IZA Institute of Labor Economics

Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 12774

Birth Order, Parental Health Investment, and Health in Childhood

Gerald J. Pruckner
Nicole Schneeweis
Thomas Schober
Martina Zweimüller

NOVEMBER 2019

I Z A Institute of Labor Economics

Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 12774

Birth Order, Parental Health Investment, and Health in Childhood

Gerald J. Pruckner
Johannes Kepler University Linz and CDECON

Nicole Schneeweis
Johannes Kepler University Linz, IZA and CEPR

Thomas Schober
Johannes Kepler University Linz and CDECON

Martina Zweimüller
Johannes Kepler University Linz

NOVEMBER 2019

ISSN: 2365-9793

IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Birth Order, Parental Health Investment, and Health in Childhood*

This paper provides a comprehensive analysis of the relationship between birth order, health at birth and in childhood, and parental health investment using administrative data from Austria. We find significant birth order effects on health at birth and in primary school. These effects are positive, in that later-born siblings are healthier than the first-born child, and increase with birth order. Consequently, first-born children are more likely to consume medical drugs and to utilize medical services. We also find differences in parental health investment. First-born children are more likely to receive preventive medical care and immunization against measles, mumps, and rubella.

JEL Classification: I10, I12, I14, J12, J13

Keywords: birth order, parental health investment, parental health behavior, health at birth, health in childhood, health care utilization, vaccinations

Corresponding author:
Thomas Schober
Department of Economics
Johannes Kepler University, Linz
Altenbergerstr. 69
4040 Linz
Austria

E-mail: thomas.schober@jku.at.

* For helpful discussions and comments, we would like to thank Martin Halla, Rudolf Winter-Ebmer, participants at the research seminar of the Department of Economics in Linz, the Annual Meeting of the Austrian Health Economic Association 2019 in Vienna, the Economics of Human Development Workshop at the University of Sydney 2019, and the Annual Conference of the European Society of Population Economics 2019 in Bath. We gratefully acknowledge financial support from the Austrian Federal Ministry for Digital and Economic Affairs and the National Foundation for Research, Technology, and Development.

1 Introduction

In the Western world, first-born children have higher cognitive and non-cognitive skills, acquire more education, and receive higher earnings than their later-born siblings.[1] Recent research also documents a link between birth order and parental behavior, as first-born children receive greater attention and cognitive stimulation in (early) childhood.[2] The observed negative relationship between birth order and human capital outcomes seems to be driven by differences in parental behavior and not by biological differences (Kristensen and Bjerkedal, 2007; Barclay, 2015b; Black et al., 2018; Lehmann et al., 2018).

This paper contributes to the literature on birth order and health, which to date provides mixed evidence. While this research documents that first-borns as adults are taller (Myrskylä et al., 2013), have superior cardio-respiratory fitness (Barclay and Myrskylä, 2014), a lower mortality risk (Barclay and Kolk, 2015), and better self-reported physical and mental health (Black et al., 2016), it also indicates that first-borns have a higher body mass index and are more likely to be overweight or obese and to have high blood pressure (Jelenkovic et al., 2013; Black et al., 2016). At birth, first-born children are less healthy than their later-born siblings. They are more likely to be born pre-term and with low birth weights, and their mothers are more likely to suffer from pregnancy complications (Brenøe and Molitor, 2018; Lehmann et al., 2018; Breining et al., forthcoming). In summary, the existing literature demonstrates that despite their disadvantages in terms of health at birth, first-borns as adults have better health in some dimensions. Initially, this result is not as anticipated; however, pre- and post-natal maternal behavior seems to favor first-born children. Mothers are more likely to attend prenatal care in their first pregnancy and are more likely to breastfeed the first-born child (Buckles and Kolka, 2014; Black et al., 2016; Brenøe and Molitor, 2018; Lehmann et al., 2018).[3] This difference in maternal behavior is consistent with the previously mentioned research regarding birth order effects on human capital outcomes. First-born children benefit from greater parental attention, although this difference may also reflect the mother's compensating behavior resulting from the poorer health of both: the mother in her first pregnancy and the first-born child.

[1]See Black, Devereux and Salvanes (2005), Kantarevic and Mechoulan (2006), Black, Devereux and Salvanes (2011), Barclay (2015a), Hotz and Pantano (2015), Monfardini and See (2016), Pavan (2016), Black, Grønqvist and Öckert (2018) and Lehmann, Nuevo-Chiquero and Vidal-Fernandez (2018) for evidence from developed countries. In contrast, Ejrnæs and Pörtner (2004) and De Haan, Plug and Rosero (2014) provide evidence that birth order positively affects education in developing countries.

[2]See Price (2008), Buckles and Kolka (2014), Hotz and Pantano (2015), Pavan (2016), Black, Grønqvist and Öckert (2018), Lehmann, Nuevo-Chiquero and Vidal-Fernandez (2018).

[3]The evidence on smoking during pregnancy is ambiguous. While women are less likely to smoke at the beginning of or during their first pregnancy compared to later ones (Brenøe and Molitor, 2018; Black et al., 2016), women who have smoked before or at the beginning of pregnancy are less likely to stop or reduce smoking during later pregnancies than during the first (Black et al., 2016; Lehmann et al., 2018) Similarly, mothers are also less likely to reduce their alcohol consumption during later pregnancies (Lehmann et al., 2018).

This paper offers two primary contributions: First, to the best of our knowledge, we provide the first estimates of birth order effects on *parental health investment* in childhood. Previous research has focused on parental health investment in the pre- and postnatal periods, such as prenatal care, breastfeeding, smoking, and alcohol use. Second, we analyze *health status* and *health care utilization* in childhood. Recent evidence on birth order effects on childhood health is based on measures of health care utilization as a proxy for health status. Brenøe and Molitor (2018) use Danish registry data on inpatient and outpatient hospital admissions and emergency room contacts to demonstrate that the health disadvantage for first-borns decreases with age and becomes insignificant after age six. Björkegren and Svaleryd (2017) study birth order effects in Sweden, and use hospital admissions registry and mortality data to show that first-born children exhibit poorer health until age six, a disadvantage that is later reversed. In later childhood and adolescence, children with a higher birth order are more likely to be hospitalized for injuries, avoidable conditions, alcohol-related problems, or mental health issues.

Our paper provides a comprehensive analysis of the relationship between birth order and a child's health until age ten using high-quality administrative data from Austria. The Austrian welfare state provides cost-free access to (almost) all health care services for children including preventive care and vaccinations. In this setting, birth order effects on health-related outcomes should not be driven by financial resource constraints due to the birth of a further child.

We combine measures of health status with measures of health care utilization and parental health investment. Population data used among multiple cohorts allow us to control for cohort effects, and to exploit within-family variation in birth order to account for confounding family-level factors, such as genetic endowments, the family background, family size, or maternal age at first birth. We focus on children in families with two to four children.

We find a statistically significant and quantitatively important health disadvantage for first-born children at birth. Compared to their second-born siblings, first-borns are 40 percent more likely to be born preterm, 66 percent more likely to have low birth weights, and 38 percent more likely to be hospitalized for perinatal conditions in the quarter of birth. The estimated coefficients' magnitudes increase with birth order. As argued by Brenøe and Molitor (2018), later-born children's health advantage at birth can be explained by a biological mechanism that improves nutrient supply to the fetus with each pregnancy (Khong et al., 2003; Gluckman and Hanson, 2004).

We also find that birth order positively affects health in childhood. Based on administrative data from primary school health examinations, we show that first-born children have poorer health outcomes than their later-born siblings between the ages of six and ten. For instance, they have a 23 percent higher prevalence of hearing problems and a more than 50 percent higher prevalence of motor skill issues. We also find evidence—

although somewhat weaker—that first-borns are more likely to have allergies and dental issues, and are more likely to be obese compared to their second-born siblings. Notably, a higher prevalence of obesity is also found among first-born adults (Black et al., 2016), which may relate to a lower nutrient supply to first-borns in utero (Wells et al., 2011).

We complement these results with an analysis of health care utilization in childhood and parental health investments. First, we provide evidence of significant birth order effects on health care utilization. Children with a lower birth order are more likely to consume medical drugs and use inpatient and outpatient medical services. However, we acknowledge that lower or higher health care utilization may not necessarily indicate a better or worse health status, but also reflect parents' behavior.

Second, we use two measures of parental health investment. The first involves participation in a large-scale public health screening program, the mother-child-pass (MCP) program, which monitors the health of expectant mothers and their children until age five. Our second measure of parental health investment is uptake of 6-in-1 vaccines (against whooping cough, polio, diphtheria, tetanus, influenza type b, and hepatitis B) and vaccines against measles, mumps, and rubella (MMR). Both vaccinations are free, and are recommended by the national vaccination plan. We also find significant birth order differences in parental health investment in toddlers and preschoolers. First-born children are more likely to participate in preventive medical visits between the ages of two and five. The estimated difference between first- and second-born siblings is 3 percent at age two, and 9 percent at age five. The coefficients are even larger in magnitude for higher birth orders. The difference between first- and fourth-born siblings is 14 percent at age two and 36 percent at age five. Participation in health screenings in the first year of life is not related to birth order. This result is as anticipated, as participation in all health screenings for children up to 14 months of age is a prerequisite for receiving childcare benefits.

While we do not find any birth order effects regarding the 6-in-1 vaccine by the age of two, the MMR vaccine's uptake is almost 10 percent higher for first-borns compared to their second-born siblings, and 25 percent higher compared to their fourth-born siblings. We show that the estimated birth order effects on immunization rates and health screening participation rates are not driven by differences in health at birth. We also find that parents delay later-born children's immunization against MMR beyond the age of two. Still, we estimate a statistically significant difference in vaccine uptake of almost 3 percent for second-born children and almost 10 percent for fourth-born children by the age of four.

These results illustrate parents' behavioral differences relative to their children's birth order. Differences in health screening participation may be due to additional constraints on time, attention, or other resources, but updated beliefs about these screenings' effectiveness may also play a role. However, an update in beliefs is unlikely to explain the lower vaccine uptake among later-born children. We discuss the potential reasons why vaccine uptake may differ across siblings, and why the birth order effect may differ across types of vaccines. A plausible explanation for both is that vaccine uptake and health screening participation are related. Children who do not participate in screening in their second year of life are also less likely to receive the recommended immunizations for this age. This implies that even if the reason for non-participation in screenings is that parents do not consider these screenings as a sensible health investment, they are more likely to miss out on another health investment: certain immunizations against childhood diseases. Thus, we interpret our findings as a change in parental health investment with birth order, which occurs due to past experiences and time constraints.

A common issue in the literature regarding birth order and health is the implicit assumption that family size is exogenous to children's health endowments. Following Björkegren and Svaleryd (2017), we address this concern by estimating whether the probability of a subsequent birth relates to the recent child's health endowment at birth. Our results indicate a positive correlation, suggesting that the estimated positive birth order effects on child health should be interpreted as lower bounds.

This study's results complement recent empirical contributions by Black et al. (2016), Brenøe and Molitor (2018), and Björkegren and Svaleryd (2017). As adult health is impacted by health at birth, parental health investments in childhood, as well as the individual's own health behavior in child- and adulthood, this study contributes to a better understanding of the complex relationship between birth order and adult health. Differences in parental health investments may also explain part of the negative relationship between birth order and human capital outcomes. Moreover, our findings suggest that scope exists for social policy to offset these differences in parental behavior.

The remainder of this paper is as follows: Section 2 discusses the data and institutional background in Austria. Section 3 explains the estimation strategy, and Section 4 presents our results and discusses possible mechanisms. Section 5 concludes and provides a discussion of potential policy implications.

2 Data and Institutional Background

2.1 The Austrian Health Care System

The Austrian Bismarck-type health care system guarantees almost universal access to high-quality services for the entire population. Mandatory health insurance covers such medical expenses as hospitalization, visits to general practitioners (GPs) and medical specialists in the outpatient sector, and medication. Moreover, this social health insurance offers free participation in the mother-child-pass (MCP) program, which monitors the health of expectant mothers and their children over a period of approximately 70 months. It is comprised of five prenatal examinations, five postnatal infant examinations (up to 14 months of age), and four health screenings of toddlers and preschoolers (between 22 and 62 months of age). The examinations are provided by outpatient care gynecologists, pediatricians, and GPs. A cost-free provision of the 6-in-1 vaccine (against diphtheria, tetanus, pertussis, polio, influenza type b, and hepatitis B) and MMR vaccines complements the MCP program.

Nine provincial health insurance funds (or *Gebietskrankenkassen* in German) provide health insurance for all private-sector employees and their dependents, representing approximately 75% of the population.[4] Health insurance funds cannot be chosen freely, as affiliation with an insurance institution is determined by the individual's place of residence and occupation. Outpatient health care expenditures are predominantly funded by wage-related social security contributions from employers and employees. Hospital treatments are co-financed by social security contributions and general tax revenues at different federal levels. Private health insurance can be used to complement statutory health insurance, but only plays a minor role in Austria.[5]

2.2 Data

Birth order We use data from several administrative data sources; specifically, we combine data from the Austrian Birth Register, the Family Allowance Database, and the Austrian Social Security Database to identify all births between 1974 and 2015 and each child's birth order. We restrict the analysis to families with two to four children, in which the first child was born in 1984 or later, and all siblings have the same mother. We exclude families with multiple births, as we cannot assign a birth order to these children. See Appendix A for further details.

Health at birth and in childhood The Austrian Birth Register provides data on health at birth for all children born between 1984 and 2007. It includes detailed information on such birth outcomes as birth weight and length, mode of birth, Apgar scores, and gestational length. Table 1 provides a detailed description of all outcome variables to be used in the empirical analysis, and Appendix A.1 provides sample statistics for the birth registry sample. Childhood health information is based on data from school health examinations in Upper Austria, one of Austria's nine federal states. Upper Austria comprises approximately one-sixth of the Austrian population and workforce. In 2009, the regional government began a structured data collection of school health exams to assess pupils' general health status. Our empirical analysis uses health examination data from 130 primary schools between 2009 and 2016, which cover the first four years of compulsory education, when children are typically between six and ten years old. School health

[4]Other insurance institutions offer mandatory health insurance for certain occupational groups, such as farmers, civil servants or self-employed workers.

[5]Public health expenditures accounted for 77 percent of total health expenditures in 2011. While 17 percent of total health expenditures were private household out-of-pocket expenditures, only 5 percent were covered by private health insurance (OECD, 2013).

examinations include the child's medical history as reported by the parents and a physical examination of the child; Table 1 describes the outcome variables and Appendix A.2 provides further details on the data and estimation sample, including summary statistics.

Health care utilization The Upper Austrian Health Insurance Fund provides data on health care use between 2005 and 2015; this fund covers more than one million people in Upper Austria. The registry data includes detailed information on medical attendance in the outpatient sector (GPs and specialists in various medical fields) and for medication according to Anatomical, Therapeutic, Chemical (ATC) classification system codes. Inpatient information covers hospitalizations—including admission diagnoses for each individual—according to the International Classification of Diseases (ICD-10) scheme. Quarterly data is available on physician visits, hospital stays, and prescription drugs, which we aggregate into annual observations per year of life for each insured child. For example, for health care utilization at age five, we consider the quarter when the child turns five and the three preceding quarters. Appendix A.3 provides details on the estimation sample, including summary statistics.

Parental health investment We use two measures for parental health investment. Our first variable measures participation in the MCP program, which involves large-scale public health screening. Our health care utilization data for each child indicate whether he or she has participated in each of the nine health screenings between birth and age five. Table A.5 in the Appendix provides an overview of the MCP program's scope, excluding prenatal screenings. As previously mentioned, we aggregate the data into annual observations per year of life for each insured child. Accordingly, at age one we measure whether a child has participated in at least one of the five postnatal health examinations. At age two, we measure whether a child has participated in the sixth health screening. Participation indicators at age three, four, and five are based on participation in the seventh, eighth, and ninth health screenings.

Our second measure of parental health investment is uptake of the 6-in-1 and MMR vaccines. Vaccination data are provided by the Upper Austrian regional government, which subsidizes recommended childhood vaccinations, and can be linked using a unique individual identifier. Both vaccinations are free, and are recommended in the national vaccination plan.[6] Our outcomes measure whether a child has received at least one vaccination of each type—6-in-1 and MMR—within the first two, three, and four years of life. Appendix A.4 provides details on the estimation sample, including summary statistics.

[6] The national vaccination schedule has changed over time, but it is always recommended that children receive at least three doses of the 6-in-1 vaccine in the first year, and one dose of the MMR vaccine by age two (ECDC, 2019).

3 Empirical strategy

We estimate the following model for child i in family f:

$$Y_{if} = \alpha + \sum_{j=2}^{4} \beta_j I(BO_{if} = j) + \gamma Girl_{if} + \delta_f + \sum_{t=2}^{T} \theta_t I(BC_{if} = t) + \epsilon_{if} \quad (1)$$

where Y_{if} denotes the outcome and BO_{if} denotes the birth order of child i in family f. Further, $Girl_i$ indicates if the child is female, δ_f is a mother fixed effect, BC_{if} denotes the child's birth cohort measured by year-by-month of birth indicators, and ϵ_{if} is the remaining error term. We cluster standard errors at the mother-level.

This estimation approach exploits only within-family variations in birth order and accounts for time-constant family-level confounding factors, such as genetic endowments, maternal age at first birth, family background, and family size. It is also important to control for cohort effects to account for siblings born in different age cohorts. Conditional on the mother fixed effect, controlling for the child's birth cohort implies controlling for the mother's age at birth, as these two variables are perfectly collinear. Thus, our estimation model also accounts for the maternal age at birth increasing with the child's birth order.

The identification of birth order effects relies on the assumption that family size is exogenous to children's health endowments, or specifically, the decision to have additional children does not correlate with the existing children's health status. We will address this issue in further detail in Section 5.

4 Results

4.1 Health at birth and in childhood

Health at birth We find that birth order positively affects newborns' health (Table 2). Compared to their first-born siblings, later-born infants have a higher birth weight and are less likely to be born with low birth weights (below 2,500 grams), and are less likely to be born premature. They are also less likely to be small for their gestational age and have Apgar 5 scores of less than 7.[7] Our sample of Upper-Austrian children as observed through the health care utilization data reveals that later-born children are less likely to be hospitalized for perinatal conditions. As the remaining analysis is based on samples of Upper-Austrian children, we re-estimate birth order effects on health at birth for children born in Upper Austria and find similar results (see the Appendix, Table B.1). Birth

[7]The Apgar score provides a standardized method for reporting the clinical status of newborns after one, five, and ten minutes. It comprises five subcomponents (color, heart rate, reflexes, muscle tone, and respiration), each of which is given a score of 0, 1, or 2. The resulting score ranges from 0 to 10 ("good"). The American College of Obstetricians and Gynecologists (ACOG, 2015) defines five-minute Apgar scores of 7 to 10 as reassuring, scores of 4 to 6 as moderately abnormal, and scores of 0 to 3 as low.

order effects on health at birth are statistically significant and quantitatively important. Compared to the first-born child, the second-born sibling is 158 grams (5 percent) heavier, 2.7 percentage points (66 percent) less likely to have low birth weight, and 2.9 percentage points (40 percent) less likely to be born premature. The magnitudes of the coefficients increase for third- and fourth-born siblings, and are in a similar range as those obtained by Brenøe and Molitor (2018).[8] As explained in detail by Brenøe and Molitor (2018), the medical literature provides a plausible explanation for birth order's positive effects on health at birth. Specifically, the maternal constraint hypothesis (Gluckman and Hanson, 2004) states that physiological constraints that presumably limit nutrient supply to the fetus are reduced with each pregnancy, resulting in better fetal growth in higher-order pregnancies. This literature suggests that the birth order effect on health at birth has predominantly biological origins. Consistent with this hypothesis, Black et al. (2018) find that biological birth order positively affects both cognitive and non-cognitive skills.

Childhood health Our school health examination data allows for an assessment of children's health conditions between the ages of six and ten. We pool all children in this age range and control for the child's monthly age (see Appendix A.2). Table 3 presents the estimation results. We find that birth order positively affects children's health. Second-born children have a 23 percent lower prevalence of ear, nose or throat (ENT) problems and a more than 50 percent lower prevalence of motor skill issues. At the 10 percent significance level, we find that second-born children are less likely to be affected by allergies, dental issues, and obesity as compared to their first-born siblings.[9] The latter result is consistent with a lower prevalence of overweight, obesity, and high blood pressure among later-born adults (Black et al., 2016).[10] Our estimates also show that second-born—and in particular, third-born children—are physically more active than their older siblings.

Wells et al. (2011) indicate that first-borns have lower birth weights, but catch up within the first years of life. By age four, first-borns have a higher weight and are taller than later-borns. This "overshoot" in growth is associated with higher blood pressure and risk of cardiovascular disease. Our estimation results indicate a similar pattern. Despite lower weights and lengths at birth, first-borns are 0.5 cm (0.4 percent) taller and 1.9

[8] Table B.2 in the Appendix provides further results, and demonstrates that later-born children are less likely to have birth weights below 1,500 grams and Apgar 10 scores below 7. They are also less likely to be born by Caesarian section, and their lengths at birth are significantly greater than that of their first-born siblings. We also find that the birth order effects are positive and similar in different birth-cohort subsamples (see the Appendix, Figure B.2).

[9] The medical literature points to a lower risk of later-born children developing allergies, although these results are not based on within-family analyses (e. g. Bernsen et al., 2003; Kusunoki et al., 2012).

[10] These findings reflect the Fetal Origins of Adult Disease hypothesis (Barker, 1995), which relates the fetus' limited nutrient supply to adult diseases, such as coronary heart disease and diabetes. More recently, and based on this hypothesis, the Development Origins of Health and Disease paradigm has emerged (Gluckman and Hanson, 2006; Gluckman et al., 2007), which states that early life influences can alter later disease risk.

percentage points (27 percent) more likely to be obese than their second-born siblings.[11]

We do not find a significant difference across birth order in the prevalence of certain diseases (e. g., epilepsy, diabetes, asthma) and vision and locomotor problems. Moreover, all coefficients for fourth-born children are statistically insignificant.

Our regressions based on birth registry and school health examination data indicate positive health effects for higher-order births. As the data sources provide different health measures, it is difficult to assess whether the health differences found at birth increase, stabilize, or converge in the following years. We further address this question by analyzing health care utilization data, which are available throughout the period from birth to age ten.

4.2 Health care utilization

We provide estimation results for birth order effects on the consumption of medical drugs, doctor's visits, and hospitalizations for children between the ages of one and ten. Table 4 reveals that birth order has quantitatively important and highly significant negative effects on health care utilization.

Prescription drugs Second-born children are significantly less likely to consume medical drugs than their older siblings between the ages of four and ten. The coefficients for third- and fourth-born children exhibit even larger magnitudes. The largest disparities in drug prescriptions are observed at age seven. Compared to the first-born child in the family, second-, third- and fourth-born children are 18, 29, and 31 percent less likely to consume medical drugs at age seven, respectively. Further, the birth order effects on drug prescriptions in three-year-olds is surprisingly positive. One plausible explanation for this result is the presence of a contagion effect. Younger siblings may catch common contagious diseases from their older siblings, and particularly from those who already attend childcare or primary school. We will address this issue further below.

Doctor visits The pattern for doctor's visits is similar; with a few exceptions, we find negative birth order effects on the utilization of physicians. The probability of a second-born child visiting his or her doctor at age four is 2.7 percentage points (3 percent) lower than that for the first-born sibling. The corresponding coefficients increase in magnitude up to 6 and 11 percent for third- and fourth-born children, respectively. Birth order's negative impact on physician visits can be observed at almost all ages between four and ten. Moreover, in accordance with the results on health at birth, later-born children are less likely to see a physician in the first two years of life.

Hospitalizations At the ages of five and seven, higher-order births exhibit a significantly lower probability of hospitalization compared to their older siblings. Second-born children are 3.2 percentage points (25 percent) less likely to be hospitalized at the age

[11] Note that we do not find a statistically significant effect on BMI, and the likelihood to be over- or underweight (not reported in Table 3).

of five, and 2.4 percentage points (24 percent) less likely to be hospitalized at the age of seven. Birth order effects on hospitalizations at other ages are mostly negative, albeit not statistically significant.

Subcategories of health care utilization Figures 1, 2, and 3 graphically represent birth order effects for second-born children on the aggregate, and the most important subcategories of drug prescriptions, doctor's visits, and hospitalizations.[12] The development of estimated coefficients for second-born children during childhood reveals two distinct patterns that become evident in Figure 1. For medication groups that include to a greater extent medication for common contagious diseases (i. e., antiinfectives for systemic use or medications for the respiratory and musculoskeletal systems), we find a higher probability of drug prescriptions in second-born children in the first, second, and third years of life, and a lower probability from age four onward.[13] The same pattern is observed for the aggregate of drug prescriptions. The probability of drug prescriptions for the alimentary tract and metabolism, as well as for dermatological use, is lower in second-born children than in their older siblings from the first year of life onward, before the effects become insignificant at higher ages.[14]

Figures 2 and 3 depict estimates for doctor's visits and hospitalizations. The development of birth order effects for the utilization of ear, nose, and throat (ENT) health care services over children's ages complies to a great extent with the pattern found for medication against common contagious diseases. Later-born children reveal a higher probability to be treated by ENT specialists in their first three years, and a lower probability thereafter. Estimations of birth order effects on hospitalization due to diseases of the respiratory system, ears, and eyes—which is the most common reason for hospitalization between the ages of one and ten—also indicate a higher probability for second-born children until the age of three, and a lower probability thereafter.[15]

In summary, these findings corroborate the previously mentioned contagion effect. The probability of both medication and medical treatment for common contagious diseases in the first three years of life is significantly higher in second-born children than in their older siblings. Second-born children can be expected to have bacterial and viral infections earlier because they are exposed to these diseases at earlier ages than their first-born

[12]For the full regression output, see the Appendix, Tables B.3 through B.6.

[13]In our sample of children, antiinfectives for systematic use are almost exclusively comprised of antibiotics; medications for the respiratory system are predominantly means against coughs, colds, allergies, and asthma; and the group of drugs for the musculoskeletal system almost exclusively includes anti-inflammatory products.

[14]The average prescription rate over the first ten years of life is 0.61 for any drug, 0.43 for antiinfectives, 0.15 for respiratory medications, 0.06 for musculoskeletal medications, 0.14 for alimentary tract/metabolic medications, and 0.10 for dermatological medications.

[15]We also find some evidence that birth order positively affects hospitalizations for injuries, poisoning, and other external causes at the ages of two, four, and eight (see the Appendix, Table B.6). This finding is consistent with Brenøe and Molitor (2018), who demonstrate that later-born children are more likely to be hospitalized for injuries in early childhood and late adolescence. The analysis of other disease categories is not useful since the prevalence of these diseases in childhood is (fortunately) low.

siblings. While first-born children in particular are exposed to contagious diseases as soon as they attend childcare, second-born siblings are already exposed to these diseases as soon as their older sibling attends childcare. As our sample's average birth spacing (between first- and second-born children) is 3.6 years, and the childcare enrollment rate among three- to five-year-olds was between 0.8 and 0.9 in the sample period, the average second-born sibling is already exposed to contagious diseases through his or her older sibling from birth onward.[16] An unresolved question remains as to whether early exposure to infectious pathogens and the associated consumption of medical drugs—and particularly antibiotics—negatively affects long-term health and cognition.[17]

Health status or behavior Lower or higher levels of health care utilization may not necessarily indicate a better or worse health status, but also reflects parents' behavior. Even if it is difficult to unequivocally distinguish health from behavioral effects, the level of detail in our registry data indicates whether different health care service components reflect the utilization of curative services to improve poor health, or preventive services to maintain good health. Thus, we interpret hospitalization and the consumption of prescription drugs as better indicators of individual health status than physician's visits.[18] Consequently, the less frequent utilization of hospital treatment and medical drugs in second-born children from age four onward indicates their superior health, and supports our previously discovered health effects based on birth registry and school health examination data.

4.3 Parental health investment

Health screenings and vaccinations are preventative health care services, and their utilization can convey parental health behaviors and investments. Panel A in Table 5 reports birth order effects on the probability of participating in preventive medical care in the mother-child-pass (MCP) program for children of different ages. Participation rates significantly decrease with birth order from the children's second year of life onward. At age two, second-born children have a 2.8 percentage-point lower participation rate in these screenings compared to their first-born siblings. Given a mean of 82 percent, the participation rate at age two is 3 percent lower among second-born children. The magnitudes of the coefficients increase with the child's birth order and age, reaching a maximum of 22.6 percentage points for fourth-born children at age five. At that age, fourth-born children

[16] Later-born siblings may also be exposed earlier if they first attend childcare at an earlier age. However, childcare enrollment rates among children below the age of three were low in the sample period. In 2008, only 6.7 percent were enrolled in Upper Austria (Statistik Austria, Kindertagesheimstatistik 2018).

[17] Medical evidence is largely based on animal and cohort studies, and provides no convincing evidence of a causal relationship. For instance, Örtqvist et al. (2014) reveal that the negative correlation between childhood exposure to antibiotics and asthma is caused by confounding factors, and partially occurs due to reverse causality.

[18] Note that our hospitalization variable covers only inpatient hospital stays. Therefore, we are confident that this outcome is a viable measure of health status.

are 36 percent less likely to participate in health screenings compared to their first-born siblings. We do not observe significant birth order effects in the first year of life, which can be explained by the MCP program's incentive structure, as participation in health screenings during the first year of life is mandatory to receive child care benefits. Consequently, 93 percent of children in our sample participate in the program during their first year of life.[19]

These results illustrate the behavioral differences of parents relative to their children's birth order. We find that parents decrease their willingness to participate in postnatal health screenings with each additional child, but we cannot identify the reasons for these behavioral changes. On the one hand, parents may divide their resources—or specifically, time—between their children, and subsequently provide fewer to each child after the arrival of a sibling. On the other hand, parents' beliefs may change regarding health screenings' effectiveness, and they may learn that participation did not significantly contribute in terms of health.

One may ask whether the lower participation rates in health screenings among later-born children can be explained by their superior health at birth. We answer this question by re-estimating birth order effects on screening participation, and control for a binary variable that indicates whether the child has been hospitalized for perinatal conditions in the first quarter after birth. Our sample's hospitalization rate for perinatal conditions is 15 percent. Panel B in Table 5 presents our estimation results, and confirms negative birth order effects on screening participation between the ages of two and five as well as no effects in the first year of life.

Table 5 also shows estimated birth order effects on vaccination rates. We find no evidence of a birth order effect on the 6-in-1 vaccine, and significant birth order effects on the MMR vaccine. Compared to first-borns, second-born children are 6.1 percentage points (10 percent) less likely to have received at least one dose of the MMR vaccine by age two.[20] The previous section indicates that later-born children are more likely to contract common contagious diseases in the first three years of life; consequently, parents may be more likely to delay immunization beyond the age of two. The last four columns in Panel A of Table 5 analyze vaccination rates by ages three and four; it seems that later-born children are immunized against MMR at a later age, as the birth order effect declines in magnitude with the child's age. Compared to first-borns, the vaccination rate of second-born children is 10 percent lower by age two, 4 percent lower by age three, and 3 percent lower by age four.[21] Vaccine uptake may also relate to health at birth. Panel

[19] Child care benefits are paid to mothers or fathers on parental leave. The monthly amount (ranging from €436 to €2,000) depends on the chosen type of parental leave scheme (flat-rate or income-related) and the duration of parental leave.

[20] Note that three out of four doses of the 6-in-1 vaccine are recommended in the first year of life, while both doses of the MMR vaccine are recommended in the second year of life.

[21] A higher incidence of contagious diseases in the first three years of life is a potential, but not the only explanation for the delay in MMR vaccinations observed among later-born children. The delay could also

B in Table 5 demonstrates that the magnitude of the negative birth order effect actually increases when we control for health at birth, suggesting a positive correlation between health at birth and vaccine uptake.[22]

Our findings indicate a negative relationship between birth order and parental health investment, which cannot be simply explained by differences in health at birth or delayed vaccinations among later-born children. Thus, we will discuss the potential reasons why parental health investments and vaccines' uptake in particular—may differ across siblings, and why birth order effects may differ across the types of vaccines. First, vaccination uptake may relate to participation in the MCP program, as the physician checks the child's immunization status at the MCP visit and typically recommends immunizations according to the national immunization plan. We observe that both participation in the MCP program in the first year of life and uptake of the 6-in-1 vaccine, which is recommended in the first year, do not relate to birth order. In contrast, participation in the MCP program in the second year of life and uptake of the MMR vaccine as recommended in the second year negatively relate to birth order. This finding suggests that children who do not participate in the MCP program are less likely to receive immunizations against childhood diseases. Further, this implies that if non-participation occurs because parents do not consider health screenings as a health investment, they are more likely to miss out on another health investment (vaccination). Second, vaccination carries some risk of adverse reaction, and parents may decide not to vaccinate later-born children because the first-born sibling had experienced adverse effects. However, common side effects are mild (e.g., redness and swelling at the injection site, or fever), and severe reactions are exceptionally rare; thus, we do not believe that this can explain the estimated birth order effect or the difference in this effect across types of vaccines.[23] Third, the MMR vaccine was highly controversial in the sample period. In 1998, a now-retracted study published in the *Lancet* suggested a link between the MMR vaccine and autism. This study had received substantial media attention, resulting in a decrease in vaccination uptake, and particularly among highly educated parents (Anderberg et al., 2011). The study was retracted in 2010. Since all children in our sample were born after the MMR controversy begun, it is highly unlikely that this controversy explains the negative birth order effects on MMR vaccine uptake.

Overall, we interpret our findings as a change in parental health investment with birth order that has likely occurred due to parents' past experiences and constraints on time and attention.

be due to time constraints or parental choice. Our data does not allow us to discriminate between these different explanations.

[22]Note that we find a (marginally) significant birth order effect on the 6-in-1 vaccine uptake, conditional on health at birth.

[23]We did not find evidence of significant differences in the incidences of mild reactions between these vaccines. The scientific evidence regarding severe reactions points to a slightly higher, but still exceptionally low incidence of severe reactions after the MMR vaccination (IOM (Institute of Medicine), 2012).

5 Discussion & Conclusion

This paper indicates that birth order positively affects health at birth and in childhood. As our estimation strategy relies on within-family variation, it accounts for unobserved confounding family-level factors. The identification of birth order effects is based on the assumption that family size is exogenous, or specifically, the decision to have an additional child does not correlate with existing children's health. If parents refrain from having an additional child when the most recent child has low health, our estimated birth order effects should be interpreted as lower-bound results.

We provide evidence regarding the sign of the correlation between the first child's health and family size (similar to Björkegren and Svaleryd, 2017) by estimating whether the probability of a subsequent birth relates to the first child's health, conditional on a range of maternal characteristics measured at birth. We measure the first child's health in several ways. First, we consider data from the Family Allowance Database in measuring the child's disability status in the first year of life.[24] In our estimation sample of families with one to four children, 1.8 percent of first-born children are disabled in the first year of life. Second, we measure the first child's health with health at birth indicators, such as low birth weight, preterm birth, or small for gestational age. Third, we construct a health index based on sex-specific birth weights and gestation lengths. This index has a mean of zero and standard deviation of one, with higher values indicating better health at birth. The Appendix, Figure B.1 shows the distribution of this index.

We find evidence of a positive correlation between the first child's health and the likelihood of a subsequent birth (Table 6). It seems that families are less likely to have a second child if the first child is disabled, had a low birth weight, was born premature, or was small for gestational age. Similarly, a low health index value relates to a less likely subsequent birth.[25] These results suggest that family size positively correlates with the first child's health. This implies that first-borns in our sample of families with two to four children are positively selected, and any positive birth order effects on health most likely represent a lower bound of the true relationship.[26]

This paper comprehensively analyzes birth order and health status at birth and in

[24]We define a binary variable *disabled before age 1* that indicates whether a child has received an increased family allowance due to disability. Such an increased allowance is granted if a child has a physical or mental disability of at least 50 percent; for instance, this applies to children with developmental disorders due to a physical, learning, language, or behavioral impairment (e.g., learning disabilities or attention deficit hyperactivity disorder).

[25]We also find a negative correlation for values above the 90th percentile. Many of these children are macrosomic; 42 percent are born weighing more than four kilograms, and 36 percent are large for their gestational age. Medical research indicates that macrosomia is associated with maternal obesity and gestational diabetes, obstetric labor complications, and postpartum health problems. Large babies are at greater risk of fetal asphyxia, shoulder dystocia, birth trauma, hypoglycemia, later-life obesity, and cardiovascular diseases (e.g., Jolly et al., 2003).

[26]Black et al. (2018) and Pavan (2016) show that endogenous fertility does not drive the negative birth order effects on (non-)cognitive skills.

childhood, health care utilization, and parental health investments. Health at birth significantly increases with birth order, as we find significant birth order effects for birth weight, preterm birth, Apgar scores, or perinatal conditions. We use school health examination data to show that birth order also positively influences childhood health. Although these estimates are statistically less significant, we find that first-born children are more likely affected by allergies, hearing problems, dental issues, motor skill issues, and obesity. The analysis of health care utilization, such as hospitalizations, drug prescriptions, and doctor's visits indicates corresponding effects. In contrast, we find that parental investment in children's health—measured by participation in preventive medical care and vaccinations, tend to favor earlier-born children.

Differential parental behaviors relative to their health investments could explain the mixed results concerning birth order effects on adult health outcomes if early life investments cannot compensate for the disadvantages at birth across all health dimensions. Although we observe only two aspects of health investment, they may indicate general changes in parents' behavior regarding their children's health. The literature has well-established that early-life conditions can affect individual outcomes throughout the life cycle. Therefore, differences in parental health investments may also explain part of the negative relationship between birth order and long-term human capital outcomes, such as educational attainment and wages.

Although birth order is not subject to policy intervention, our findings on parental health investments indicate scope for social policy. Parents are less likely to attend preventive medical check-ups with later-born children, and these children are less likely to receive important vaccinations. Parents are likely unaware of their differential behavior. Although birth order cannot be altered, the knowledge of its impact can be used to develop prevention and treatment strategies to further the development of later-born children.

Finally, from an academic perspective, birth order effects on children's health reveals the importance of considering birth order in within-family studies, and particularly when analyzing health outcomes.

References

Anderberg, Dan, Arnaud Chevalier and Jonathan Wadsworth (2011), 'Anatomy of a Health Scare: Education, Income and the MMR Controversy in the UK', Journal of Health Economics **30**, 515–530.

Barclay, Kieron (2015a), 'A Within-Family Analysis of Birth Order and Intelligence using Population Conscription Data on Swedish Men', Intelligence **48**, 109–122.

Barclay, Kieron (2015b), 'Birth Order and Educational Attainment: Evidence from Fully Adopted Sibling Groups', Intelligence **49**, 134–143.

Barclay, Kieron and Martin Kolk (2015), 'Birth Order and Mortality: A Population-Based Cohort Study', Demography **52**, 613–639.

Barclay, Kieron and Mikko Myrskylä (2014), 'Birth Order and Physical Fitness in Early Adulthood: Evidence from Swedish Military Conscription Data', Social Science & Medicine **118**, 66–77.

Barker, David J. (1995), 'Fetal Origins of Coronary Heart Disease', BMJ **311**(6998), 171–174.
URL: *http://www.bmj.com/content/311/6998/171*

Bernsen, Roos M. D., Johan C. de Jongste and Johannes C. van der Wouden (2003), 'Birth Order and Sibship Size as Independent Risk Factors for Asthma, Allergy, and Eczema', Pedriatric Allergy and Immunology **14**(6), 464–469.

Björkegren, Evelina and Helena Svaleryd (2017), Birth Order and Child Health, Working Paper 2017:16, Institute for Evaluation of Labor Market and Education Policy (IFAU), Uppsala.

Black, Sandra E., Erik Grønqvist and Björn Öckert (2018), 'Born to Lead? The Effect of Birth Order on Non-Cognitive Abilities', Review of Economics and Statistics **100**(2), 274–286.

Black, Sandra E., Paul J. Devereux and Kjell G. Salvanes (2005), 'The More the Merrier? The Effect of Family Size and Birth Order on Children's Education', The Quarterly Journal of Economics **120**(2), 669–700.

Black, Sandra E., Paul J. Devereux and Kjell G. Salvanes (2011), 'Older and Wiser? Birth Order and IQ of Young Men', CESifo Economic Studies **1**(1), 103–120.

Black, Sandra E., Paul J. Devereux and Kjell G. Salvanes (2016), 'Healthy(?), Wealthy and Wise: Birth Order and Adult Health', Economics and Human Biology **23**, 27–45.

Breining, Sanni N., Joseph J. Doyle, David N. Figlio, Krzysztof Karbownik and Jeffrey Roth (forthcoming), 'Birth Order and Delinquency: Evidence from Denmark and Florida', Journal of Labor Economics .

Brenøe, Anne Ardila and Ramona Molitor (2018), 'Birth Order and Health of Newborns: What Can We Learn from Danish Registry Data?', Journal of Population Economics **31**, 363–395.

Buckles, Kasey and Shawna Kolka (2014), 'Prenatal Investments, Breastfeeding, and Birth Order', Social Science & Medicine **123**, 141–148.

De Haan, Monique, Erik Plug and José Rosero (2014), 'Birth Order and Human Capital Development. Evidence from Ecuador', Journal of Human Resources **49**(2), 359–392.

ECDC (2019), 'Vaccine Scheduler - Austria: Recommended Vaccinations', `https://vaccine-schedule.ecdc.europa.eu`. [Accessed 2019-04-08].

Ejrnæs, Mette and Claus C. Pörtner (2004), 'Birth Order and the Intrahousehold Allocation of Time and Education', Review of Economics and Statistics **86**(4), 1008–1019.

Gluckman, Peter D. and Mark A. Hanson (2004), 'Maternal Constraint of Fetal Growth and its Consequences', Seminars in Fetal and Neonatal Medicine **9**, 419–425.

Gluckman, Peter D., Mark A. Hanson and Alan S. Beedle (2007), 'Early Life Events and Their Consequences for Later Disease: A Life History and Evolutionary Perspective', American Journal of Human Biology **19**, 1–19.

Gluckman, Peter D. and Mark A. Hanson, eds (2006), Developmental Origins of Health and Disease, Cambridge University Press, Cambridge.

Hotz, V. Joseph and Juan Pantano (2015), 'Strategic Parenting, Birth Order, and School Performance', Journal of Population Economics **28**, 911–936.

IOM (Institute of Medicine) (2012), Adverse Effects of Vaccines: Evidence and Causality, The National Academies Press, Washington, DC.

Jelenkovic, Aline, , Karri Silventoinen, Per Tynelius, Mikko Myrskylä and Finn Rasmussen (2013), 'Association of Birth Order with Cardiovascular Disease Risk Factors in Young Adulthood: A Study of One Million Swedish Men', PLoS ONE **318**, 1717–1717.

Jolly, Matthew C., Neil J. Sebire, John P. Harris, Lesley Regan and Stephen Robinson (2003), 'Risk Factors for Macrosomia and its Clinical Consequences: A Study of 350,311 Pregnancies', European Journal of Obstetrics, Gynecology and Reproductive Biology **111**(1), 9–14.

Kantarevic, Jasmin and Stéphane Mechoulan (2006), 'Birth Order, Educational Attainment and Earnings: An Investigation Using the PSID', Journal of Human Resources **41**(4), 755–777.

Khong, T. Yee, E.D. Adema and Jan Jaap H.M. Erwich (2003), 'On an Anatomical Basis for the Increase in Birth Weight in Second and Subsequent Born children', Placenta **24**(4), 348–353.

Kristensen, Petter and Tor Bjerkedal (2007), 'Explaining the Relation between Birth Order and Intelligence', Science **8**(5).

Kromeyer-Hauschild, Katrin, Martin Wabitsch, Detlef Kunze, Frank Geller, Hans-Christian Geiß, Volker Hesse, Alexandra von Hippel, Uwe Jaeger, Dieter Johnsen, Wolfgang Korte et al. (2001), 'Perzentile für den Body-mass-Index für das Kindes- und Jugendalter unter Heranziehung verschiedener deutscher Stichproben', Monatsschrift Kinderheilkunde **149**(8), 807–818.

Kusunoki, Takashi, Kumiko Mukaida, Takeshi Morimoto, Mio Sakuma, Takahiro Yasumi, Ryuti Nishikomori and Toshio Heike (2012), 'Birth Order Effect on Childhood Food Allergy', Pediatric Allergy and Immunology **23**, 250–254.

Lehmann, Jee-Yeon K., Ana Nuevo-Chiquero and Marian Vidal-Fernandez (2018), 'The Early Origins of Birth Order Differences in Children's Outcomes and Parental Behavior', Journal of Human Resources **53**(1), 123–156.

Monfardini, Chiara and Sarah Grace See (2016), 'Birth Order and Child Cognitive Outcomes: An Exploration of the Parental Time Mechanism', Education Economics **24**(5), 481–495.

Myrskylä, Mikko, Karri Silventoinen, Aline Jelnkovic, Per Tynelius and Fin Rasmussen (2013), 'The Association between Height and Birth Order: Evidence from 652 518 Swedish Men', J Epidemiol Community Health **67**, 571–577.

OECD (2013), Health at a Glance 2013, OECD Publishing, Paris.

Örtqvist, Anne K., Cecilia Lundholm, Helle Kieler, Jonas F. Ludvigsson, Tove Fall, Weimin Ye and Catarina Almqvist (2014), 'Antibiotics in Fetal and Early Life and Subbsequent Childhood Asthma: Nationwide Population Based Study with Siblings Analysis', BMJ: British Medical Journal **349**(7987).

Pavan, Ronnie (2016), 'On the Production of Skills and the Birth Order Effect', Journal of Human Resources **51**(3), 699–726.

Price, Joseph (2008), 'Parent-Child Quality Time. Does Birth Order Matter?', Journal of Human Resources **43**(1), 240–265.

The American College of Obstetricians and Gynecologists (2015), 'Committee Opinion No. 644: The Apgar Score', Obstetrics & Gynecology **126**(4), 914.

Wells, Jonathan C.K., Pedro C. Hallal, Felipe F. Reichert, Samuel C. Dumith, Ana M. Menezes and Cesar G. Victora (2011), 'Associations of Birth Order with Early Growth and Adolescent Height, Body Composition, and Blood Pressure: Prospective Birth Cohort from Brazil', American Journal of Epidemiology **174**(9), 1028–1035.

Zweimüller, Josef, Rudolf Winter-Ebmer, Rafael Lalive, Andreas Kuhn, Jean-Philippe Wuellrich, Oliver Ruf and Simon Büchi (2009), Austrian social security database, Working Paper 0903, The Austrian Center for Labor Economics and the Analysis of the Welfare State, Johannes Kepler University Linz, Austria.

6 Tables and Figures

Table 1: Definition of main outcome variables

Outcome	Description
(a) Health at birth	
Birth weight	Weight in kilograms
Low birth weight	Birth weight less than 2,500g
Preterm birth	Gestation period is shorter than 37 weeks
Small for gestational age	Birth weight for gestational age and sex is below the 10th percentile
Low Apgar score	Apgar score after 5 minutes is less than 7
(b) Childhood health	
Current diseases	Child has epilepsy, diabetes, asthma, ADHD, headache, or stomachache
Allergies	Child has any allergies
Vision problems	Child has strabismus, poor eyesight, or needs glasses/contact lenses
ENT problems	Child has any ear, nose, or throat abnormalities or hearing impairments
Dental issues	Child has tooth decay, malocclusion or dental braces
Locomotor problems	Any disorder of the locomotor system: thorax, shoulders, pelvis, spine, muscles, upper and lower extremities, and feet.
Motor skill issues	Trouble with coordination, balance, or fine or gross motor skills
Obesity	BMI ($BMI = w/h^2$, weight w in kg and height h in m) over the 97th percentile according to the age- and sex-specific distribution defined in Kromeyer-Hauschild et al. (2001)
Height	Height in cm
Low physical activity	Extracurricular physical activity once per week or less often
(c) Health care utilization	
Hospitalization	Indicator for any hospitalization
Perinatal conditions	Hospitalization due to perinatal conditions in the quarter of birth (International Classification of Diseases—ICD Version 10, codes P00–P96), congenital malformations, deformations, and chromosomal abnormalities (Q00–Q99)
Respiratory system, ears, eyes	Hospitalization due to respiratory diseases (J00–J99), diseases of the eye and adnexa (H00–H59), and diseases of the ear and mastoid process (H60–H95)
Injury, poisoning, external causes	Hospitalization due to injury, poisoning and certain other consequences of external causes (S00–T98)
Any drug	Indicator for any drug prescription
Antiinfectives for systemic use	Code J drug prescriptions from the Anatomical Therapeutic Chemical (ATC) classification system
Respiratory system	ATC Code R drug prescriptions
Musculo-skeletal system	ATC Code M drug prescriptions
Alimentary tract and metabolism	ATC Code A drug prescriptions
Dermatologicals	ATC Code D drug prescriptions
Any physician	Indicator for visit to any outpatient GP or medical specialist
ENT specialist	Visit to medical doctor dealing with conditions of the ear, nose, and throat
(d) Parental health investment	
Mother-child-pass examination	Preventive medical checkup within the MCP program, which offers free health screenings for children up to age five
6-in-1 vaccination by age 2/3/4	Child has received at least one dose of the 6-in-1 vaccine (whooping cough, polio, diphtheria, tetanus, haemophilus influenzae type b, and hepatitis B) until the age of 2/3/4
MMR vaccination by age 2/3/4	Child has received at least one dose of the MMR (measles, mumps, and rubella) vaccine until the age of 2/3/4

Table 2: Birth order effects on health at birth

	Birth weight	Low birth weight	Preterm birth	Small for gest. age	Apgar 5 below 7	Perinatal conditions
Birth order 2	0.158***	−0.027***	−0.029***	−0.051***	−0.007***	−0.057***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.007)
Birth order 3	0.222***	−0.037***	−0.036***	−0.066***	−0.012***	−0.067***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.013)
Birth order 4	0.268***	−0.043***	−0.038***	−0.070***	−0.015***	−0.050**
	(0.004)	(0.002)	(0.003)	(0.002)	(0.001)	(0.022)
Mean of outcome	3.339	0.041	0.072	0.081	0.009	0.151
No. of Observations	1,247,438	1,247,438	1,247,438	1,247,438	1,245,425	51,673
Min birth month	1984m1	1984m1	1984m1	1984m1	1984m1	2005m1
Max birth month	2007m12	2007m12	2007m12	2007m12	2007m12	2015m12

Notes: Regressions include mother fixed effects, year by month of birth fixed effects, and an indicator to denote females. Standard errors are clustered at the mother level, noted in parentheses; $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 3: Birth order effects on health in childhood

	Current diseases	Allergies	Seeing problems	ENT problems	Dental issues
Birth order 2	-0.002	-0.035^{*}	-0.016	-0.023^{**}	-0.032^{*}
	(0.012)	(0.020)	(0.023)	(0.012)	(0.018)
Birth order 3	0.012	-0.056	-0.061	-0.046^{*}	-0.044
	(0.026)	(0.041)	(0.045)	(0.024)	(0.037)
Birth order 4	0.002	-0.070	-0.098	-0.067	-0.007
	(0.043)	(0.067)	(0.072)	(0.042)	(0.062)
N	20,224	14,967	10,977	19,987	21,773
Mean of outcome	0.08	0.18	0.17	0.10	0.42
Min. birth month	1998m12	1999m6	2000m12	1998m12	1998m12
Max. birth month	2010m7	2010m7	2010m7	2010m7	2010m7
	Locomotor problems	**Motor skills issues**	**Obesity**	**Height**	**Low physical activity**
Birth order 2	-0.016	-0.026^{***}	-0.019^{*}	-0.536^{**}	-0.042^{*}
	(0.016)	(0.009)	(0.011)	(0.213)	(0.022)
Birth order 3	-0.019	-0.037^{*}	-0.025	-0.955^{**}	-0.105^{**}
	(0.032)	(0.019)	(0.023)	(0.438)	(0.044)
Birth order 4	0.012	-0.002	-0.016	-0.769	-0.090
	(0.055)	(0.032)	(0.036)	(0.720)	(0.074)
N	19,171	19,866	22,293	22,307	15,833
Mean of outcome	0.27	0.05	0.07	132.79	0.58
Min. birth month	1998m12	1998m12	1998m9	1998m9	1998m12
Max. birth month	2010m7	2010m7	2010m7	2010m7	2010m7

Notes: Regressions include mother fixed effects, year by month of birth fixed effects, year by month of age fixed effects, and an indicator to denote females. Standard errors are clustered at the mother level, noted in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Birth order effects on health care utilization

	Age									
	1	2	3	4	5	6	7	8	9	10
Any drug										
Birth order 2	0.013	0.006	0.036***	−0.055***	−0.054***	−0.080***	−0.101***	−0.092***	−0.058***	−0.035***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Birth order 3	−0.007	0.003	0.051***	−0.102***	−0.081***	−0.105***	−0.166***	−0.136***	−0.102***	−0.055***
	(0.017)	(0.016)	(0.016)	(0.016)	(0.018)	(0.019)	(0.019)	(0.018)	(0.018)	(0.018)
Birth order 4	0.005	−0.024	0.072***	−0.130***	−0.055*	−0.128***	−0.178***	−0.137***	−0.122***	−0.056*
	(0.027)	(0.026)	(0.027)	(0.027)	(0.030)	(0.032)	(0.032)	(0.032)	(0.031)	(0.031)
Mean	0.71	0.71	0.66	0.67	0.67	0.62	0.57	0.53	0.51	0.49
Any physician										
Birth order 2	−0.006**	−0.004	−0.000	−0.027***	−0.009***	0.004	−0.009**	−0.011***	−0.015***	−0.012***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Birth order 3	−0.013**	−0.013*	−0.001	−0.059***	−0.016**	0.013*	−0.025***	−0.017*	−0.020**	−0.024***
	(0.006)	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)
Birth order 4	−0.018*	−0.022**	−0.008	−0.101***	−0.012	0.023*	−0.031**	−0.006	−0.024	−0.031*
	(0.010)	(0.011)	(0.012)	(0.014)	(0.014)	(0.014)	(0.016)	(0.016)	(0.016)	(0.016)
Mean	0.96	0.95	0.95	0.94	0.95	0.94	0.93	0.92	0.92	0.91
Hospitalization										
Birth order 2	−0.008	0.010	0.006	−0.011*	−0.032***	−0.004	−0.024***	−0.004	−0.003	−0.005
	(0.008)	(0.007)	(0.006)	(0.006)	(0.007)	(0.007)	(0.006)	(0.006)	(0.005)	(0.005)
Birth order 3	−0.007	0.025*	0.001	−0.009	−0.048***	0.001	−0.051***	−0.005	0.002	−0.004
	(0.016)	(0.014)	(0.012)	(0.013)	(0.014)	(0.013)	(0.012)	(0.011)	(0.010)	(0.010)
Birth order 4	−0.002	0.028	0.008	0.012	−0.070***	0.031	−0.060***	−0.009	−0.007	−0.015
	(0.027)	(0.024)	(0.021)	(0.021)	(0.024)	(0.023)	(0.021)	(0.019)	(0.018)	(0.018)
Mean	0.20	0.16	0.12	0.12	0.13	0.12	0.10	0.08	0.07	0.07
N	45823	49818	51223	51414	44701	44738	43522	43408	44912	46653
Min. birth month	2004m10	2003m10	2002m10	2001m10	2000m10	1999m10	1998m10	1997m10	1996m10	1995m10
Max. birth month	2014m12	2013m12	2012m12	2011m12	2010m12	2009m12	2008m12	2007m12	2006m12	2005m12

Notes: Regressions include mother fixed effects, year by month of birth fixed effects, and an indicator to denote females. Standard errors are clustered at the mother level, noted in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Birth order effects on parental health investment

	Mother-child-pass visit at age [a]					Vaccinations at age 2[b]		at age 3[b]		at age 4[b]	
	1	2	3	4	5	6-in-1	MMR	6-in-1	MMR	6-in-1	MMR
Panel A: Baseline											
Birth order 2	−0.004	−0.028***	−0.043***	−0.071***	−0.058***	0.003	−0.061***	0.008*	−0.026***	0.009*	−0.019***
	(0.004)	(0.007)	(0.007)	(0.008)	(0.008)	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)
Birth order 3	−0.015*	−0.060***	−0.096***	−0.120***	−0.128***	−0.009	−0.112***	0.000	−0.064***	0.000	−0.053***
	(0.008)	(0.014)	(0.015)	(0.016)	(0.017)	(0.009)	(0.011)	(0.009)	(0.010)	(0.010)	(0.011)
Birth order 4	−0.018	−0.111***	−0.131***	−0.224***	−0.226***	−0.010	−0.153***	0.006	−0.088***	0.009	−0.071***
	(0.013)	(0.024)	(0.026)	(0.027)	(0.029)	(0.015)	(0.018)	(0.015)	(0.017)	(0.017)	(0.018)
N	45823	49818	51223	51414	44701	80009	80009	71878	71878	63853	63853
Mean of dep.	0.928	0.819	0.761	0.646	0.631	0.784	0.621	0.797	0.721	0.803	0.741
Min. birth month	2004m10	2003m10	2002m10	2001m10	2000m10	2002m1	2002m1	2002m1	2002m1	2002m1	2002m1
Max. birth month	2014m12	2013m12	2012m12	2011m12	2010m12	2014m12	2014m12	2013m12	2013m12	2012m12	2012m12
Panel B: Controlling for perinatal conditions											
Birth order 2	−0.003	−0.039***	−0.029***	−0.044***	−0.056***	−0.005	−0.088***	−0.009	−0.042***	−0.012*	−0.034***
	(0.004)	(0.008)	(0.010)	(0.014)	(0.018)	(0.007)	(0.009)	(0.007)	(0.008)	(0.007)	(0.008)
Birth order 3	−0.014*	−0.079***	−0.072***	−0.080***	−0.147***	−0.019	−0.151***	−0.023*	−0.087***	−0.030**	−0.073***
	(0.008)	(0.016)	(0.021)	(0.028)	(0.036)	(0.013)	(0.018)	(0.014)	(0.016)	(0.015)	(0.017)
Birth order 4	−0.016	−0.136***	−0.116***	−0.157***	−0.212***	−0.019	−0.198***	−0.028	−0.131***	−0.037	−0.119***
	(0.014)	(0.028)	(0.034)	(0.047)	(0.060)	(0.023)	(0.030)	(0.024)	(0.028)	(0.026)	(0.030)
N	43915	37962	31616	24161	15536	35018	35018	31914	31914	28963	28963
Mean of dep.	0.928	0.827	0.783	0.680	0.707	0.809	0.641	0.821	0.746	0.826	0.765
Min. birth month	2005m1	2005m1	2005m1	2005m1	2005m1	2005m1	2005m1	2005m1	2005m1	2005m1	2005m1
Max. birth month	2014m12	2013m12	2012m12	2011m12	2010m12	2014m12	2014m12	2013m12	2013m12	2012m12	2012m12

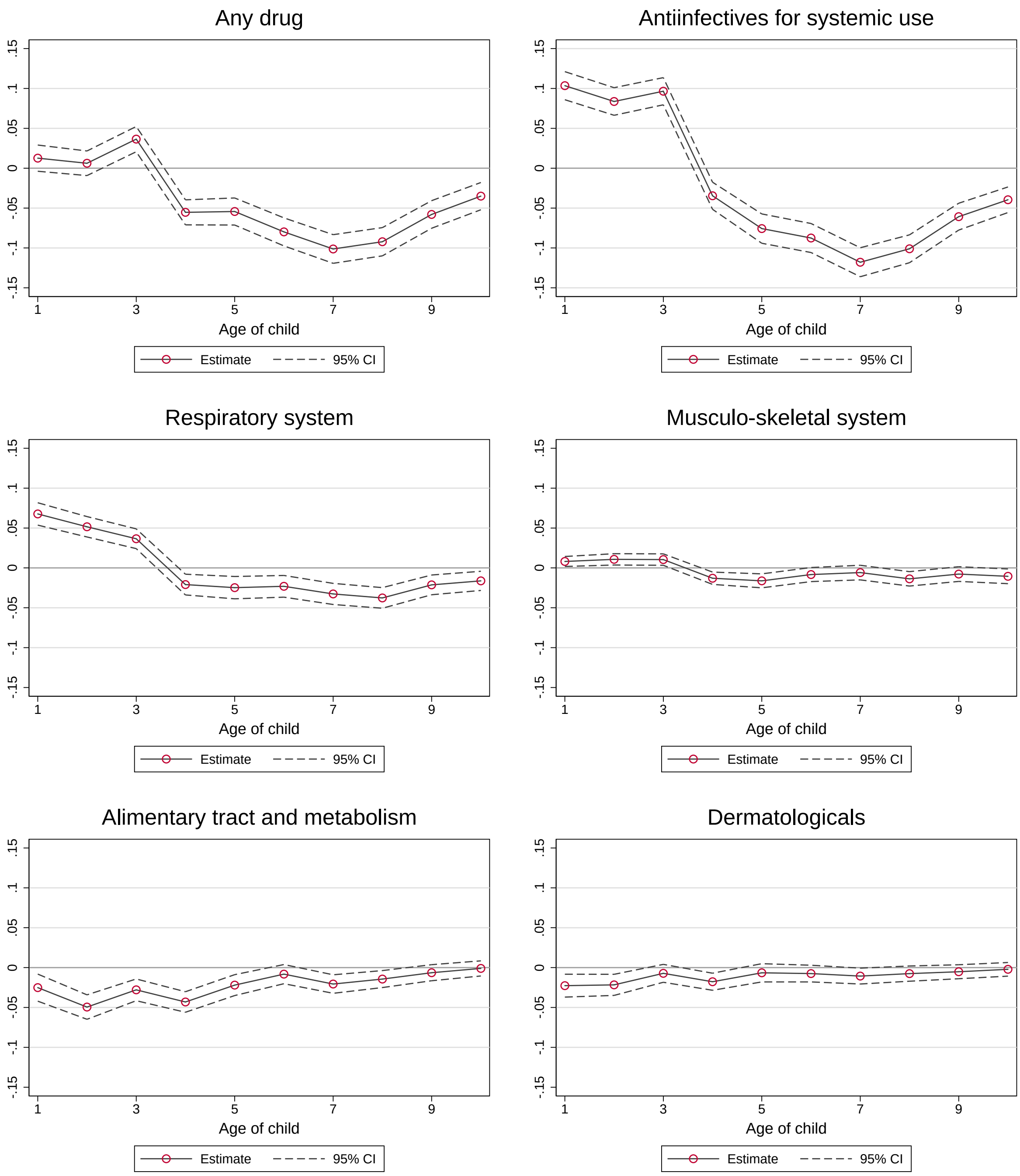
Notes: The baseline regressions in Panel A include mother fixed effects, year by month of birth fixed effects, and an indicator to denote females. In Panel B, we additionally control for a binary variable that indicates whether a child has been hospitalized for perinatal conditions in quarter of birth. Standard errors clustered at the mother level, noted in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [a]Binary variable masuring whether a child has participated in health screenings at the given age. Accordingly, it measures whether a child at age one has participated in at least one of the five postnatal health examinations. Participation indicators at ages 2, 3, 4, and 5 are based on participation in the sixth, seventh, eighth, and ninth health screening. [b]Binary variable measuring whether a child has received at least one vaccination of each type—the 6-in-1 and MMR—within the first two, three, and four years of life.

Table 6: Probability of having an additional child

	Prob(>1 child) in families with one to four children				
	(1)	(2)	(3)	(4)	(5)
Health of *first* child					
Disabled before age 1	−0.041***				
	(0.007)				
Low birth weight (<2500g)		−0.037***			
		(0.002)			
Preterm birth			−0.028***		
			(0.002)		
Small for gestational age				−0.015***	
				(0.002)	
Health index[a]					
0-10th percentile					−0.029***
					(0.002)
10-20th percentile					−0.011***
					(0.002)
20-30th percentile					−0.008***
					(0.002)
30-40th percentile					−0.002
					(0.002)
40-50th percentile					0.000
					(0.002)
60-70th percentile					0.002
					(0.002)
70-80th percentile					0.003
					(0.002)
80-90th percentile					−0.003
					(0.002)
90-100th percentile					−0.006***
					(0.003)
(50th-60th percentile: omitted)					
N	254,835	683,749	683,749	683,749	683,749
Mean of outcome	0.643	0.662	0.662	0.662	0.662
Mean of health measure	0.018	0.056	0.082	0.113	
Min birth year	1994	1984	1984	1984	1984
Max birth year	2000	2000	2000	2000	2000

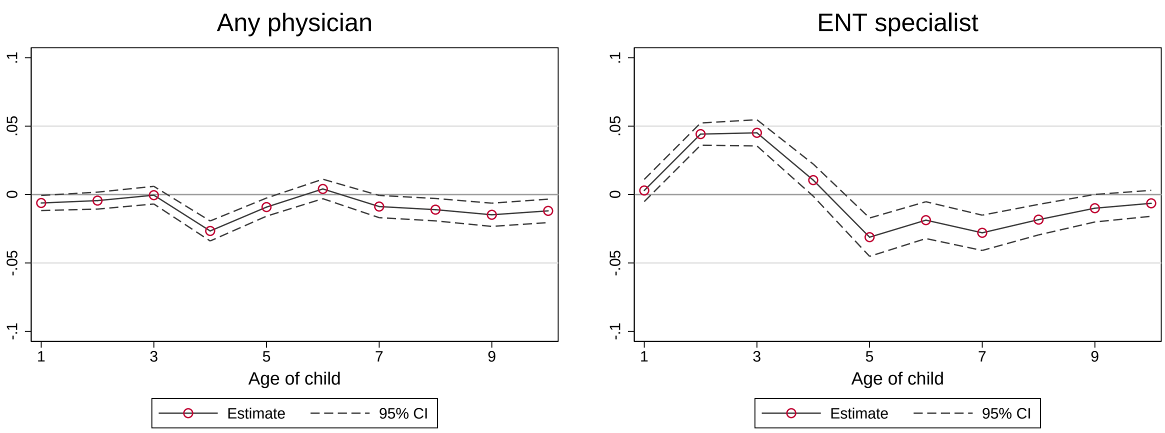
Notes: Regressions include an extensive set of controls for maternal characteristics (age, province, employment, job, education, religion, country of birth, and family status), and the child's sex and birth year. Robust standard errors are noted in parentheses; $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. [a]The health index has a mean of zero and a standard deviation of one, and is based on the child's sex-specific birth weight and gestational length; higher values indicate better health at birth.

Figure 1: Drug prescriptions in childhood



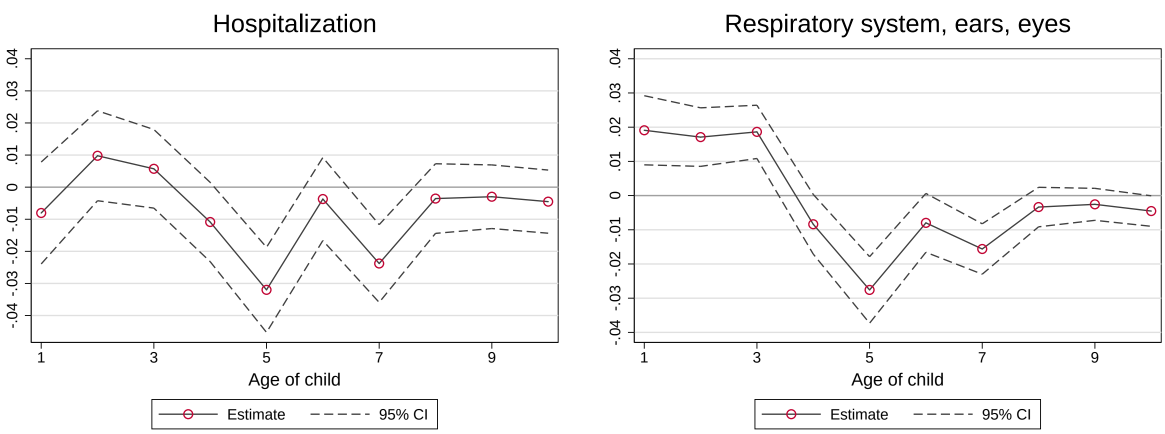
Notes: These figures plot estimated coefficients and 95% confidence intervals for second-born children for different outcomes based on separate regressions by the child's age (see Tables 4, B.3, and B.4).

Figure 2: Physician visits in childhood



Notes: These figures plot the estimated coefficients and 95% confidence intervals for second-born children for different outcomes based on a separate regression by the child's age (see Tables 4 and B.5).

Figure 3: Hospitalizations in childhood



Notes: These figures plot the estimated coefficients and 95% confidence intervals for children of birth order 2 for different outcomes based on a separate regression by the child's age (see Tables 4 and B.6).

Web Appendix

This Internet appendix is not for publication, but provides additional material discussed in the unpublished manuscript 'Birth Order, Parental Health Investment and Health in Childhood' by Gerald J. Pruckner, Nicole Schneeweis, Thomas Schober and Martina Zweimüller. It comprises two sections: Section A describes our data and estimation samples, while Section B displays additional estimation results.

A Data & estimation samples

We combine data from three administrative data sources to determine each child's birth order. Our primary data source is the Austrian Birth Register, which covers all births in Austria from 1974–2007. We expand the available sample by supplementing this register with two additional data sources. The Family Allowance Database from the Austrian Ministry of Social Affairs contains information on paid family allowances, and can be used to identify births from 2008–2012. Finally, we incorporate the Austrian Social Security Database (ASSD, Zweimüller et al., 2009) to identify births from 2013–2015 using information on children's co-insurance. Subsequently, the total sample includes 1.7 million children from 0.74 million families. We assess the quality of the family structural data by comparing the births in 2007, as we have information from all three data sources for this year. Of the births observed in the birth register, 97.9% can be matched to the family allowance data, and 84.2% to the ASSD.

A.1 Health at birth

Information on health at birth comes from the Austrian Birth Register, and includes such newborn health information as the birth weight and length, mode of birth, Apgar scores, and gestational length. Table A.1 displays the estimation sample's summary statistics.

Table A.1: Summary statistics for birth register sample

Variable	Observations	Mean	SD	Min	Max
Family structure					
Family size	1,247,438	2.423	0.630	2	4
First-born	1,247,438	0.436		0	1
Second-born	1,247,438	0.436		0	1
Third-born	1,247,438	0.109		0	1
Fourth-born	1,247,438	0.019		0	1
Child is female	1,247,438	0.487		0	1
Birth year of child	1,247,438	1996	6.261	1984	2007
Health at birth					
Birth weight (kg)	1,247,438	3.339	0.512	0.3	5.8
Low birth weight (<2.5kg)	1,247,438	0.041		0	1
Very low birth weight (<1.5kg)	1,247,438	0.006		0	1
Premature birth (<37 weeks)	1,247,438	0.072		0	1
Small for gestational age	1,247,438	0.081		0	1
Apgar-5 below 7	1,245,425	0.009		0	1
Apgar-10 below 7	1,236,613	0.003		0	1
Length at birth (cm)	1,247,438	50.551	2.584	25	60
Caesarean section[a]	691,873	0.153		0	1

Notes: The sample includes all children born in families with two to four children, in which the first child was born between 1984 and 2006. [a]The mode of delivery is only observed since 1995.

A.2 Health in childhood

Health status in childhood is measured using data on school health examinations. This data provides information on previous childhood diseases (scarlet fewer and chickenpox), current diseases (epilepsy, diabetes, asthma, ADHD, headache, and stomach ache), allergies, and previous surgeries and injuries. Parents also have to report the extent of physical activity outside school and the number of hours spent on watching television, sitting at the computer, or using mobile phones. In the medical examination, the school doctor tests the child's visual and hearing abilities, examines his or her ears and throat, teeth, language and motor skills, and coordination. Moreover, the physician measures the child's body weight and height, pulse, and blood pressure. An examination of the locomotor system includes a visual inspection of the thorax, the shoulders, the pelvis, the spine, the muscles, the upper and lower extremities, and the feet. We construct variables for outcomes that indicate *current* health problems, and merge some outcomes into categories, for instance, the indicator for locomotor problems is equal to one if the child has any of the above mentioned disorders of the locomotor system. See Table 1 in the paper for a description.

We observe school health examination outcomes between 2009 and 2016 based on data from 130 primary schools in Upper Austria, although data is not available for each school in every year. Previously, community general practitioners (GPs) were responsible for school health examinations. However, school doctors recently assumed the task, and they act on behalf of the regional government if the GP has retired. Simultaneously, the Upper Austrian government began a structured data collection of examination results. Our sample includes all health examinations of primary-school children between the ages of six and ten, implying that an individual child can be observed more than once. Our estimations pool all observations and control for the child's monthly age. Table A.2 shows the estimation sample's summary statistics.

Table A.2: **Summary statistics for school health examination sample**

Variable	Observations	Mean	SD	Min	Max
Family structure					
Family size	22,555	2.553	0.689	2	4
First-born	22,555	0.417		0	1
Second-born	22,555	0.454		0	1
Third-born	22,555	0.109		0	1
Fourth-born	22,555	0.020		0	1
Child is female	22,555	0.489		0	1
Birth year of child	19,547	2005	2.093	1998	2010
Health in childhood					
Current diseases	20,224	0.081		0	1
Allergies	14,967	0.176		0	1
Vision problems	10,977	0.174		0	1
ENT problems	19,987	0.104		0	1
Dental issues	21,773	0.424		0	1
Locomotor problems	19,171	0.270		0	1
Motor skills issues	19,866	0.053		0	1
Obesity	22,293	0.070		0	1
Height	22,307	132.794	9.091	104.0	168.5
Low physical activity	15,833	0.582		0	1

Notes: The sample includes children with school health examination data in families with two to four children. The sample size varies due to missing observations.

A.3 Health care utilization and mother-child-pass examinations

Information on health care utilization between 2005 and 2015 is provided by the Upper Austrian Health Insurance Fund. The data includes information on a quarterly basis regarding physician's visits, hospital stays, and prescription drugs. We aggregate the data into annual observations per year of life for each insured child. For example, for health care utilization at age five, we consider the quarter when the child turns five and the three preceding quarters. Consequently, the binary outcome variables indicate the use of different health care services within one year.

When we analyze health care utilization at a certain age, we consider only observations of children who are insured in the corresponding period. Therefore, the cohorts of children used and the sample size depend on the age studied. Table A.3 displays the summary statistics calculated over all available observations of children between the ages of one and ten. Table A.4 provides additional information on health care utilization by the child's age.

Table A.3: Summary statistics for health care utilization & mother-child-pass examination sample

Variable	Observations	Mean	SD	Min	Max
Family structure					
Family size	466,212	2.529	0.670	2	4
First-born	466,212	0.404		0	1
Second-born	466,212	0.455		0	1
Third-born	466,212	0.120		0	1
Fourth-born	466,212	0.021		0	1
Child is female	466,212	0.490		0	1
Birth year of child	466,212	2005	3.979	1995	2014
Hospitalizations					
Hospitalization	466,212	0.119		0	1
Respiratory system, ears, eyes	466,212	0.043		0	1
Injury or poisoning	466,212	0.021		0	1
Physician visits					
Any physician	466,212	0.938		0	1
GP or pediatrician, net of MCP-visits	466,212	0.872		0	1
Mother-child-pass examination	242,979	0.756		0	1
ENT specialist	466,212	0.101		0	1
Prescriptions					
Any drug	466,212	0.616		0	1
Antibiotics for systemic use	466,212	0.427		0	1
Alimentary tract and metabolism	466,212	0.144		0	1
Respiratory system	466,212	0.153		0	1
Musculoskeletal system	466,212	0.054		0	1
Dermatologicals	466,212	0.095		0	1

Notes: The sample includes children with health care information from families with two to five children. The summary statistics consider all available observations of children between the ages of one and ten. Information on mother-child-pass (MCP) examinations also considers observations of children between the ages of one and six.

Table A.4: Means of health care utilization outcomes by child's age

	Age									
	1	2	3	4	5	6	7	8	9	10
Hospitalization										
Hospitalization	0.20	0.16	0.12	0.12	0.13	0.12	0.10	0.08	0.07	0.07
Respiratory system, ears, eyes	0.07	0.05	0.05	0.06	0.06	0.05	0.03	0.02	0.02	0.01
Injury or poisoning	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
Physician visits										
Any physician	0.96	0.95	0.95	0.94	0.95	0.94	0.93	0.92	0.92	0.91
ENT specialist	0.05	0.05	0.08	0.13	0.17	0.15	0.13	0.10	0.09	0.08
Mother-child-pass examination	0.93	0.82	0.76	0.65	0.63	0.19	0.00	0.00	0.00	0.00
Prescriptions										
Any drug	0.71	0.71	0.66	0.67	0.67	0.62	0.57	0.53	0.51	0.49
Antiinfectives for systemic use	0.39	0.49	0.48	0.51	0.52	0.47	0.40	0.36	0.33	0.30
Respiratory system	0.17	0.16	0.15	0.16	0.17	0.16	0.15	0.14	0.14	0.14
Musculo-skeletal system	0.03	0.04	0.04	0.05	0.06	0.06	0.06	0.07	0.07	0.07
Alimentary tract and metabolism	0.29	0.23	0.18	0.15	0.13	0.11	0.09	0.08	0.08	0.07
Dermatologicals	0.17	0.15	0.11	0.10	0.09	0.08	0.07	0.06	0.06	0.06
No. of Observations	45,823	49,818	51,223	51,414	44,701	44,738	43,522	43,408	44,912	46,653

Notes: This table shows the share of children who use the listed health care service by age. We aggregate information for each age from the quarter in which the child's birthday occurs and the three preceding quarters. The sample includes children with health care information from families with two to four children.

Table A.5: Overview of the mother-child-pass program

No.	Age of child	Examinations	
Postnatal infant screenings			
P1	1st week	Child examination; hip ultrasound	
P2	4th to 7th week	Child examination; orthopedic examination; hip ultrasound	
P3	3rd to 5th month	Child examination	
P4	7th to 9th month	Child examination; ear, nose, and throat examination	
P5	10th to 14th month	Child examination; eye examination	
Developmental screenings for toddlers and preschoolers			
D1	22nd to 26th month	D1-D4:	Anamnesis; physical examination; nutritional status;
D2	34th to 38th month		behavior; mental development; speech and language
D3	46th to 50th month	D1:	comprehensive eye and vision examination
D4	58th to 62th month		

A.4 Vaccinations

Vaccine data between 2002 and 2016 are provided by the regional government of Upper Austria, which subsidizes recommended childhood vaccinations by providing vouchers to families. We analyze the vaccination status at age two by using children born between 2002 and 2014 in Upper Austria. Vaccination outcomes at ages three and four are restricted to cohorts born before 2013 and 2012, respectively. We exclude children born in Linz and Steyr, as these cities use separate systems to monitor vaccinations. Table A.6 displays the estimation sample's summary statistics.

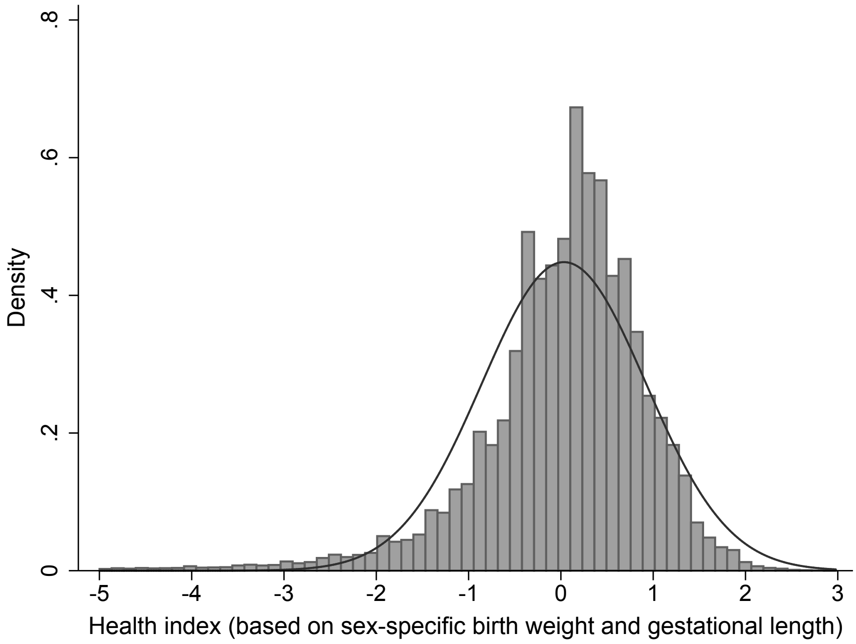
Table A.6: **Summary statistics for vaccination sample**

Variable	Observations	Mean	SD	Min	Max
Family structure					
Family size	80,009	2.454	0.641	2	4
First-born	80,009	0.401		0	1
Second-born	80,009	0.445		0	1
Third-born	80,009	0.129		0	1
Fourth-born	80,009	0.025		0	1
Child is female	80,009	0.487		0	1
Birth year of child	80,009	2008	3.455	2002	2014
Vaccinations					
6-in-1 vaccination at age 2	80,009	0.784		0	1
6-in-1 vaccination at age 3	71,878	0.797		0	1
6-in-1 vaccination at age 4	63,853	0.803		0	1
MMR vaccination at age 2	80,009	0.621		0	1
MMR vaccination at age 3	71,878	0.721		0	1
MMR vaccination at age 4	63,853	0.741		0	1

Notes: The sample includes children born in Upper Austria between 2002 and 2014 in families with two to four children. Information on vaccinations at age three (or four) includes children born between 2002 and 2013 (or 2012).

B Further tables and figures

Figure B.1: Distribution of the health index



Notes: The health index has a mean of zero and a standard deviation of one, and combines sex-specific birth weights and gestational lengths. This was calculated for a sample of all children in families with one to four children, in which the first child was born between 1984 and 2000. Higher index values indicate a higher birth weight and gestational length.

Table B.1: Birth order effects on health at birth—Upper Austria

	(1) Birth weight	(2) Low birth birth weight	(3) Preterm birth	(4) Small for gest. age	(5) Apgar 5 below 7
Birth order 2	0.165***	−0.028***	−0.029***	−0.050***	−0.007***
	(0.003)	(0.001)	(0.002)	(0.002)	(0.001)
Birth order 3	0.233***	−0.038***	−0.039***	−0.064***	−0.012***
	(0.005)	(0.003)	(0.003)	(0.003)	(0.001)
Birth order 4	0.288***	−0.045***	−0.045***	−0.068***	−0.017***
	(0.009)	(0.004)	(0.006)	(0.005)	(0.002)
Mean of outcome	3.363	0.038	0.070	0.072	0.009
No. of Observations	228,977	228,977	228,977	228,977	228,748
Min birth month	1984m1	1984m1	1984m1	1984m1	1984m1
Max birth month	2007m12	2007m12	2007m12	2007m12	2007m12

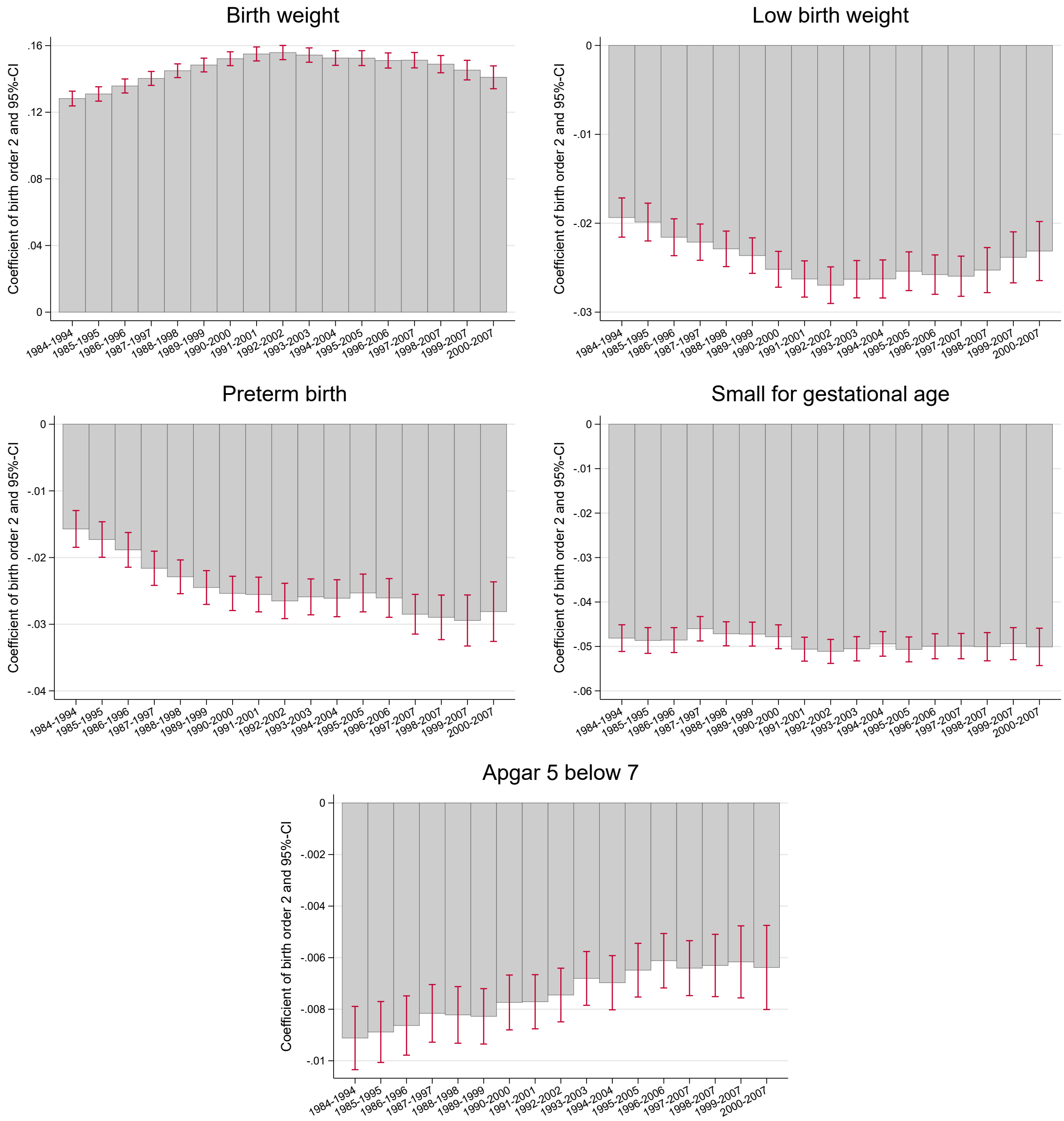
Notes: Regressions include mother fixed effects, year by month of birth fixed effects, and an indicator for females. Standard errors clustered at the mother level are noted in parentheses; $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table B.2: Birth order effects on birth health—further results

	(1) Log birth weight	(2) Birth weight below 1500g	(3) Length at birth	(4) Log length	(5) Apgar 10 below 7	(6) Caesarian section
Birth order 2	0.051***	−0.004***	0.499***	0.010***	−0.003***	−0.040***
	(0.000)	(0.000)	(0.006)	(0.000)	(0.000)	(0.001)
Birth order 3	0.073***	−0.008***	0.697***	0.014***	−0.007***	−0.049***
	(0.001)	(0.000)	(0.013)	(0.000)	(0.000)	(0.002)
Birth order 4	0.088***	−0.010***	0.834***	0.017***	−0.010***	−0.051***
	(0.002)	(0.001)	(0.023)	(0.000)	(0.001)	(0.004)
Mean of outcome	5.797	0.006	50.551	3.922	0.003	0.153
No. of Observations	1,247,438	1,247,438	1,247,438	1,247,438	1,236,613	691,873
Min birth month	1984m1	1984m1	1984m1	1984m1	1984m1	1995m1
Max birth month	2007m12	2007m12	2007m12	2007m12	2007m12	2007m12

Notes: Regressions include mother fixed effects, year by month of birth fixed effects, and an indicator for females. Standard errors clustered at the mother level are noted in parentheses; $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Figure B.2: Second-born birth order effects on health at birth by birth cohort group



Notes: These figures illustrate the estimated second-born birth order coefficients and 95% confidence intervals for various (overlapping) birth cohort groups. Regressions include mother fixed effects, year by month of birth fixed effects, and an indicator to denote females. Standard errors are clustered at the mother level.

Table B.3: Birth order effects on drug prescriptions (1)

	Age									
	1	2	3	4	5	6	7	8	9	10
Antiinfectives for systemic use										
Birth order 2	0.104***	0.084***	0.097***	−0.035***	−0.076***	−0.088***	−0.118***	−0.101***	−0.061***	−0.040***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)
Birth order 3	0.120***	0.097***	0.143***	−0.070***	−0.118***	−0.119***	−0.177***	−0.143***	−0.113***	−0.079***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.019)	(0.019)	(0.019)	(0.018)	(0.018)	(0.017)
Birth order 4	0.113***	0.096***	0.177***	−0.078***	−0.104***	−0.137***	−0.219***	−0.156***	−0.137***	−0.082***
	(0.030)	(0.029)	(0.029)	(0.029)	(0.033)	(0.032)	(0.032)	(0.031)	(0.030)	(0.029)
Mean	0.39	0.49	0.48	0.51	0.52	0.47	0.40	0.36	0.33	0.30
Respiratory system										
Birth order 2	0.068***	0.052***	0.037***	−0.021***	−0.025***	−0.023***	−0.033***	−0.038***	−0.021***	−0.016***
	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)
Birth order 3	0.095***	0.072***	0.054***	−0.036***	−0.028*	−0.036**	−0.053***	−0.067***	−0.037***	−0.018
	(0.015)	(0.013)	(0.013)	(0.013)	(0.015)	(0.014)	(0.014)	(0.013)	(0.013)	(0.012)
Birth order 4	0.116***	0.123***	0.111***	−0.016	−0.030	−0.043*	−0.058**	−0.107***	−0.052**	−0.042**
	(0.025)	(0.023)	(0.022)	(0.023)	(0.026)	(0.025)	(0.024)	(0.023)	(0.023)	(0.021)
Mean	0.17	0.16	0.15	0.16	0.17	0.16	0.15	0.14	0.14	0.14
Musculo-skeletal system										
Birth order 2	0.008**	0.011***	0.010***	−0.013***	−0.016***	−0.008*	−0.006	−0.014***	−0.008	−0.011**
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
Birth order 3	0.023***	0.020***	0.024***	−0.022***	−0.021**	−0.012	−0.010	−0.032***	−0.008	−0.022**
	(0.007)	(0.008)	(0.008)	(0.008)	(0.009)	(0.009)	(0.010)	(0.009)	(0.010)	(0.010)
Birth order 4	0.048***	0.037***	0.032**	−0.038***	−0.029*	−0.026	−0.015	−0.031*	0.008	−0.040**
	(0.013)	(0.013)	(0.014)	(0.014)	(0.016)	(0.016)	(0.017)	(0.016)	(0.018)	(0.017)
Mean	0.03	0.04	0.04	0.05	0.06	0.06	0.06	0.07	0.07	0.07
N	45823	49818	51223	51414	44701	44738	43522	43408	44912	46653
Min. birth month	2004m10	2003m10	2002m10	2001m10	2000m10	1999m10	1998m10	1997m10	1996m10	1995m10
Max. birth month	2014m12	2013m12	2012m12	2011m12	2010m12	2009m12	2008m12	2007m12	2006m12	2005m12

Notes: Regressions include mother fixed effects, year by month of birth fixed effects, and an indicator to denote females. Standard errors clustered at the mother level are noted in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table B.4: Birth order effects on drug prescriptions (2)

	Age									
	1	2	3	4	5	6	7	8	9	10
Alimentary tract and metabolism										
Birth order 2	−0.025***	−0.049***	−0.028***	−0.043***	−0.022***	−0.008	−0.021***	−0.014***	−0.006	−0.001
	(0.009)	(0.008)	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)
Birth order 3	−0.026	−0.042***	−0.025*	−0.055***	−0.017	0.009	−0.026**	−0.007	−0.004	−0.003
	(0.017)	(0.016)	(0.014)	(0.013)	(0.013)	(0.013)	(0.012)	(0.011)	(0.010)	(0.010)
Birth order 4	0.018	−0.048*	−0.033	−0.046**	−0.005	0.016	−0.022	−0.012	0.000	0.009
	(0.029)	(0.026)	(0.023)	(0.022)	(0.023)	(0.021)	(0.020)	(0.019)	(0.017)	(0.017)
Mean	0.29	0.23	0.18	0.15	0.13	0.11	0.09	0.08	0.08	0.07
Dermatologicals										
Birth order 2	−0.023***	−0.022***	−0.007	−0.018***	−0.007	−0.007	−0.011**	−0.008	−0.005	−0.002
	(0.007)	(0.007)	(0.006)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)
Birth order 3	−0.031**	−0.022	−0.005	−0.019*	−0.006	−0.004	−0.019*	−0.012	−0.000	0.005
	(0.015)	(0.014)	(0.012)	(0.011)	(0.012)	(0.011)	(0.010)	(0.010)	(0.009)	(0.009)
Birth order 4	−0.016	−0.011	0.025	−0.031*	0.002	−0.019	−0.032*	0.001	−0.012	0.009
	(0.025)	(0.023)	(0.020)	(0.019)	(0.020)	(0.019)	(0.018)	(0.016)	(0.016)	(0.017)
Mean	0.17	0.15	0.11	0.10	0.09	0.08	0.07	0.06	0.06	0.06
N	45823	49818	51223	51414	44701	44738	43522	43408	44912	46653
Min. birth month	2004m10	2003m10	2002m10	2001m10	2000m10	1999m10	1998m10	1997m10	1996m10	1995m10
Max. birth month	2014m12	2013m12	2012m12	2011m12	2010m12	2009m12	2008m12	2007m12	2006m12	2005m12

Notes: Regressions include mother fixed effects, year by month of birth fixed effects, and an indicator for females. Standard errors clustered at the mother level are noted in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table B.5: Birth order effects on doctor's visits

	Age									
	1	2	3	4	5	6	7	8	9	10
ENT specialist										
Birth order 2	0.003	0.044***	0.045***	0.011*	−0.031***	−0.019***	−0.028***	−0.018***	−0.010*	−0.006
	(0.004)	(0.004)	(0.005)	(0.006)	(0.007)	(0.007)	(0.007)	(0.006)	(0.005)	(0.005)
Birth order 3	0.008	0.065***	0.058***	0.009	−0.044***	−0.035**	−0.050***	−0.038***	−0.021**	−0.007
	(0.009)	(0.008)	(0.010)	(0.012)	(0.014)	(0.014)	(0.013)	(0.012)	(0.010)	(0.010)
Birth order 4	0.002	0.055***	0.069***	0.020	−0.070***	−0.029	−0.049**	−0.048**	−0.025	−0.002
	(0.015)	(0.014)	(0.016)	(0.020)	(0.024)	(0.023)	(0.022)	(0.020)	(0.018)	(0.016)
Mean	0.05	0.05	0.08	0.13	0.17	0.15	0.13	0.10	0.09	0.08
N	45823	49818	51223	51414	44701	44738	43522	43408	44912	46653
Min. birth month	2004m10	2003m10	2002m10	2001m10	2000m10	1999m10	1998m10	1997m10	1996m10	1995m10
Max. birth month	2014m12	2013m12	2012m12	2011m12	2010m12	2009m12	2008m12	2007m12	2006m12	2005m12

Notes: Regressions include mother fixed effects, year by month of birth fixed effects, and an indicator to denote females. Standard errors are clustered at the mother level, as noted in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table B.6: Birth order effects on hospitalization rates

	Age									
	1	2	3	4	5	6	7	8	9	10
Respiratory system, ears, eyes										
Birth order 2	0.019***	0.017***	0.019***	−0.008*	−0.028***	−0.008*	−0.016***	−0.003	−0.003	−0.005**
	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.003)	(0.002)	(0.002)
Birth order 3	0.020*	0.023***	0.019**	−0.012	−0.042***	−0.011	−0.026***	−0.011*	−0.002	−0.008*
	(0.011)	(0.009)	(0.008)	(0.009)	(0.010)	(0.009)	(0.008)	(0.006)	(0.005)	(0.005)
Birth order 4	0.032*	0.015	0.044***	−0.003	−0.066***	−0.002	−0.030**	−0.025**	−0.010	−0.012
	(0.019)	(0.015)	(0.013)	(0.015)	(0.017)	(0.015)	(0.013)	(0.010)	(0.008)	(0.008)
Mean	0.07	0.05	0.05	0.06	0.06	0.05	0.03	0.02	0.02	0.01
Injury or poisoning										
Birth order 2	−0.009**	0.009**	−0.002	0.005*	0.002	0.002	0.001	0.005**	0.001	0.001
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Birth order 3	−0.013*	0.015**	−0.008	0.007	0.000	0.003	0.001	0.009*	0.003	0.005
	(0.008)	(0.008)	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Birth order 4	−0.027**	0.025*	−0.022**	0.003	−0.004	0.007	0.006	0.010	0.006	−0.002
	(0.013)	(0.013)	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.008)
Mean	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
N	45823	49818	51223	51414	44701	44738	43522	43408	44912	46653
Min. birth month	2004m10	2003m10	2002m10	2001m10	2000m10	1999m10	1998m10	1997m10	1996m10	1995m10
Max. birth month	2014m12	2013m12	2012m12	2011m12	2010m12	2009m12	2008m12	2007m12	2006m12	2005m12

Notes: Regressions include mother fixed effects, year by month of birth fixed effects, and an indicator to denote females. Standard errors clustered at the mother level are noted in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.