row shows that couples' who have lost a child are somewhat more likely to have a lower education level, to be born in another country, and to have more children.[27] As expected, the probability of having an unhealthy child, or having lost a child, is larger if you have many children, as is evident from the last two columns. However, the difference between the groups is larger for infant mortality, which is also in line with the results that families that experience the death of a child are likely to have another child. The education level is lower among families that have a child who has been admitted to hospital; a pattern which is visual for all conditions. Foreign-born parents are underrepresented among children admitted to hospital for any cause, but are more likely to have a child admitted to hospital with conditions related to mental health, self-harm, and alcohol consumption. Overall, the differences in family background factors between the analytical sample and the full population are small. Nevertheless, we will now study whether there are any heterogeneous effects with respect to parental education. Regarding whether the effects

[26] Another potential measure of access to parental resources is spacing; short spacing may imply less own time with the parents. Since we find that spacing is affected by the health and death of earlier-born children, we abstain from studying this since an analysis of the effect of spacing would suffer from endogeneity problems

[27] Families are defined as highly educated if the mother has more than 12 years of schooling. In the Swedish setting, this implies that she has continued to study after high school.

vary across family size, the results presented in the Appendix, Table A 1 and Table A 5, show that the birth-order effects are similar.

Table 9 Descriptive statistics in families with and without a sick or dead child, respectively

	High education	High education	Foreign born	Foreign born	Family size	Family size
A dead/sick child in the family	Yes	No	Yes	No	Yes	No
Infant mortality	0.405	0.464	0.152	0.148	3.818	2.792
	(0.491)	(0.499)	(0.359)	(0.355)	(1.305)	(1.016)
Hospitalized 0–6	0.545	0.572	0.158	0.164	2.914	2.695
	(0.498)	(0.495)	(0.365)	(0.370)	(1.132)	(0.918)
Hospitalized 7–12	0.485	0.524	0.140	0.158	3.049	2.724
	(0.500)	(0.499)	(0.347)	(0.365)	(1.168)	(0.935)
Hospitalized 13–18	0.443	0.487	0.135	0.149	3.031	2.673
	(0.497)	(0.500)	(0.341)	(0.356)	(1.153)	(0.893)
Hospitalized 19–24	0.377	0.447	0.132	0.143	3.007	2.672
	(0.485)	(0.497)	(0.339)	(0.350)	(1.153)	(0.898)
Perinatal 0–6	0.540	0.560	0.167	0.159	2.956	2.793
	(0.498)	(0.496)	(0.373)	(0.366)	(1.219)	(1.012)
Injury 0–6	0.552	0.557	0.152	0.162	3.088	2.784
	(0.497)	(0.497)	(0.359)	(0.368)	(1.246)	(1.017)
Injury 7–12	0.491	0.514	0.138	0.154	3.119	2.793
	(0.500)	(0.500)	(0.344)	(0.361)	(1.218)	(0.996)
Injury 13–18	0.433	0.477	0.133	0.145	3.116	2.752
	(0.496)	(0.499)	(0.340)	(0.352)	(1.221)	(0.961)
Mental 13–18	0.412	0.474	0.172	0.142	3.273	2.781
	(0.492)	(0.499)	(0.377)	(0.349)	(1.335)	(0.986)
Self-harm 13–18	0.384	0.472	0.187	0.143	3.371	2.795
	(0.486)	(0.499)	(0.390)	(0.350)	(1.358)	(1.002)
Alcohol 13–18	0.398	0.473	0.169	0.143	3.273	2.791
	(0.490)	(0.499)	(0.375)	(0.350)	(1.318)	(0.998)

7.1 Educational attainment

It is possible that the birth-order effects could vary across families depending on parental educational attainment, as parents with a higher education are likely to have more resources, which they could potentially use to mitigate investment deficits in younger children. We test if family background is important in a simple model where we interact birth order with educational attainment. To save space, only the main results are reported in Table 10, which strongly indicate that there does not seem to be any heterogeneity in terms of the mother's educational attainment. If anything, the results in Column (2) show a small negative effect on perinatal conditions and congenital malformations, implying that a higher education among mothers might exacerbate the negative birth-order effect.[28]

[28] Our results are in line with the findings in previous studies. Black et al. (2005) split the sample by mother's education (12 years used as the cut-off) finding small differences. If anything, they find slightly stronger effects among mothers with high education on children's education. Bjerkedal et al. (2007) find stronger negative birth-order

Table 10 Birth-order effects by mother's education

	(1) Hosp	(2) Perinatal & cong. mal	(3) Hosp	(4) Hosp	(5) Mental	(6) Hosp
	Age 0–6	Age 0–6	Age 7–12	Age 13–18	Age 13–18	Age 19–24
Birth order 2	-0.014***	-0.040***	-0.001	0.017***	0.004***	0.017***
	(0.004)	(0.003)	(0.002)	(0.002)	(0.001)	(0.002)
Birth order 3	-0.012	-0.042***	-0.000	0.025***	0.006***	0.024***
	(0.008)	(0.005)	(0.004)	(0.004)	(0.001)	(0.004)
Birth order 4	-0.009	-0.043***	-0.002	0.034***	0.009***	0.029***
	(0.012)	(0.007)	(0.006)	(0.006)	(0.002)	(0.006)
Birth order >4	0.001	-0.039***	-0.003	0.039***	0.010***	0.026***
	(0.016)	(0.010)	(0.008)	(0.009)	(0.004)	(0.009)
High edu*Birth	0.002	-0.002	0.004	0.000	-0.001	0.001
order 2	(0.005)	(0.003)	(0.002)	(0.002)	(0.001)	(0.002)
High edu*Birth	-0.006	-0.008*	0.002	-0.001	-0.002	0.006
order 3	(0.007)	(0.004)	(0.004)	(0.003)	(0.001)	(0.004)
High edu*Birth	0.007	-0.010	0.009	0.004	-0.003	0.004
order 4	(0.012)	(0.007)	(0.006)	(0.007)	(0.003)	(0.008)
High edu*Birth	0.008	-0.009	0.001	0.005	0.003	0.005
order >4	(0.021)	(0.012)	(0.012)	(0.013)	(0.006)	(0.016)
Obs.	644,589	644,589	1155264	1474603	1474603	1463458
R-sq.	0.618	0.608	0.534	0.525	0.500	0.505
Mean	0.368	0.087	0.164	0.188	0.020	0.199
N clusters	360,806	360,806	578,318	737,256	737,256	709,654

Notes: Results from linear probability models with family fixed effects. The omitted category is firstborn child. Standard errors are clustered by family. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression and all regressions include controls for mother's age at birth, and indicators for the child's birth cohort and gender. For siblings with different fathers, indicators for father's cohort and educational attainment are included.

7.2 Gender

Next we study whether the birth-order effects differ between boys and girls. It is important to study heterogeneity across gender for several reasons. To start with, it is known from the previous literature (e.g. Mörk et al., 2014) that boys and girls have different probabilities of being hospitalized for certain conditions. For example, boys are more likely to be injured and girls have a higher risk of being hospitalized for mental conditions in adolescence. Birth-order effects on educational attainment and earnings have also been shown to be larger for girls (Black et al., 2005). We control for gender in all our regressions, but that will not help us understand whether the effects that we observe are driven by one gender. Once more, we study potential heterogeneity by setting up a simple model where we interact birth order with gender.

Table 11 shows the results for children aged 0–6 and 7–12. The result that stands out is that girls are healthier than boys, in terms of all diagnoses, at these young ages. Concerning the differential birth-order effects across gender, the results are not conclusive. In the youngest age category, gender differences in health are small, and the

effects on IQ between first- and second-born child in families with highly educated mothers, but no difference between second- and third-born children.

interactions are only statistically significant for perinatal conditions and congenital malformations. However, these effects depend on the differences in means between boys and girls. Correcting for this, the difference in health between a later-born boy and his firstborn brother is as large as the difference between a later-born girl and her firstborn sister. The difference in hospitalization over birth order is, however, higher for girls 7–12 years old (ranging from 5 to 9 percent over birth order) than for boys. Concerning perinatal conditions and congenital malformations at age 7–12, second-born boys have a marginally lower risk of being hospitalized. This negative effect disappears for girls and, if anything, it increases marginally over birth order.

In Table 12, we look more closely at gender differences in the older age groups. At age 13–18, the birth-order effects are marginally stronger for girls than for boys for hospitalization; the effect ranges from 10–26 percent for girls over birth order, to be compared with 8–17 percent for boys. The largest differences are found for hospitalizations related to mental conditions and alcohol-related hospitalizations. A third-born girl is 48 percent more likely to be hospitalized for mental conditions as compared to a firstborn girl. This gap is 18 percent between a firstborn boy and a third-born boy. For alcohol related conditions, third-born girls are 61 percent more likely to be admitted to hospital as compared to firstborn girls, whereas the difference between third-born and firstborn boys is 27 percent.

In the oldest age group, 19–24, the heterogeneous effects are once again small. Since females are less likely to end up in hospital for injuries, the birth-order effect is somewhat larger for females. A second-born male is 9 percent more likely to be admitted to hospital for injuries as compared to a firstborn male, whereas the difference is 15 percent for females. For self-harm, the effect is only statistically significant for females: a fourth born female is 28 percent more likely to be admitted for self-harm compared to firstborn female. However, self-harm is rare among males in this age span.

Table 11 Birth-order effects, by gender at age 0-12

	(1) Hosp	(2) Perinatal cong. mal	(3) Resp eye/ear	(4) Injury	(5) Avoidable	(6) Cancer
Panel A: Age 0–6						
Birth order 2	-0.019***	-0.047***	0.020***	0.011***	0.008***	-0.001
	(0.005)	(0.003)	(0.004)	(0.002)	(0.003)	(0.001)
Birth order 3	-0.018**	-0.052***	0.032***	0.019***	0.016***	-0.001
	(0.008)	(0.005)	(0.006)	(0.004)	(0.004)	(0.001)
Birth order 4	-0.011	-0.050***	0.041***	0.020***	0.024***	-0.002
	(0.012)	(0.007)	(0.009)	(0.006)	(0.007)	(0.002)
Birth order >4	-0.012	-0.053***	0.045***	0.022**	0.023**	-0.002
	(0.017)	(0.010)	(0.013)	(0.009)	(0.009)	(0.002)
Female	-0.086***	-0.037***	-0.055***	-0.014***	-0.023***	-0.000
	(0.005)	(0.003)	(0.003)	(0.002)	(0.002)	(0.001)
Birth order 2	0.012*	0.012***	0.006	-0.002	0.004	0.000
*Female	(0.006)	(0.004)	(0.005)	(0.003)	(0.003)	(0.001)
Birth order 3	0.007	0.010**	0.004	-0.008**	-0.001	0.001
*Female	(0.007)	(0.004)	(0.005)	(0.004)	(0.004)	(0.001)
Birth order 4	0.008	0.006	0.006	-0.005	-0.002	0.001
*Female	(0.011)	(0.006)	(0.008)	(0.006)	(0.006)	(0.001)
Birth order>4	0.032**	0.020**	0.013	0.005	-0.000	0.001
*Female	(0.014)	(0.008)	(0.010)	(0.007)	(0.008)	(0.002)
Obs.	644,589	644,589	644,589	644,589	644,589	644,589
R-sq.	0.618	0.608	0.615	0.572	0.597	0.573
Mean female	0.329	0.072	0.124	0.050	0.061	0.004
Mean male	0.405	0.101	0.174	0.065	0.082	0.004
N clusters	360,806	360,806	360,806	360,806	360,806	360,806
Panel A: Age 7–12						
Birth order 2	-0.003	-0.002**	-0.005***	0.005***	-0.002**	-0.000
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
Birth order 3	-0.004	-0.002	-0.009***	0.009***	-0.002*	-0.001
	(0.004)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Birth order 4	-0.004	-0.002	-0.010***	0.013***	-0.002	-0.000
	(0.006)	(0.002)	(0.003)	(0.004)	(0.002)	(0.001)
Birth order >4	-0.008	-0.002	-0.012***	0.011**	-0.001	0.001
	(0.009)	(0.003)	(0.004)	(0.005)	(0.003)	(0.001)
Female	-0.042***	-0.008***	-0.007***	-0.019***	-0.003***	-0.000
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
Birth order 2	0.009***	0.002***	0.001	0.002	0.001	0.000
*Female	(0.003)	(0.001)	(0.002)	(0.002)	(0.001)	(0.000)
Birth order 3	0.010***	0.002**	0.002	0.002	0.001	0.001
*Female	(0.004)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Birth order 4	0.011*	0.003**	0.001	0.001	-0.001	0.000
*Female	(0.006)	(0.002)	(0.003)	(0.004)	(0.002)	(0.001)
Birth order>4	0.013	0.005**	0.002	0.001	-0.004	-0.000
*Female	(0.008)	(0.002)	(0.004)	(0.005)	(0.003)	(0.001)
Obs.	1,155,264	1,155,264	1,155,264	1,155,264	1,155,264	1,155,264
R-sq.	0.534	0.522	0.530	0.509	0.526	0.509
Mean female	0.145	0.007	0.034	0.040	0.014	0.003
Mean male	0.182	0.014	0.040	0.058	0.016	0.003
N clusters	578,318	578,318	578,318	578,318	578,318	578,318

Notes: Results from linear probability models with family fixed effects. The omitted category is firstborn child. Standard errors are clustered by family. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression and all regressions include controls for mother's age at birth, and indicators for child's birth cohort. For siblings with different fathers, indicators for father's cohort and educational attainment are included.

Table 12 Birth-order effects, by gender at age 13–24

	(1) Hosp	(2) Resp & eye/ear	(3) Injury	(4) Avoidable	(5) Mental	(6) Self-harm	(7) Alcohol
Panel A: Age 13–18							
Birth order 2	0.015***	0.004***	0.007***	0.003***	0.002***	0.001***	0.003***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Birth order 3	0.019***	0.008***	0.009***	0.005***	0.003*	0.001	0.003***
	(0.004)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Birth order 4	0.027***	0.009***	0.016***	0.005***	0.004*	0.002*	0.006***
	(0.006)	(0.003)	(0.004)	(0.002)	(0.002)	(0.001)	(0.002)
Birth order >4	0.031***	0.007*	0.010	0.007**	0.005	0.001	0.006**
	(0.009)	(0.004)	(0.006)	(0.003)	(0.004)	(0.002)	(0.003)
Female	0.001	0.008***	-0.023***	0.005***	0.005***	0.006***	-0.001*
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Birth order 2	0.005*	0.002	0.001	-0.001	0.002*	0.001	0.001
*Female	(0.003)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Birth order 3	0.012***	0.001	0.003	-0.002**	0.005***	0.003***	0.004***
*Female	(0.004)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Birth order 4	0.017***	0.004	0.002	0.000	0.006***	0.005***	0.004*
*Female	(0.006)	(0.003)	(0.004)	(0.002)	(0.002)	(0.001)	(0.002)
Birth order>4	0.019**	0.002	0.004	-0.003	0.011**	0.008***	0.005
*Female	(0.009)	(0.004)	(0.006)	(0.003)	(0.004)	(0.003)	(0.003)
Obs.	1,474,603	1,474,603	1,474,603	1,474,603	1,474,603	1,474,603	1,474,603
R-sq.	0.525	0.512	0.508	0.519	0.500	0.485	0.487
Mean female	0.192	0.037	0.054	0.017	0.024	0.010	0.012
Mean male	.0184	0.027	0.076	0.013	0.017	0.003	0.011
N clusters	737,256	737,256	737,256	737,256	737,256	737,256	737,256
Panel B: Age 19–24							
Birth order 2	0.018***	0.003***	0.007***	0.002**	0.000	0.001	0.001*
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Birth order 3	0.027***	0.004**	0.009***	0.004***	-0.002	-0.000	0.002
	(0.004)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)
Birth order 4	0.027***	0.007***	0.010**	0.005***	0.001	0.000	0.002
	(0.006)	(0.003)	(0.004)	(0.002)	(0.003)	(0.002)	(0.002)
Birth order >4	0.023**	0.007*	0.013**	0.004	-0.002	-0.003	0.002
	(0.010)	(0.004)	(0.006)	(0.003)	(0.004)	(0.002)	(0.003)
Female	0.016***	0.001	-0.033***	0.004***	0.001*	0.004***	-0.003***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
Birth order 2	-0.002	0.001	-0.000	-0.000	0.002	0.001*	0.001
*Female	(0.003)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Birth order 3	-0.003	0.003	0.001	-0.001	0.004***	0.002*	0.001
*Female	(0.004)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Birth order 4	0.007	-0.003	0.002	-0.002	0.004	0.003*	0.001
*Female	(0.007)	(0.003)	(0.004)	(0.002)	(0.003)	(0.002)	(0.002)
Birth order>4	0.010	-0.001	-0.003	0.004	0.005	0.005*	0.002
*Female	(0.010)	(0.004)	(0.006)	(0.003)	(0.005)	(0.003)	(0.003)
Obs.	1,463,458	1,463,458	1,463,458	1,463,458	1,463,458	1,463,458	1,463,458
R-sq.	0.505	0.490	0.494	0.483	0.513	0.491	0.495
Mean female	0.207	0.030	0.045	0.016	0.026	0.011	0.007
Mean male	0.192	0.028	0.077	0.013	0.022	0.006	0.009
N clusters	709,654	709,654	709,654	709,654	709,654	709,654	709,654

Notes: Results from linear probability models with family fixed effects. The omitted category is firstborn child. Standard errors are clustered by family. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression and all regressions include controls for mother's age at birth, and indicators for child's birth cohort. For siblings with different fathers, indicators for father's cohort and educational attainment are included.

8 Conclusions

In this paper, we examine the relationship between birth order and child health. We find that firstborns are more likely to be hospitalized due to congenital malformations and perinatal conditions in early childhood. However, the disadvantage of firstborn children at birth is reversed in older age when younger siblings are more likely to be hospitalized for injuries and avoidable conditions. Our results indicate that the dilution hypothesis, which emphasizes the importance of constrained parental resources, is crucial for our understanding of birth-order effects. In adolescence, we find positive birth-order effects on hospitalizations, including hospitalizations related to poor mental health and alcohol-related conditions. The causes for hospitalization suggest that later-born siblings are involved in more risky behavior, have a less healthy life style and worse mental health in older age. A concern when using within family variation is that families with an unhealthy or dead child are different from other families, implying that the estimated effects are only valid within these particular groups. However, families with a sick child, or who have lost a child, do not differ that much on observables and our results show no evidence of any substantial heterogeneous effects with respect to, for example, mother's education level or family size.

Birth-order effects may also arise as a result of endogenous fertility decisions. We show that a large part of the negative birth-order effects on infant mortality are non-causal, and instead related to parents' fertility response to the loss of a child. Families, of all sizes, who lose a child are more likely to have another child, giving rise to a non-causal negative effect of birth order on infant mortality. Taking some of the endogenous responses into account by removing the last born child, we show that there is still a negative effect of birth order on infant mortality. We also find that hospitalization at an early age affects subsequent fertility decisions, but in the opposite direction. Parents with an unhealthy child are less likely to have another child. This effect is, however, much smaller, especially for higher parity fertility choices, and is less likely to explain the birth-order effects on health. The endogenous fertility responses are also in line with the dilution hypothesis; caring for a sick child is likely to require considerable resources both in terms of time usage, but also financially as well as emotionally. In contrast, the early loss of a child will free resources and given families' preference for children, the fertility response will be the opposite. Hence, we conclude that endogenous fertility responses are important to take into consideration when studying birth-order effects, and possibly other questions related to the family environment.

That the family environment is important for health outcomes is informative for policies which aim at improving child outcomes. The clear birth-order effects on conditions such as injuries and avoidable conditions already at an early age suggest that later-born children get less parental attention.

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Appendix

Table A 1 Hospitalization by family size, with and without family fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	2-Child families		3-Child families		4-Child families		>4Child families		All	
Panel A. Hospitalization age 0–6										
Birth order 2	-0.028***	-0.006	-0.017***	-0.010*	-0.012	-0.016	-0.019	-0.026	-0.023***	-0.013***
	(0.002)	(0.006)	(0.003)	(0.006)	(0.008)	(0.012)	(0.017)	(0.022)	(0.002)	(0.004)
Birth order 3			-0.033***	-0.012	-0.015*	-0.024	-0.022	-0.039*	-0.035***	-0.015**
			(0.004)	(0.010)	(0.008)	(0.016)	(0.017)	(0.023)	(0.003)	(0.007)
Birth order 4					-0.010	-0.015	-0.033*	-0.049*	-0.039***	-0.007
					(0.010)	(0.021)	(0.018)	(0.026)	(0.004)	(0.010)
Birth order>4							-0.026	-0.042	-0.045***	0.003
							(0.019)	(0.030)	(0.007)	(0.015)
Fam FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Obs.	303,083	303,083	222,729	222,729	78,662	78,662	40,115	40,115	644,589	644,589
R-sq.	0.014	0.664	0.017	0.602	0.021	0.563	0.024	0.481	0.015	0.618
Mean	0.367	0.367	0.363	0.363	0.378	0.378	0.384	0.384	0.368	0.368
N clusters	185,978	185,978	120,727	120,727	38,482	38,482	15,619	15,619	36,0806	36,0806
Panel B. Hospitalization age 7–12										
Birth order 2	-0.006***	0.004	0.001	0.002	0.004	0.005	-0.000	-0.002	-0.003***	0.001
	(0.001)	(0.003)	(0.002)	(0.003)	(0.004)	(0.005)	(0.007)	(0.008)	(0.001)	(0.002)
Birth order 3			-0.009***	-0.005	0.005	0.010	-0.001	-0.004	-0.009***	0.001
			(0.002)	(0.005)	(0.004)	(0.007)	(0.008)	(0.010)	(0.002)	(0.003)
Birth order 4					-0.003	0.008	-0.005	-0.008	-0.011***	0.001
					(0.005)	(0.010)	(0.008)	(0.012)	(0.003)	(0.005)
Birth order>4							-0.013	-0.015	-0.015***	-0.002
							(0.009)	(0.015)	(0.004)	(0.008)
Fam FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Obs.	527,716	527,716	411,693	411,693	146,076	146,076	69,779	69,779	1,155,264	1,155,264
R-sq.	0.009	0.621	0.009	0.499	0.011	0.429	0.014	0.355	0.009	0.534
Mean	0.159	0.159	0.165	0.165	0.173	0.173	0.177	0.177	0.164	0.164
N clusters	310833	310833	190466	190466	56052	56052	20967	20967	578318	578318

Table A1. Cont.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	2-Child families		3-Child families		4-Child families		>4Child families		All	
Panel C. Hospitalization age 13–18										
Birth order 2	0.010***	0.021***	0.010***	0.015***	0.014***	0.013***	0.008	0.007	0.011***	0.017***
	(0.001)	(0.003)	(0.002)	(0.003)	(0.003)	(0.004)	(0.006)	(0.007)	(0.001)	(0.002)
Birth order 3			0.009***	0.025***	0.021***	0.024***	0.015**	0.014	0.012***	0.025***
			(0.002)	(0.005)	(0.004)	(0.007)	(0.007)	(0.009)	(0.002)	(0.003)
Birth order 4					0.025***	0.036***	0.022***	0.026**	0.017***	0.035***
					(0.005)	(0.010)	(0.008)	(0.012)	(0.003)	(0.005)
Birth order>4							0.027***	0.030**	0.021***	0.040***
							(0.009)	(0.015)	(0.004)	(0.008)
Fam FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Obs.	690,063	690,063	519,880	519,880	180,611	180,611	84,049	84,049	1,474,603	1,474,603
R-sq.	0.004	0.623	0.005	0.479	0.007	0.401	0.010	0.346	0.005	0.525
Mean	0.180	0.180	0.189	0.189	0.204	0.204	0.219	0.219	0.188	0.188
N clusters	413,331	413,331	233,082	233,082	66,005	66,005	24,838	24,838	737,256	737,256
Panel D. Hospitalization age 19–24										
Birth order 2	0.010***	0.020***	0.018***	0.015***	0.021***	0.016***	0.029***	0.017**	0.019***	0.017***
	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.005)	(0.005)	(0.007)	(0.001)	(0.002)
Birth order 3			0.026***	0.025***	0.033***	0.023***	0.041***	0.015	0.028***	0.026***
			(0.003)	(0.005)	(0.004)	(0.007)	(0.007)	(0.010)	(0.002)	(0.003)
Birth order 4					0.046***	0.040***	0.059***	0.024*	0.037***	0.031***
					(0.006)	(0.011)	(0.008)	(0.014)	(0.003)	(0.006)
Birth order>4							0.074***	0.029*	0.041***	0.028***
							(0.009)	(0.017)	(0.004)	(0.009)
Fam FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Obs.	691,001	691,001	511,186	511,186	177,433	177,433	83,838	83,838	1,463,458	1,463,458
R-sq.	0.007	0.583	0.008	0.469	0.011	0.411	0.015	0.355	0.009	0.505
Mean	0.188	0.188	0.201	0.201	0.219	0.219	0.242	0.242	0.199	0.199
N clusters	389,624	389,624	226,426	226,426	671,10	671,10	264,94	264,94	709,654	709,654

Notes: Results from linear probability models. The omitted category is firstborn child. Standard errors are clustered by family. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression. In regressions with family fixed effects we include controls for mother's age at birth, and indicators for the child's birth cohort and gender. For siblings with different fathers, indicators for father's cohort and educational attainment are included. In regressions without family FE, we add father's characteristics and controls for mother's age at first birth, and indicators for mother's educational attainment and cohort. In (7) we add indicators for family size.

Table A 2 Birth-order effects, hospitalization and diagnoses, age categories 0–1 and 0–3

	(1) Hospitalization	(2) Perinatal & congenital mal.	(3) Respiratory & eye/ear	(4) Injury	(5) Avoidable	(6) Cancer
Panel A: Age 0–1						
Birth order 2	-0.004	-0.040***	0.036***	0.003***	0.014***	-0.000
	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)	(0.000)
Birth order 3	0.008	-0.046***	0.054***	0.003	0.022***	-0.000
	(0.006)	(0.004)	(0.004)	(0.002)	(0.003)	(0.001)
Birth order 4	0.021**	-0.046***	0.070***	0.002	0.030***	-0.001
	(0.009)	(0.006)	(0.006)	(0.003)	(0.004)	(0.001)
Birth order >4	0.041***	-0.042***	0.079***	0.004	0.035***	-0.000
	(0.013)	(0.009)	(0.009)	(0.004)	(0.006)	(0.001)
Obs.	645,554	645,554	645,554	645,554	645,554	645,554
R-sq.	0.611	0.609	0.596	0.561	0.585	0.568
Mean	0.228	0.079	0.078	0.014	0.038	0.002
N clusters	360,944	360,944	360,944	360,944	360,944	360,944
Panel B: Age 0–3						
Birth order 2	-0.009***	-0.041***	0.032***	0.005***	0.011***	-0.001
	(0.003)	(0.002)	(0.002)	(0.001)	(0.002)	(0.000)
Birth order 3	-0.004	-0.046***	0.047***	0.009***	0.018***	-0.001
	(0.007)	(0.004)	(0.005)	(0.003)	(0.004)	(0.001)
Birth order 4	0.003	-0.046***	0.060***	0.008*	0.025***	-0.002*
	(0.010)	(0.006)	(0.007)	(0.004)	(0.005)	(0.001)
Birth order >4	0.014	-0.041***	0.066***	0.013**	0.027***	-0.002
	(0.014)	(0.009)	(0.010)	(0.006)	(0.008)	(0.002)
Obs.	644,893	644,893	644,893	644,893	644,893	644,893
R-sq.	0.616	0.608	0.609	0.567	0.594	0.560
Mean	0.307	0.083	0.120	0.034	0.061	0.003
N clusters	360,860	360,860	360,860	360,860	360,860	360,860

Notes: Results from linear probability models with family fixed effects. The omitted category is firstborn child. Standard errors are clustered by family. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression and all regressions include controls for mother's age at birth, and indicators for child's birth cohort and gender. For siblings with different fathers, indicators for father's cohort and educational attainment are included.

Table A 3 Birth-order effects on longer hospital stays

	More than 1 day				More than 7 days			
	(1) Age 0–6	(2) Age 7–12	(3) Age 13–18	(4) Age 19–24	(5) Age 0–6	(6) Age 7–12	(7) Age 13–18	(8) Age 19–24
Birth order 2	-0.010***	0.000	0.010***	0.013***	-0.007***	0.001	0.002***	0.005***
	(0.003)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Birth order 3	-0.004	-0.000	0.014***	0.020***	-0.002	0.002	0.004***	0.009***
	(0.006)	(0.003)	(0.003)	(0.003)	(0.004)	(0.001)	(0.002)	(0.002)
Birth order 4	0.002	-0.002	0.019***	0.023***	0.004	0.000	0.003	0.010***
	(0.009)	(0.004)	(0.004)	(0.005)	(0.006)	(0.002)	(0.002)	(0.003)
Birth order>4	0.014	-0.008	0.017***	0.022***	0.015*	-0.001	0.004	0.005
	(0.013)	(0.006)	(0.006)	(0.007)	(0.009)	(0.003)	(0.004)	(0.004)
Obs.	644,589	1,155,264	1,474,603	1,463,458	644,589	1,155,264	1,474,603	1,463,458
R-sq.	0.617	0.535	0.527	0.499	0.608	0.530	0.516	0.492
Mean	0.242	0.091	0.110	0.123	0.082	0.022	0.032	0.038
N clusters	360806	578318	737256	709654	360806	578318	737256	709654

Notes: Results from linear probability models with family fixed effects. Omitted category is firstborn child. Standard errors are clustered by family. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression and all regressions include controls for mother's age at birth, and indicators for child's birth cohort and gender. For siblings with different fathers, indicators for father's cohort and educational attainment are included.

Table A 4 Birth-order effects on hospitalizations not related to alcohol

	Age 13–18			Age 19–24		
	(1) Mental - alc	(2) Self harm - alc	(3) Injury - alc	(4) Mental - alc	(5) Self harm - alc	(6) Injury - alc
Birth order 2	0.001	0.001***	0.006***	-0.000	0.001	0.007***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)
Birth order 3	0.001	0.002***	0.008***	-0.001	0.000	0.008***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
Birth order 4	0.001	0.003***	0.013***	0.001	0.001	0.010***
	(0.002)	(0.001)	(0.003)	(0.002)	(0.001)	(0.003)
Birth order >4	0.003	0.003*	0.009*	-0.001	-0.002	0.009*
	(0.002)	(0.002)	(0.005)	(0.003)	(0.002)	(0.005)
Obs.	1,474,603	1,474,603	1,474,603	1,463,458	1,463,458	1,463,458
R-sq.	0.501	0.488	0.507	0.509	0.491	0.492
Mean	0.012	0.005	0.061	0.017	0.006	0.058
N clusters	737,256	737,256	737,256	709,654	709,654	709,654

Notes: Results from linear probability models with family fixed effects. The omitted category is firstborn child. Hospitalizations related to mental conditions, self-harm and injuries, where the same individual has not been hospitalized for alcohol related conditions in the same age category, are considered. Standard errors are clustered by family. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression and all regressions include controls for mother's age at birth, and indicators for child's birth cohort and gender. For siblings with different fathers, indicators for father's cohort and educational attainment are included.

Table A 5 Birth-order effects on infant mortality by family size, with and without family fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	2-Child families		3-Child families		4-Child families		>4-Child families		All	
Birth order 2	-0.001***	-0.004***	-0.002***	-0.014***	-0.001	-0.015***	0.001	-0.007***	-0.001***	-0.011***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)	(0.000)
Birth order 3			-0.013***	-0.044***	-0.010***	-0.043***	0.000	-0.020***	-0.008***	-0.033***
			(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.000)	(0.001)
Birth order 4					-0.023***	-0.081***	-0.002	-0.035***	-0.015***	-0.052***
					(0.002)	(0.003)	(0.002)	(0.004)	(0.001)	(0.001)
Birth order >4							-0.011***	-0.058***	-0.019***	-0.068***
							(0.003)	(0.005)	(0.001)	(0.002)
Fam FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Obs.	753,493	753,493	564,567	564,567	197,231	197,231	93,264	93,264	1,608,555	1,608,555
R-sq.	0.002	0.551	0.005	0.406	0.007	0.344	0.007	0.287	0.007	0.392
Mean	0.002	0.002	0.008	0.008	0.015	0.015	0.015	0.015	0.007	0.007
N clusters	409111	409111	234823	234823	68753	68753	26831	26831	739518	739518

Notes: Results from linear probability models. Omitted category is firstborn child. Standard errors are clustered by family. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression. In regressions with family fixed effects we include controls for mother's age at birth, and indicators for child's birth cohort and gender. For siblings with different fathers, indicators for father's cohort and educational attainment are included. In regressions without family FE, we add father's characteristics and controls for mother's age at first birth, and indicators for mother's educational attainment and cohort.

Table A 6 Birth-order effects on health ages 7–12 and 19–24, restricted sample

	(1) Hospital-ization	(2) Perinatal cong. mal	(3) Resp eye/ear	(4) Injury	(5) Avoidable	(6)	(7)
Panel A: Hospitalization different causes age 7–12							
Birth order 2	-0.002*	-0.004**	0.009***	-0.002	0.000		
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)		
Birth order 3	-0.003	-0.006*	0.012***	-0.002	-0.001		
	(0.002)	(0.004)	(0.004)	(0.002)	(0.001)		
Birth order 4	-0.004	-0.009*	0.021***	-0.003	-0.001		
	(0.003)	(0.005)	(0.006)	(0.003)	(0.002)		
Birth order >4	-0.007*	-0.014*	0.018**	-0.008	-0.001		
	(0.004)	(0.008)	(0.009)	(0.005)	(0.002)		
Obs.	375,947	375,947	375,947	375,947	375,947		
R-sq.	0.535	0.550	0.530	0.544	0.519		
Mean	0.011	0.043	0.051	0.017	0.003		
N clusters	194,684	194,684	194,684	194,684	194,684		
Panel B: Hospitalization different causes age 19–24							
	Hospital-ization	Resp eye/ear	Injury	Avoidable	Mental	Self-harm	Alcohol
Birth order 2	0.018***	0.003**	0.009***	0.001	0.001	0.001	0.002**
	(0.003)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Birth order 3	0.022***	0.005*	0.013***	0.003*	0.000	0.000	0.002
	(0.006)	(0.003)	(0.004)	(0.002)	(0.003)	(0.002)	(0.002)
Birth order 4	0.025**	0.007	0.016**	0.004	0.006	0.002	0.003
	(0.010)	(0.004)	(0.006)	(0.003)	(0.005)	(0.003)	(0.003)
Birth order >4	0.037**	0.004	0.025**	0.005	0.002	0.001	0.004
	(0.015)	(0.006)	(0.010)	(0.005)	(0.007)	(0.004)	(0.004)
Obs.	536,064	536,064	536,064	536,064	536,064	536,064	536,064
R-sq.	0.521	0.504	0.509	0.497	0.522	0.501	0.502
Mean	0.209	0.029	0.067	0.015	0.028	0.010	0.010
N clusters	267,896	267,896	267,896	267,896	267,896	267,896	267,896

Notes: Results from linear probability models with family fixed effects. The omitted category is firstborn child. Standard errors are clustered by family. *** significant at 1%, ** at 5%, * at 10%. Each column represents a separate regression and all regressions include controls for mother's age at birth, and indicators for child's birth cohort and gender. For siblings with different fathers, indicators for father's cohort and educational attainment are included.

Table A 7 Diagnoses and ICD10 codes

Variable	Definition
Hospitalization	=1 if admitted to hospital that year with any medical condition
Hospitalization for diagnoses code indicating alcohol abuse	=1 if admitted to hospital with diagnosis codes T51, X45, X65, Y15, F10, K70, K85, K86.0–1 E24.4, G31.2, G62.1, G72.1, I42.6, K29.2, 035.4,
Hospitalization for diagnoses code avoidable conditions	=1 if admitted to hospital with diagnosis codes D50, E10–E11, E13–E14, E86 G40–G41, H66–H67, H66–H67, I11, I20, I29, I50, J02–J03, J06,J43–J47, K24, K26–K28, K52, N10–N12, N70, N73–N74, O15, R56
Hospitalization for injury or poisoning	=1 if admitted to hospital with diagnosis codes S00–T98
Hospitalization for diseases of the respiratory system and conditions related to ears and eyes	=1 if admitted to hospital with diagnosis codes J00–J99 or H00–H95
Hospitalization for diagnoses code indicating self-harm behavior	=1 if admitted to hospital with diagnosis codes Intentional self-harm X60–X84, event of undetermined intent Y10–Y34
Hospitalization for diagnoses code indicating mental health problems	=1 if admitted to hospital with diagnosis codes F00–F99
Hospitalizations for cancer/tumors	=1 if admitted to hospital with diagnosis codes C00–D48
Hospitalizations for perinatal conditions and congenital malformations	=1 if admitted to hospital with diagnosis codes P00–P96 and Q00–Q99