Health outcomes of only children across the life course: An investigation using Swedish register data

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Abstract

The proportion of only children – children with no full biological siblings – is growing in high-income settings, but we know little about their life course outcomes and how this is related to long-term health. Previous studies of only children have tended to focus on short-term, developmental and intellectual outcomes of only children in early life or adolescence, and provide mixed evidence. Using Swedish population register data on children born between 1940 and 1975, we compare only children with children of different sibship types, taking into account birth order, family size and half-siblings, to account for increased family complexity. We consider physical health outcomes measured at late adolescence (height, body mass index and fitness scores), and mortality. Only children with and without half-siblings had lower height and fitness scores, were more likely to be overweight or obese, and had higher mortality, than those with 1 or 2 biological siblings. Only children without half-siblings generally did better than only children with half-siblings, suggesting additional disadvantage accruing to only children experiencing parental disruption. With the exception of height, the results held after adjustment for parental characteristics and after employing within-family cousin comparison designs. In mortality models, some of the excess risk for only children was explained by adjustment for fertility, marriage and educational history. There is a need for further evidence on family size and life course outcomes across settings with different levels of social and health selectivity of only children.

Introduction

Only children- that is, children with no biological siblings- constitute a substantial, and growing proportion of all sibship groups in high-income, low fertility settings, and this increase is projected to continue (Frejka, Hoem, and Sobotka 2008). Previous studies of only children have tended to focus on short-term, developmental and intellectual outcomes of only children in early life or adolescence (Toni Falbo and Polit 1986; T. Falbo 2012; Mancillas 2006; Blake 1981b). Although findings generally present a positive picture about only children, some studies report disadvantages for only children (Mancillas 2006). Our understanding of the long-term health consequences of being an only child is even more limited. There are suggestions that only children experience health and mortality disadvantages across the life course (Baranowska-Rataj, Barclay, and Kolk 2017). Recent studies have demonstrated the importance of sibship characteristics such as birth order and family size for life course health outcomes (Barclay and Myrskylä 2014a; Barclay and Kolk 2015; Baranowska-Rataj, Barclay, and Kolk 2017), but only children are typically excluded from these analyses for methodological reasons.[1] Furthermore, with increased family complexity, it is necessary to distinguish between different types of only children, such as those who have half siblings, and assess whether outcomes differ in blended families (Fomby, Goode, and Mollborn 2016). More evidence is needed to understand the extent of the excess health risk accruing to different types of only children and how it might be explained.

This study uses Swedish population register data to examine the health outcomes of only children relative to children in multi-child sibling groups in greater detail, as well as to examine explanations for any disparities. We compare only children with children from a range of different sibship types, taking into account birth order, family size and the presence of half-siblings in order to account for increased family complexity and how this might result in different health outcomes between only children and other sibship groups. We consider a range of physical health outcomes measured at late adolescence, and mortality. To reduce confounding factors, we adjust for parental sociodemographic and socioeconomic characteristics and also employ within-family cousin comparison designs to adjust for all time-invariant factors that remain constant within the extended family. The study extends the current literature by using high-quality longitudinal data capturing medium and long-term health outcomes, distinguishing only children without half-siblings from those who have half-siblings, and by the use of a novel methodological design to reduce the impact of selection effects on our estimates.

The outcomes of only children: theory and empirical research

The family environment is generally seen as a critical influence on short- and long-term health and wellbeing, and academic interest in the differences between only children and those with siblings dates back over 100 years. Much negative stereotyping of only children can be traced to child psychologists writing in the late 19th and early 20th century. Psychologist G. Stanley Hall famously claimed in his 1898 study that "being an only child is a disease in itself" (cited in (Fenton 1928), and his contemporary Alfred Adler, who wrote extensively on birth order, also took a dim view of only children, considering them spoilt and negatively socially selected, with neurotic, mentally unstable parents (Adler 1930). Studies from the US, UK, Netherlands, Korea and China have demonstrated the persistence of a negative 'only child stereotype' in the population, where only children are depicted as being selfish, spoilt, anxious, and lacking in social skills (Mancillas 2006). In the US, for example, Gallup polls from 1980s- 2018 show that just 2-3% of adults surveyed think that it is ideal to have only one child (Saad 2018). A common reason given by parents for their desire to have a second child was the desire to avoid having an only child (Toni Falbo and Polit 1986).

Potential explanatory mechanisms for differences between only children and children from multi-child sibling groups

A number of theories have been proposed to explain how family size and birth order should affect long-term outcomes, some of which suggest that only children should be advantaged, and others that they should be disadvantaged. According to the resource dilution hypothesis (Blake 1981a; Downey 2001), only children should have a development advantage because they do not have to share their parents with other siblings and should therefore enjoy the undivided attention and

[1] Many recent studies use a sibling comparison design to reduce residual confounding by shared factors in the family of origin, and as only children have no comparator sibling, they are necessarily dropped from the analytical sample.

resources of their parents. Economic theories that describe the 'trade-off' between child quality and quantity also suggest that only children should benefit from the undivided economic and time resources of the parents (Becker and Lewis 1973). Another influential theory that has been proposed is the confluence hypothesis (Zajonc 1976). The confluence hypothesis argues that the average degree of cognitive stimulation in the household varies over time as more children are born, and that this affects the cognitive development of children. For example, a first-born interacts exclusively with his or her cognitively mature parents, which is a very stimulating environment for that first-born. A second-born, however, interacts with both the parents as well as his or her much less cognitively developed older sibling. Likewise the first-born also then interacts with an even less cognitively stimulating newborn. The confluence hypothesis generally predicts advantages for only children as they are raised in a household with a consistently higher average degree of cognitive stimulation. However, a later theoretical supplement to the confluence hypothesis suggested that the advantage of first-born children may derive from tutoring their younger siblings. The rehearsal of knowledge and its communication to younger siblings is likely to benefit the development of first-born and earlier-born children generally in comparison to later-borns, but only children would never have the opportunity to tutor any younger siblings.

An important alternative explanation for why only children may be different from children with siblings is selection in terms of which parents have only one child. A recent paper comparing standardised test scores at age 15 across 31 low fertility countries found that only children generally do better in countries with a higher proportion of only children. This pattern suggests that negative selection in terms of the characteristics of parents who have only one child may explain the only child disadvantage in countries where only children do worse (Choi and Monden n.d.). Choi and Monden also found that where only children did have lower test scores, this could generally be explained by lower parental socioeconomic status. Only children are also more likely to be the offspring of parents who separated or divorced; an analysis of Swedish data from 1971-1994 showed higher divorce rates for women with one child, compared with women at parity 2 or 3 (Andersson 1997). Progression to parity two is also affected by parental health and wellbeing, and parents who have a particularly difficult experience with the first child may be less likely to have any more children (Margolis and Myrskylä 2015). These patterns underscore the importance of accounting for the characteristics of the parents of only children as well as carefully considering the surrounding context.

Previous empirical research: non-health outcomes

A series of reviews and meta-analyses suggest that only children do not have intellectual or developmental disadvantages in early life: indeed, in some domains they seem to do better than children with siblings (Toni Falbo and Polit 1986; T. Falbo 2012; Polit and Falbo 1987). This only child advantage can also be found in studies of only children using data from China, where the one-child policy may be considered an exogenous shock on family size (J.-Q. Chen and Goldsmith 1991; Poston, and Falbo 1990; T. Falbo 2012; Toni Falbo and Poston 1993). However, some notable studies do document multidimensional disadvantages for only child in China (Cameron et al. 2013).

One possibility that has not received much attention in the existing literature is that the better outcomes experienced by only children are sensitive to the choice of comparison group and the stage of the life course at which the outcomes are measured. In reviews from Western countries, the only child educational and intellectual advantage was only found in comparisons with later borns; first- or second-borns from two-sibling groups do equally well as only children (T. Falbo 2012). This pattern is still consistent with the resource dilution hypothesis since first-born children live their lives as only children until the birth of a second sibling. There is also some suggestion that the only child advantage on intelligence and educational achievement diminishes with age (T. Falbo 2012). However, only children typically have higher educational attainment than children raised in multi-child sibling groups in the long run (Gee 1992), which may be explained by only children having greater access to parental resources for paying tertiary education costs, an important factor for educational attainment in countries like the US (T. Falbo 2012).

Only a handful of studies have examined the long-term social and demographic outcomes of only children (Gee 1992; Blake 1981a; Diekmann and Engelhardt 1999; Bobbitt-Zeher, Downey, and Merry 2016; Trent and Spitze n.d.; Blake, Richardson, and Bhattacharya 1991). Some studies have examined whether only children are less sociable than those with siblings by looking at adult social participation and affiliation, but generally the results are mixed with no strong evidence in either direction (Blake 1981a; Blake, Richardson, and Bhattacharya 1991; Trent and Spitze n.d.). Other studies have found that only children have higher divorce rates than children raised in multi-child sibling groups in Canada, the US, and Germany (Bobbitt-Zeher, Downey, and Merry 2016; Diekmann and Engelhardt 1999; Gee 1992), which may be explained by the fact that only children are more likely to have divorced or separated parents (e.g. see Andersson 1997). Research has also found that only children have lower fertility and more likely to be childless in Sweden (Kolk 2014) and Canada (Gee 1992), which is consistent with the evidence for intergenerational fertility patterns (Murphy and Wang 2001), though a US study found that the fertility of only-children did not differ from children in two-child families after adjustment for background characteristics (Blake 1981a). Given that parity and family relationships are related to other later-life outcomes such as mortality (Barclay et al. 2016), lower fertility and higher divorce rates may be important for explaining why only children seem to have higher mortality in Sweden (Baranowska-Rataj et al. 2017).

Previous empirical research: health outcomes

Despite the large literature examining whether only children differ in terms of personality development and cognitive and educational outcomes, there has been much less research examining whether they differ in terms of health outcomes. The resource dilution hypothesis (Blake 1981a) would predict that only children would reap health benefits as well as developmental advantages by not sharing parental resources with siblings. There are likely to be direct benefits attributable more material resources for health care, and having greater parental attention for their physical and psychological needs in childhood. As some studies suggest higher educational attainment for only children (Gee 1992; T. Falbo 2012), only children may experience indirect health benefits by virtue of their higher socio-economic status. More generally, classical theories from economics on the trade-off between quantity and quality of children (Becker and Lewis 1973), and from demography which posit an inverse relationship between family size and offspring survival (Cleland 2001) would also suggest better health outcomes for only children through enhanced resources and greater parental investment which might have direct and indirect influences on life course health.

On the other hand, the parents of only children may be negatively selected in a number of ways that could impact offspring health. For example, reduced parity progression may be related to adverse first birth experiences which reduce parental wellbeing (Margolis and Myrskylä 2015), or may be related to parent’s poorer health reducing fecundability. The trend for increasing numbers of only children is linked to advanced maternal age, which is associated with adverse birth and offspring outcomes (Kenny et al. 2013), despite higher socioeconomic status ameliorating risks (M. Myrskylä, Barclay, and Goisis 2017). Only children are more likely to have divorced, separated, or absent parents (Andersson 1997), which has been found to be associated with a range of negative social and health outcomes (Goisis, Özcan, and Van Kerm 2019; Amato and Anthony 2014; McLanahan, Tach, and Schneider 2013; Strohschein 2005).The literature on intergenerational family patterns indicates that only children are more likely to divorce or separate themselves (Dronkers and Härkönen 2008), and if they have had half-siblings, to experience multi-partner fertility (Lappegård and Thomson 2018).

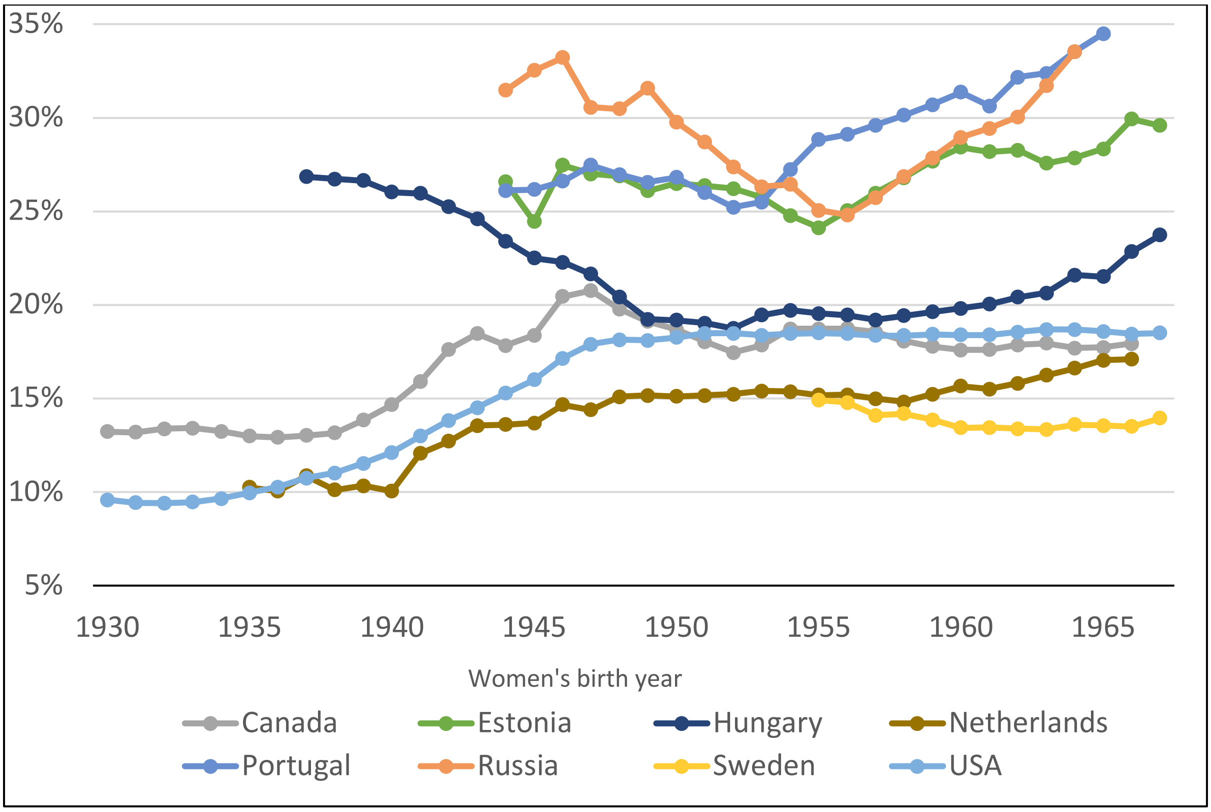
Despite the considerable theoretical motivation, few have actually studied the health outcomes of only children. Studies focusing on short term health outcomes have found a consistent pattern of higher child and adolescent obesity rates in only children compared to those with siblings across a range of contexts including the United States (Datar 2017; R. H. Mosli et al. 2016), Denmark (Haugaard et al. 2013), China (Li et al. 2017; Min et al. 2017; Cheng 2013), Brazil (de Oliveira Meller et al. 2015) and Japan (Wang et al. 2007). These patterns may be explained by differential maternal feeding practices (Rana H. Mosli et al. 2015). However, a study looking at UK and Brazilian cohorts found no differences in obesity and blood pressure between only children and children with siblings at 18 years of age (Howe et al. 2014). Hence, as for educational outcomes (Choi and Monden n.d.), only child health outcomes might vary across contexts due to varying selection in terms of parental characteristics.

The long-term health effects of being raised as an only child have been explored even less. Findings from a recent Swedish study suggested that only children have higher mortality rates than children raised with siblings, even after socioeconomic factors were accounted for (Baranowska-Rataj, Barclay, and Kolk 2017). The explanation for this pattern is not entirely clear, but we may be able to speculate based on previous studies of birth order and health if we accept that only children may share some characteristics with first-borns. A Norwegian study found that first-borns (of which only children are a unique sub-set) were more likely than later-borns to be obese and have higher blood pressure at age 40 (Black, Devereux, and Salvanes 2016), suggesting that this weight disadvantage may be carried through life. On the other hand, first-borns had more favourable health behaviours like lower smoking and alcohol consumption which may offset negative health risks (Black, Devereux, and Salvanes 2016). However, the overall picture from the literature on birth order and health is that first-borns tend to have lower mortality compared to later-borns (Barclay and Kolk 2015), suggesting that it may not be appropriate to assume that only children fare similarly to first-borns. Recent advances in the study of sibship and health have tended to use sibling fixed-effect designs (Baranowska-Rataj, Barclay, and Kolk 2017; Barclay and Kolk 2015; Barclay and Myrskylä 2014b)(K. Barclay and Myrskylä 2014a; K. Barclay and Kolk 2015; Baranowska-Rataj, Barclay, and Kolk 2017), which by necessity discard only children as they have no siblings to compare to. Therefore, only children's health outcomes over the life course deserve further attention.

Demographic context of this study

The proportion of women who have one child varies widely in high-income countries. Women from Eastern and Southern European countries are more likely to have one child than women from Northern and Western Europe, and other high-income countries like USA and Japan (see Fig.1, based on completed cohort fertility estimates). Of women born in 1965, 34% in Portugal had one child, compared with 14% in Sweden, raising questions about the degree of selectivity across contexts. Although studies demonstrate the entrenchment of the 2-child family ideal in Europe (Sobotka and Beaujouan 2014), Fig.1 shows that the proportion of women having one child has been increasing since 1960 in some contexts, but stable in Sweden, the US and Canada. Reduced parity progression from 1 to 2 children may be related to changing partnership and fertility trends typical of the second demographic transition (Lesthaeghe 2010). Postponement of the first birth may reduce the likelihood of progressing to a second due to reduced fecundity at later ages. Increasing divorce and separation (regardless of subsequent repartnering) may delay or reduce fertility. Finally, increasing family complexity including increases in blended and step-families, may reduce the number of biological children women have with one partner, without affecting the average family size. The continuation of these trends in high-income countries (Sobotka 2017) mean that biological only children will become increasingly prevalent.

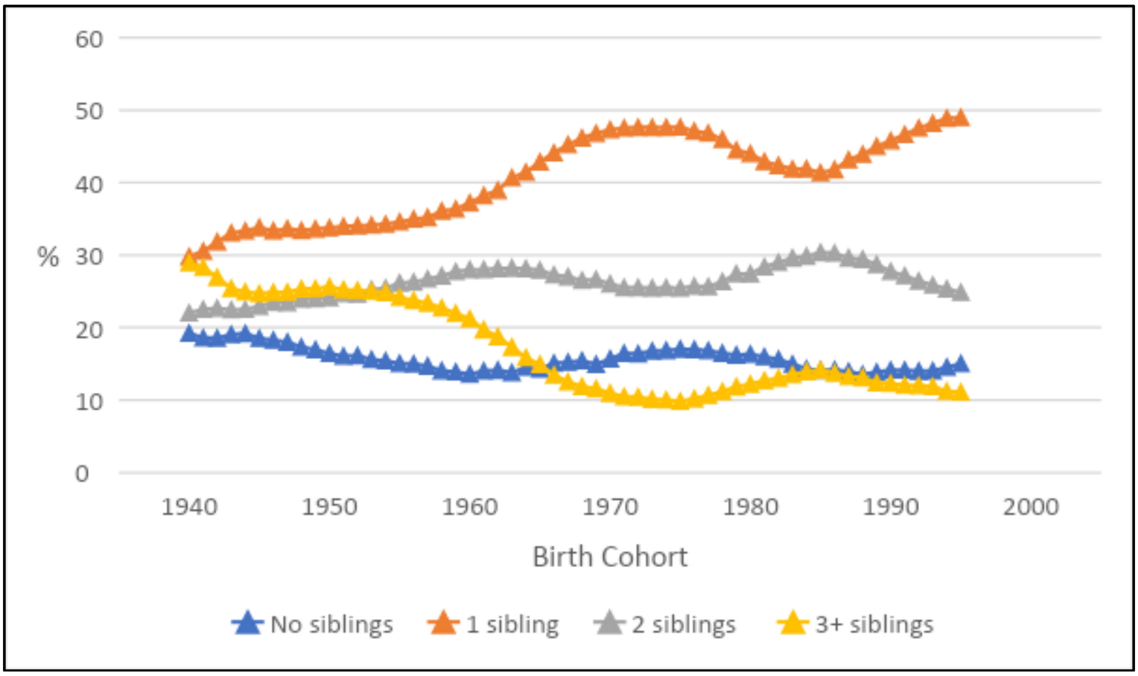
Figure 1: Percentage of women who had one child, according to women's birth cohort 1930-65, selected high income countries



Source: Human Fertility Database (https://www.humanfertility.org/cgi-bin/main.php), authors' calculations based on cohort parity progression ratios.

Although the proportion of women having only one child has increased in some contexts, it is important to distinguish between family size from the perspective of parents and children (Preston 1976) . In Sweden the proportion of women having one child has remained low and stable, meaning that for the Swedish birth cohorts covered in this paper born 1940-1975, being an only child was far from the norm. The majority of Swedish children had 1 or 2 biological siblings (Fig.2); the proportion of children with no siblings has never exceeded 20%. Among those born before 1945, the proportion of only children was around 19%, this subsequently declined to a low of 13.8% in the 1963 birth cohort, followed by a slight increase for the 1975 cohort, before remaining at around 14-15% for millennials born 1980-1995. Figure 2 also shows a marked decline in children with 3 or more siblings, and a growing entrenchment of the 2-child norm. The separation and divorce rate is Sweden is relatively high, contributing to increases in the proportion of children with half siblings (Thomson 2014). Among the 1940 cohort, just 7.8% of children had half-siblings, this had increased by nearly 4 times to reach 26.6% in the 1975 cohort. This means that a growing share of 'biological' only children would have at least one half-sibling, which could mean they experience some of the (possibly positive) effects of having siblings (dependant on shared residence), but on the other hand may suffer from the negative effects of family disruption and divorce. In the Swedish context children with half-siblings have poorer educational performance (Turunen 2014). Only children are an increasingly heterogeneous group, something which is not usually accounted for in previous studies but which we are about to explore given the richness of the data we use in this study.

Figure 2: Children according to biological sibship size, birth cohorts 1940-1995, born in Sweden



Figures based on birth records of children with a shared biological mother and father.
Source: Swedish population register, authors' calculations.

Research questions and contribution

Given the paucity of evidence on the topic, the first aim of this paper is to investigate health outcomes of only children relative to other types of sibling groups at various stages of the life course from late adolescence (age 17-20) to mortality at age 50 and over. A novelty of our approach is distinguishing between 'real' only children and those with half siblings, which may help us to account for some of the only child disadvantage found in other studies (Baranowska-Rataj, Barclay, and Kolk 2017). We draw comparisons between only children and children raised in multi-child sibling groups while taking account of both family size and birth order. Our second aim is to investigate the likely explanatory factors, or confounders, for any only child differences we see by adjusting for a range of parental health and social characteristics, and child characteristics that might help to explain later life health outcomes. In addition, we employ a novel within-family design that compares first cousins who share a maternal grandmother to one another to act as an additional control for shared factors in the extended family.

Data and Methods

Data

In this study we use Swedish population register data to examine how sibling group size, and particularly only child status, in the family of origin is related to health in early adulthood and mortality. Each individual in Sweden has a unique personal identification number (PIN) that is universally used for administrative purposes. A key administrative register that we use in this study is the Swedish multigenerational register, which allows us to link individuals to their parents and siblings. We examine sibling groups where all the children were born in Sweden in order to maximize the accuracy of the parent-child sibling linkages. A key part of our analysis is the distinction between children who were or were not raised in blended families. As a consequence, we exclude any children who are missing information on either the maternal or paternal linkage, but this is less than 1% in the birth cohorts that we study. We also exclude children in sibling groups with multiple births such as twins, as birth order is an important component of our analysis, and multiple births confuse the assignment of birth order.

We examine the relationship between sibling group size and four outcome variables: height, physical fitness, being overweight or obese, and mortality. Apart from mortality, information on all the other outcome variables are drawn from the Swedish military conscription register. In Sweden, men were universally required to report to military conscription tests between ages 17 and 20 to determine their physical and psychological suitability for military service. We use data on height, physical fitness, and BMI for cohorts born 1965–1975. Since only men were required to report to conscription tests in Sweden, we do not have data on these measures for women. However, although the outcome measures are available for men only, the measures of sibling group size and other characteristics of the sibling group are based on the whole sibling groups, including brothers and sisters.

The other main register that we use is the Swedish mortality register, which contains detailed information on all deaths in Sweden between 1960 and 2017. Although our access to the Swedish mortality register includes data for the period 1960–2017, the multigenerational registers that allow family members to be linked to one another are incomplete before the 1990s. (Centralbyråns 2011). We start our analysis of all-cause mortality at age 50, and to be included in our analytical sample our birth cohorts must have survived to age 50. We also exclude anybody who ever emigrated from Sweden before age 50. Table 1 details how we reach our analytical sample for both the conscription data analysis and the mortality analysis.

Table 1: Sample exclusion process for this study

Analysis of male health outcomes at age 17-20	N included	N excluded
Total men born in Sweden 1965-75	634,403	
ID for both parents	626,970	7,433
No multiple births	611,610	15,360
No missing values on conscription variables	532,659	78,951
Not missing grandmother ID and has maternal cousins	370,955	161,704
Analysis of mortality		
Total men and women born in Sweden 1940-60	2,305,911	
ID for both parents	2,146,263	159,648
No multiple births	2,074,826	71,437
Did not emigrate or die before age 50	1.939,202	78,624
No missing values on key covariates	1,910,086	29,116

Sibling Group Size, Birth Order, and Blended Families

The key explanatory variable in our study is sibling group size. Although our study focuses on only children, we think we can get a more complete picture and a better understanding of the health of only children if we contrast them to children raised in sibling groups with two, three or four or more children, rather than to assume that multi-child sibling group are homogenous. We also explicitly model birth order as part of our sibling group size variable, as it is valuable to consider whether only children have similar outcomes to first-born children in multi-child sibling groups given that both only children and first-borns spend a period of time in early childhood with the exclusive attention of the parents and without competition from siblings. Furthermore, since later-born children generally do worse than first-borns, later-born siblings lower the average achievement in multi-child sibling groups. This means that a detailed consideration of the interplay of family size and birth order is essential for comparing the outcomes of only children to children in larger families. Our key explanatory variable has the following nine categories:

- Only child
- First-born in a two-child sibling group
- Second-born in a two-child sibling group
- First-born in a three-child sibling group
- Second-born in a three-child sibling group
- Third-born in a three-child sibling group
- First-born in a sibling group with four or more children
- Middle-born in a sibling group with four or more children
- Last-born in a sibling group with four or more children

We calculate our variable for family size and birth order based on maternal fertility. That is to say, an individual designated as an only child is the only biological child of the mother, but the biological father may have had other children. To take account of complex families, our main analyses always feature an interaction between our nine-category family size and birth order variable with a binary variable for whether the index person has any half-siblings or not (who can only come from paternal extra-partner fertility). Hence, our analyses include 18 categories which reflect the interaction between sibship size, birth order and the presence of any half sibling.

Outcome Variables

Height

Height, measured in centimeters, is standardized (z-scores) for our analyses.

Physical Fitness

Our measure for physical fitness is based on a measure of maximal working capacity, measured in watts (fysisk arbetsförmåga i watt). Maximal working capacity (MWC)— measured as the maximum resistance attained in watts when riding on a stationary bike (one of the most effective ways of measuring aerobic fitness) for 5–10 minutes—is closely related to maximal oxygen uptake ($V0_2$max), also known as maximal aerobic capacity. The correlation between these two variables has been reported to be approximately 0.9 (Patton, Vogel, and Mello 1982). The variable for MWC is an important predictor of mortality in adulthood among men (Sandvik et al. 1993) . Because a measure of MWC in watts is not intuitively easy to interpret, we standardize this outcome measure using z-scores.

BMI

We calculate BMI as mass (in kilograms) divided by height (in metres) squared at the time of conscription test. Using the standard cutoff points, we focus on whether our index persons were overweight or obese at the time of the military conscription test, meaning whether they had a BMI of 25 or greater.

Mortality

We study mortality in the period 1990–2017 for Swedish men and women born 1940–1960. We focus on all-cause mortality starting at age 50. For our 1940 birth cohort that means we study them from age 50 in 1990 through to age 77 in 2017. For our 1960 cohort we follow them from age 50 through to age 57.

Covariates

We also include a number of control variables in our models that previous studies have shown to covary with both our explanatory variable and our outcome variables. These include the birth year of the index person (1965,1966,...,1977), which is associated with family size as well as secular trends in our health measures. We control for both maternal age at the time of birth (15-19,20-24,....,35-39,40+), and paternal age at the time of birth (15-19,20-24,...,40-44,45+), as age at childbearing covaries with family size and birth order as well as health outcomes. We also use information on maternal and paternal educational attainment, with eight categories: primary (<9 years), primary (9 years), secondary (10-11 years), secondary (12 years), tertiary (13-15 years), tertiary, but not including postgraduate qualifications (15+ years), and postgraduate qualifications (approximately 16-20 years). The final, eighth, category indicates whether the variable for education has a missing value.

To further adjust for socioeconomic conditions in the family of origin, we adjust for the socioeconomic status of the mother and father as reported in the 1960 census. This variable is based upon information on occupation and occupational status, and has 12 categories in the 1960 census: [1] entrepreneurs in agriculture, forestry, etc.; [2] workers in agriculture, forestry, etc.; [3] entrepreneurs in industrial, commercial, transport and service occupations; [4] entrepreneurs in the free professions (doctors, lawyers, etc.); [5] company executives (employees); [6] officials (supervisors, technicians, office and commercial staff etc.); [7] workers other than group 2; [8] employees in the service profession; [9] military; [10] persons with unidentifiable professions; [11] students (non-work); [12] other non-employed or students. We also include an additional category, [13], for missing information. Since we use this covariate only as a control variable we argue that it is useful to use this detailed categorisation, particularly as it was designed to capture important features of the Swedish occupational distribution at the time the information was collected. Further controls include a binary variable for whether the parents had divorced by the time the index person had reached age 16, and binary variables for whether the mother or father had died before the index person reached age 17.

In our analyses of mortality we also control for a number of variables that capture important sociodemographic and socioeconomic factors in the adulthood of our index persons. These include covariates for whether the mother or father had died before age 50, marital status at age 50 (unmarried, married, divorced, widowed), the index person's own educational attainment (same categories as used for the educational attainment of the index person's parents), the index person's own socioeconomic status taken from the 1990 census, and the number of children that the index person had by age 50 (0,1,...,6+). All of these variables have been shown to covary with family size as well as health outcomes ((Cherlin, Chase-Lansdale, and McRae 1998; Barclay et al. 2016; Mikko Myrskylä et al. 2014; Rostila and Saarela 2011; Weitoft et al. 2003; Torssander and Erikson 2010)).

Statistical Analyses

Military conscription Data

To study the relationship between sibling group size in the family of origin and our various health outcomes derived from the military conscription register, we use ordinary least squares as well as linear regression with cousin fixed effects. Our outcome variables for physical fitness and height are continuous, but we analyse being overweight or obese as a binary variable. For the analysis of being overweight or obese, we use linear regression in the form of linear probability models with robust Huber-White standard errors (Stock and Watson 2008).

The fixed effects are applied to the cousin group. In the manuscript we focus on the results from analyses comparing cousins who shared a maternal grandmother, but in supplementary analyses we also conduct cousin comparisons where cousins share a paternal grandmother. The use of maternal cousin fixed effects implicitly adjusts for all factors that are shared within the maternal cousin group. Thus, the within-family comparison adjusts for the size of the parental sibling group, as well as grandparental resources (e.g. wealth) and other resources shared across the extended kin group. This may include material assets such as a shared wealth (e.g. a shared vacation home), but also symbolic aspects such as a shared surname or a common family history and identity. The fixed-effects approach also inherently adjusts for factors that are difficult to observe and measure, such as all elements of shared socioeconomic background to the extent that such factors are indeed shared by cousins. For each outcome variable (height, physical fitness, and overweight/obese), we estimate two models using the full population:

$$y = \beta_1 SGSBO \times Blended + \beta_2 BirthYear + \alpha + \varepsilon$$

$$y = \beta_1 SGSBO \times Blended + \beta_2 BirthYear + \beta_3 X + \alpha + \varepsilon$$

where y is our outcome variable, *SGSBO x Blended* is our nine-category sibling group size and birth order variable interacted with a binary variable for whether the index person had any paternal half-siblings or not (yielding 18 discrete categories), *BirthYear* is a categorical variable for year of birth (1965,1966,...,1975), α is the constant, and ε is the error term. In model 2 we introduce additional control variables indexed by X, a vector of covariates including categorical variables for maternal and paternal age at the time of birth of the index person, categorical variables for maternal and paternal educational attainment, categorical variables for maternal and paternal socioeconomic status (drawn from the 1960 census), a binary variable for whether the parents had divorced by the time the index person had reached age 16, and binary variables for whether the mother or father had died before the index person reached age 17. Further details on these covariates is available in the prior subsection.

For each of our three military conscription outcome variables we also estimate a third model, using linear regression with maternal grandmother cousin fixed effects:

$$y_{ij} = \beta_1 SGSBO_{ij} \times Blended_{ij} + \beta_2 BirthYear_{ij} + \beta_3 X_{ij} + \delta_j + \varepsilon_{ij}$$

where the subscripts *i* and *j* refer to sibling *i* in cousin group *j*, and δ_j designates the cousin fixed effect. Model 3 includes the same vector of control variables, *X*, that were included in Model 2. The analytical sample for Model 3 is based on cousin groups that share a maternal grandmother, and we exclude individuals who are 'only cousins'. An individual might not have any maternal cousins either because their parent was an only child, or because all aunts and uncles were childless.

Mortality

To study mortality, we use survival analysis in the form of Cox proportional hazard regression (Cox 1972). The proportional hazards model is expressed as:

$$h\ (t \mid X_{1,\dots,}X_k) = h_0(t) exp\left(\sum_{j=1}^{k} \beta_j X_j(t)\right)$$

where $h\ (t \mid X_{1,\dots,}X_k)$ is the hazard rate for individuals with characteristics $X_{1,\dots,}X_k$ at time t; $h_0(t)$ is the baseline hazard at time *t*; and β_j, *j* = 1, ... , *k* are the estimated coefficients. Because the failure event in our analysis is the death of the individual, the baseline hazard of our model, $h_0(t)$, is age. Individuals are censored on first migration out of Sweden, at death, or in 2017 - whichever comes first. We estimate the following three models:

$$log\ h(t) = \beta_1 SGSBO \times Blended + \beta_2 Sex + \beta_3 BirthYear$$

$$log\ h(t) = \beta_1 SGSBO \times Blended + \beta_2 Sex + \beta_3 BirthYear + \beta_4 Childhood$$

$$log\ h(t) = \beta_1 SGSBO \times Blended + \beta_2 Sex + \beta_3 BirthYear + \beta_4 Childhood + \beta_5 Adulthood$$

where $log\ h(t)$ is the log hazard of mortality, *SGSBO x Blended* is our nine-category sibling group size and birth order variable interacted with a binary variable for whether the index person had any paternal half-siblings or not (yielding 18 discrete categories), *Sex* is a binary variable for biological sex, *BirthYear* is a categorical variable for year of birth (1940,1941,...,1960), and *Childhood* is a vector of covariates that relate to the childhood environment including categorical variables for maternal and paternal age at the time of birth of the index person, categorical variables for maternal and paternal educational attainment, and categorical variables for maternal and paternal socioeconomic status (drawn from the 1960 census). Finally, *Adulthood* is a vector of covariates related to important sociodemographic and socioeconomic factors measured before age 50, including binary variables for whether the mother or father had died before age 50, marital status at age 50, the index person's own educational attainment, the index person's own socioeconomic status taken from the 1990 census, and the number of children that the index person had by age 50 (0,1,...,6+).

Results

Table 2 shows descriptive statistics for our analysis samples, using both the military conscription data and the mortality register. There were proportionally more only children and children with 3 or more siblings in the earlier cohorts born 1940-60, compared with those born 1965-75. The proportion of children from blended families was also higher in the 1965-75 cohort. The parental age profile had shifted in the later cohorts towards childbearing being concentrated in the 20s and early 30s. In the later cohorts, parents were more likely to have a greater number of years of education, and tertiary education rates has increased for both mothers and fathers.

Table 2: Descriptive statistics from the analysis samples showing variables relating to parent and child characteristics common across the mortality and conscription analysis

	Mortality analysis ***b.1940-60***	**Conscription analysis** ***b.1965-75***
Sample N	1,910,086	532,659
Child characteristics		
Sibling group / birth order		
1 (Only child)	13.6	8.8
2 (First)	17.7	23.3
2 (Last)	16.7	22.6
3 (First)	9.4	10.2
3 (Middle)	9.1	9.9
3 (Last)	7.5	10.0
4+ (First)	5.7	3.3
4+ (Middle)	15.9	7.6
4+ (Last)	4.6	4.3
Blended sibling group		
Non-blended	85.9	75.3
Blended	14.1	24.7
Female	49.0	0.0
Paternal age at time of birth		
15-19	0.9	1.4
20-24	12.5	19.8
25-29	26.4	36.7
30-34	26.8	23.9
35-39	18.6	10.9
40-44	9.7	4.8
45+	5.1	2.5
Maternal age at time of birth		
15-19	4.8	7.0
20-24	24.3	31.9
25-29	30.0	35.8
30-34	22.9	17.1
35-39	13.2	6.4
40+	4.8	1.8
Father's education		
Primary (<9 years)	44.5	30.2
Primary (9 years)	2.9	7.5
Secondary (10-11 years)	12.4	24.0
Secondary (12 years)	7.6	16.5
Tertiary (13-15 years)	2.8	8.3
Tertiary (15+ years)	4.0	10.8
Postgraduate (16-20 years)	0.5	1.5
Missing	25.5	1.1
Mother's education		
Primary (<9 years)	54.6	20.7
Primary (9 years)	6.5	10.7
Secondary (10-11 years)	18.0	38.1
Secondary (12 years)	1.9	7.0
Tertiary (13-15 years)	2.4	10.1

Tertiary (15+ years)	2.6	12.5
Postgraduate (16-20 years)	0.1	0.4
Missing	14.0	0.4
Socio-economic status, 1960, father		
Entrepreneurs in agriculture, forestry	10.8	6.8
Workers in agriculture, forestry	3.9	4.0
Entrepreneurs in the industrial, commercial, transport and service professions	7.9	4.4
Entrepreneurs in the free professions (doctors, lawyers, etc.	0.9	0.4
Company executives (employees)	1.9	0.8
Officials (supervisors, technicians, office and trade staff, etc.)	27.9	17.1
Other employees	35.9	39.0
Employees in service professions	5.1	1.3
Military	0.7	0.9
Unidentified profession	0.1	0.1
Students (non-work)	0.2	11.0
Other non-employed or students	3.0	6.9
Missing	1.9	7.5
Socio-economic status, 1960, mother[2]		
Entrepreneurs in agriculture, forestry	10.9	5.9
Workers in agriculture, forestry	4.2	2.6
Entrepreneurs in the industrial, commercial, transport and service professions	8.4	4.4
Entrepreneurs in the free professions (doctors, lawyers, etc.	1.0	0.4
Company executives (employees)	2.2	0.8
Officials (supervisors, technicians, office and trade staff, etc.)	23.8	28.8
Other employees	42.4	27.1
Employees in service professions	1.1	6.1
Military	1.0	0.4
Unidentified profession	0.1	0.1
Students (non-work)	0.3	10.7
Other non-employed or students	2.4	5.3
Missing	2.1	7.5
Father died before child age 17		2.9
Father died before child age 50	59.4	
Mother died before child aged 17		1.1
Mother died before child age 50	32.8	
Parents divorced before child age 16		17.4

Physical health at ages 17-20

Figure 3 shows the results for height z-scores for men aged 17-20. All models show height z-scores according to sibling group size and birth order defined by maternal fertility, taking 'real' only children (i.e. with no full or half-siblings) (OC) as a reference category. The remaining 8 sibling group/birth order categories we indicate with a number 2,3, or 4+ relating to sibling group size, and F, M, or L to indicate birth order. Thus, a first born child from a 3-sibling group is marked with F/3. In Figures 3-6 we distinguish non-blended families with blue circles and blended families with orange squares. In Figures 3, 4 and 5 Model 1 – the baseline model - is only adjusted for birth year. Model 2 includes controls for parents' education, socio-economic status, age at the time of birth, whether either parent died before the child was aged 17, and whether the parents divorced before the child was aged 16 in addition to birth year. Model 3 shows the same model specification as model 2, but run on a sub-sample and including maternal grandmother FE, in other words, comparing sets of maternal cousins to one another, to adjust for shared factors in the maternal family of origin that may confound the association between family size and health outcomes.

In model 1, among the non-blended families, only children had significantly lower height scores than children from sibling groups of 2 children. There was no significant difference in height scores between non-blended only children and children from non-blended sibling groups of 3 children. On the other hand, 'real' only children were substantially advantaged in height compared with those from 4+ sibling groups. There were no significant differences between only children with or without half siblings. However, for all other sibling group/ birth order categories, children from blended families had lower height. After adjustment for parental characteristics (model 2), some of the differences between non-blended only children and those with full siblings diminished, and non-blended only children were only disadvantaged compared with non-blended first borns from a 2-sibling group. In model 2, a monotonic decrease in height with birth order becomes more evident for sibling groups 2 and 3. In model 3, the differences between only children and others for height z-scores attenuates to non-significance.

Figure 4 shows the same models but using linear probability models to estimate the probability of being overweight or obese at ages 17-20. As above, in all models non-blended and blended only children were not significantly different in their health outcomes. However, in contrast to the analyses examining height as an outcome, model 2 shows that only children had significantly higher probabilities of being overweight/obese compared with nearly every other sibship constellation, except for blended last-born children of larger sibling groups. Non-blended only children had a higher probability of being overweight/obese than any other non-blended sibling group. In fully adjusted models, the difference between non-blended only children and non-blended children with 1 sibling was equivalent to 2-3 percentage points. There was also a positive relationship between higher birth order and risk of overweight/obesity. Model 3, additionally adjusted for maternal grandmother fixed effects, shows approximately the same pattern of only child disadvantage but with lower statistical power and wider confidence intervals (due to the smaller sample size used in this set of analyses).

Figure 3: Results for standardised height scores among men at age 17-20, according to sibling group size, birth order and blended family status, Swedish men born 1965-75.

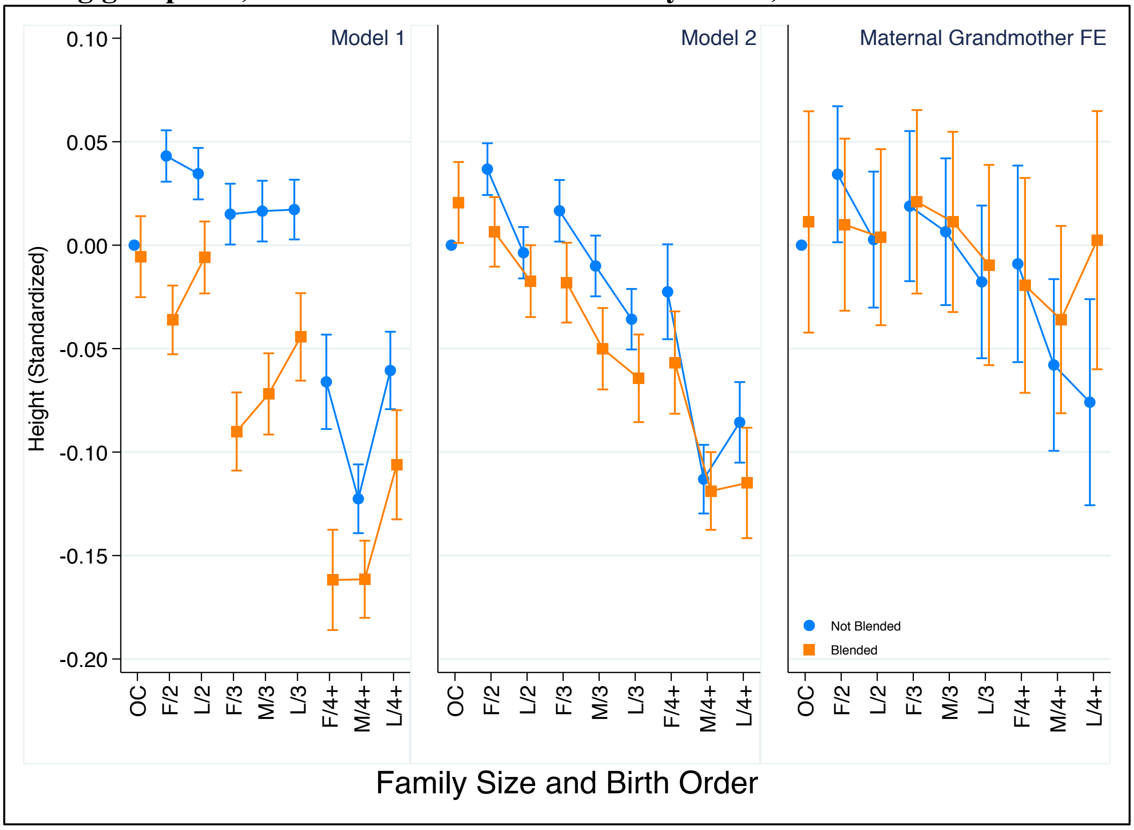


Figure 4: Results for overweight and obesity among men at age 17-20, according to sibling group size, birth order and blended family status, Swedish men born 1965-75

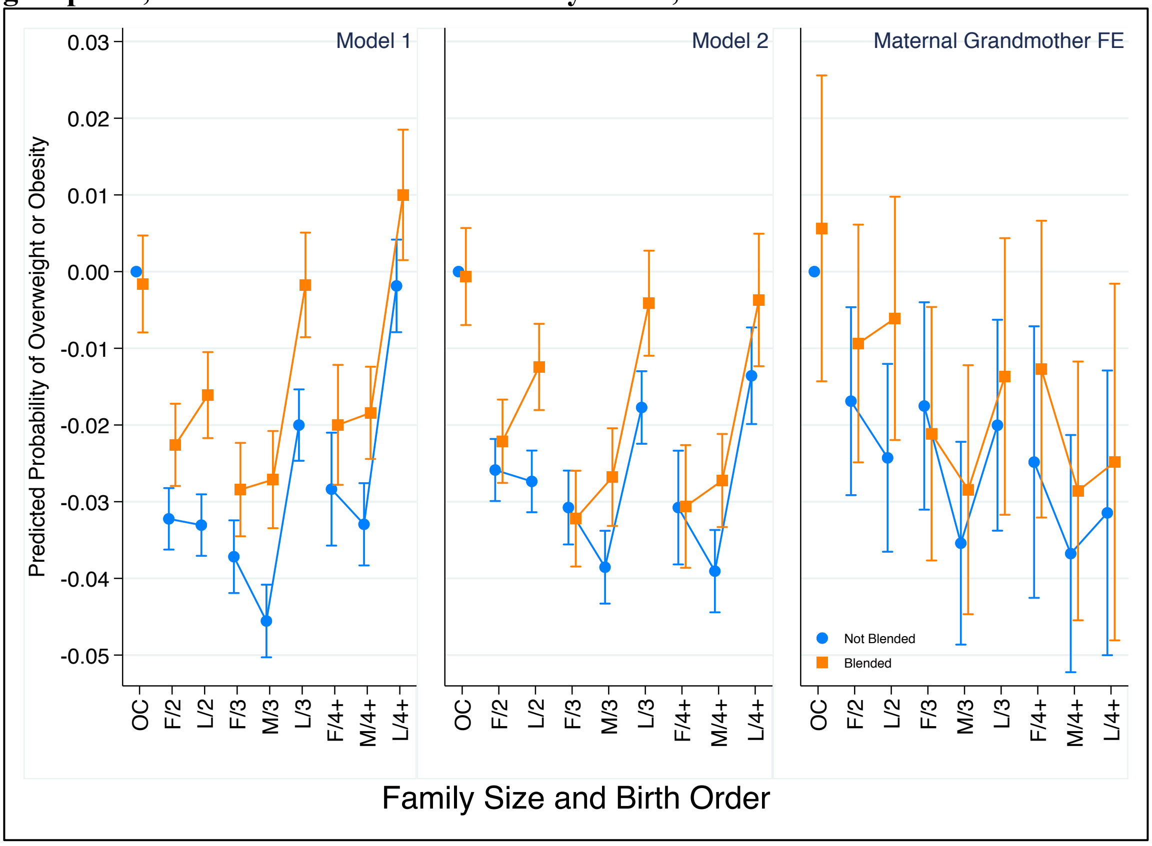


Figure 5: Results for standardised fitness scores among men at age 17-20, according to sibling group size, birth order and blended family status, Swedish men born 1965-75

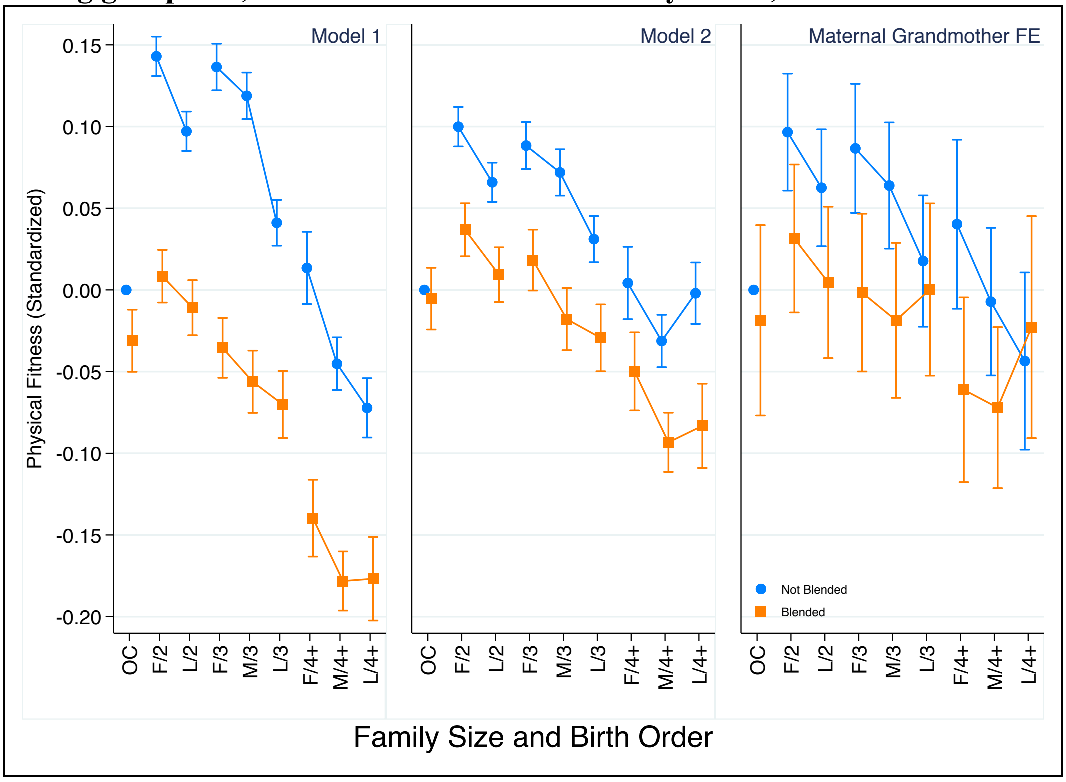


Figure 5 displays the results for standardised fitness scores, and shows that only children, regardless of their blended status, have poorer fitness than non-blended children from 2-and 3-sibling groups, and similarly low fitness scores as non-blended children from siblings groups of 4 or more. After adjustment for parental characteristics, the disparity between only children and those with siblings attenuated, but only children still had approximately 10% of a standard deviation lower fitness scores compared with first borns with one sibling. In model 2 adjusted for parental characteristics only children were also worse off than blended, first born children from 2-sibling groups. Otherwise, in models 1 and 2, blended children had significantly lower fitness than children from non-blended families. Regardless of blended status, there was a negative relationship between birth order and fitness score. Model 3 using cousin fixed-effects shows approximately the same pattern of effects as in model 2.

Mortality results

Figure 6 shows results for all-cause mortality at age 50 and over by sibling group size, birth order and blended family status. Because we found no interaction effects between sibling group size, birth order, and gender, we are showing pooled models for men and women. Model 1 shows estimates adjusted for birth year and gender, and model 2 additionally adjusts for parental characteristics parental age, education socio-economic status, and parental death before the age of 50. Model 3 additionally adjusts for life course characteristics of the child measured at age 50: civil status, attained education, socio-economic status and parity[2].

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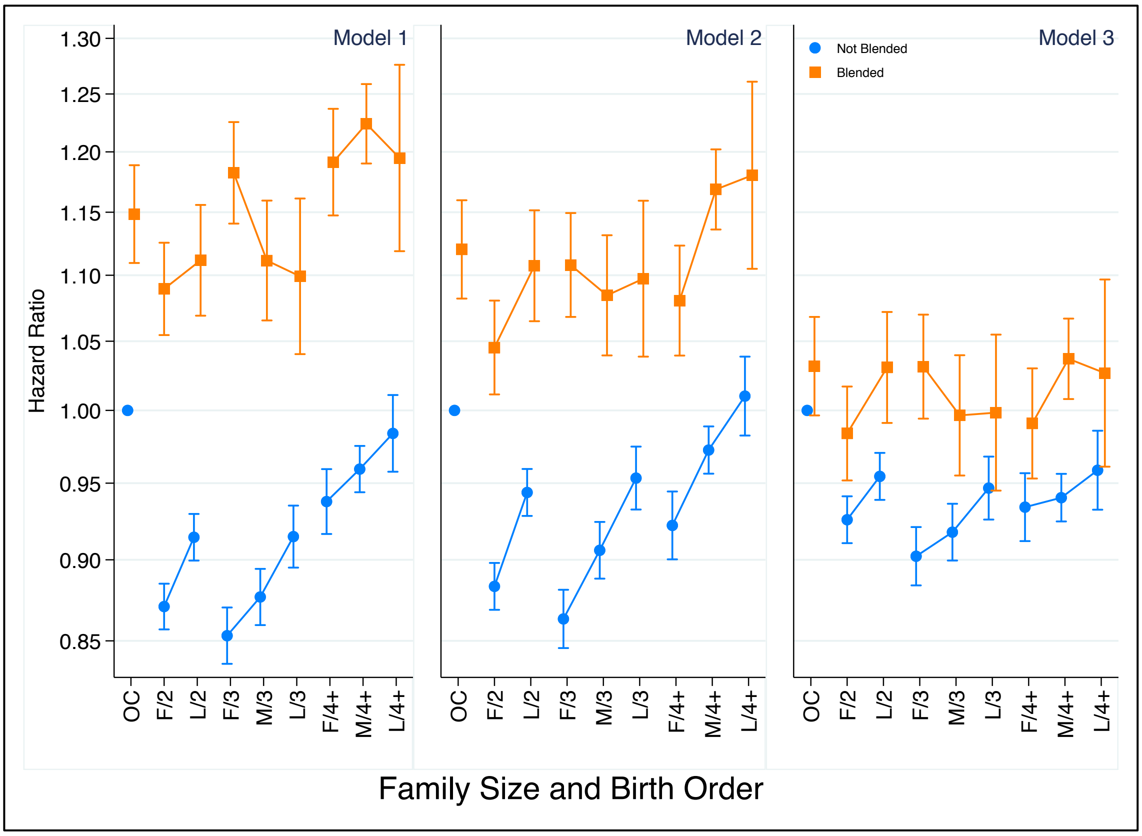
[2] Because the Swedish multigenerational register starts at 1932, we were unable to obtain information on maternal grandmothers for the older cohorts in the mortality sample, therefore we did not run cousin fixed-effects for the mortality outcome.

Comparing non-blended sibling groups to one another, only children clearly have a higher hazard of mortality. Non-blended children with 1 or 2 siblings, and first and middle borns with 3 or more siblings have significantly lower mortality, and this effect persists after controls for parental characteristics (model 2). After adjustment for life course factors, the gap between only children and other sibling groups reduces, suggesting that some of the negative influence is mediated through family history and socio-economic factors. By contrast with earlier analyses, blended only children have significantly worse outcomes for mortality than non-blended only children. However this disparity reduces to non-significance after controls for life course factors in model 3. In fact, in all models, for nearly all sibling groups, children from blended families have higher mortality than those from non-blended groups, but this substantially reduces after controls for life course factors, suggesting this negative effect is mediated by poorer life course outcomes.

Figure 6: Results for all-cause mortality at age 50+, according to sibling group size, birth order and blended family status, Swedish men and women born 1940-60, mortality 1990-2017



Robustness checks

For all outcomes from conscription data, we fitted identical models using paternal grandmother FE, and these showed no substantial differences to those obtained when looking at maternal cousins. For mortality models, we fitted the same models starting the mortality follow-up at 1990, rather than age 50, and found broadly the same pattern of effects.

We also investigated the effect of using slightly different specifications of family size and half-sibling status, by classifying children into family size group based on both maternal and paternal fertility. This would mean that an only child where *either* the mother or the father had a child with another partner would be classified as 'only child, blended' (in contrast to the version above based on maternal fertility alone, where blended only children are those with paternal half-siblings).

Overall, the pattern of effects was similar, with the exception that the contrast between non-blended and blended only children became more pronounced. Blended only children appeared to be at a consistent disadvantage on all measures compared with non-blended only children.

Discussion

This paper is the first to our knowledge to investigate the health of only children relative to other sibling group sizes and birth orders using high quality, large-scale administrative data on a range of objectively measured health outcomes. Our first aim was to assess the extent of any only child health disadvantage, relative to other sibling constellations, and our study provides evidence that Swedish only children (regardless of the presence of half siblings) are likely to be shorter, are more likely to suffer from overweight or obesity, and have lower levels of physical fitness in late adolescence compared to children from larger families with no half siblings. On the whole, at adolescence only children, regardless of half-siblings, do better on these health measures than children from larger, blended families. Our mortality results also confirm that 'real' only children have higher death rates in early old age compared to children with full biological siblings, but do similarly or worse than children with half-siblings. Generally, these patterns persist after robust controls for parental and family characteristics.

The logical next question is then, why do we still see this consistent health disadvantage for only children? A candidate explanation is residual confounding on parental characteristics, particularly health status. It is likely that parents of only children are negatively selected in a context such as Sweden where there is a strong 2-child norm, leading to poorer outcomes for their offspring. Our adjustments for parental health were rather restricted (just premature death) and it is possible that other health and wellbeing factors prevent parity progression. This also points to the importance of considering context when assessing family effects of health.

There was a striking difference between only children and other sibling groups for BMI. The finding that only children have a higher BMI is consistent with previous research from a range of middle and high-income contexts which higher and lower levels of only child selectivity (Datar 2017; R. H. Mosli et al. 2016; Haugaard et al. 2013; Li et al. 2017; Min et al. 2017; Cheng 2013; de Oliveira Meller et al. 2015; Wang et al. 2007). This points to a cross-contextual mechanism rather than, or in addition to, selectivity. Previous researchers have suggested parental feeding practices (Rana H. Mosli et al. 2015). It could also be that while not having to share parental/household resources like attention and time may benefit only children in some areas like educational outcomes (T. Falbo 2012), an excess of food resource for only children may be detrimental. Sharing food with siblings may prevent overeating and weight gain. However, given the importance of child and adolescent for life course health outcomes, this deserves further exploration, possibly by considering cross-cohort effects.

One of the strengths of this study over previous studies of only children is that we have the ability to distinguish only children with and without half-siblings. This is important because one of the hypothesised explanations for an only child disadvantage is negative selectivity (T. Falbo 2012), and one mechanism might be a disrupted family background which may lead to a range of adverse outcomes. We might expect only children with half-siblings to have experienced some kind of parental separation and be further disadvantaged, however our results show no substantial health differences between only children with and without half siblings at adolescence. For blended only children, it may be that the effect of having a disrupted family background is mitigated by the experience of growing up with half-siblings, or living in an environment where the mother has repartnered and produced further offspring may point to a successful repartnering and greater resources. More generally, our results also highlight that children from blended families are persistently disadvantaged on health measures, and that some of this could be explained by poorer life course family and socio-economic outcomes.

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