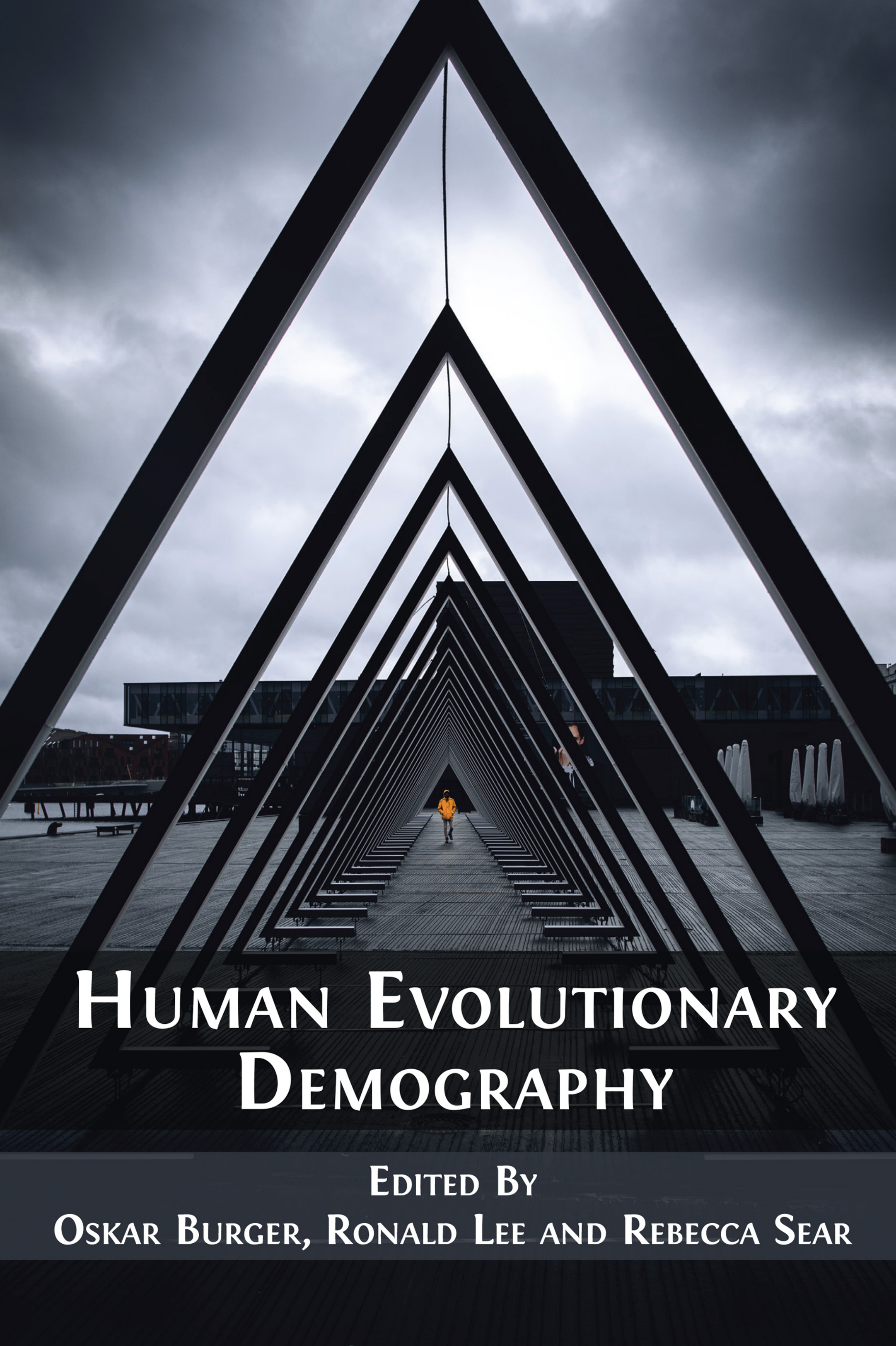

# Human Evolutionary Demography

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# 20. Did Grandmothers Enhance Reproductive Success in Historic Populations?: Testing Evolutionary Theories on Historical Demographic Data in Scandinavia and North America

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Human reproductive success requires both producing children and making investments in the development of offspring. To a large extent these investments are made by the parents of the child, but researchers are now looking beyond the nuclear family to understand how extended kin, notably grandmothers, enhance reproductive success by making transfers to progeny of different kinds. The extent to which kin influence fertility and mortality outcomes may vary across different socio-economic and geographic contexts; as a result, an international comparative framework is used here to sharpen our understanding of the role of kin in reproduction. This chapter assesses the role of grandmothers in fertility outcomes in a comparative historical demographic study based on data from Scandinavia and North America. The individual-level data used are all longitudinal and multigenerational, allowing us to address the impact of maternal and paternal grandmothers on the fertility of their daughters and daughters-in-law. Attending to heterogeneous effects across space and time as well as within-family differences via the use of fixed effects models, we discover broader associations of the paternal grandmother with higher fertility across the four regions. We also find a general fertility advantage associated with the post-reproductive availability or recent death of the maternal grandmother in the four populations. Important variations across regions nevertheless exist in terms of the strength of the association and the importance of the grandmother's proximity. Our interpretation is that grandmothers were generally associated with high-fertility outcomes, but that the mechanism for this association was co-determined by family configurations, resource allocation and the advent of fertility control.

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## Introduction

In the evolutionary theory of aging, menopause and especially the extended period of post-reproductive lifespan enjoyed by humans has long been considered a puzzle (e.g. Rogers 1993; Peccei 2001; Ladhenperä et al. 2004), and much research effort has been devoted to explaining this phenomenon both theoretically and empirically (Williams 1957; Lee 2003). While not unique in experiencing menopause (e.g. Paul 2005), human females are alone in having relatively low post-reproductive mortality (e.g. Hill & Hurtado 1991; Voland et al. 2005; Hawkes et al. 1998, 2000; Kaplan et al. 2000). Menopause may be seen as an adaptation which increases fitness: aging mothers with declining age-related fecundity or whose reproduction concluded in midlife could instead assist their own daughters in their reproduction (Williams 1957). While researchers concur that the long post-reproductive life span among humans is not just an artifact of the aging process, but a result of evolutionary processes, there is an extensive literature questioning some of the theoretical mechanisms of why and when menopause developed. (Hawkes et al. 1998; Hill and Hurtado 1991; Peccei 2001, 2005; Rogers 1993). Reproductive success is a key to evolution, and it is determined by both the number of offspring (fertility) and the survival of offspring and their parents (mortality). In this way human reproduction requires both producing children and making investments in the development of offspring, activities which take place over a considerable amount of time. To a large extent these investments are made by the mother of the child, but it is also widely recognized that other individuals make investments in children either directly through caregiving, or indirectly by helping their mothers. Lee (2003) highlights the role of such transfers in explaining variations in human aging. While fathers also play an important role in child development (Mace & Sear 2005), researchers have looked beyond the nuclear family to understand how extended kin affect reproductive success of mothers by making transfers of different kinds. The benevolent role of maternal grandmothers has been central to this argument (Voland et al. 2005; Hawkes et al. 1998). By helping their daughters in different ways, women in post-reproductive ages could increase the number and quality of their grandchildren, thereby promoting fitness.

The extent to which kin influence fertility and mortality outcomes may vary by socio-economic and geographic contexts; as a result, an international comparative framework is needed to sharpen our understanding of the role of kin in reproduction. The aim of this chapter is to assess the role of grandmothers for fertility among their daughters in a comparative historical perspective. We use historical demographic data from Scandinavia and North America to assess the role of kin in fertility before the fertility transition. The individual-level data used are all longitudinal and multigenerational, allowing us to address the association between the presence and proximity of grandmothers and the fertility of their daughters or daughters-in-law. We compare the impact of paternal and maternal grandmothers, as well as analyze heterogeneous effects across space and time. To distinguish women belonging to different generations, we identify grandmothers as the generation F0, mothers (our subjects) as the generation F1 and children (those who are born to our subjects) as generation F2.

## Background

We draw upon two analytic frameworks featured in evolutionary anthropological studies: the helpful grandmother hypothesis (e.g. Hawkes et al. 1998, 2000; Hawkes & Coxworth 2013;

Voland et al. 2005), which describes the positive influence of post-reproductive women (F0) on grandchildren's survival, and the concept co-operative breeders, a "relatively unusual childrearing system in which mothers receive help from many other individuals in raising offspring…". (Beise 2004; Mace & Sear 2005; Sear & Coall 2011; Sear 2015; Hawkes & Smith 2009). Both analytic frameworks emphasize the important role played by kin in fertility, survival and longevity. These hypotheses have been applied in historical demographic studies of several different contexts. For example, in a study of a parish in Northwest Germany, Voland and Beise (2002) found maternal grandmothers to reduce infant mortality substantially, while they found opposite effects of paternal grandmothers (Voland and Beise 2002; see also Beise 2004). They interpret this negative impact of paternal grandmothers as a result of conflict between the maternal grandmother and the paternal grandmother. Fertility-enhancing effects of grandmothers have been reported in pioneer-era Utah (Hawkes and Smith 2009), yet studies which have addressed the inter-generational transmission of fertility have obtained divergent results (Brunet & Vézina 2015; Kolk 2013), as have studies of the transmission of longevity from parents to children (Houde et al. 2008; Brunet and Vézina 2015; van den Berg et. al 2017). In historic Quebec, Desjardins et al. (1991) report a "very weak and not significant" intergenerational transmission of fertility; an additional 2001 article by Gagnon and Heyer found the association of mother's and daughter's fertility to be "almost null" (Gagnon & Heyer 2001). The latter study, however, was more concerned with the consequences of the intergenerational transmission of fertility for the evolution of a population's gene pool and did not adjust for potential confounders. A new study directly addressing the grandmother effect in historic Quebec concluded that living maternal grandmothers enabled daughters to increase the number of children born by 2.1, and that this effect was stronger among maternal grandmothers living in proximity (Engelhardt et. al. 2019). A recent study of late-nineteenth-century Utah distinguished women whose mothers manifested high or low fertility relative to the fertility of the mother's own cohort; women whose mother had relatively high fertility demonstrated, in turn, higher parity progression ratios (Jennings, Sullivan & Hacker 2012; Anderton et al. 1987). A broader study of recent net marital fertility (children $< 5$) in 1880 United States found a modest positive effect of paternal grandmothers: women with potential mothers-in-law living in adjacent households had about 2% more children than women with no potential mothers-in-law living nearby (Hacker and Roberts, 2017).

Sear and Coall (2011) review the literature on the impact of grandmothers on fertility in different contexts, before and after the fertility transition. Most studies seem to identify some kind of grandparent influence on fertility, but both the direction of the influence and which grandparent is most important differs widely across studies. Nonetheless, a conclusion from the review of pre-transitional societies is that paternal grandmothers seem to promote fertility, while maternal grandmothers if anything seem to reduce fertility. However, as these reported patterns are inconsistent it is difficult to reach a consensus about the role of grandmothers on offspring fertility. Indeed, Sear and Coall call for more data to shed more light on this issue. We suggest that some of the variability in the literature is related to different family systems in different contexts, which have implications for co-residence and proximity of grandmothers.

There are a number of potential proximate explanations responsible for a fertility-enhancing grandmother effect. First, while the presence of a grandmother may have helped new mothers initiate breastfeeding, it also is possible that the presence of a grandmother stimulates earlier weaning, allowing the mother to engage in other productive activities and leaving more child care to the grandmother. At the same time the shorter period of lactation would enhance subsequent fertility, and hence shorten birth intervals for mothers with a grandmother present (Gauthier 1991; Hawkes et al. 2000). Secondly, the presence of a grandmother might promote mothers' access to resources in the form of better nutrition, and possibly a lower workload, two conditions which would promote higher fertility in pre-transitional contexts (Sear and Coall 2011). Thirdly, grandmothers could exercise social pressure on their daughters to reproduce in order to maximize the number of grandchildren, although such an effect is likely to vary by context. Some have argued that the social pressure to bear more children would be greatest from paternal grandmothers who prioritize grandchildren as successors or as workers for the family patrimony and who may be less concerned about the physical costs of childbearing for the mother (Mace and Sear 2005; Sear and Coall 2011). Maternal grandmothers, on the other hand, may have encouraged their own daughters to limit or at least space births out of a concern for the hazards of repeated childbearing (Sear and Coall 2011).

We address our research questions with four robust datasets drawn from one Scandinavian and three North American populations, applying a common set of analyses of birth intervals. Our internationally comparative approach resembles that used in prior research on fertility and longevity involving these data (Smith, Gagnon et al. 2009; Gagnon et al. 2009; Dribe et al. 2017). While previous analyses of demographic behavior during this period have explored genetic predispositions, early-life conditions and socio-economic status, the mediating influence of kin on these processes remains largely underexplored. In particular, we highlight the role of proximity and availability (via vital status) of grandmothers, exploring whether the hypothesized positive influence of grandmothers on fertility varied by their residential proximity to their children and grandchildren. Finally, we consider differences between maternal and paternal grandmothers, controlling for proximity to the daughters/daughters-in-law.

## Context

The Scandinavian population included in this trans-Atlantic comparative study are persons residing in five rural parishes (Halmstad, Hög, Kågeröd, Kävlinge, and Sireköpinge) in Scania, located in southern Sweden.[1] The period is defined as births occurring from 1766 to 1899 (Table 1). These parishes had a total of 3,900 inhabitants in 1830. By the end of 1900, this figure had increased to 5,500, suggesting approximately the same growth rate as Sweden as a whole. The selected parishes are close in geographical location, showing the variations that could occur in a community regarding size, topography, and socioeconomic conditions. Both life expectancy at birth and fertility was somewhat higher than for Sweden as a whole in the nineteenth century, but closely followed the same development over time (Quaranta 2013: 53; Bengtsson and Dribe 2010). Mortality started to decline in the late eighteenth century, when infant mortality began to fall, closely followed by child mortality. Infant mortality in the area fell from around 250 per thousand in the 1760s to around 100 per thousand in 1900 (Johansson 2004), which is similar to the development for Sweden as a whole (Hofsten and Lundström 1976, Table 46). From about the mid-nineteenth century, adult mortality started to decline as well. Life expectancy at birth increased from about 40 years in the beginning of the nineteenth

1 http://www.ed.lu.se/databases/sedd

century to around 50 years in 1900. Over the same period life expectancy at age 20 increased from 37 years to 46 years (Statistics Sweden 1999: Table 5.4). Fertility in Sweden, as well as in the region we are looking at, started to decline around 1880 and followed a quite typical pattern where industrialization, urbanization and previous mortality decline all contributed to the decline; total fertility in the country declined from 4.2 in 1880 to 1.8 in 1930 (Dribe 2009; Bengtsson and Dribe 2014). Mean age at first marriage was 25.4 for women and 27.9 for men in the five parishes in 1815–1894. About 12 percent of men and 20 percent of women in the same period were never married at age 45, a proportion which increased substantially over the nineteenth century (Dribe and Lundh 2014: 222–23).

Table 1: Summary of periods, demographic indicators and case counts Scania (Sweden), St. Lawrence Valley (Quebec), Saguenay (Quebec), and Utah

| | Scania | Q-SL | Q-Sag | Utah |
|---|---|---|---|---|
| *Period under study* | | | | |
| Births of children (F2) | 1758–1883* | 1666–1791 | 1843–1963 | |
| Births of mothers (F1) | 1784–1899 | 1650–1750* | 1807–1914** | 1847–1919* |
| | | | | |
| *Demography* | | | | |
| Infant Mortality Rate | 100/1000 in 1900 | 240.9/1000 | 1861: 144/1000 | 72–87/1000 |
| Life Expectancy at birth | 1800: 40; 1900: 50 | 35.5 | 1861–1931: 48–54 | |
| Life Expectancy at age 20 | 1800: 37; 1900: 46 | 53.9 | | |
| Total Fertility Rate | 4.2 in 1880; 1.8 in 1930 | 11 | up to the 1930s: 10–11 | 8–11 |
| Timing of fertility decline | 1880 | 20th century | 1930–1960 | 1880 |
| Mean age at marriage - men | 28 | 26 | 1850–1890: 25 | 25 |
| Mean age at marriage - women | 25 | 22 | 1850–1890: 22 | 21 |
| % never married at age 45/50 | men: 12%; women: 20% | 6.5–10% | 1850–1890: 3–5% | |
| | | | | |
| *Population in analysis* | | | | |
| Population | 3,900 in 1830; 6,300 in 1939 | 70,000 in 1760 | 5,241 in 1851; 190,142 in 1951 | 200,000 in 1890 |
| Number of F1 mothers | 927 | 9,921 | 18,547 | 182,069 |
| Number of F2 children | 2,865 | 71,166 | 143,365 | |
| Number of parishes/counties | 5 | 135 | 122 | |

Q-SL = Quebec - St. Lawrence Valley
Q-Sag = Quebec Saguenay Lac St-Jean region
*Criteria used for data selection
** Selection was based on marriage: women who married in the region from the beginning of settlement (first marriage recorded in 1842) to 1929 were selected (first marriages only).
Sources:
Scania: Quaranta 2013; Bengtsson and Dribe 2010; Johansson 2004; Hofsten and Lundström 1976; Dribe 2009; Dribe and Lundh 2014
Q-SL: Charbonneau et. al. 2000; Amorevieta-Gentil 2010; Ouellette et al. 2012; Dillon 2010;
Q-Sag: Bouchard 1996; Pouyez et Lavoie 1983
Utah: Bean et al. 1990

Crossing the Atlantic Ocean, our earliest North American population studied is the colonial population of the St. Lawrence Valley in Quebec, encompassing reproducing women born from 1650 to 1750 and their births occurring from 1666 to 1791 (Table 1). From an initial group of 6,500 founders, the colony grew via natural reproduction to over 70,000 by 1760 and 180,000 by the end of the eighteenth century (Desjardins 2008: 78; Charbonneau et. al. 2000: 104,106). This population was marked by high marriage intensity, an early age at marriage, high fertility and high infant mortality. In clonial Quebec, infant mortality was higher than that observed in Scania; about 241 per 1,000 from 1640–1779 overall but rising from 171 per 1,000 for children born before 1680 to 225–350 per 1,000 during and after the British conquest (1750 to 1779) (Charbonneau et. al. 2000: 124; Amorevieta-Gentil 2010: 131). Life expectancy at birth for the whole population born from 1608 to 1760 was 35.5 years, while those who lived to at least age 20 could expect to live to 54 years; adult longevity increased by 2 to 3 years during the latter part of the eighteenth century (Charbonneau et. al. 2000: 126; Ouellette et. al. 2012: 588–89). While the late-nineteenth-century Scanian population studied showed signs of fertility control, the Catholic population of Quebec practiced natural fertility and bore large families: the total fertility rate of the Quebec population born 1680 to 1760 was 11, while families had on average 7.3 children (Gagnon et. al. 2009; Dribe et. al. 2017; Charbonneau et. al. 2000: 123). The mean age at marriage for Quebec women and men was 2–3 years younger than observed in Scania, 22 for women and 26 for men. A larger proportion of colonial Quebec women were ever-married compared to their counterparts in Scania: just 6–10% of Quebec persons aged 50+ had never married (Dillon 2010: 153; Charbonneau et. al. 2000: 113).

Many demographic and economic patterns evident in the seventeenth- and eighteenth-century Quebec population of the St. Lawrence valley can also be observed within the nineteenth- and twentieth-century Saguenay region, the second Quebec population studied. Our analysis of the Saguenay population includes reproducing women who married in the region between 1842 and 1929. These women were born between 1807 and 1914, and their children between 1843 and 1963 (Table 1). The Saguenay region, located approximately 200 kilometers north of Quebec City, was characterized by its relative geographical isolation and cultural uniformity. The colonization of the region by French Canadians began in the 1830s and the population grew rapidly from 5,241 in 1851 to 190,142 in 1951 (Pouyez et al. 1983). Nuptiality and fertility characteristics until the first decades of the twentieth century were similar to colonial Quebec. Age at marriage was low — 22 on average for women and 25 for men — and the proportion ever married was high with only 3 to 5% of the population aged 50+ never married. Fertility was also high with an average of about 10 to 11 children in complete families up until the 1930s (Gagon et. al. 2009; Dribe et al. 2017; Bouchard 1996: 179) as the fertility transition occurred later in the Saguenay region than in the rest of Quebec and other parts of Canada (Gauvreau et al. 2007). However, life expectancy at birth was higher than in colonial Quebec at 48 years in 1861 and reaching 53.5 in 1931 while the infant mortality rate was much lower at 144 per 1,000 in 1861 (Pouyez et al. 1983).

Our fourth historic population is located in Utah, in the western United States, and examines women born from 1850 to 1919 (Table 1). Utah was characterized by rapid settlement which began in 1847 primarily by members of the Church of Jesus Christ of Latter-day Saints (LDS). LDS immigration into Utah was also accompanied by non-LDS immigration, though initially these non-LDS migrants represented a smaller proportion of this migration stream. Individuals and families who joined the LDS church and who immigrated were generally from the eastern seaboard United States and from Northern and Western Europe. According to data from the U.S. Census Bureau, the resident population of the state grew from just over 11,000 in 1850 to over 200,000 by 1890 and then to over 500,000 by 1930. This rapid rate of growth reflected both high natural increase and substantial immigration. Fertility rates in Utah during this period were the highest in the United States, certainly owing in part to the pro-natalist doctrine of the LDS faith, as well as economic forces promoting increased fertility in the rural and agriculturally dominated West relative to other parts of the United States. The total fertility rate of married women born 1860 to 1864 was 10.6, nearly as high as that observed in colonial Quebec and in the Saguenay region (Bean et al. 1990: 130). However, as seen in the Scanian population, substantial fertility decline was evident by the 1880s (Bean et al. 1990:135–6). At 72–87 per 1,000 children, Utah's infant mortality rates during this time were lower than those observed in the earlier colonial Quebec population and in the Saguenay region for the same period but not as low as those observed in Scania. Women's mean age at marriage in Utah was 21 while that for men was 25, averages which are younger than those observed in Scania and similar to those seen in colonial Quebec and in Saguenay.

The four populations studied vary in terms of socio-economic setting. The Scanian population studied is almost entirely rural. One of the parishes developed into a small town by the end of the nineteenth century following the construction of the main railroad on the west coast. Even though Sweden allowed partible inheritance, and from 1845 onwards equal inheritance for sons and daughters, farms were normally transferred to one of the children while the others were compensated in different ways. It was more common to transfer to a son than to a daughter (or son-in-law), but the latter happened frequently as well (Dribe & Lundh 2005a). As a result, women more often moved to their husbands' place of origin, but it was not uncommon for the husbands to move to the wives' place of origin. Among nineteenth-century farmers, freeholders as well as tenants, grandparents usually co-resided with the son or daughter who took over the farm, while intergenerational co-residence seems to have been much less common among the non-landed groups (Dribe & Lundh 2005b; Lundh & Olsson 2002). Hence, rather than making assumptions based on normative practices, it is vital to control for proximity when analyzing the impact of grandparents.

The Quebec St. Lawrence valley population was also largely agricultural, with most families residing on small farms. The colonial Quebec population included only three urban areas with a mix of trades, artisans, merchants, military and small number of social elites such as government officials. The nineteenth- and early twentieth-century Saguenay population also consisted mainly of farmers, with many who combined farm work with logging the forests during the winter. In contrast to the colonial Quebec population, however, industrialization had begun with the implantation of pulp industries at the turn of the twentieth century and progressed much faster with the arrival and expansion of important aluminum and hydro-electric plants before World War II (Igartua and de Fréminville, 1983; Bouchard, 1996). Land transmission both in colonial Quebec and in Saguenay was gendered, as it usually passed to one or more sons. The transmission practices were generally "pluri-établissement" rather than strict primogeniture, with efforts made to settle all surviving sons, ideally on land in proximity to the family patrimony, though migration could be used, either by the whole family or by brothers as a strategy to perpetuate the agricultural mode of life (Dechêne 1974: 244, 248; Greer 1985:

74; Dépatie 1990: 177, 189; Lavallée 1992: 212; Bouchard 1996: 212, 333; Dillon 2010: 144–45; Beauregard et al. 1986: 399). Daughters often moved to the parish of residence of the husband. In the St. Lawrence valley, up to two-thirds of women moved between their own parish of baptism and the parish of marriage/baptism of the first child (Dillon 2016: Table 3; Beauregard et al. 1986: 402), while in the Saguenay region, about one-third of marriages involved spouses from different parishes (Bouchard 1996: 266). As a result, a gendered intergenerational transmission of migration propensity may be observed (Gagnon et al. 2006), as men settled around their male kin. As a result, women may have been more likely to reside in proximity to the paternal grandmothers than the maternal grandmothers.

Like the Saguenay population, the Utah population featured an increasingly mixed economy, with settlers chiefly engaged in farming. The non-LDS populations, on the other hand, were disproportionately engaged in mining and the railroads during the development of the American West. This development was made manifest by the connection of two railroad systems linking the eastern and western portions of the United States and culminating in northern Utah in 1869, a transition symbolized by the driving of the Golden Spike in Promontory Utah.

Drawing upon the substantial information regarding these four populations, we offer five fundamental hypotheses. First, we hypothesize that living paternal and maternal grandmothers will be positively associated with shorter waiting times to next birth of their reproductive-age daughters or daughters-in-law. The presence of grandmothers may have increased fertility via several mechanisms: grandmothers may have stimulated earlier weaning by liberating the mother for other activities; they may have promoted mothers' health via improved nutrition and a lowered physical workload; and they may have exerted a social pressure on mothers to bear more children. Second, we hypothesize a special role played by grandmothers living close by, whose proximity may have entailed nutritional and/or labour-saving benefits. A grandmother's physical presence could also signal access to a broader circle of extended kin and their physical resources. Owing to those benefits, we hypothesize that fertility-enhancing effects will be stronger among grandmothers living in proximity, and that some of the effects may persist among adult daughters whose grandmothers had died recently. Third, we propose that the availability of a grandmother at higher birth orders may wield a stronger relative effect, as mothers at this point in their life course may have been more busy and in greater need of help. While women at this stage of the life course may have benefitted from the presence of older daughters who provided child care for younger siblings, access to their mother or mother-in-law may have also posed a clear advantage in women's ability to continue bearing children. Fourth, since paternal grandmothers may have been concerned with the need to produce young workers for the family patrimony while maternal grandmothers may have been more concerned with their daughter's health, we hypothesize stronger fertility-enhancing effects with respect to paternal grandmothers. Furthermore, since across these contexts many women moved to their husband's place of residence, possibly even their husband's family patrimony, paternal grandmothers may have been more often physically present and able to contribute to their daughter-in-law's fertility outcomes. Fifth and finally, we expect to see stronger size effects in Utah, a population with high fertility yet with more population heterogeneity (LDS versus non-LDS) and which was beginning to undergo the fertility transition, potentially leading to greater differentiation of fertility outcomes.

## Microdata Sources

We draw upon four data sets encompassing three regions: the Scanian Economic-Demographic Database (SEDD), representing southern Sweden, the Registre de la population du Québec ancien (RPQA), representing the seventeenth- and eighteenth-century Quebec colony of the St. Lawrence Valley, the BALSAC database, representing the nineteenth- and twentieth-century Saguenay Lac St.-Jean region of Quebec, and the Utah Population Database (UPDB), representing the settler population of the state of Utah during its frontier era and its subsequent development into the early portion of the twentieth century. What is central to the analysis are the three generations that are fundamental to test our hypotheses. As stated in our introduction, we adopt the following notation to describe the three generations:

F0: Grandmothers

F1: Mothers (the subject in fertility analyses)

F2: Children (the births of children represent the fertility outcomes)

The Scanian Economic Demographic Database (SEDD) is based on family reconstitutions and local population registers, which include information on demographic events and migration for all household members and families in households (Bengtsson et al. 2017). Vital events were checked against birth and death registers to adjust for possible under-recording of events in the population registers. In this study, we use data from 1766 to 1899. Between 1766 and 1814 the data are based on family reconstitutions and linked annual information at the family level on place of residence, land holdings and occupation. From about 1815 onwards data are based on population registers with individual information on migration to and from households, vital events, etc. The resulting database contains all individuals (men and women) born in the different parishes or migrating to them. Instead of sampling particular cohorts, every individual is followed from birth or time of arrival in the parishes to death or migration out of the parishes. The dataset for analysis was constructed using the programs developed in Quaranta (2015).

Data on the population of the St. Lawrence Valley, Québec, a population spanning both the French and English regimes, are drawn from the *Registre de la population du Québec ancien* (RPQA), a parish register-based family reconstitution of the Québec Catholic population from 1621 to 1799 (Dillon et al. 2017). The RPQA data are mainly based on linked baptismal, marriage and burial acts, with some supplementary information deriving from complementary sources such as marriage contracts. The database includes all identified Catholic individuals who were born, married or died in the parishes of the St. Lawrence Valley. These data feature complete information on dense kin networks: in the context of Québec's natural fertility regime, individuals could have as many as 9 siblings, the age spread of siblings could be 20 years, and younger siblings could be the same age as the children born to their eldest siblings (Dillon et al. 2017: 7).

The Saguenay data are drawn from the BALSAC population database which includes church and civil records for an almost exclusively Catholic population. All births, marriages, and deaths that occurred in Saguenay from the onset of colonization to 1971 have been transcribed and linked using family reconstitution methods to form the BALSAC database (BALSAC 2019). Individuals in this database are followed until they die or migrated out of the Saguenay region.

The Utah microdata come from the Utah Population Database (UPDB) (Pedigree and Population Resource 20122). The core of the historic portion of the settler population and their descendants within the UPDB are based upon information from over 185,000 three-generation family documents provided by the Genealogical Society of Utah. These genealogical records provide data on migrants to Utah and their descendants born from the early 1800s to the mid-1970s (Smith, Mineau et al 2009). These data have been supplemented with vital records that further describe the numbers, dates, and locations of births and deaths for individuals and their family members represented in the UPDB.

## Selection, Methods and Operationalization of Variables

### Selection

In terms of time period, our data are selected from the earliest year feasible for each data set. The Scanian analysis selected women under observation from January 1, 1766, to December 31, 1899, while the three North American studies selected reproducing women born over specified seventeenth to early twentieth-century periods (see Table 1). Our general aim is to study pre-transition populations, and as such the mothers (hereafter called F1) are selected for a pre-transition period in each of the four datasets. However, in the case of Scania and Utah, some of our intervals move into the period when changes associated with the fertility transition are beginning to happen. The Scanian data cover the period 1766–1900, and include 927 mothers (F1) and 2,865 children (F2). The Quebec RPQA database provides data from the earliest period, analyzing 9,921 mothers (F1) born between 1650 and 1750; the births of their 71,166 children (hereafter called F2) extend from 1666 to 1791. The Saguenay data encompass 18,547 mothers who married in the region between the beginning of settlement (first marriage recorded in 1842) up to 1929. These women were born from 1807 up to 1914, and the births of their 143,365 children cover the years 1843 to 1963. The UPDB sample used in the analysis reported in this paper include 182,069 women born in Utah between 1850 and 1919 who are observed living in Utah after age 15.

In general, mothers with known dates and places of birth and death or outmigration, who married at least once and have had at least one child are selected. These selections were made in order to study a population of women (and their husbands) who are not sterile, and to ensure data quality and completeness. We also excluded a modest number of observations for reasons of data-consistency and date and link quality. We analyze the fertility of women in their first marriage, and include women with both full and curtailed reproductive periods; women who married yet died before menopause or who lost their husband before menopause (here defined as age 50) were also included. Since our analyses concern inter-birth intervals, the time at risk of the mother begins with the previous birth. Furthermore, the time at risk of the mother is right censored at age 50 or if the mother or her husband died before the mother reaches age 50. Inter-birth intervals are typically longer than first-birth intervals due to the delayed return to fecundability after a period of amenorrhea associated with breastfeeding. If the inter-birth interval was more than 5 years long, an intervening birth may have been missed. In these cases, we censored the interval at 5 years, with subsequent intervals retained for analysis.

The RPQA analysis includes only subjects and husbands born in Quebec, includes all parish-to-parish migrants, and excludes only a small number of women or children who emigrated from Quebec. The maternal and paternal grandmothers are examined in separate models, and for each model, we select the grandmothers whose death date is known or whose date of outmigration is known (in the case of Scania). Since the number of maternal and paternal grandmothers whose death date is known varies, the total number of observations per dataset varies somewhat per model.

## Method

We used Cox proportional hazard models for all analyses. We employ models without and with family fixed effects (based upon observations grouped by sibship), stratifying on the grandmother (F0). Results derived from models which do not incorporate fixed effects reflect differences across all families, potentially indicating healthful or detrimental behaviors on the part of particular families. Our fixed effects models, on the other hand, control for inter-familial variations and thus focus on differences within groups of sisters or sisters-in-law. To better compare our fixed effects results and non-fixed effects results, all regression analyses have constrained the denominator for all models to mothers with at least one sister or sister-in-law. We present results for all birth intervals together (birth intervals 2+), as well as results specifically for the 2nd and 3rd birth intervals, birth intervals 4 and higher, and birth intervals 9 and higher (for Quebec and Utah only; the number of observations in the Scania data do not allow for analyses of birth intervals 9 and higher).

## Variable Operationalization

The dependent variable of prime interest is the time to the next birth, with all inter-birth intervals considered together or stratified by birth order. Our independent variables of interest are the vital status and proximity of the maternal and paternal grandmothers. These are time-varying variables, since the vital status and proximity of the grandmother will change in the course of her daughter or daughter-in-law's reproductive life and in the course of her grandchildren's youth. Since the Scania data encompass five parishes, grandmothers who migrated out of the 5-parish region have unknown destinies, and thus are given a unique 5th value "outmigrated". The Utah database distinguishes between grandmothers who were alive and living in the same county from those who were alive and living in a different county. The location of the grandmother is determined by comparing the time and place of their death to the birth parish of the last grandchild born prior to the grandmother's death (Quebec) or the closest county among all the F1's births (Utah). In Scania the vital and proximity status of the grandmother is determined by considering whether she resided in the same parish as the mother and her date of death (if the death occurred in the 5-parish region). The grandmother variables thus include the following values:

i. Grandmother alive & in same parish
ii. Grandmother alive & in different parish/county (Quebec & Utah only)
iii. Grandmother died 0–4 years ago (Quebec & Utah; Scania: died in same 5-parish region)
iv. Outmigrated from the parish & status unknown (Scania only)
v. Grandmother died more than 5 years ago (Quebec & Utah; Scania: died in same 5-parish region) (This value serves as the reference group)

Since grandmothers' attention to their daughters and grandchildren was potentially diffused across a variety of children and grandchildren (brothers and sisters of the F1 and cousins of the F2), we also control for the size of ego's or her husband's sibship (time-varying). These controls are applied in models that did not use fixed effects. When we use a fixed effects specification this variable drops out and is accounted for by the fixed effects. When analyzing the role of maternal grandmothers, we control for the size of ego's sibship, and when analyzing the role of paternal grandmothers, we control for the size of ego's husband's sibship. When using fixed effects models, we do not need to control for the size of ego's or her husband's sibship since these do not vary for a given grandmother.

We include in our models a range of control variables: the age of the mother at the previous birth (continuous), and the age of the mother at previous birth squared (continuous), the birth rank of the mother (continuous), the birth rank of the previous child (continuous), whether the previously-born child died before age 1 (time-varying and continuous), current year or mother's year of birth to represent the historical period (continuous and time-varying), and urban versus rural place of birth/marriage of the mother (Quebec and Utah only). In the Quebec St. Lawrence Valley data, death dates are not known for many children (F2) born toward the end of our study period, requiring an adjustment to the "previously-born child died before age 1" variable. In the absence of a death date, we used date of marriage to identify children who had not died in infancy. Children for whom neither a death nor a marriage is recorded are classified in a separate value "destiny unknown". We omit ego's mother's and father's ages at death, as this information is unknown in the SEDD database. The Utah analyses also control for membership in the Church of Jesus Christ of Latter-day Saints. Since the Catholic populations included in both Quebec databases are generally homogeneous with respect to high fertility behavior, there is no religion variable included in the Quebec data. Similarly, religion is not included for Scania, as almost the entire population belonged to the Lutheran state church (Bengtsson and Dribe 2014).

## Description of Results

### Descriptive Statistics

The four regions represented in our study encompass a variety of historic settings, periods and conditions. Accordingly, both similarities and differences across our populations are evident in the means and percentage distributions for the demographic and social characteristics included in our analyses (Tables 2 and 3). These descriptive statistics are weighted by the person-years under observation, and stratified by birth intervals, and encompass all mothers (F1) in analysis, whether or not they had a sister or sister-in-law. Whereas the Scanian data include entirely rural parishes (save for the last decades of the nineteenth century when one of the parishes grew into a small town), both Quebec files include a modest proportion of urban dwellers (up to a quarter in the case of the Saguenay region). On the other hand, about 40% of Utah residents lived within the Wasatch Front, four counties that would evolve into today's urban corridor. Another distinction of the Utah population is that nearly two-thirds of this population were members of the Church of Jesus Christ of Latter-day Saints; active members of this church generally have high fertility, do not smoke or consume alcohol, are socially integrated via their church activities, and they often fast one day a month, all behaviors that promote health and enhance fertility.

Table 2: Descriptive statistics (means and percentages), Maternal Grandmother, by region and birth intervals Scania, Quebec-St. Lawrence, Quebec-Saguenay Lac St. Jean and Utah, 1650–1900

| | Birth Intervals 2+ | | | | Birth Intervals 2 & 3 | | | | Birth Intervals 4+ | | | | Birth Intervals 9+ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Scania | Q-SL | Q-Sag | Utah | Scania | Q-SL | Q-Sag | Utah | Scania | Q-SL | Q-Sag | Utah | Q-SL | Q-Sag | Utah |
| Maternal grandmother status (%) | | | | | | | | | | | | | | | |
| Alive & living in same parish/county | 50.81 | 27.64 | 28.90 | 50.72 | 63.51 | 35.77 | 35.37 | 56.53 | 44.15 | 25.36 | 27.36 | 47.59 | 20.73 | 23.25 | 38.54 |
| Alive & living in different parish/county | | 27.83 | 33.13 | 23.44 | | 32.00 | 38.93 | 24.92 | | 26.66 | 31.75 | 22.64 | 22.75 | 27.13 | 20.48 |
| Dead 0–4 years | 11.21 | 10.55 | 9.52 | 6.05 | 9.39 | 8.71 | 8.13 | 4.55 | 12.15 | 11.06 | 9.85 | 6.86 | 12.53 | 11.41 | 9.06 |
| Dead 5+ years | 33.03 | 33.99 | 28.44 | 19.79 | 21.84 | 23.52 | 17.57 | 14.00 | 38.90 | 36.92 | 31.04 | 22.91 | 43.99 | 38.21 | 31.92 |
| Outmigrated | 4.95 | | | | 5.26 | | | | 4.79 | | | | | | |
| Previously-born child died before age 1 (%) | 9.18 | 20.46 | 22.73 | 6.89 | 9.65 | 17.95 | 22.13 | 6.43 | 8.93 | 21.17 | 22.87 | 7.14 | 26.58 | 26.26 | 8.90 |
| Previously-born child - destiny unknown (%) | | 8.58 | | | | 7.59 | | | | 8.86 | | | 9.01 | | |
| Mother's age at previous birth | 32.62 | 30.41 | 30.59 | 28.61 | 27.66 | 23.66 | 22.95 | 23.63 | 35.22 | 32.31 | 32.42 | 31.11 | 36.68 | 36.76 | 36.95 |
| Number of children ever born | 3.95 | 6.83 | 7.21 | 5.45 | 1.49 | 2.51 | 2.51 | 2.52 | 5.24 | 8.08 | 8.33 | 6.64 | 10.61 | 11.32 | 10.39 |
| Mother's sibship size | 5.59 | 9.43 | 9.70 | 7.91 | 5.55 | 9.36 | 9.58 | 7.80 | 5.60 | 9.55 | 9.73 | 7.96 | 9.70 | 9.87 | 8.14 |
| Mother's birth rank | 3.47 | 5.06 | 4.63 | 4.68 | 3.46 | 5.05 | 4.60 | 4.74 | 3.47 | 5.10 | 4.64 | 4.65 | 5.10 | 4.71 | 4.56 |
| Year (Utah: Mother's year of birth) | 1849 | 1753 | 1913 | 1910 | 1847 | 1747 | 1905 | 1907 | 1850 | 1754 | 1914 | 1912 | 1758 | 1919 | 1915 |
| Urban residence (Utah: = Wasatch) (%) | | 16.99 | 23.21 | 39.48 | | 18.00 | 18.75 | 42.21 | | 16.70 | 24.27 | 38.01 | 16.62 | 26.66 | 34.25 |
| Member of Latter-day Saints Church (%) | | | | 37.33 | | | | 60.17 | | | | 64.01 | | | 64.76 |
| Number of births | 2,865 | 71,166 | 42,604 | 125,750 | 1,203 | 18,642 | 10,101 | 46,254 | 1,662 | 52,524 | 32,503 | 79,496 | 17,625 | 11,913 | 13,715 |
| Number of mothers | 927 | 9,921 | 5,169 | 26,362 | 886 | 6,250 | 5,169 | 25,609 | 673 | 3,671 | 4,655 | 20,792 | 672 | 3,069 | 5,877 |

Q-SL = Quebec - St. Lawrence Valley
Q-Sag = Quebec Saguenay Lac St-Jean region
Blank cells = information not available or not applicable
Scania: "same parish" = 5-parish region (very local)
Sources: Scania: SEDD 2017; Q-SL: PRDH - RPQA 2014; Q-Sag: BALSAC 2017; Utah: UPDB 2014

Table 3: Descriptive statistics (means and percentages), Paternal Grandmother, by region and birth intervals Scania, Quebec-St. Lawrence, Quebec-Saguenay Lac St. Jean and Utah, 1650–1900

| | Birth Intervals 2+ | | | | Birth Intervals 2 & 3 | | | | Birth Intervals 4+ | | | | Birth Intervals 9+ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Scania | Q-SL | Q-Sag | Utah | Scania | Q-SL | Q-Sag | Utah | Scania | Q-SL | Q-Sag | Utah | Q-SL | Q-Sag | Utah |
| | | | | | | | | | | | | | | | |
| Alive | | | | | | | | | | | | | | | |
| Alive & living in same parish/county | 40.36 | 21.29 | 31.90 | 45.53 | 55.80 | 28.29 | 42.30 | 52.20 | 32.39 | 19.19 | 29.50 | 41.94 | 14.01 | 22.40 | 31.650 |
| Alive & living in different parish/county | | 24.37 | 23.50 | 21.71 | | 32.41 | 29.10 | 24.18 | | 22.16 | 22.20 | 8.10 | 15.99 | 18.70 | 16.780 |
| Dead 0–4 years | 11.20 | 12.37 | 11.00 | 7.17 | 11.34 | 10.39 | 8.60 | 5.44 | 11.13 | 12.91 | 11.60 | 29.58 | 13.94 | 13.40 | 10.420 |
| Dead 5+ years | 43.13 | 41.97 | 33.50 | 25.59 | 27.63 | 28.29 | 20.00 | 18.18 | 51.14 | 45.74 | 36.70 | 20.38 | 56.06 | 45.60 | 41.150 |
| Outmigrated | 5.30 | | | | 5.22 | | | | 5.34 | | | | | | |
| Previously-born child died before age 1 (%) | 8.60 | 20.19 | 22.70 | 6.88 | 8.82 | 17.48 | 21.90 | 6.39 | 8.48 | 20.93 | 22.90 | 7.15 | 26.36 | 26.00 | 8.940 |
| Previously-born child - destiny unknown (%) | | 8.35 | | | | 7.16 | | | | 8.68 | | | 8.96 | | |
| Mother's age at previous birth | 32.63 | 30.48 | 30.60 | 28.62 | 27.63 | 23.62 | 22.80 | 23.63 | 35.21 | 32.37 | 32.40 | 31.12 | 36.73 | 36.80 | 36.960 |
| Number of children ever born | 3.97 | 6.87 | 7.25 | 5.48 | 1.51 | 2.51 | 2.51 | 2.52 | 5.24 | 8.08 | 8.35 | 6.65 | 11.29 | 11.34 | 10.390 |
| Father's sibship size | 5.61 | 9.48 | 9.40 | 7.42 | 5.47 | 9.38 | 9.30 | 7.31 | 5.68 | 9.51 | 9.40 | 7.47 | 9.61 | 9.51 | 7.580 |
| Year (Utah: Mother's year of birth) | 1854 | 1754 | 1913 | 1910 | 1851 | 1749 | 1905 | 1907 | 1855 | 1756 | 1914 | 1912 | 1760 | 1919 | 1915 |
| Urban residence (Utah: = Wasatch) (%) | | 13.63 | 23.00 | 39.34 | | 14.45 | 18.30 | 42.00 | | 13.40 | 24.10 | 37.91 | 13.72 | 26.43 | 34.820 |
| Member of Latter-day Saints Church (%) | | | | 63.21 | | | | 60.81 | | | | 64.50 | | | 65.180 |
| Number of births | 2,313 | 62,050 | 39,963 | 122,910 | 969 | 16,158 | 9,384 | 45,163 | 1,344 | 45,892 | 30,579 | 77,747 | 15,474 | 11,253 | 13,376 |
| Number of mothers | 761 | 8,508 | 4,795 | 25,713 | 714 | 5,311 | 4,777 | 24,981 | 545 | 3,197 | 4,356 | 20,331 | 590 | 2,880 | 5,743 |

Q-SL = Quebec - St. Lawrence Valley
Q-Sag = Quebec Saguenay Lac St-Jean region
Blank cells = information not available or not applicable
Scania: "same parish" = 5-parish region (very local)
Sources: Scania: SEDD 2017; Q-SL: PRDH - RPQA 2014; Q-Sag: BALSAC 2017; Utah: UPDB 2014

A comparison of demographic indicators across our four populations reveal one important difference: higher infant mortality in both Quebec populations, measured as the percent of previously-born children who died before the age of 1 year. In the case of the Quebec St. Lawrence Valley population, considering the percent of children known to have died before age 1 together with those whose destiny is unknown (but which may include some infant deaths), from 20% to 29% of children born in the previous birth interval died in infancy, and this percentage rose to a minimum of 26% and a maximum of 36% for birth intervals 9+ (Tables 2 & 3, Q-SL). This high level of infant mortality in colonial Quebec is indicated in a 2010 study of Quebec infant mortality from 1640 to 1779 (Amorevieta-Gentil 2010: 131) and is a sharp contrast to the experience in Utah (Bean et al 2002). Amorevieta-Gentil identified steadily rising infant mortality rates in Quebec across the eighteenth century, with frequent mortality spikes resulting mostly from epidemic diseases such as smallpox, typhus, or measles, as well as social and health crises resulting from the British Conquest (1756-1763) (Amorevieta-Gentil 2010; Bruckner et al. 2018). Infant mortality rates between 1765 and 1779 ranged from 250 to 350 per thousand (Amorevieta-Gentil 2010: 131). The levels of infant mortality were somewhat lower in the Quebec Saguenay region (23%), since the data for this region extend into the mid-twentieth century, when fertility was still high but public health measures had begun to lower the infant death rate (Gaumer and Authier 1996). Infant mortality in the Quebec Saguenay region was nevertheless higher than that exhibited in either Scania or Utah. In these two regions, the percentage of previously-born children who died before age 1 was about 9% and 7% respectively, a result which may reflect improved health practices or conditions. Another notable difference across our populations concerns the number of children ever born and included in analysis, which is about 7 children in the case of the two Quebec populations (birth intervals 2+), 5.5 children in the case of Utah and 4 children in the case of Scania. Accordingly, mother's and father's sibship size is generally higher in the two Quebec populations (about 9 to 10, Tables 2 & 3) and in Utah (9) but lower in Scania (6 for both mothers and fathers). Mother's age at previous birth is slightly lower in the two Quebec populations (30-31 years) compared to the Utah and Scanian populations (about 33).

Finally, we present the percent distribution of maternal and paternal grandmothers' vital status and proximity across birth intervals. For the data concerning birth intervals 2+, maternal grandmothers in Utah are distinguished by greater survival: 75% of maternal grandmothers in Utah were alive, compared to just 55% of maternal grandmothers in Quebec-St. Lawrence Valley. Maternal grandmothers in the Quebec Saguenay region, on the other hand, almost matched their Utah counterparts in terms of survival (62% were alive for birth intervals 2+). Similar regional differences across North America prevailed for the paternal grandmothers (Table 3), at lower percentages across the board (e.g. 67% in Utah, 55% in Quebec Saguenay and 46% in Quebec St. Lawrence Valley). Since the Scania data identifies maternal and paternal grandmothers as alive only if they were also living in one of the five rural parishes, we cannot make exactly the same survival comparison that we did with the Quebec and Utah grandmothers, but we do see that 40–50% of paternal and maternal grandmothers in Scania were both alive and living in proximity to their daughters or daughters-in-law (F1). About 5% of maternal and paternal grandmothers in Scania are indicated as having outmigrated from the area of study. Half of the grandmothers in Utah were not only alive but also living in the same county as their daughter. In the two Quebec regions, on the other hand, just over a quarter of grandmothers were both alive and living within the same parish as their own daughter. In the Saguenay region, nearly a third of paternal grandmothers were both alive and living in the same parish as their daughters-in-law, but the same was true for only 21% of St. Lawrence Valley paternal grandmothers. Notwithstanding the tendency of Quebec families to transmit property through the male line, somewhat larger proportions of Quebec St. Lawrence Valley women resided in proximity to their own mother (26%) than to their mother-in-law (21%). This distinction was in part related to the larger percentages of paternal grandmothers who had already died (56% compared to 46% of maternal grandmothers). In all cases, at higher birth intervals, larger percentages of grandmothers were distributed in the "Dead 0–4 years" and "Dead 5+ years" categories, representing how the passage of time would gradually deprive mothers of their potential helpers.

## Multivariate Analysis

Across the regions included in our study, we observe significant and positive influences of both maternal and paternal grandmothers on fertility outcomes of their daughters. The strength and consistency of these effects vary, but it is noteworthy that the grandmother effect is observable across such diverse contexts. In most cases, we show non-fixed effects and then fixed effects versions of our models; applying fixed effects often increases the strength of our positive hazard ratios for fertility, but not always. These distinctions are important, as significant positive hazard ratios in fixed-effects models indicate differences across sisters, whereas significant positive hazard ratios in non-fixed effects models indicate differences across families. Tables 4 and 5 present abridged results, focusing on the variables of interest "Maternal Grandmother Status" and "Paternal Grandmother Status"; appendices A and B present the full results for Tables 4 and 5, including all control variables.

Our internationally comparative analysis has demonstrated a positive association of grandmothers' availability and presence with daughters' fertility (shorter birth intervals); nevertheless, the context and timing of this effect differed across our populations. In Scania, living grandmothers promoted higher-order fertility (4+). This effect was similar for maternal and paternal grandmothers, but was evident in non-fixed effects models only, suggesting differences across families were more important in the Scanian context. Among Scanian women bearing children of birth rank 4 and higher, those whose mother or mother-in-law was alive and living in the same parish experienced a 1.123 to 1.162 times higher hazard of next birth compared to those whose mother or mother-in-law had died more than five years earlier (Table 4, model 17 and Table 5, model 47). This effect was manifested more broadly in the case of Scanian paternal grandmothers, for all birth intervals (2+): we observe that women whose mother-in-law was alive and living in the same parish had a 14% higher hazard of next birth compared to women whose mother-in-law died more than five years earlier (Table 5, model 31). Paternal grandmothers in Scania were also associated with fertility-enhancing effects if they had outmigrated or if they had died recently rather than 5+ years ago. In fact, the hazard of next birth was higher if the paternal grandmother had died recently or had outmigrated than if she was alive (Table 5 models 31, 39 and 47). Our Scanian analyses pertaining to maternal grandmothers manifest somewhat different patterns. We observe a fertility-enhancing effect of available maternal grandmothers only in the case of women giving birth to children of birth rank 4+, once again in a non-fixed effect model (Table 4, model 17). More generally, maternal grandmothers in Scania who had outmigrated were associated with longer birth intervals (Table 4, models 5 and 21); this was also the case of Scanian maternal grandmothers who had died recently (Table 4 model 5). Thus, we observe in Scania a reasonably consistent fertility-enhancing effect of living paternal grandmothers juxtaposed with a fertility-diminishing effect of deceased or outmigrated maternal grandmothers.

Table 4: Women's risk of next birth, by maternal grandmother status Scania, Quebec and Utah, 1650–1900, Abridged Table

| Maternal Grandmother status (ref: dead 5+ years) | Scania | | Q-SL | | Q-Sag | | Utah | |
|---|---|---|---|---|---|---|---|---|
| | H.R. | P>z | H.R. | P>z | H.R. | P>z | H.R. | P>z |
| Birth Intervals 2+, No Fixed Effects | 1* | | 2 | | 3 | | 4 | |
| Alive & in same parish / county | 1.071 | 0.159 | 1.052 | 0.000 | 1.022 | 0.216 | 1.012 | 0 |
| Alive & in different parish / county | | | 1.065 | 0.000 | 1.028 | 0.107 | 0.997 | 0.468 |
| Dead 0–4 years | 1.037 | 0.586 | 1.040 | 0.016 | 1.013 | 0.577 | 1.016 | 0 |
| Outmigrated (Sweden only) | 0.971 | 0.665 | | | | | | |
| Birth Intervals 2+, Fixed Effects | 5 | | 6 | | 7 | | 8 | |
| Alive & in same parish / county | 0.885 | 0.299 | 1.111 | 0.000 | 1.081 | 0.032 | 1.025 | 0.035 |
| Alive & in different parish / county | | | 1.131 | 0.000 | 1.094 | 0.014 | 1.002 | 0.842 |
| Dead 0–4 years | 0.821 | 0.039 | 1.083 | 0.000 | 1.062 | 0.049 | 1.025 | 0.062 |
| Outmigrated | 0.501 | 0.000 | | | | | | |
| Birth Intervals 2 & 3, No Fixed Effects | 9 | | 10 | | 11 | | 12 | |
| Alive & in same parish / county | 0.997 | 0.973 | 0.992 | 0.738 | 1.025 | 0.540 | 0.998 | 0.67 |
| Alive & in different parish / county | | | 1.036 | 0.176 | 1.039 | 0.338 | 0.976 | 0.01 |
| Dead 0–4 years | 0.974 | 0.825 | 1.004 | 0.918 | 1.141 | 0.017 | 1.006 | 0.368 |
| Outmigrated | 0.981 | 0.860 | | | | | | |
| Birth Intervals 2 & 3, Fixed Effects | 13 | | 14 | | 15 | | 16 | |
| Alive & in same parish / county | 1.142 | 0.641 | 1.163 | 0.063 | 1.065 | 0.592 | 1.028 | 0.326 |
| Alive & in different parish / county | | | 1.288 | 0.000 | 1.141 | 0.268 | 1.001 | 0.978 |
| Dead 0–4 years | 1.084 | 0.731 | 1.107 | 0.135 | 1.176 | 0.102 | 1.03 | 0.335 |
| Outmigrated | 0.703 | 0.314 | | | | | | |
| Birth Intervals 4+, No Fixed Effects | 17 | | 18 | | 19 | | 20 | |
| Alive & in same parish / county | 1.123 | 0.057 | 1.064 | 0.000 | 1.019 | 0.330 | 1.015 | 0 |
| Alive & in different parish / county | | | 1.069 | 0.000 | 1.025 | 0.195 | 1.002 | 0.668 |
| Dead 0–4 years | 1.071 | 0.399 | 1.046 | 0.010 | 0.983 | 0.510 | 1.019 | 0 |
| Outmigrated | 0.974 | 0.764 | | | | | | |
| Birth Intervals 4+, Fixed Effects | 21 | | 22 | | 23 | | 24 | |
| Alive & in same parish / county | 0.950 | 0.758 | 1.104 | 0.000 | 1.108 | 0.017 | 1.03 | 0.054 |
| Alive & in different parish / county | | | 1.098 | 0.002 | 1.097 | 0.033 | 1.004 | 0.782 |
| Dead 0–4 years | 0.820 | 0.117 | 1.083 | 0.000 | 1.037 | 0.314 | 1.028 | 0.108 |
| Outmigrated | 0.636 | 0.043 | | | | | | |
| Birth Intervals 9+, No Fixed Effects | | | 25 | | 26 | | 27 | |
| Alive & in same parish / county | | | 1.069 | 0.007 | 1.045 | 0.157 | 1.024 | 0.013 |
| Alive & in different parish / county | | | 1.088 | 0.000 | 1.021 | 0.491 | 1.025 | 0.079 |
| Dead 0–4 years | | | 1.056 | 0.056 | 1.008 | 0.831 | 1.037 | 0.004 |

*Numbers in abridged table refer to models in Appendix A
Q-SL = Quebec - St. Lawrence Valley
Q-Sag = Quebec Saguenay Lac St-Jean region
Blank cells = information not available or not applicable
Scania: "same parish" = 5-parish region (very local)
Sources: Scania: SEDD 2017; Q-SL: PRDH - RPQA 2014; Q-Sag: BALSAC 2017; Utah: UPDB 2014

Table 5: Women's risk of next birth, by paternal grandmother status
Scania, Quebec and Utah, 1650–1900, Abridged Table

| Paternal Grandmother status (ref: dead 5+ years) | Scania | | Q-SL | | Q-Sag | | Utah | |
|---|---|---|---|---|---|---|---|---|
| | H.R. | P>z | H.R. | P>z | H.R. | P>z | H.R. | P>z |
| Birth Intervals 2+, No Fixed Effects | 31* | | 32 | | 33 | | 34 | |
| Alive & in same parish / county | 1.142 | 0.014 | 1.092 | 0 | 1.116 | 0.000 | 1.019 | 0 |
| Alive & in different parish / county | | | 1.092 | 0 | 1.094 | 0.000 | 1.014 | 0.001 |
| Dead 0–4 years | 1.200 | 0.015 | 1.067 | 0 | 1.052 | 0.027 | 1.021 | 0 |
| Outmigrated | 1.052 | 0.704 | | | | | | |
| Birth Intervals 2+, Fixed Effects | 35 | | 36 | | 37 | | 38 | |
| Alive & in same parish / county | 0.975 | 0.847 | 1.061 | 0.041 | 1.019 | 0.587 | 1.034 | 0.004 |
| Alive & in different parish / county | | | 1.091 | 0.003 | 1.040 | 0.304 | 1.024 | 0.034 |
| Dead 0–4 years | 1.037 | 0.736 | 1.081 | 0.000 | 1.025 | 0.407 | 1.035 | 0.01 |
| Outmigrated | 0.526 | 0.488 | | | | | | |
| Birth Intervals 2 & 3, No Fixed Effects | 39 | | 40 | | 41 | | 42 | |
| Alive & in same parish / county | 1.107 | 0.245 | 1.062 | 0.025 | 1.081 | 0.042 | 1.011 | 0.066 |
| Alive & in different parish / county | | | 1.043 | 0.105 | 1.064 | 0.129 | 1.019 | 0.051 |
| Dead 0–4 years | 1.157 | 0.243 | 1.076 | 0.041 | 1.072 | 0.199 | 1.009 | 0.16 |
| Outmigrated | 1.438 | 0.095 | | | | | | |
| Birth Intervals 2 & 3, Fixed Effects | 43 | | 44 | | 45 | | 46 | |
| Alive & in same parish / county | 0.862 | 0.621 | 1.125 | 0.177 | 0.941 | 0.593 | 1.045 | 0.124 |
| Alive & in different parish / county | | | 1.128 | 0.168 | 0.978 | 0.858 | 1.037 | 0.186 |
| Dead 0–4 years | 0.932 | 0.780 | 1.165 | 0.030 | 1.096 | 0.347 | 1.043 | 0.18 |
| Outmigrated | 3.00E+12 | 1.000 | | | | | | |
| Birth Intervals 4+, No Fixed Effects | 47 | | 48 | | 49 | | 50 | |
| Alive & in same parish / county | 1.162 | 0.031 | 1.095 | 0.000 | 1.125 | 0.000 | 1.02 | 0 |
| Alive & in different parish / county | | | 1.107 | 0.000 | 1.099 | 0.000 | 1.012 | 0.015 |
| Dead 0–4 years | 1.268 | 0.012 | 1.064 | 0.000 | 1.041 | 0.109 | 1.025 | 0 |
| Outmigrated | 0.908 | 0.572 | | | | | | |
| Birth Intervals 4+, Fixed Effects | 51 | | 52 | | 53 | | 54 | |
| Alive & in same parish / county | 0.830 | 0.334 | 1.008 | 0.816 | 1.023 | 0.591 | 1.039 | 0.012 |
| Alive & in different parish / county | | | 1.069 | 0.058 | 1.028 | 0.532 | 1.022 | 0.116 |
| Dead 0–4 years | 1.091 | 0.557 | 1.061 | 0.024 | 1.002 | 0.964 | 1.043 | 0.017 |
| Outmigrated | 0.000 | 1.000 | | | | | | |
| Birth Intervals 9+, No Fixed Effects | | | 55 | | 56 | | 57 | |
| Alive & in same parish / county | | | 1.073 | 0.013 | 1.225 | 0.000 | 1.026 | 0.007 |
| Alive & in different parish / county | | | 1.151 | 0.000 | 1.133 | 0.000 | 1.022 | 0.128 |
| Dead 0–4 years | | | 1.099 | 0.001 | 1.032 | 0.403 | 1.009 | 0.469 |

*Numbers in abridged table refer to models in Appendix B
Q-SL = Quebec - St. Lawrence Valley
Q-Sag = Quebec Saguenay Lac St-Jean region
Blank cells = information not available or not applicable
Scania: "same parish" = 5-parish region (very local)
Sources: Scania: SEDD 2017; Q-SL: PRDH - RPQA 2014; Q-Sag: BALSAC 2017; Utah: UPDB 2014

When we cross the Atlantic Ocean to the seventeenth- and eighteenth-century Quebec St. Lawrence Valley settlement, we observe stronger and more consistent associations between the presence of a grandmother and the risk of next birth. Maternal and paternal grandmothers in the Quebec St. Lawrence Valley region who were alive and living in the same or a different parish were almost always associated with a higher hazard of next birth, for most birth intervals. In the analyses focusing on maternal grandmothers, effect sizes were strengthened in fixed effect models, suggesting that maternal grandmother availability differentiated fertility outcomes across sets of sisters more than it did across families. In the fixed effects model for all birth ranks 2+, Quebec St. Lawrence Valley women whose own mother was alive and living in the same or different parish had a 11% and 13% higher hazard of next birth compared to women whose mother had died more than five years ago (Table 4, model 6). The highest hazard ratios observed in the maternal grandmother analyses concern birth intervals 2 & 3 in the fixed effects models (hazard ratios of 1.163 and 1.288 for alive & in same or different parish respectively, although the former hazard ratio has a significance level of .063, just above the .05 threshold; Table 4 model 14). Quebec St. Lawrence Valley women whose mothers-in-law were alive also manifested higher fertility. For example, women giving birth to children of birth ranks 4+ had a 10–11% higher hazard of next birth if their mother-in-law was alive, regardless of her proximity status. The fact that the hazard ratios in the paternal grandmother analyses demonstrate slightly higher effect sizes, contrary to the maternal grandmother analyses, suggest that paternal grandmother availability made more of a difference across families. Even women whose mother or mother-in-law had recently died manifested modestly higher hazards of next birth compared to women whose mother or mother-in-law had died more than five years earlier. Overall, we view fertility-enhancing effects of both maternal and paternal grandmothers in the Quebec St. Lawrence Valley population, with somewhat greater effect sizes observed with respect to maternal grandmothers.

Moving forward in time to the nineteenth- and twentieth-century Saguenay, Quebec, region, we once again observe positive and statistically significant associations between grandmothers' availability and women's time to next birth. In the case of this population, the "grandmother effect" is more evident with respect to paternal grandmothers and in non-fixed effects models rather than fixed effects models. Women giving birth to children of any birth rank 2+ had a higher hazard of next birth if their mother-in-law was alive and living in proximity (hazard ratio 1.116) or if their mother-in-law was alive but living in a different parish (hazard ratio 1.094). These women also had a slightly higher hazard of next birth if their mother-in-law had only recently died (hazard ratio 1.052, Table 5, model 33, non-fixed effect model). The same associations are demonstrated in the non-fixed effects models for birth intervals 4+ and 9+, with the highest effect sizes demonstrated for the highest birth intervals of 9+: in this latter case, Saguenay women had a 23% and 13% higher hazard of next birth if their mother-in-law was alive and living in the same parish or in a different parish (Table 5, model 56). Maternal grandmothers in the nineteenth-century Saguenay region were also associated with fertility-enhancing effects, but less consistently, and more often in fixed effect models. For example, women giving birth to children of any birth rank (2+) had a 8% higher hazard of next birth if their own mother was alive and living in the same parish, and a 9% higher hazard of next birth if their mother was alive and living in a different parish (Table 4, fixed effects model 7). Maternal grandmothers were also associated with a faster time to next birth for birth intervals

4+ (Table 4, fixed effects model 23). Despite the existence of a positive grandmother effect for both maternal and paternal grandmothers in the Saguenay region, we observe generally larger effect sizes in the cases of paternal grandmothers. As observed in the Quebec St. Lawrence Valley population, non-fixed effect models yielded more important results with respect to paternal grandmothers in the Saguenay region, whereas significant maternal grandmother effects in the Saguenay emerge in the fixed effect models.

In late-nineteenth- and early twentieth-century Utah, we find fertility-enhancing effects mainly among paternal grandmothers; effects which are more modest in terms of effect size than those observed in the two Quebec regions and in the Scania region. The general trends observed among paternal grandmothers in Utah are nevertheless similar to those observed in the Quebec populations: women giving birth to children of birth ranks 2 or more had a marginally higher (hazard ratios of 1.02 and 1.01, respectively) hazard of next birth if their mother-in-law was alive and living in the same or in a different parish (Table 5, model 34). These results were true in both fixed effects and non-fixed effects models (Table 5, models 34 and 38). When examining specific birth intervals, we observe positive paternal grandmother effects in Utah with respect to birth intervals 4+ and 9+ (Table 5, models 50, 54 and 57). Maternal grandmothers in Utah were likewise associated with modest, though statistically-significant, fertility-enhancing effects. We observe a small positive association between the presence and proximity of a maternal grandmother and fertility generally for birth ranks 2+ (hazard ratios of 1.01 or 1.02, either fixed effects or non-fixed effects models, Table 4, models 7 and 8), for birth intervals 4+ and for birth intervals 9+ (non-fixed effects in both cases, Table 4, models 20 and 27).

Our multivariate analysis included a range of demographic control variables (mother's age at previous birth, mother's age at previous birth squared, mother's or father's sibship size, mother's birth rank, the birth rank of the previously-born child and whether the previously-born child had died before age 1) as well as several contextual variables (year, religious affiliation for Utah and urban-rural status for Quebec and Utah) (Appendices A and B). The hazard of next birth was influenced in predictable ways by our demographic control variables, and we present here the main contrasts across our four populations. Across all variables, including our variable of interest, the strongest positive hazard of next birth was associated with the death of the previously-born child. Infant mortality interrupted breast-feeding, prompting an early return of menstruation and risk of conception. In Scania, women whose previous child died before age 1 had as much as five times the hazard of next birth compared to women whose previous child survived (Appendix A, maternal grandmother analysis, birth intervals 2–3, model 13). The same variable in the Quebec and Utah models also manifested a strong positive association with the hazard of next birth, though the size of the hazard ratios for each North American region was smaller, reaching no more than 2.126 in the case of Quebec St. Lawrence Valley (Appendix A, maternal grandmother, model 14). Mother's age at previous birth was also strongly and positively associated with the hazard of next birth. The age association is U-shaped, with highest hazard ratios observed in the early twenties; thus this continuous variable, entered into models which also control for the birth rank of the previous child, indicates that women's waiting time to next birth was shorter as they aged from the late teenage years into their twenties. Once again, we see somewhat higher hazard ratios in the case of Scania than in Quebec and Utah (see, for example, hazard ratios of 1.399 in Scania versus the hazard ratios 1.203, 1.133 and .979 in Quebec St. Lawrence, Quebec Saguenay and Utah respectively, Appendix A, maternal grandmother analysis, birth intervals 2+, models 5, 6, 7 and 8). In the case of the two Quebec populations, higher birth ranks of the previously-born child were associated with lower hazards of next birth, particularly for birth intervals 2 & 3 in the fixed effects models (hazard ratios of .617 to .633 Appendices A and B, models 14, 15, 44 and 45). In the non-fixed effects models, we included mother's or father's sibship size to see if the grandmother effect was diluted for mothers with many siblings or siblings-in-law. The hazard ratios for this variable, though almost always above 1 and statistically significant, were very modest, ranging from 1 in Utah (Appendix A, model 27, maternal grandmother, birth intervals 9+ and Appendix B model 42, paternal grandmother, birth intervals 2 and 3) to 1.030 in the Saguenay region (Appendix A, model 11, maternal grandmother, birth intervals 2 & 3; exceptionally, one hazard ratio below the value of one, .682, is evident in the Saguenay population, Appendix B, model 41, paternal grandmother, birth intervals 2 and 3).

Our contextual control variables did not yield many notable results in terms of the size of the hazard ratio. For all four regions, the association of period (year as a time-varying continuous variable) with the hazard of next birth was often statistically significant but the hazard ratios were usually just under or just over 1. The hazard ratios for period were more often statistically significant in the fixed effects models, and tended to decrease when fixed effects were applied. For example, in the case of the maternal grandmother analyses, birth ranks 2+, non-fixed effects models, the hazard of next birth either increased or decreased each year by a factor of 1.000, .999, 1 and .998 in the case of Scania, Quebec St. Lawrence, Quebec Saguenay and Utah respectively (Appendix A, models 1, 2, 3 and 4; only the results for models 2 and 4, Quebec St. Lawrence and Utah, were statistically significant). The same model with fixed effects applied demonstrate a modest shift to hazard ratios consistently below one: .983, .988, .990 and .994 for these four regions (Appendix A, models 5, 6, 7 and 8). Residence in urban areas in the Quebec St. Lawrence population was generally associated with a very small increase in the hazard of next birth, almost always in non-fixed effects models. For example, in the maternal and paternal grandmother analyses concerning all birth ranks 2+, Quebec St. Lawrence women had a 1.032 and 1.024 higher hazard of next birth if they lived in an urban area (Appendix A, model 2 and Appendix B, model 32). The Quebec-Saguenay population, covering women born in a later period but living in a largely rural area, manifests instead the more usual negative association of urban or semi-urban residence with fertility; however, these results were statistically significant only in analyses concerning the highest birth orders, 9+. In the maternal grandmother analyses, Saguenay women giving birth to children of rank 9+ had a .923 and .987 hazard of next birth if they lived in a semi-urban or urban place of residence compared to their rural-dwelling counterparts (Appendix A, model 29, fixed effects; a similar result, .927, prevails in the case of urban-dwelling women, birth rank 9+ in the paternal grandmother analyses, Appendix B, model 56, non-fixed effects). In Utah, women who lived in the urban district of Wasatch had longer waiting times to next birth, particularly with respect to birth intervals 2 and 3, where the hazard ratio of next birth was .986 (maternal grandmother analysis) and .983 (paternal grandmother analysis) (Appendices A and B, fixed effects models 12 and 42). Conversely, in Utah active Mormon women consistently had a lower hazard of next birth. These hazards are modest and generally lower in the fixed effects models, with the lowest hazard ratio observed for birth ranks 2+, fixed effect model: .985 in the maternal grandmother analysis and .982 in the paternal grandmother analysis (Appendix A, model 8 and Appendix B, model 38).

## Discussion and Conclusion

In this chapter we have taken the first steps towards a comparative analysis of the impact of grandmothers on the reproductive outcomes of their children. We have studied four different contexts in North America and Scandinavia for which we have longitudinal individual-level data spanning three generations over long periods of time. Several interesting findings have emerged. Taken together, our results point to important effects of kin on reproductive success of families, much in line with predictions from anthropological theories on cooperative breeding. Paternal grandmothers consistently promote fertility across all four regions, particularly in Scania, with the maternal grandmother marginally more important in the Quebec St. Lawrence region. Women whose mothers-in-law were alive had children at a faster pace than other women. The availability or recent death of the paternal grandmother was associated with a higher hazard of next birth in 4 out of 8 models for Scania, 6 out of 8 models for Quebec-St. Lawrence, 4 out of 8 models for Quebec-Saguenay, and 5 out of 8 models for the state of Utah. We also find a general fertility advantage associated with the availability or recent death of the maternal grandmother in the four populations, in 3 out of 8 models in Scania, 6 out of 8 models in Quebec-St. Lawrence, 5 out of 8 models for Utah and 2 out of 8 models for the Quebec-Saguenay region. These findings are consistent with theories on cooperative breeding which argue that the help women receive from grandmothers, and possibly also other kin, facilitates childbearing and induces couples to have more children. We nevertheless observe notable variations across these regions.

In Scania, paternal grandmothers were associated with fertility-enhancing effects if they were either present, or outmigrated or recently died; Scanian maternal grandmothers were associated with higher fertility outcomes for birth ranks 4 or higher. Maternal grandmothers did not show the same consistent impact on fertility as the paternal grandmothers across all regions, but they were important in colonial-era Quebec. The Quebec St. Lawrence Valley population demonstrated the most consistent maternal and paternal grandmother associations. In addition, in several models for this seventeenth- and eighteenth-century Quebec population, the hazard ratio is modestly stronger if the grandmother is not proximate rather than if she is. Both maternal and paternal grandmothers in the Saguenay region were associated with higher fertility, but the largest hazard ratios in the Saguenay models are evident for birth ranks 9+, rather than across different birth ranks as in the case of the Quebec St. Lawrence Valley. While maternal grandmothers showed fertility-enhancing effects in Utah, the effect sizes for Utah's maternal grandmothers were slightly smaller or not statistically significant compared to the results shown in the Utah paternal grandmother analysis.

Differences across these populations also emerge in terms of the relevance of using fixed effects models, which compare fertility outcomes across sets of sisters or sisters-in-law, or non-fixed effects models, which compare fertility outcomes across families. The fixed effect models accounted for genetic and environmental effects on both longevity and fertility which were potentially shared within families. The distinct relevance of fixed and non-fixed effect models across Scania, Quebec and Utah is important, as it may signal possible differences in the underlying mechanism of the grandmother effect in each of the four regions, as well as the relative importance of inter-familial heterogeneity in each country in terms of health, environment, social class and other factors. In Scania, the positive association of the paternal and maternal grandmother with fertility generally emerged in non-fixed effects models, suggesting that fertility outcomes in this Swedish region were differentiated across families. Paternal grandmothers were associated with higher fertility even if they had recently died or had outmigrated. In this instance, the higher fertility of daughters-in-law may result from a positive selection in terms of the resources of the extended family which led the grandparents to move at an advanced age. At the same time, two non-fixed effects models for Scania indicate sisters' fertility outcomes diverged when the maternal grandmother was absent: mothers' fertility was lower if the maternal grandmother was recently dead or had outmigrated.

In the two Quebec populations, on the other hand, the use of stratified and non-stratified models illuminated important differences between maternal and paternal grandmothers. The highest hazards of next birth with respect to living maternal grandmothers were generally observed in fixed effects models, whereas the highest hazards of next birth when the paternal grandmother was alive were more often seen in the non-fixed effects models. The maternal grandmother analysis suggests greater differences across sisters within the same family than across the colony as a whole, and indicates as well that the fertility-enhancing effects of maternal grandmothers in historic Quebec were highly life course-dependent. At the beginning of their reproductive careers, women (F1) experienced higher fertility when they had access to their own mothers, the maternal grandmothers, and it did not much matter if their own mother lived in proximity. Perhaps maternal grandmothers in historic Quebec were willing to travel to help each successive daughter bear her first few children or to lend a hand during difficult periods. The maternal grandmother will likely want all of her daughters to succeed, and will make the accommodations and compensations necessary to distribute her assistance across her own daughters. However, the pertinence of the fixed effects models for the maternal grandmother analysis suggests that sisters who began their childbearing career while their own mother was still alive benefitted disproportionately from her assistance, relative to sisters who commenced childbearing in the absence of their mother. The assistance of the paternal grandmother, on the other hand, was not differentiated across her daughters-in-law, perhaps because her focus was indeed on lending assistance to her own daughters. The greater pertinence of non-fixed effects models in the paternal grandmother analysis suggests that her availability (even in a different parish or recently-dead) functioned as a proxy for support from a broader kinship network or from a family endowed with greater access to food or labour resources, such as a more-developed farm, or a farm located in an agriculturally-productive frontier location.

In Utah, fertility-enhancing grandmother effects were evident among both maternal and paternal grandmothers, in non-fixed and fixed effects models and at varying parity levels, with slightly higher size effects in the paternal grandmother analyses. The effect sizes observed in the Utah hazard ratios were notably smaller than those observed in the two Quebec populations as well as the Scania population. The Utah population encompasses nineteenth- as well as twentieth-century births, and as such portrays fertility patterns in a largely rural context which is nevertheless beginning to experience the demographic transition. The modest effect sizes shown in the Utah analyses may reflect contrasting influences on the part of Utah grandmothers: during the early stages of the demographic transition, some Utah grandmothers may have continued to encourage or facilitate high fertility while the "early innovators" were already beginning to discourage rapid childbearing (see Jennings, Sullivan & Hacker 2012). While the Scanian population also included mothers experiencing the early stages of the transition, the more important role of the paternal grandmother in Scania may signal continued discrepancies across women in terms of the familial resources the paternal grandmother represented. The Quebec St. Lawrence Valley population, on the other hand, embodied a natural fertility regime while most of the families included in the Quebec Saguenay population would also have practiced natural fertility. As a result, Quebec women bore children across the breadth of their reproductive lifespan and shared their own mother, the maternal grandmother, with several sisters. Each woman's reproductive phase intersected with the vital status of the maternal grandmother to form a particular nexus; accordingly, sisters in Quebec were differently advantaged in terms of their reproductive outcomes. Inter-familial variations in the Quebec paternal grandmother analyses, as was the case in Scania, may be more clearly understood in terms of the differentiation of resources across families. Our findings, overall, highlight the importance of paternal and maternal grandmothers for reproductive behavior in quite diverse historic contexts. Grandmothers usually fostered high-fertility outcomes, but family configurations, the stages of the life course, resource allocation and the advent of fertility control mediated the relative importance of this effect.

Appendices A and B are available online at https://doi.org/10.11647/OBP.0251#resources

Appendix A: Women's risk of next birth, by select characteristics (maternal grandmother)

Appendix B: Women's risk of next birth, by select characteristics (paternal grandmother)

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2 Note this chapter has been posted on the Open Science Framework website since 13/01/2020, after it was accepted for publication, so the references will reflect when the chapter was written and not the OBP publication date.

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