Fading family lines

- Women and men without children, grandchildren and great-grandchildren in 19th, 20th, and 21st century Northern Sweden.

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Abstract : In our study we examined the extent and why specific family lines die out. We studied the late 19th-century population of the Skellefteå region of northern Sweden and all their descendants, accounting for emigration. This was done across four generations who were observed from 1885 to 2007. The first generation in our sample consists of men and women born between 1885-1899 (N=5,850) and we identify their children, grandchildren and great-grandchildren. We find that almost half, 48%, of the first generation did not have any living descendants (great-grandchildren) by the end of the study period. The risk of a family line ending was driven primarily either by low fertility or death during reproductive ages in the first generation. Those who left few descendants in the first generation had increased risks of not having descendants in later generations. Both high- and low-status occupational groups had greater levels of not leaving any descendants. Almost all lineages that made it to the third generation also made it to the fourth generation.

Introduction

Continuing a family lineage and leaving descendants great meaning both from an individual perspective (Kotre 1984), has societal social and economic consequences (Goody 1973; Hunter and Rowles 2005), and is relevant for evolutionary based behavioural theory (Smith 2017). Yet, very little is known in terms of how common it is not to leave any descendants in a multigenerational perspective, and we have not identified any earlier studies that go beyond grandparenthood. There is also an insufficient understanding of the demographic causes of family line cessation – whether it is caused by high mortality or low fertility - and for which generation family line cessation occurs. We further lack an understanding of the socioeconomic drivers of this phenomenon, and how these factors relate to fertility and mortality outcomes.

In order to investigate these research topics, we study the how family lines in Sweden over the course of four generations, a period where the population size almost doubled through natural population growth and where Swedish mortality levels were among the lowest in the world. Our study uses both historic government data derived from parish registers, as well as recent administrative register data. Our dataset consists of men and women born between 1885-1899 (N=5,850) in Skellefteå, a coastal area in North-Eastern Sweden and their children, grandchildren and great-grandchildren. We investigate to which extent differences in lineage survival are driven by fertility, mortality, and socioeconomic characteristics for each successive generation.

What causes family lineages to die out?

The topic of our study - the proportion of individuals who leave no descendants after 1, 2, and 3 generations – is determined by demographic factors that are strongly related to the sociodemographic context. In a narrow sense, the proportion having no great-grandchild can be viewed as a demographic process in 3 generations, in which descendant(s) in each generation either die before having children, or live through their reproductive years without having any children. The first of these mechanisms, the role of mortality, has declined in importance over time as mortality at young ages has been falling rapidly over the 19th and 20th century. The second mechanisms related to fertility and childlessness (we use childlessness as a shorthand for having no children surviving to the end of their reproductive period), which can both be desired and undesired, and in low-fertility and low-mortality societies is the primary pathway to understand why an individual leave no descendants.

Finally to understand the lack of descendants across multiple generations, also the number of children an individual has plays an important role, as each additional child increases the probability that at least one child will bear grandchildren[1]. The proportion leaving no descendants over multiple generations can be viewed as a succession of probabilities for each generation to be childless. Below we discuss childlessness and its causes in a contemporary sociocultural context. It is the topic that has been most extensively covered in previous demographic literature. We follow this with a discussion on previous empirical studies of lack of descendants over various generational time spans (having children, having grandchildren, and studies making estimations over very large time spans).

[1] This pattern has been a matter of some controversy in evolutionary studies of human behavior, as it was theorized that low fertility may have been an evolutionary strategy to maximize the quality of ones children, who in turn would translate their superior socio-material situation into a larger number of grandchildren (or later decendants). It is now generally agreed that this seems not to be the case in contemporary western societies (e.g. Borgerhoff Mulder 1998; Goodman et. al. 2012).

In pre-industrial societies, mortality was the most common reason a newborn child did not leave any descendants (e.g. Low 1991). The proportion of men and women never having children was high in most of northwestern Europe as well, including Sweden (Rowland 2007). In northwestern European populations a large share of the population also never married, in what has been described as a Malthusian marriage system in which proportion marrying and age at marriage responded to wages and economic resources (e.g. Wrigley and Schofield 1981). Marriage and access to reproduction was strongly linked to occupational status in 19th century Sweden (Low, Clarke, and Lockridge 1991).

Before the fertility transition, the cumulative risk that a women or man either died before reproductive ages, or ended up not having children (most commonly through not marrying) was high. Therefore, despite high marital fertility, population growth was moderate. Throughout our study period, mortality was reduced, and average fertility declined dramatically. The net effect was that the number of surviving offspring was more stable over this period. The period we study has been one of increasingly effective and more affordable contraceptives combined with better sexual and reproductive education and knowledge (Kling 2006).

In contemporary societies people may end up without offspring for a variety of reasons, including a lack of partner, a feeling that one is financially insecure or because they pursue activities are difficult to combine with having children (Coleman, Basten, and Billari 2015; De Jong and Sell 1977), while mortality is a less important pathway (Lee 2003). More individuals prioritize careers and lifestyles that can be at odds with childbearing (Lesthaeghe 1983; Liefbroer and Billari 2010). Many perceive that there is an incompatibility between career goals, and childbearing – and fear the costs of childbearing (both in terms of resources and time use), particularly early in adulthood (Balbo, Billari, and Mills 2013; Tanturri 2013). Some become childless because they postpone childbearing for too long, many fail to establish a stable partnership in time, while others are unable to conceive due to primary infecundity (Bennett, Krishnamurthi, Barker-Collo, Forouzanfar, Naghavi, Connor, Lawes, Moran, Anderson, and Roth 2014; Merz and Liefbroer 2012; Tanturri 2013). Some choose not to have children while others end up childless due to a variety of life events and unforeseen factors that means they may not be able to realize the fertility preferences they once or currently have (Mynarska, Matysiak, Rybińska, Tocchioni, and Vignoli 2015). Some see parenthood as an ideal – but postpone attempts at childbearing to ages where fecundity markedly drops, and may end up without children (Kreyenfeld and Konietzka 2017; Saarela and Skirbekk 2019).

Sweden has since the late 19th century been characterized by relatively long education and comparatively low levels of mortality and childbearing (Murtin 2012). Longer education has generally related to later and lower fertility (Cochrane 1979; Colleran and Snopkowski 2018; Skirbekk, Kohler, and Prskawetz 2004). In recent decades, however, educational variation in fertility and childlessness in Sweden has been relatively low (Beaujouan, Brzozowska, and Zeman 2016; Jalovaara, Neyer, Andersson, Dahlberg, Dommermuth, Fallesen, and Lappegård 2018; Kolk and Barclay 2019), though differences are larger by income where both high-income men and women are much more likely to have children (Kolk 2019).

Preferences towards childlessness

Population level surveys in high-income countries suggest that most prefer to have having children -- very low percentages say that they would like to not have any children (Kreyenfeld, Kuhnt, and Trappe 2017; Miettinen and Szalma 2014). Among 18-40 year olds, only 5% of women and 7% of men across EU in 2011 stated they see childlessness as ideal – and the percentage are still lower in Sweden where only 2% of the women and 4% of the men have a stated preference for childlessness (Miettinen and Szalma 2014).

There is often social pressure to have children – both from relatives and society at large. Qualitative interviews suggest that many of those who are childless often feel that they are perceived of 'lesser value', as expressed through negative language and stereotyping from families and communities (O'Driscoll 2016). Childlessness may be particularly difficult for individuals who in family matters are more conservative, for instance religiosity has been found to be positively linked to fertility and likelihood of parenthood (Mosher and Hendershot 1984; Philipov and Berghammer 2007) and more religious individuals may find it difficult to be childless when their communities promote family formation (Moss and Baden 2015). In general, however, the acceptance of childlessness has increased over time in the Western world and in Sweden (Noordhuizen, de Graaf, and Sieben 2010). There has been a growing tolerance for having few or no children, and acceptance of childlessness is now relatively high in Sweden, also in comparison with other European countries (Merz and Liefbroer 2012).

It is a common among individuals with adult children to wish for grandchildren (Hanson and Auden 2014; Taiapa, Dip, and Felicity Ware MA 2013). The longing for grandparenthood has been found to be stronger at older ages and especially among those who are in poor health (Tomer and Eliason 2008). Many parents of adult children encourage them to enter parenthood – and argue for the benefits of having children and offer resources and time provisions in the case they have grandchildren, including financial cash transfers and housing support (Lee and Mason 2011; Margolis and Wright 2017; Pink 2018). Passing on knowledge, culture and beliefs is important for many older individuals (Silverstein and Giarrusso 2013). Many individuals become more culturally traditional with age and transferring culture to the next generation can be an important aim at later life stages (Chen and Feng 2011; Axinn and Thornton 1993; Deaton 2009).

Having descendants, including grandchildren has been found to be important for the quality of life of many older individuals (Lumby 2010; Muller and Litwin 2011). Benefits from having grandchildren in terms of levels of wellbeing has been identified among both women and men (Bates and Taylor 2013; Euler 2011). Grandparents may, following longer life expectancies, survive for longer potential period – allowing more shared years with their grandchildren (Chapman, Lahdenperä, Pettay, and Lummaa 2017; Margolis 2016).

Less is known about desires and preferences for leaving a legacy or having descendants in a longer time perspective. Anthropological studies have documented that having descendants play a prominent role in many pre-modern belief systems (e.g. Lévi-Strauss 2013; Palmer and Steadman 1997). For example, Confucian patrilineal societies put a great cultural value on having male descendants across multiple generations (Wolf and Huang 1980). Researchers have also documented that leaving a legacy for future descendants remains an important life goal for many individuals (e.g. Hunter and Rowles 2005), though quantitative studies on this topic is scarce. At least some individuals in contemporary society, also put a value on procreation and a genetic legacy as such, even if they will not meet any of their descendants (Riggs and Russell 2010). At an ever-grander perspective, some people also put value to the eventual survival of their sociocultural group, or even humanity at large (Lenman 2002).

Previous literature

Childlessness and grandchildlessness

A large literature have documented the prevalence of childlessness across the world (Kreyenfeld and Konietzka 2017; Persson 2010; Rowland 2007). A small but increasing literature have focused on proportions having grandchildren. Postponed and lowered fertility levels that have decreased the number of children, but also over time the number of subsequent descendants that Europeans have at a given age in the post-war period (Frejka and Sardon 2004; Sardon 1991). By the mid-2000s, almost 30% of the Swiss 70-79 year olds do not have grandchildren (Börsch-Supan et al. 2008). The share of 55-year-old Swedes who do not have grandchildren rose from 30% to 65% between 1990 and 2005, though a sizeable proportion of these will have grandchildren later (Lundholm and Malmberg 2009). Further, due to migration, poor relations and busy schedules, many elderly do not have much contact to their biological grandchildren (Burnette, Sun, and Sun 2013).

As childlessness differ by gender, (great-) grandchildlessness may also differ between men and women. Recent evidence suggest that men in several countries have been found to be more likely to be childless, which most likely imply an increase in male (great) grandchildlessness (Skirbekk and Blekesaune 2013; Zhang 2011). Further, particularly low status men are likely to be childless (Barthold, Myrskylä, and Jones 2012; Skirbekk 2008), which may affect the social and health related aspects of not having offspring in the longer term.

In the first decades of the 20th century, women were more likely than men to be childless in many European countries, following high male war-related mortality (Morgan 1991; Rowland 2007; Sobotka 2004). However, Sweden had a neutral position during the world wars and gender differences in mortality was largely unaffected by these trends, and throughout the 20th century men had higher levels of childlessness than women. Childlessness decreased in the early part of the 20th century and then increased compared from mid-century onwards (Myrdal and Myrdal 1935; Sobotka 2017).

A recent, and rapidly increasing literature has been examining the prevalence and timing of grandparenthood over the life course (e.g. Chapman, Lahdenperä, Pettay, and Lummaa 2017; Leopold and Skopek 2015; Margolis 2016; Skopek and Leopold 2017). A cross country comparison of contemporary grandparenthood in the US and 24 European countries is provided by Leopold and Skopek (2015). They find that compared to the United States (where on average grandparenthood occurs at the age of 49 among women, 52 years among men), grandparenthood in Eastern Europe occurred up to three years earlier in life (depending on the country); while in Western Europe, up to eight years later. They also found that grandparental estimated life expectancy shared with grandchildren is highest (35 years) among grandmothers in East Germany and the United States; the shortest (21 years) among grandfathers in West Germany and Spain. Over time, following increases in life expectancy, the duration of co-existence between grandparents and grandchildren has changed, while postponed fertility decreases it (Chapman, Lahdenperä, Pettay, and Lummaa 2017). Among West German women lower fertility among highly educated mothers has a strong effect -- lower-educated women's chances of becoming a grandmother were similar to higher-educated women's chances of becoming a mother (Skopek and Leopold 2017). Some studies use microsimulations, which allows projections of grandparenthood of current living individuals, under assumptions of different future mortality and fertility rates (Margolis and Verdery 2019).

Our approach differs from most previous recent research on grandparenthood in that we are not conditioning our focus on survival of our index persons. Other research has focused on the personal experience of having a grandchild, while we are interested in the probability that a person surviving to adulthood would ever have grandchildren or great-grandchildren (regardless of if they survive to experience it). As such, our research is more relevant for fundamental multigenerational processes and for examining eventually proportions leaving social or genetic descendants, while being less relevant for subjective experiences of having descendants.

Studies of lineage extinction over multiple generations

Studies focused on the proportions ever-leaving descendants in a longer time perspective have primarily relied on other data sources than survey data, and has typically not used micro level data. Studies on family extinction have a long history in the sciences, already examined by Galton and Watson in 1875, on basis of surnames and "one-sex population" models (Watson and Galton 1875). Lotka revisited the question (Lotka 1931). Lineage extinction is likely to have been very common in evolutionary history. This have resulted in genetic bottlenecks, where the genetic information of only a few individuals have been transferred to next generations (Raup 1994). Models in ecology exist to assess the frequency of a local group eventual ending up extinct (Colantonio, Lasker, Kaplan, and Fuster 2003; Fox 2005; Hamza, Jagers, and Klebaner 2014; Raup 1994). Some such studies have examined surnames in historical populations to model propensities of lineage extinctions (Fox and Lasker 1983; Yasuda, Cavalli-Sforza, Skolnick, and Moroni 1974). Yasuda, Cavalli-Sforza, Skolnick, and Moroni (1974) finds that 58% of medieval surnames, in a sample from the upper Parma Valley (an area in Northern Italy), are no longer existing in the second half of the 20th century – most family names have disappeared; and the frequency of disappearance is greater the fewer number of original bearers there were.

A small number of studies have examined lineages from a demographic perspective using empirical data. Song, Campbell, and Lee (2015) examined the growth rate of patrilines using historical Chinese, treating their patricians as their unit of analysis, but basing their data on micro-level records. They found that high status patrilineages had a lower probability of extinction at each point in time, but not that successful patrilines had a larger number of sons on average.

Higher social status has been associated with lower risk of lineage extinction in China in one of few studies that have looked at this using genealogical data (Song, Campbell, and Lee 2015). Prior to the demographic transition, high status individuals were likely to marry younger and to have higher fertility (Livi-Bacci 1999). When higher status individuals had a greater number of descendants in periods of low population growth, this implies elevated lineage extinction for other groups (Low 1990; Skirbekk 2008; Zerjal, Xue, Bertorelle, Wells, Bao, Zhu, Qamar, Ayub, Mohyuddin, Fu, Li, Yuldasheva, Ruzibakiev, Xu, Shu, Du, Yang, Hurles, Robinson, Gerelsaikhan, Dashnyam, Mehdi, and Tyler-Smith 2003). In contemporary societies, given decreased mortality among all social groups, and that high social status increasingly related to low and postponed fertility; high social status may have ceased to represent the same advantage to ensuring lineage survivorship (Goodman, Koupil, and Lawson 2012; Skirbekk 2008).

Two Swedish studies have focused on the number of surviving descendants in 3 and 4 generations. Goodman, Koupil, and Lawson (2012) estimated the number of grandchildren of men and women born 1915–1929 in Sweden. Kolk and Hällsten (2017) used data from northern Sweden and examined both educational and reproductive outcomes over 4 generations. Both studies where prospective, and had a main focus on number of descendants (ie. fitness). However, both studies had to make assumptions to either select a population of reproducing and geographically immobile initial generations (Kolk and Hällsten 2017), or rely on cohorts where all generations of descendants had not completed their childbearing (Goodman, Koupil, and Lawson 2012), and based on their focal cohort they primarily examined grandparenthood. Both studies also did not study on proportions without any descendants directly, and neither study could provide answer to the proportion of individuals without great-grandchildren. To our knowledge, the phenomenon of family line cessation over four generations has not been ever tested empirically using representative (and largely un-truncated data) for any population including grandchildren and great-grandchildren.

Our contribution

Our study period is simultaneous with the fertility transition in Sweden. The fertility transition takes place a few decades later in our study region than in central Sweden (Alm

Stenflo 1994). Cohort fertility falls from an average of around 5 children per woman at the turn of the century, until cohort fertility stabilizes at just below 2 for most cohorts of the 20th century. In Sweden, between 1875 and 1960 the share of the population who died before age 45 fell from 40% to only 4% (Statistics Sweden 1997). This increase in survival through key childbearing years would suggest that mortality became a decreasingly important cause of not having descendants over time.

To understand the processes relating to the likelihood of not having children, grandchildren, and great-grandchildren, it is important to understand the demographic pathways: did individuals die before reaching sexual maturity, or did they survive into adulthood but bear no children? Did individuals have children, but no grandchildren or great-grandchildren? How does occupation and fertility affect the probability to have no descendants after the first, second and third generation? These are the topics that we answer by means of longitudinal data over 4 generations spanning 3 different centuries. Studying proportions that fail to reproduce in the later stages of the demographic transition, as is done in the current study, can be of particular interest in understanding the adaption and selection processes that take place in contemporary populations (Field, Boyle, Telis, Gao, Gaulton, Golan, Yengo, Rocheleau, Froguel, and McCarthy 2016).

Data and Methods

Data description

Our data is based on a combination of parish records and modern administrative registers from the Swedish government. The data spans from 1885 to 2007. In the late 19th century, Skellefteå was predominantly a farming region with a large share of farmers who owned their own land. The area underwent rapid industrialization at the beginning of the 20th century where the mining industry played an important role. At the beginning of the 20th century, among our index cohorts around 63% worked in farming. The fertility transition took place at the beginning of the 20th century, and the fertility behaviour of our index cohort is accordingly highly variable. These data sources allow us to follow fertility of our starting generation, their children, and grandchildren, and estimate proportions without descendants at varying number of generations.

Figure 1 shows life expectancy and fertility for the region from the 1860s onward, and supplemental figure 1 includes a map of the area under study. Northern Sweden is during the 19th century characterized by high fertility, and high rates of childlessness (Alm Stenflo 1994; Kolk 2011). During the 20th century fertility rapidly falls to replacement levels in Sweden with still quite high levels of childlessness for both men and women (Alm Stenflo 1994). Mortality is consistently falling throughout the period of our study, which was marked declines in infant and child mortality (Statistics Sweden 1997).

The earlier part of our data from the 19th century through 1955 consists of digitized records maintained by the parish administration on childbearing, mortality, and migration of the population (Alm Stenflo 1994; Westberg, Engberg, and Edvinsson 2016). Our historical data includes a number of adjacent parishes in the Skellefteå region, in north-west Sweden on the coast of the Baltic Sea, where our data include the complete population of the region. These data are linked with contemporary digitized Swedish population registers that include the complete population of Sweden. The modern data is available from 1960 onwards, with fertility histories from 1932, and individuals are linked by means of unique national personal identification numbers, introduced in 1947. The availability of registry data and complete population coverage decreases the risk of errors and bias in the data (Bhrolcháin, Beaujouan, and Murphy 2011), in particular given the rigorous paternity investigations and low proportions of missing fathers (less than 1%) in Swedish registers (Statistics Sweden 2010). Our index cohorts consist of individuals born between 1885 and 1899 (which we refer to as G1), as these cohorts are suitable for assessing the number of children (G2), grandchildren (G3), and great-grandchildren (G4), while also minimizing loss due to outmigration in the historical parishes. We have chosen our cohorts in order to minimize the impact of internal migration (Clarke and Low 1992). We discuss how local migration implies that we overestimate childlessness by a couple of percentage points, and how we reached such a conclusion in supplemental material 1.

Our study population is defined as all men and women born between 1885 and 1899. Our data goes back considerably further than that, but in order to ensure that migration does not significantly impact our results in the pre-1947 period, these are the most suitable cohorts for studying family dynasties. Our study population is defined as men and women born in the Skellefteå region, who were still alive at age 15. They are also conditioned on either presence in the Skellefteå parishes until age 45, or an observed death before age 45. Individuals of our first generation who migrated out of the area are excluded from our analysis completely. We also conduct our analyses without and with conditioning on survival to age 45 (including/excluding members that died between ages 15 and 45), to examine to which degree childlessness is due to death before the end of reproductive ages. We link our index population to their children, and grandchildren, and great-grandchildren.

This means that childlessness refers to members of G1 who had no children. Similarly, "grandchildren" refers to the children of G2, and "great-grandchildren" refers to the children of G3. The linkage across generations is done using birth certificates and baptism certificates in the historical records and by means of official government birth records after 1947. Linkage rates are typically very high both in the historical and contemporary registers (above 95% have information on both parents), but in a few cases we will underestimate the fertility of men, due to missing information on fatherhood in the registers. In both the historical and contemporary case, parenthood refers to biological parenthood as registered by the relevant authorities. Our selections of cohorts to allow us to capture the complete reproductive careers of 3 generations. As some individuals will have children very late in life, we will miss a few cases of childbearing in the final generation. In supplemental figure 2 we show the birth years of members of G1, G2, and G3. Over 90% of G3 are born before 1967 and 96% born before 1972. As eventual childbearing (and first childbearing in particular) is virtually complete by age 40 (and higher order childbearing is irrelevant for measures of childlessness) this means that we will underestimate the proportion of individuals where no member of G3 had a child, but for all members of G3 this will be less than 1%. None of our fertility measures are conditioned on civil status, but are strictly related to registered parenthood.

The older part of our data consists of parish registers collected by the Swedish state church from the 18th century to 1955. These records include both vital events, as well as occupation, and include information on all migrations in or out of the area. As such they resemble contemporary administrative data that can be used for prospective analyses where the population at risk can be identified. Following the introduction of personal identity numbers in Sweden in 1947, these records are then linked to contemporary administrative registers of the complete population, for which digitized information is available from 1960 and fertility information as early as 1932. As a consequence of this, we have accurate demographic information, including migration, for the entire period, yet our historical data is limited to a specific region of Sweden from 1885-1955. While our study takes place after the large outbound migrations to North-America from Sweden, there were non-trivial amounts of domestic migration in the 20th century. As we cannot observe demographic events outside Skellefteå until 1947, this implies that some individuals who migrate outside of the region could incorrectly be categorized as childless. Fortunately, we have access to outmigration records for these individuals, and can therefore assess the impact of such migration. We describe the generally modest impact of such migration (changing our estimates by the order of less than 3%) on our results in our migration supplemental material 1.

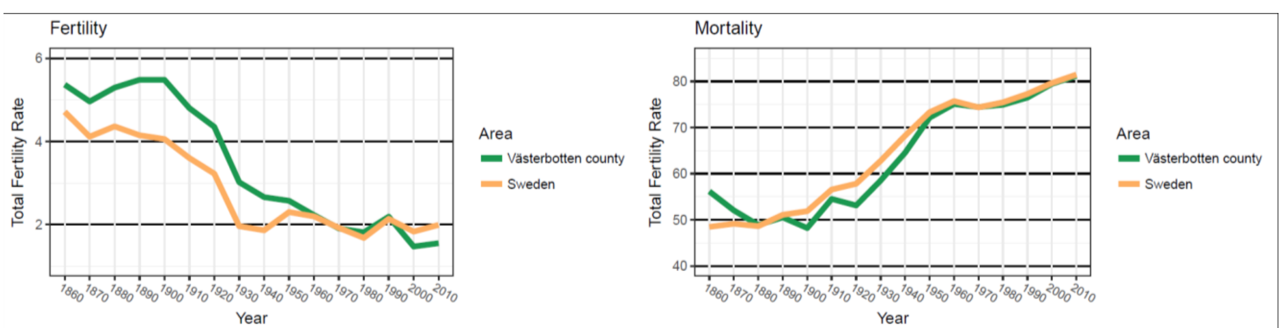


Figure 1: Life expectancy and fertility in Sweden and Västerbotten county (where Skellefteå is located)

Methods

For most of our analysis, we present the proportion of G1 that have any children, any grandchildren and any great-grandchildren. The measures of no great-grandchildren are strictly higher or equal to the proportion of people having no children and no grandchildren, as not all people having children will have future descendants. We present results where we further examine if this proportion differs by sub-group such as sex, survival to at least age 15 or survival to the end of reproductive ages (age 45). We also present further analyses where we show the bivariate relationship between both fertility outcomes in G1, and occupation, and their relationship with lineage survival. In some analyses we only examine descendants of a single sex. These models include only women or men, ignoring offspring of the opposite sex. As such, a measure of the proportion with no great-grandchild for men for our single-sex models reflects the number of men that had any son, who had any son, who had any son. This for example corresponds to the survival of surname for men (given a patrilineal naming tradition).

Our measure of occupation is based on highest occupation in the household, and as such it may be related to the spouse (typically the husband) of G1 instead of G1. For these reasons we only present results on occupational status for both sexes combined. We use four categories for our occupational status measure that are based on the HISCO system to measure occupational class (Westberg, Engberg, and Edvinsson 2016). These four measures capture the two essential dimensions of occupational status, people working in agricultural and non-agricultural sectors, and a division into high and low social status. The number of individuals in the non-agricultural occupations are very small, so a more fine-grained division is not meaningful. The measure is calculated from the highest observed

HISCO occupation during the life course, and can thus be measured at different ages for different individuals. The categories include: agricultural landowners, high-status occupations, non-agricultural workers, and agricultural non-land owners. Agricultural workers include all land-owning farmers and account for 30% of our sample. High-status occupations include a broad range of high-status and middle-status administrative occupations, as well as various occupations related to teaching and religious organizations (5.4%). Non-agricultural workers include a diverse group of lower status occupations not related to agriculture (33%). While our final category includes agricultural workers who are involved in agriculture production but do not own any land and thus have fewer resources than agricultural landowners (11%). The high share of farmers with ownership of their own land reflects a long historical pattern of freeholders in northern Sweden. Some of the non-tenured landowners can most likely be characterized as life-cycle servants. Around 20% have no known occupation, in many cases because they died relatively young. We present descriptive statistics in supplemental table 1 for all our variables of interest. All input data for our graphs are available in supplemental file 1.

We also run a number of regression analyses, which are multivariate ordinary least square regressions with robust standard errors (linear probability models), where the dependent variables are any children, any grandchildren and any great-grandchildren, respectively. Regression coefficients are interpreted as an increase in the probability of being childless at each category (where 0.25 is equivalent to 25% difference). These results are presented in supplemental table 2.

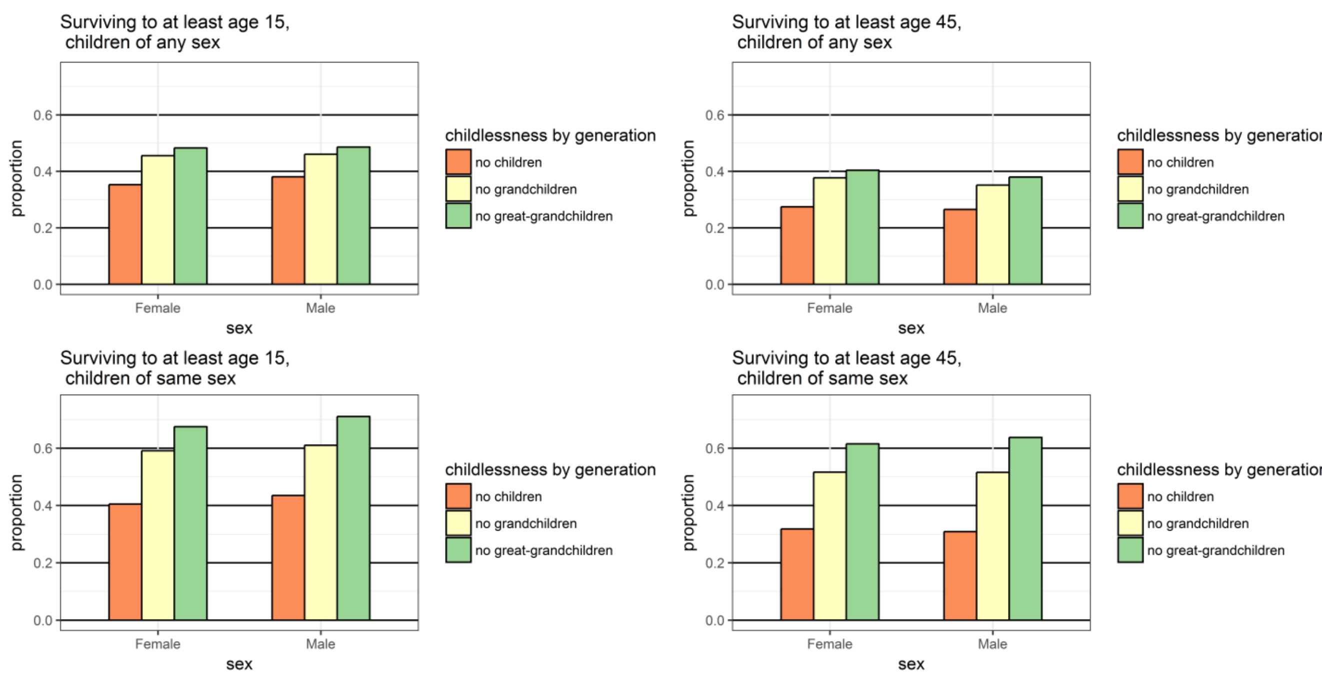
Results

Our data consists of local parish registers for the Skellefteå region from 1885 to 1955. This is linked with digital administrative registers of the complete population of Sweden starting in 1960 until 2007. The results are based on the generation of men and women born between 1885-1899. We show the percentage of both men and women from the original generation who by the end of 2007 had i) no children, ii) no grandchildren, or iii) no great-grandchildren.

Our overall main results are presented in figures 2a and 2b. We find that among those who survived to age 15, 36% of women and 38% of men do not have any children. This number increases to 46% for no grandchildren and to 48% for no great-grandchildren and is the same for men and women. Men are more likely to be childless in the first generation, though there are no sex differences when considering subsequent generations. We present data for individuals who survived beyond their primary childbearing years (ages 15-45), to examine the relative contribution of mortality in childbearing years to differences in childlessness (figure 2b). Our results show that mortality between the ages of 15 and 45 contributes an additional 11% to the probability of having no descendants (at each generation) for men and 8% for women. Mortality during primary reproductive years is associated with sex differences in proportions without descendants, with men surviving to age 45 having a lower risk of no descendants than women. Overall, our results suggest that an important path to having no descendants in the beginning of the 20^{th} century Sweden was related to premature death in adulthood, and that this was true for both men and women. Survival to age 15 was around 83% for the 1891 cohort in Skellefteå, so the proportion newborn not having descendants is approximately 17% higher than the proportions for those surviving to age 15.

Figure 2 Proportion not having descendants in the following generations, by sex, and by survival status. Men and women born in Skellefteå in 1885-1899.

Upper left (2a): Descendants at each generations surviving to at least age 15. Upper right (2b) Descendants at each generations surviving to at least age 45. Lower left (2c): Descendants of the same sex at each generation surviving to at least age 15. Lower right (2d) Descendants of the same sex at each generation surviving to at least age 45.

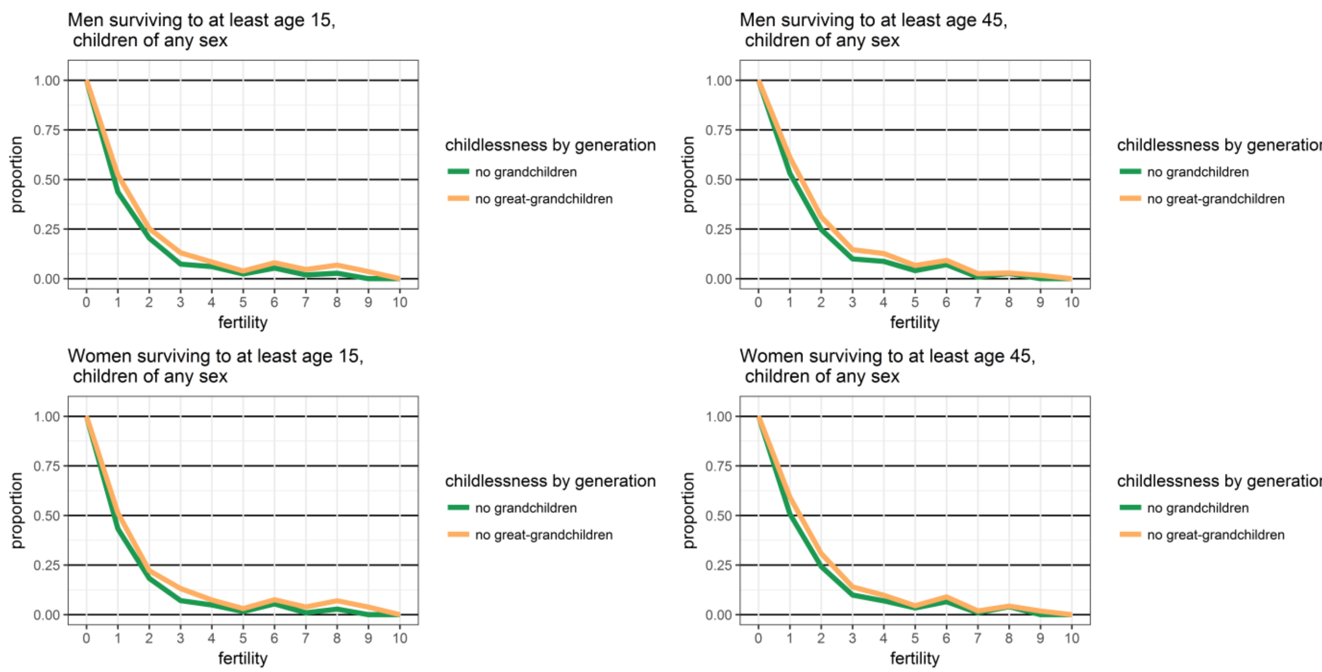


In figures 2c and 2d, we show the proportion of the population that have descendants of the same sex (exclusive matrilineal or patrilineal decent –or put differently – for example sons, having grandsons, having great-grandsons). This corresponds to the survival of surnames (which are passed on from fathers to sons in many societies). In countries with inequal inheritance rights of bequests, occupation, titles, or land (Swedish law stipulated equal inheritance of sons and daughters but there were in practice exceptions), could have important social consequences. When studying absence of any descendants along a same-sex lineage is predictably much higher than for offspring of any sex. 71% of men have no great-grandsons, and 67% of women have no great-granddaughters. The proportion of men and women having no grandson or granddaughter is 61% and 59%, respectively. Mortality has a fairly similar effect on same-sex lineage survival as on two-sex overall survival.

We analyse how the number of children in the first generation relates to the probability of lineage cessation. Our findings suggests that high fertility in this generation is strongly related to long-term lineage survival. We study this by examining the degree to which fertility in the first generation (G1) is related to long-term lineage survival (Figure 3). Lineage cessation is strongly concentrated in families with only one or two children. In families with one child, 47% of women and 56% of men had no grandchildren and 85% of women and 87% of men had no great-grandchildren. Among individuals with two children, 75% of women and 79% of men had no grandchildren, where 69% of women and 75% of men had no great-grandchildren. On the other hand, for individuals with three or more children, the proportion that did not have great-grandchildren is very small, and for very high fertility only a few percentages.

Figure 3. Proportion not having descendants in the following generations, by fertility in G1, sex, and by survival status. Men and women born in Skellefteå in 1885-1899.

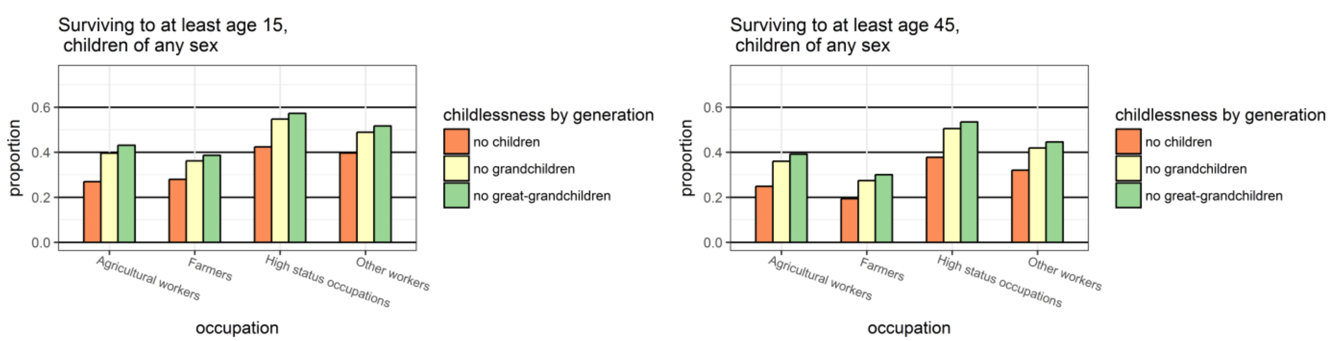
Upper Left (3a): Men surviving to at least age 15, by fertility of G1. Upper Right (3b): Men surviving to at least age 45, by fertility of G1. Lower Left (3c): Women surviving to at least age 15, by fertility of G1. Lower Right (3d): Women surviving to at least age 45, by fertility of G1.



Finally, we examined childlessness by occupation of the first generation using household occupational status (figure 4). Overall we find the highest eventual lineage cessation among those who had higher occupational status (57% had no great-grandchildren) and the lowest lineage cessation among the relatively well-off farmers who owned their own land (38%). Agricultural workers without land ownership had slightly higher probabilities of not having great-grandchildren (43%), while non-agricultural workers have proportions more comparable to high-status individuals (52%). As such, it seems to be that men and women employed in agricultural occupations had lower proportions without descendants than other groups. The findings suggest that either having a high or low status occupation and social position implied that an individual had relatively few children a lower likelihood of lineage survival. Having a mid-level social position was evolutionary more beneficial in this period.

Figure 4. Proportion not having descendants in the following generations, by occupation in G1, and by survival status. Men and women born in Skellefteå in 1885-1899.

Left (4a): Descendants at each generation surviving to at least age 15. Right (4b): Descendants at each generation surviving to at least age 45.



Our original cohort consists of the complete population resident in Skellefteå. As such, many of the men and women are related to each other, and often have siblings in the same population. While this is indicative of any human population, it means that to some extent our men and women are not independent lineage founders. To further examine this we examined a model with only first-born and another model with only last-born individuals within a sibling group. We report our findings from this sub-sample in supplemental figure

S1. Overall, the lineage cessation probabilities in both these two sub-populations were very similar to our complete population.

Beyond our bivariate analyses, we also run several regressions where we examined the independent effect of earlier presented covariates. These results are presented in supplemental table 2. We use three dependent variables: having at least one child, at least one grandchild, or at least one great-grandchild. Overall, our regression results are consistent with previous bivariate associations, though almost all differences by survival status, sex, and occupational status are mediated by fertility in G1. That is, conditioned on the number of children in G1, other characteristics have weak or no effect. An interaction between sex and fertility suggests that no great-grandchildren are more common among women with only 1 or 2 children than for men with only 1 or 2 children.

Conclusions

We study family line cessation spanning more than a century - and provide an accurate empirical assessment of a phenomenon that previously has only been assessed through fewer generations – or using indirect and imprecise methods such as surnames. Our study shows that even in a population characterized by strong population growth, the extinction of individual lineages was common. Our study finds that almost half of those who reached age 15 born in 1885-1899 had no great-grandchildren by the early 21st century. The proportion having no grandchild is almost as high. The main reason for the lineage cessation was low fertility. Childlessness for survivors to age 45 was high in the first generation (27% for women and 28% for men) and proportions without great-grandchildren were much higher among those that had only one or two children. Premature mortality in the first generation contributed a lesser but still substantial degree (mortality between age 15 and 45 contributed 11% for men and 8% for women).

The most important risk factor for lineage extinction is having few or no children in the first generation. The extinction risk was not evenly distributed between social groups but was highest among high- *and* low-status occupational groups. Our findings support the notion that evolutionary advantages of high fertility are very strong, and an important source of differences in fertility by socioeconomic status. We also show that when an individual has at least five children, eventual lineage survival to the fourth generation is almost certain (around 95% have at least one great-grandchild).

More research is needed to understand consequences the social, biological, demographic and economic implications of expanding and shrinking family lines (Elinder, Erixson, and Waldenström 2018). The large-scale lineage cessation we observe can have both individual and population-level consequences. That a large share of the population fails to reproduce is evidence of a cultural and genetic evolutionary process (Ehrlich 2000; Kolk, Cownden, and Enquist 2014; Richerson and Boyd 2008). Lineage extinction can impact the distribution and diversity of genetic patterns at the population level, with implications for contemporary gene distributions (Mathieson, Lazaridis, Rohland, Mallick, Patterson, Roodenberg, Harney, Stewardson, Fernandes, and Novak 2015; Oleksyk, Smith, and O'Brien 2010).

The extent of lineage extinction has important implications for the accumulation of wealth in families, and for economic inequality (Elinder, Erixson, and Waldenström 2018). A given scale of linage extinction could have consequences for social inequality and for the dilution or concentration of financial resources due to inheritance, and whether wealth in families will be passed on to later generations. Inequalities in reproduction across multiple generations may be linked to contemporary wealth inequality would be a highly relevant topic for future research. We need to work more on whether specific socioeconomic or cultural characteristics of the past could influence contemporary fertility and mortality patterns and whether the association of these characteristics to lineage cessation is becoming weaker or stronger across generations. We also need to better understand individuals preferences for how family lines change and the risk of cessation across generations, and the importance people put or do not put to such aspects.

The changes we observed occurred in a context in which the Swedish population almost doubled in size (through natural population growth) – and in a period where Sweden had among the highest standards of living and lowest mortalities in the world. The current situation in Sweden, where natural population growth is much lower, with below replacement fertility and high shares who do not reproduce (yet with very low mortality) can represent a situation where lineage cessation is much higher than what the case has been in the past century. As the research question we answer in this paper, is not yet known for most individuals born in the 20th century, simulations would be needed to understand contemporary family lineage cessation probabilities, its causes and socioeconomic correlates. However, researchers should be careful in that both patterns of mortality and fertility may be shaped by lineage-specific contextual factors.

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Data and materials availability: All input data for figures of the manuscript are present in Supplemental file S1. Access and linkage and analysis of the data has been approved by a Swedish national ethical review board (2012/1501-31) and data has been made available by Statistics Sweden. Individual level data is protected by Swedish law, and requires an application to a Swedish ethical review board, and Statistics Sweden. Aggregated data related to this paper may be requested from the authors.