The consequences of sibling formation on survival and reproductive success across different ecological contexts: A comparison of the historical Krummhörn and Quebec populations[1]

Jonathan Fox*, Kai Willführ**, Alain Gagnon***, Lisa Dillon***, and Eckart Voland****

* Freie Universität Berlin, Germany

**Max Planck Institute for Demographic Research, Rostock, Germany

***Université de Montréal, Canada

****Justus-Liebig-Universität, Gießen, Germany

Abstract

This article investigates the relationship between additional siblings and the probability of offspring survival, marriage, and fertility across the historical populations of the Quebec (1670-1799) and Krummhörn regions (1720-1874). Both populations existed in agriculturally based economies, but differ in important ways. The Krummhörn population faced a fixed supply of land, which was concentrated amongst a small number of farmers. Most individuals were landless agricultural workers who formed a relatively competitive labor supply for the large farmers. In contrast, individuals in Quebec had access to a large supply of land, but with far fewer available agricultural workers, had to rely on their family to develop and farm that land. Results indicate that more siblings of the same gender were generally associated with increases in mortality during infancy and childhood, later ages of first marriage, and fewer numbers of children ever born. For mortality and age at first marriage, the effects of sibling formation appear strongest in the Krummhörn region. Notwithstanding these observed differences, the general consistency and robustness of the sibship effect across the different ecological and economic contexts is our most interesting result. In addition, through side-by-side comparison of across-family and within-family analyses, we argue that sibling competition – or sacrifice – is manifested as an internal familial dynamic, but is obscured in non-fixed effects models by a broader trend of family cooperation. Through this comparison we are able to reconcile family solidarity and sibling competition/sacrifice as co-existing phenomena. Results are robust to inclusion of covariate interactions with time, inclusion of indicators for high levels of extrinsic risk, estimation of shared frailty models, alternative methods of dealing with ties in the dataset, including recomposed families in the dataset, excluding individuals whose death dates are “heaped,” and excluding individuals born to large families.

Keywords: Sibling effects; infant mortality; child mortality; reproductive success; inter and intra familial competition; Saint Lawrence Valley; Krummhörn

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1. Introduction

This article investigates the relationship between the presence of additional siblings, in particular of the same gender, and the probabilities of survival, marriage, and reproductive success in the historical populations of the St. Lawrence Valley in Quebec, Canada between 1670 and 1799 and of Krummhörn, Germany between 1720 and 1874. These populations existed in dramatically different economic and social contexts. Although both were agriculturally based, they differed in the constraints faced in the amount of land and available labor. The population of the Krummhörn region faced a fixed supply of land and a large supply of agricultural labor to work that land, while the population of the Quebec region had a largely unconstrained supply of land but a limited labor force. These differences reflected themselves in the family formation of the two different populations. Fertility in the Quebec population approached natural fertility rates, and family sizes were correspondingly large (Charbonneau, Desjardins, Légaré, and Denis 2000). The stricter resource constraints faced by families in the Krummhörn population led to comparatively lower fertility and smaller family sizes (Voland and Dunbar 1995). We exploit these differences to test whether the intensity of intra-familial (within-family) competition is stronger or weaker in ecological contexts which faced constraints on available land (Krummhörn) versus those that faced constraints on available labor (Quebec).

In all ecological contexts, families engage in some combination of cooperation to ensure the overall success of the family and competition between its members over the available resources. The role of cooperation among family members, often considered within the cooperative breeders framework, has been demonstrated for a variety of different mammal species, and seems to be limited to those in which females can produce multiple offspring per birth (Lukas and Clutton-Brock 2012). Kinship networks have been shown to be important in the raising of children (Sear and Mace 2008), and the importance of kin in establishing reproductive success has been used to explain, for example, the presence of grandmothers (Hawkes 2004). Children, especially older children, are a potentially important source of household labor (Nag, White, and Peet 1978), and older siblings may contribute to the growth and development of younger siblings (Kramer 2005).

On the other hand, family members, and siblings in particular, represent resource competitors. Competition between siblings starts before birth when fetuses demand resources also in demand by their born siblings. Likewise, newborn and young children compete for limited parental resources (e.g. parental attention) that is shared with their siblings. The consideration of siblings as competitors is the perspective taken by the resource dilution model, which frames increases in family size as leading to a greater dilution of resources, which in turn adversely impacts individual outcomes for the children within the family. Steelman, Powell, Werum, and Carter (2002) review a variety of studies related to this framework that find resource dilution as measured by sibship size has been associated with poorer educational outcomes.

The cooperative breeders and resource dilution frameworks briefly outlined above indicate that siblings can act as both competitors and allies. Correlations between sibship size and outcomes will thus represent some combination between the above, and is an important consideration in explaining the wide variety of sibship effects found in the literature, some of which we survey in the section below. We expect the relative importance of the different effects to depend on the environmental context. In particular, we expect the benefit of additional siblings to be higher in contexts where inter-family (between-family) competition occurs with familial expansion and cooperation is important relative to contexts where intra-family competition leads to displacement and smaller families. We find the first context in the frontier and expanding population of historical Quebec and the second in the saturated and hierarchical society of historical Krummhörn.

To identify the effects of larger sibships on outcomes, this study relies on a thematically and geographically comparative approach. We contrast the effect of having additional siblings across three demographic outcomes (mortality for infants and children, age at first marriage, and the number of children ever born) in order to understand the relative impact of sibship size and configuration on demographic destinies at four different points in the life course: infancy, early childhood, at marriage, and in the course of reproduction.[2] From the reasons outlined above, we expect the presence of additional siblings to be more strongly associated with increases in mortality, delays at marriage, and fewer numbers of children ever born in the Krummhörn.

In addition to differences in the population contexts, we also expect to observe differences between males and females. Both the populations were patriarchal societies, and daughters did not commonly inherit landed property as sons did. Consequently girls may compete to larger degree with their sisters, and boys to a larger degree with their brothers (Beise and Voland 2008). Although there were differences in the transmission of inheritances to men in the two different societies, we do not have a strong reason to anticipate significantly different gender distinctions in the two societies, and therefore expect relatively uniform results across gender.

2. Previous Research

Research related to the relationship between sibship size and sibling outcomes has occurred in the context of a variety of academic disciplines using many different populations and estimated with a range of statistical methods. Perhaps then not surprisingly, findings related to the direction and magnitude of additional siblings on outcomes such as height, survival, parental care, and age at menarche are mixed. In this section, we do not wish to cover the entirety of the large literature that exists relating to sibship effects, but sample some of the different findings within this literature to demonstrate the variety of methods, populations, and findings. We refer readers interested in more comprehensive overviews to one of the multiple good survey articles covering this topic. Lawson and Mace (2011) reviews over ten different studies related to sibship effects in hunter-gatherer and agriculturist societies, and find the effects to be study and gender specific (Lawson and Mace 2011 pp. 334). Sear and Mace (2008) covers studies related to kinship effects

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[2] Although not presented in the article, sibship effects for the outcome of age at first birth have also been estimated and are qualitatively the same as those for age at first marriage.

in general for contemporary, historical, and agriculturist populations. They restrict their sample of sibship studies to those with siblings at least 3 years older to concentrate on findings related to potential “helpers at the nest.” Of the five studies covered, the presence of older siblings was positively associated with child survival in four, and not significantly related to child survival in the fifth (Sear and Mace 2008, pp. 6-7). Steelman et. al. (2002) approach from perspective of sociology, and, surveying a large set of articles, discuss the resource dilution and confluence theories behind the common finding of sibship size being negatively linked with educational and other status outcomes.

Without controlling for environment, directions and magnitudes of sibship effects on offspring outcomes need to be considered within the context of their population(s). Borgerhoff-Mulder (1998) provides a good example of this in its use of the Kipsigis agro-pastoralist tribe in Kenya to link offspring outcomes with parental investment (measured through family size), as it considers those effects within the specific cultural and institutional context of the society. When differences in the ecological contexts are observable, some studies have exploited that as an identifying mechanism. Gibson and Gurmu (2011), for example, compares families with inheritable resources to those without, arguing that the presence or absence of inheritable resources modulates the presence of sibling rivalry. Öberg (2015) is another article that tracks the relationship between sibship size and height over time during different periods of the demographic transition in Sweden to find that resource dilution can at least partly explain the negative association of sibship size with height.

In addition to identifying environmental shifts as in Gibson and Gurmu (2011) and Öberg (2015), a common approach in identifying sibship effects has been to control for observable environmental characteristics through the estimation of statistical models that include variable covariates. Such an approach appears in, for instance, Helfrecht and Meehan (2015). These authors use a least-squares regression approach to determine that for the Ngandu horticulturist society, older siblings have positive effects on the nutritional scores of same-aged siblings, while younger siblings are associated with negative impacts. Rickard, Lumma, and Russell (2009) use a similar approach in their linear random effects models, which also allow mortality in their models to be correlated for individuals with the same mother. They find that being born after an older brother reduces the probability of reproducing and is associated with a later age at first reproduction. Hagen and Barrett (2009) estimate random effects models at the household level and determine that while the presence of adolescent sisters lowers offspring survival, the presence of brothers increases it. Suanet and Bras (2014) employ the random effects method within the Cox regression framework (often referred to as shared frailty models) and find that among those individuals who married in Dutch provinces between 1840 and 1922 that sibling position became less important for marriage timing. All of the above methods rely on the same identifying assumptions, and as such any differences between the findings regarding sibship effects rests on either the choice of included covariates or the specific population for which they are estimated. An alternative method with weaker exogeneity assumptions has been employed by Lawson and Mace (2008) and Lawson and Mace (2009). Sibship effects in these studies are estimated with models that control for individual fixed effects, thereby identified in changes in the outcome variable over time. These models control for individual time-constant unobserved effects related to both the outcome variable and covariates, and estimating these for contemporary British families, Lawson and Mace (2008) determine the presence of siblings was associated with deficits in height, that older siblings were most detrimental, and that there was no differential effect on outcomes across sibling gender. Using the same study and similar methods, Lawson and Mace (2009) determine that larger sibships were associated with lower levels of parental care for each individual child and that while sibling gender did not influence parental care, daughters received more maternal investment and sons more from fathers.

In addition to the studies discussed above, a variety of research has investigated kinship effects for the historical Krummhörn and Quebec populations that form the basis for analysis in this manuscript. For the Krummhörn population, Voland and Dunbar (1995) test for differences across group means to determine that the presence of older sisters was associated with a higher probability of migration, lower survival, and lower reproductive success for girls, while the presence of older brothers was associated with relatively worse outcomes for boys. Using a logit model framework for the same population, Voland and Beise (2005) find that the presence of paternal grandmothers was associated with increased stillbirth mortality. Under the same methods and using the same population, Beise and Voland (2008) compare worker families with farmer families and show that sons of farmers were much more likely to migrate in the presence of more brothers relative to sons of non-agricultural workers.

The studies above show that while the social context matters, the presence of additional siblings and other kin is generally associated with worse outcomes within the historical Krummhörn population. In contrast, studies investigating kinship and sibship effects for the historical Quebec population have generally found positive effects. Beise (2005) uses parametric hazard models to investigate for Quebec a similar question to Voland and Beise (2005), and finds that the presence of maternal grandmothers was associated with reduced child mortality. Gagnon and Mazan (2009) estimate proportional hazard models for the Quebec population to determine that additional siblings during later life was associated with lower old-age mortality, and indicate that sibling cooperation was historically important for families in the Quebec region to ensure a family's success. Dillon (2010) also uses proportional hazard models to show that for Quebec, the presence of additional siblings was generally associated with earlier age at marriage, and that this effect depended on the sex and birth rank of the subject, the sex of the siblings, and whether the siblings were married or not (Dillon 2010 pp. 27-31).

The contrast between the ecological environments of the Quebec and Krummhörn has also been previously used as an identifying mechanism regarding the presence of a stepmother. Willführ and Gagnon (2012) compare expected Lorenz curves to the Lorenz curves for the different populations to find that while in the Krummhörn region there is little evidence for "causal" death clustering that would indicate variations regarding their maternal quality, Quebec mothers exhibit a distinctively higher concentration of infant deaths. Willführ and Gagnon (2013) apply the proportional hazards method of analysis to find that while in both populations maternal loss was associated with increased infant and child mortality, the remarriage of the father differed across the two contexts. Paternal remarriage was a more or less a neutral event in Quebec, but was associated with increased child mortality in the Krummhörn region.

The variation of kinship effects in general and sibship effects in particular across the historical Quebec and Krummhörn populations is indicative of the variation of effects present in the overall literature covering this topic. Even within the special issue within which this article appears, findings differ. De Keyser et. al. (2016), Hatton (2016), and Poulain et. al. (2016) all concentrate on the relationship between having additional siblings and height, and respectively determine that the effect of additional siblings is significant but explains very little variation in height, that it is a significant immediate impact which diminishes over time, and that additional siblings have no significant effect. We believe this variation is due to siblings acting simultaneously as both competitors and allies, with the relative importance of each effect depending on the specific ecological context of the society. In societies where the familial unit is essential for the success of its individual members and resource constraints are low (i.e. frontier societies), siblings should tend to act more as cooperative breeders. In societies where the familial unit is less important and resource constraints are high (i.e. saturated, hierarchical societies), siblings should tend to act more as competitors over diluted resources.

This study adds to the literature by comparing sibship effects over the starkly different ecological contexts of the historical Quebec and Krummhoern populations. Although these are different populations and so do not fit the test for a natural experiment, this is in the spirit of studies such as Gibson and Gurmu (2011) and Öberg (2015) which consider how changes in the ecological context of their population affect the presence of sibship effects. In addition, this study examines sibship effects using methods that both control and do not control for the effect of family in moderating them. Methods prevalent in the literature such as least-squares regression, logit models, or proportional hazard models do not control for the effect of the family. Even the shared frailty models or other random effects methods do not estimate effects different in their bias or consistency from the above models that do not allow outcomes to be correlated within families (Allison 2009 pp. 21-22). Although these can all be valid methods for estimating the effects of sibship size, they are unable to separate statistically the effect of being in a large family with the effect of having an additional sibling. Before discussing the specific methods, however, we turn to the two study populations which form the basis for our study.

3. The Québec and Krummhörn study populations

The historical populations of the Quebec and Krummhörn regions were agriculturally based societies, but differed socially and institutionally. The population of the St. Lawrence Valley was a frontier society where the success of the family was dependent on the number of children and relatives willing and able to work. The Krummhörn population had higher levels of population density and more limited farmland and working opportunities. The sample construction differed slightly between the two datasets, and below we outline both the characteristics of each population as well as how the sample for analysis was constructed.

3.1 The Krummhörn region [1720-1874]

The Krummhörn data derive from a family reconstitution study based on Protestant church registers, tax rolls, and other records of the Krummhörn region in Ostfriesland (East Frisia, Germany) from the eighteenth and nineteenth centuries. We outline some of the aspects of the Krummhörn dataset, but for a more detailed description of its construction, we refer interested readers to Lycett, Dunbar, and Voland (2000). The historical Krummhörn was divided into 33 neighboring parishes, of which all are part of the dataset. This dataset includes 34,708 marriages and 80,486 birth records for cohorts between 1720 and 1850 (sample extends to 1874).

Children from the Krummhörn region are included in the analysis if their sex is known and they derive from first marriages contracted after 1720. Before 1720 records are often incomplete and important families are overrepresented. After 1874, the church was no longer responsible for the records of births, deaths, and marriages, and this task had been transferred to the civil administration (Standesämter) whose records are not available. Because of this censoring, we exclude persons born after 1849 from the models that estimate child (age 1 to 15) survival) and exclude individuals born after 1829 from the models that estimate age at marriage and the number of offspring (up to age of 45). Also excluded are individuals born to recomposed families (17,291 persons and individuals part of the wealthy landowning class (2,214 persons).[3] Columns 1 and 2 of Table 1 list the number of males and females by birth cohort included in the analyses.

Geographically the region is bordered to the north and west by the North Sea, to the south by the River Ems, and to the east the Krummhörn by sandy and infertile soil which was in former times impenetrable moorlands. Within the Krummhörn region the environment consisted of very fertile marsh soil, good for both crops and livestock. Settlement of the area had been completed in the late medieval period (Ohling 1963), and there was no significant population growth during the study period. The region is therefore a saturated habitat in which the population faced a binding constraint on land and local resource competition (Voland and Dunbar 1995). Because access to land was limited, a stratified social structure arose among the population of the Krummhörn. At the one extreme existed the social upper class of large-scale farmers with capital and status, while at the other was a lower social class made up of small-scale farmers, tenants, craftsmen, and landless workers. About 70 percent of the families in the 18th century were part of this lower social class with either no land at all, or farms too small to ensure subsistence. Farmers with below subsistence farms supplemented their income by working for the large-scale farmers

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[3] The wealthy landowning class is considered significantly different from the rest of the population, so for that reason are omitted. These families are those that own more than 75 grasen of farmland (1 gras ~ 0.36 ha).The borderline of 75 grasen is arbitrary, but fits well with historic sources concerning the definition of the social and economic upper class (for references, see Beise 2001: pp. 53). Inclusion of the wealthy landowners does not qualitatively change the results.

of the social upper class (Willführ and Störmer 2015). Although there are no recorded periods of famine or wars, like in all other parts of Europe, smallpox and other virulent agents took a significant toll within the parishes of the region during the eighteenth century. Overall, the average family size was about four children (Voland and Dunbar, 1995). With regards to social institutions, a form of ultimogeniture was practiced in which the youngest son inherited the undivided farm from the father (Ohling 1963). All of the other offspring had to be recompensed, often with cash. Daughters could expect to receive half as much as a son. As a consequence, the Krummhörn population in general was characterized by a late age at first marriage and relatively small families, with late reproduction and low birth rates.

3.2 The Québec region [1670-1799]

Data for the historical population of Québec come from the Registre de la population du Québec ancien (RPQA), created by the Programme de Recherche en Démographique Historique (PRDH) at the University of Montreal. The RPQA is a family reconstitution database with more than 700,000 linked Catholic baptisms, marriages, and burials registered in the Québec parishes of the St. Lawrence Valley from settlement in 1621 up to 1799, as well as death acts from 1800 to 1850 of persons who died at age 50+ years (Dillon, Gentil-Amorevieta, Caron, Lewis, Guay-Giroux, Desjardins and Gagnon 2015). The population was very small at the beginning, with 3,246 inhabitants at the time of the first census in 1666 (Charbonneau and Légaré 1967, pp. 1033). With relatively low levels of immigration and only a minority of immigrants founding families within the colony, Quebec grew largely through natural increase, reaching a population size of more than 70,000 by 1760 (Charbonneau, Desjardins, Légaré and Denis 2000 pp. 104). The database identifies both inter- and intra-generationally linked family members, and thus allows us to operationalize variables pertaining to life events of family members and the subject. Individuals from Quebec are included in the sample if they have been born to first marriages contracted between 1670 and 1750 and have a known sex. This excludes 17,652 individuals, leaving 50,187 males and 51,840 females born to 14,456 families available for analysis. The number of individuals by birth cohort is given in columns 3 and 4 in Table 1. Some of the individuals born in the 1770 and 1780 cohorts may not have had time to get married, and would not have had time to bear all of their children, but comprise a relatively small proportion of the population. These dates are chosen to mitigate the effects of in and out migration in the region during the early colonial period when individuals were still arriving from France as well possible effects on marriage resulting from the French-Indian war during the 1750s; these dates also allow a sufficient window of analysis for individuals born to marriages contracted up to 1750.

In contrast to the Krummhörn region, French settlers of Canada faced few land constraints. Patterns of settlement in the Quebec colony were initially circumscribed by dependence on the St. Lawrence River for transportation and the need to avoid Amerindian raids, more frequent on the south side of the river (Laberge and Mathieu 1996 pp. 47). The western part of the St. Lawrence region, around Montreal, was favored for settlement on account of its longer growing season and proximity to one of the two cities of the colony (Laberge and Mathieu 1996 pp. 48). As conflicts with Amerindians subsided, colonization progressed along both sides of the St. Lawrence, creating a continuous series of settlements between Quebec City and Montreal (Laberge, Gouger, and Boisvert 1996 pp. 58). The majority of Quebec's inhabitants were farmers, with a smaller proportion of artisans, merchants, officers, professional, and the ruling elite living in urban areas. Montréal and Québec City were the only urban regions in the St. Lawrence Valley, and nearly 80 percent of the children within our sample were born in the countryside. Along the banks of the St. Lawrence River, development of the land was limited by available workforce. Work to clear new land of trees, pull stumps, burn vegetation debris, remove rocks from the soil and create farm fields could take a French-Canadian family 15 to 20 years (Boudreau, Courville and Séguin 1997 pp. 55). Inter- and intra-generational solidarity was necessary to achieve this goal. Quebec family solidarity is observed indirectly in a number of ways. For example, nearly a quarter of all families contracting marriages for their children between 1675 and 1799 contracted a marriage between sets of brothers and sisters, known as an exchange marriage (Caron and Dillon 2013 pp. 14). The settlement of the Quebec territory by families in extended kin groupings is evident in the concentration of particular last names within the seigneuries (Laberge and Mathieu 1996 pp. 53). Immigration of non-Catholic persons was extremely limited and marriage arrangements were therefore culturally endogamous (Charbonneau, Desjardins, Légaré and Denis 2000 pp. 110-111). Alongside the demands of settlement, Quebec society was dominated by both a strong Catholic church and a patriarchal family system which together enforced religious observance and paternal familial control, limiting the number of prenuptial conceptions and promoting high birth rates (Bates 1986 pp.263 and 268-9; Bouchard 2000 pp. 195; Cliche 1988 pp. 66).

The demands of settlement as well as conservative cultural expectations fostered early ages at marriage and high fertility. Individuals who belonged to a large sibship and who settled on the pioneer front tended to encourage the settlement of a large number of their own children in proximity. This led to an intergenerational transmission of total reproductive success in the colony (Gagnon and Heyer 2001). Average ages of first marriage were especially low for the early cohorts, with mean age at marriage for women in 1660 was under 15. The summary statistics in Table 2 are more heavily weighted towards the later cohorts, which were marrying relatively later as the sex ratio stabilized. For all of the cohorts however, French Canadian women married at younger ages and with greater intensity than their European counterparts. In addition, owing to their intense natural fertility regime as well as the resultant increases in population density, French Canadians exhibited relatively high infant mortality rates. Comparing across families in Quebec, we might therefore expect large sibships to be associated with higher infant and child mortality risks, but not strongly associated with delays in marriage or reductions in the number of children ever born.

3.3 Descriptive comparison of survival and marriage in Krummhörn and Québec

The contrasting environments, social contexts, and family dynamics of Krummhörn and Quebec are evident when we compare summary statistics of infant and child mortality and marriage in the two populations. Table 2 presents proportions dying in infancy and in childhood, proportions marrying, and ages at marriage for the 25,557 women and men in the Krummhörn sample and the 102,027 women and men in the Quebec sample. We observe a strong contrast between the two populations in terms of infant mortality. Of the 12,872 males and 12,685 females in the Krummhörn sample, 13.5% of males and 12.1% of females died before age 1. The proportions were nearly twice as high for Quebec: of the 50,187 males and 51,840 females in the Quebec sample, 24.1% of males and 20.7% of females died before age 1. The two regions displayed more similar proportions for child mortality. Among the 12,872 males and 12,685 females in the Krummhörn sample, 19.3% of males and 12.1% of females died between the ages of 1 and 15. In Quebec, among the 50,187 males and 51,840 females, 15.7% of males and 14.9% of girls died between age 1 and 15.

After setting aside infants and children who died before attaining maturity, we observe that higher proportions of men and women married in Quebec. In Krummhörn, of the 8,988 males who survived until at least the age of 15, 42.7% married at least once, 35.2% died without having married, and the residual 23% likely out-migrated, as their date of death and marital status was unknown. In Quebec, of the 32,099 males who survived until at least the age of 15, 85.7% married at least once while 14.3% died without having married. The same contrast is evident among women. Of the 9,091 Krummhörn females who survived until the age of 15, 46.9% married at least once, 30% died without having married, and the residual 22% likely out-migrated, as their date of death and marital status was unknown.[4] In Quebec, on the other hand, of the 34,959 females who survived until the age of 15, 87.7% married at least once while 11.3% died without having married. The Krummhörn-Quebec contrast in marriage intensity is quite stark: even if all of the individuals in the Krummhörn population who out-migrated and thus lack marital data eventually did end up getting married, the Quebec population was marrying at rates about 15 to 20 percentage points higher.[5] Finally, we observe an important difference in women's mean age at marriage in the two populations. Although some women and men did marry relatively early in the Krummhörn region, the average age at first marriage here was almost 27 for women, and nearly 29 for men. In contrast, women's average age at first marriage in Quebec was 23, fully 4 years younger than that seen among their counterparts in the Krummhörn region. Quebec men's mean age at marriage was 27, just two years younger than that observed among men in the Krummhörn region. For women in Quebec, the particularly young age at marriage produced a larger conjugal age gap than that seen in Krummhörn.

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[4] Some part of the differences in migration proportions is potentially due to the differences in the sample construction. The Quebec dataset was built off of death records, of which very few exist for outmigrating individuals. In contrast, the Krummhörn dataset includes all persons born in the region, many of which eventually outmigrated. There were also outmigrations from Quebec, though much less numerous, as indirect methods confirm that most individuals for which only the birth certificate exists died very early in life.

[5] The differences in migration could also affect the measures of marital timing. Individuals outmigrating likely marry at later ages, so the average age of marriage for the population as a whole, including those who outmigrated, is likely higher for the Krummhörn population than shown in Table 2. In terms of comparing the two populations, this should make it more difficult to find a difference in the timing of marriage.

These descriptive statistics for the Krummhörn region and Quebec resonate with our understanding of the Krummhörn region as a context marked by limited access to land, ultimogeniture and outmigration, and of the Quebec region as a context characterized by relatively ready access to land, efforts to settle all children through a variety of transmission practices, strong religious and patriarchal controls, and high infant mortality risks. It is thus not surprising that the estimated kinship effects for these populations surveyed in Section 2 differ from one another.

4. Methods

4.1 Event History Analyses

The presence of additional siblings is considered to potentially affect infant mortality, child mortality, the timing of marriage, and the number of children ever born. To estimate sibship effects for the number of children ever born, we specify Poisson models that both include and do not include family-level fixed effects to either control or not control for unobserved effects at the family level. This is accomplished by conditioning on the total number of birth counts present in a family, and is analogous to the standard linear fixed effects model.

In estimating sibship effects for infant mortality, child mortality, and the timing of marriage, we rely on a combination of Cox proportional hazard models Cox (1972) and hazard models stratified at the family level. The proportional hazard model approach is a very popular, if not the most popular model for event history data, and has been widely applied in the study of sibship and other kinship effects (e.g. Caron and Dillon 2013; Dillon 2010; Gagnon and Mazan 2009; Milne and Judge 2011; Suanet and Bras 2014; Willführ and Gagnon 2013). Its identifying assumptions in determining variable relationships are also similar to methods such as logit or linear regressions, so it is possible to compare estimated effects from the proportional hazards model to those estimated in the broader literature. Some authors prefer shared frailty models to proportional hazard models, as these allow outcomes such as mortality to be correlated within the family or other group units. Such a framework improves the efficiency of the proportional hazards estimator (smaller standard errors), but given the size of the Quebec and Krummhörn datasets and the current state of computing power, these methods are impractical.[6] As an alternative, we adjust the cox models through the option cluster, where we cluster at the household level. Time in the model is measured in days, which mitigates the common problem proportional hazards models have with data that exhibits a large number of ties. None of the sets of ties in the dataset are over 3% of the sample size, which is significantly below the proportion for which the number of ties could be considered “large” (Alison 2014, pp. 50). For some of the outcomes below, there are instances in which examination of the Schoenefeld residuals indicated the proportional hazard assumption may be violated. For these cases we have estimated models

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[6] Attempts at estimation were only possible for the smaller Krummhörn dataset, and for that, only for the infant age group. Hazard ratio estimates in the proportional hazards model and shared frailty model for this group were nearly equivalent.

(results available in the appendix) including interactions with time to determine whether the qualitative results were affected.

The cox proportional hazard model identifies sibship effects based off of both the variation within and between families. As such, it can be difficult to determine the reasons behind any findings without additional information regarding the ecological context of the population. For example, if additional siblings cooperate and contribute towards greater familial success, and that greater familial success translates into improved outcomes for each of its individual members, then the presence of additional siblings may be associated with more positive outcomes. Alternatively, if wealthy individuals are able to turn that wealth into reproductive success thereby producing larger families, then the presence of additional siblings would also be associated with more positive outcomes. Evidence of the first scenario has been found for the historical Quebec population (Gagnon and Mazan 2009), and evidence for the second for the historical Krummhörn (Willfϋhr and Störmer 2015). For both of these populations then, family size is an indicator of familial success, albeit for different reasons.

To control for unobserved effects associated with family size, we estimate Cox regression models stratified at the family level. These models estimate separate likelihood functions for each of the different families in the dataset, so allow each family to have their own individual hazard function. The key difference between the stratified Cox regression and the proportional hazards model is that the former identifies sibship effects using the variation within families, but not between families. Such a framework is commonly referred to as a fixed effects method, and we refer subsequently to these models as the "family fixed-effects" models. In these models, each individual is compared to their family members and the differences in that family composition over time. Since such a framework controls for unobserved effects of the family, there may be significant differences in comparison with the estimates of the proportional hazard models. Estimates from the latter indicate the effect of being born to a larger family, and all the good and bad associated with that.[7] Estimates from the former indicate the effect of having an additional sibling, and how that additional sibling impacts survival and marital timing. For the fixed effect models, the familial mean is differenced out of the different dependent variables, resulting in all singulate observations being omitted from the family fixed effect analysis. In addition, the family fixed effects model controls for a large portion of the variation in individual outcomes. As such, in the sections below, we wish to emphasize the direction, significance, and difference in magnitude between the two populations rather than the specific hazard ratio estimates themselves.

Based off of the prior research and ecological contexts regarding the two populations, when the hazard ratio estimates from the proportional hazard model indicate positive effects of sibship size, but the hazard ratio estimates from the family fixed-effect models indicate negative, we interpret that as resulting from different factors in the two populations. For the Quebec, we

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[7] Especially large families may have a disproportionate impact on the results in the following sections, as these provide more observations for comparison and thus exert a greater weight in the calculation of the estimates. Limiting to families with fewer than 10 children did not affect the results.

interpret that as indicating sibling cooperation which then leads towards greater success of the family, while for Krummhörn we interpret that as indicating higher socioeconomic status (SES) families being able to turn their relative wealth into reproductive success. Ultimately, however, we cannot be sure of the reason driving the differences between the proportional hazard models, so we base our primary findings on the stratified Cox regression models.

4.2 Description of covariates

For all of the different models estimated, we include a set of covariates controlling for environmental conditions into which a person was born and lives. The primary variables of interest are those for sibling formation, namely the number of older brothers, younger brothers, older sisters, and younger sisters. These four variables are included for all of the different analyses save the infant mortality models, for which only a few cases exist where infants had younger siblings. Through these four variables we track the relationship between sibling formation separately for boys and girls.

The rest of the included covariates are included only because they may be correlated with both the dependent outcome and sibling formation and as such are discussed only briefly in the sections below. The first of these is an indicator for whether a person was born in an urban environment. This is only relevant for individuals in the Quebec population, as all individuals in the Krummhörn are considered to have lived in a rural setting. Covariates are also included for whether an individual experienced paternal loss or maternal loss, as well as a set of indicators for the ages of both the father and the mother. An individual's birth cohort is also included, to control for changes in the populations over time, as well as that individual's birth rank. We include the latter in order to isolate the effect of having an older or younger sibling, independent of any birth order effects. The final covariate included is an indicator for whether the next older sibling has died. This included only for the infant and child survival models, and is included since the loss of that older sibling may indicate extra available resources for infants or young children when birth intervals are small.

4.3 Testing for differences in the populations

Models are estimated separately for each population, and for the outcomes of infant mortality, child mortality, and timing of marriage, we wish to test for differences between the two populations. We do so through pooling the two populations and estimating a model that includes the full set of covariates (save "Birth Cohort," as the two populations do not completely overlap) as well as a full set of interactions for all of the different independent variables with an indicator for whether an individual was in the Quebec population. When the coefficients on these interaction terms are statistically significant at the 5 percent level, we consider the effects between the populations to be statistically significantly different. The full set of estimates from the pooled models is available in the appendix, and we indicate hazard ratio estimates which are statistically different between the two populations with a bold font in the tables.

5. Results

Many studies suggest gender differences among sibship effects (e.g. Borgerhoff-Mulder 1998; Milne and Judge 2011; Rickard et. al. 2009). As such, each of the above models is estimated separately for females and males. Tables 3 through 6 each feature eight models, with the first four devoted to the sample of females and the last four devoted to the sample of males. Within each of these sets are two pairs of models, the first pair presents results from the proportional hazard model (Family fixed effect = N) and the second from the family fixed-effect model (Family fixed effect = Y). Within each pair is a model using the sample of individuals from Krummhörn (KH), and one using the sample of individuals from Quebec (QUE).

5.1 Mortality for infants and children aged 1 to 15

Tables 3 and 4 present estimates from Cox proportional hazard models and family fixed-effects Cox regression models on the hazard of death prior to age 1 and between the ages of 1 and age 15, respectively. Columns 1 and 2 (girls) and 5 and 6 (boys) in Table 3 present the estimates from the proportional hazard models, and show that female and male infants in both populations faced lower probabilities of death if they were born into families with more brothers and sisters, all other variables being equal. In addition, this effect was stronger in the population of the Krummhörn. Infants and children in Krummhörn may have been even more likely to survive when they had a greater number of brothers and sisters because they were situated within particularly successful families: in this case, having a large family in a low fertility context signified a family's success to a greater extent than it did in Quebec.

Controlling for the family effect, the relationship between the number of siblings and infant mortality reverses direction. These estimates are given in columns 3 and 4 (girls) and 7 and 8 (boys). Within families, the presence of an additional older brother or older sister was associated with increased infant mortality for both girls and boys, although the association between older brothers and female infant mortality was not statistically significant. [8] From the estimates in columns 3, 4, 7, and 8, there is evidence of differences between both populations and sexes. The hazard of death for girls was most significantly affected by the presence of older sisters, while for boys, by the presence of older brothers. Although the effects were present in both populations, they were across the board weaker within the population of Quebec. And for boys in Quebec, having additional older sisters was not significant in magnitude or statistically. Other variables with statistically significant coefficients and associated with an increased hazard of death were whether an individual was born in an urban environment (Quebec only), the loss of a mother or father, higher levels of maternal age (Quebec only), and for Krummhörn, whether an individual was part of a later birth cohort. Variables with statistically significant coefficients that

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[8] The number of siblings can also affect infant survival through the replacement effect, as parents may invest more in an infant if their next older sibling has perished. As such we include a variable to control for this possible mechanism.

were associated with a decreased hazard of death were an indicator for whether the next oldest sibling had died and the birth rank of the child. Since birth rank is included in combination with the sibling variables, it acts as a proxy for the number of siblings who have died in the non-fixed effects models and a measure of placement within the family in the models controlling for family-fixed effects.

Table 4 presents estimates for the hazard of dying for children between ages 1 and 15. From columns 1 and 2 (girls) and 5 and 6 (boys) family size was generally associated with a lower hazard of death for both boys and girls, and although the association seems to be slightly stronger for the Krummhörn that difference was not statistically significant. With the inclusion of the family fixed effect, the relationship again reversed so that more brothers and sisters were mostly associated with increased child mortality. Two exceptions to this were the number of older sisters for girls and the number of younger sisters for boys. These exceptions appeared in both populations, and were not statistically significantly different. The populations did differ significantly regarding the association between the number of brothers and child mortality. The hazard of death for children was higher with additional brothers (both older and younger), but was relatively less strong for the individuals in Quebec.

Across both populations, the association between having additional siblings and infant and child mortality was negative if the family effect was controlled for, and positive if not. There is also evidence of differential impact by gender. For the fixed effects models, both brothers and sisters negatively impacted infant mortality, but brothers had the strongest effect for male infants and sisters the strongest for female infants. This relationship was slightly more complex for children aged 1 to 15, as the effect of additional older brothers was most strong for boys, but the negative impact of additional younger brothers was most strong for girls. Younger sisters were associated with an increased hazard of death for girls, but a decreased hazard of death for boys. Lastly, although evidence of sibship effects associated with increased mortality is present in both populations, the magnitude of the effects are strongest for children of the Krummhörn.

5.2 Timing of marriage

Table 5 presents estimates from Cox proportional hazard models and family fixed –effects models on the hazard of marriage. To make the two samples comparable in the face of outmigration from the Krummhörn, the sample is limited to those individuals who eventually married. As such, the hazard ratios presented in Table 5 reflect the waiting time to marriage.

For all of the different models presented, fixed effect and non-fixed effect alike, larger families were associated with delayed age at first marriage. Across the different sibling variables, the only statistically significant hazard ratio estimates which represented exceptions to this were for younger sisters in the Quebec region for girls with the family fixed effect controlled for (column 4), and for younger brothers in the Quebec region for boys for both the fixed effect and non-fixed effect models (columns 6 and 8). Having 1+ older sisters was generally associated with delayed age at marriage for both boys and girls, although the estimated hazard ratios were not statistically different than one for girls in the Quebec population (columns 4 and 8). The estimated hazard ratios on the number of older brothers were statistically significant and associated with delays in marriage for both boys and girls across both the fixed effect and non-fixed effect specifications.

The association between marital timing and the presence of brothers was significantly different between the Krummhörn and Quebec populations. This is most clearly seen looking at the estimated hazard ratios on the number of younger brothers. While in Quebec additional younger brothers are associated with an earlier age at first marriage, in Krummhörn the estimated association was for a delayed age at first marriage. And while the estimated effect from the number of older brothers is statistically significant and in the same direction for both populations, the magnitude of the effect is weaker in Quebec. The only other statistically significant differences between the populations were on the estimated hazard ratios for the number of older sisters for girls and the number of younger sisters for boys. Both were associated with increased waiting time to first marriage.

Other estimated hazard ratios that remain statistically significant once the family fixed effects are controlled for (columns 3, 4, 7, and 8) include those for maternal and paternal mortality and maternal and paternal age. In both populations the event of a parent death is associated with an earlier age at first marriage. Individuals whose parents are older also tend to get married relatively early.

These models focus only on the presence or absence of siblings and as such do not fully capture family dynamics over time. These are potentially important, as outlined in Dillon (2010), which finds that the hazard of marriage tended to be amplified if the subject had married older siblings, and attenuated by the presence of unmarried older and marriage younger siblings. As such, the incidence and timing of sibling marriages informs family dynamics, and could be the mechanism responsible for the associations described above. In order to preserve focus and space, we present these results in the appendix. From these results, the presence of married siblings does seem to be an important mechanism linking sibship size to marital outcomes. Having married siblings is strongly associated with a longer waiting time to marriage for both males and females, and seems most important in explaining the relationship between the number of married younger sisters and the waiting time to marriage for girls and the number of married younger brothers and the waiting time to marriage for boys. Controlling for family-fixed effects and the number of married siblings by age and sex, the presence of unmarried older sisters are associated with a shorter waiting time to marriage for girls in both populations (not statistically significant in the Krummhörn population). In the corresponding specification for boys, older brothers are associated with a shorter waiting time to marriage for boys in the Quebec population, but a longer waiting time to marriage for boys in the Krummhörn.

5.3 Number of children over the life course

From the non-fixed effects Poisson models (columns 1 and 2 for females and 5 and 6 for males), persons born to families with larger numbers of brothers tended to have fewer births if they were in the Krummhörn population, but more births if they were in the Quebec population. These results were statistically significant at the 5% level only for girls, however.[9] For these models, the presence of sisters was significantly associated with fewer births for girls in the Krummhörn, and higher numbers of births for boys in the Quebec region. From the coefficients on the variables controlling for the number of siblings at age 15, losing siblings was generally associated with fewer numbers of births for both boys and girls. Comparing the models that control for the effect of the family to those that do not, the importance of family effects in determining the association between sibling presence and birth outcomes seem most important for the population in Quebec. While in the non-fixed effects models larger numbers of brothers or sisters tended to be associated with higher numbers of births, in the fixed effects models the opposite was the case. From column 4, additional sisters tend to reduce the number of births for girls, and from column 8, additional brothers tend to reduce the number of births for boys. For both the fixed effect and non-fixed effect models, boys who had more sisters tended to have more children.

6. Discussion

Intra-familial competition over resources has been demonstrated in contexts ranging from historical populations in Finland (e.g. Rickard, Lumaa, and Russell 2009; Nitsch 2014), Sweden (e.g. Öberg 2015), Germany (e.g. Beise and Voland 2008; Voland and Dunbar 1995), and Holland (e.g. Suanet and Bras 2014), to contemporary horticulture societies in Ethiopia (e.g. Gibson and Gurmu 2011), Kenya (Borgerhoff-Mulder 1998), and Ecuador (e.g. Hagen and Barrett 2009), to contemporary western societies in Britain (e.g. Lawson and Mace 2008; 2009) and Australia (e.g. Milne and Judge 2011). This study compared the historical populations of the Krummhörn and the Quebec regions to gain further insight on the relationship between sibship size and offspring outcomes. For each of the outcomes considered above – infant and child mortality, waiting time to marriage, and childbearing – we found, as did Beise and Voland (2008), and Voland and Dunbar (1995), that negative effects associated with sibling formation were strongest between same-sex siblings: having additional sisters was associated with poorer health and reproductive outcomes for girls than for boys, and vice versa. For some outcomes, additional siblings of the opposite sex even seemed to be beneficial. For example, additional brothers (sisters) were associated with decreased probability of death for infant girls (boys), and additional sisters were associated with an increase in the reproductive success of males in the Quebec region. As many of the studies cited above have found, we also find notable differences across the two populations: beyond the higher mortality risks, higher proportion of persons married, and younger ages at marriage in Quebec, we observed some distinct sibship influences on those very outcomes. Within the Krummhörn region, the presence of additional same-sex

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[9] This is evidence of overall reproductive success in the Quebec population: in accordance with the "useful reproduction" literature, successfully reproducing families tended to produce more successfully reproducing generations

siblings seemed to wield more detrimental effects on subjects' demographic "success" than in the Quebec region, increasing the mortality of children aged 1 to 15 and delaying the waiting time to marriage.

The inclusion or exclusion of the family fixed effect seems to be most important in identifying the sibship effect when mortality was the outcome of interest. Using just the proportional hazards models, larger families in both populations tended to have lower levels of mortality for both children aged 1 to 15 and infants. This influence was reversed when families were allowed to have their own hazard function and the effects were identified using within-family differences. For these models, additional siblings were associated with higher infant and child mortality. Furthermore, the presence of additional same-sex siblings in Quebec households did not seem to incur the same child mortality penalty that it did in the Krummhörn region, even though Quebec families in general experienced increasing levels of child mortality across the 18th century. Perhaps the presence of multiple same-sex children did not strain household resources to the same extent within Quebec pioneer families, who enjoyed greater access to farm produce, livestock, game, and fish than their European counterparts. In addition, our models control for the survival of the immediately preceding child, a control which may restrain the interdependent link between high fertility and high infant mortality. Consistent with this particular result are the estimates across all of the different outcomes that indicate a less detrimental presence of additional older brothers to younger sons in the Quebec population. We postulate that this is due to the importance of sharing labor by siblings in that society. Most of the sons within the Quebec sample were able to build their own farm, and the costs of an additional brother are partly mitigated by their positive contribution to the family farm development.

Turning to our fertility outcome, the elevated negative impact of same-sex siblings in the Krummhörn region versus Quebec was only apparent in proportional hazard analyses which did not control for family-fixed effects. Results from these models indicate that additional brothers were significantly associated with higher numbers of births for both women and men in the Quebec region; this result may reflect intergenerational transmission of fecundability as a population characteristic. However, inclusion of the family-fixed effect in the Quebec model attenuated the positive association between additional brothers and children born to women such that it was essentially zero; moreover, the family-fixed effect model estimated that additional brothers had a significant and negative effect on the number of children born to men. In this case, focusing our analysis on within-family variation allows us to glimpse an effect of sibling competition – or rather sibling sacrifice – that the across-family analysis cannot illuminate for the Quebec population as a whole. The number of children born during the life course is related to age at marriage: siblings who married later bore fewer children. Those siblings who married later were not randomly selected, as siblings within the Quebec population of high birth rank experienced a longer waiting time to marriage Dillon (2010). The use of the fixed effects model to highlight within-family variation in birth outcomes allows this sibling differentiation to emerge. Thus, the negative effect of additional brothers on the number of own children born during the life course in Quebec probably reflected younger brothers' delayed transition to childbearing (via marriage) if they had several older brothers.

Notwithstanding the observed differences between Quebec and Krummhörn, the general consistency and robustness of the sibship effect across the different ecological and economic contexts is our most interesting result. Although there existed some differences in the magnitude of the effect, the presence of older siblings of the same gender was similarly associated with increases in infant and child mortality, a longer waiting time until marriage, and fewer children ever born, particularly when a family-fixed effect model was adopted. In fact, comparing results of models which included family-fixed effects to those which did not has proven an important procedure for guiding our interpretations. In general, the inclusion of the family-fixed effect either attenuated previously positive point estimates for the presence of additional siblings, or intensified those that were previously negative. The association of larger sibships with higher infant and child mortality, longer waiting times until marriage, and lower fertility suggests that having additional siblings creates pressures on survival and delays in life course transitions within families in different ecological contexts. This association holds true whether or not the wealthy land owners are included in the Krummhörn population sample. In fact, contextual historical information on Quebec and Krummhörn suggest that the negative pressure occasioned by additional siblings was not driven primarily by the mechanism of inheritable resources, so the presence of an association between additional siblings and poorer health and reproductive outcomes goes against the argument that sibling competition is a direct result of competition over inheritable resources found in Gibson and Gurmu (2011).

In both historical populations, inheritable resources were of relatively small concern for the majority of the population – but for different reasons. Quebec families within the sample were able to settle their sons within existing parishes or move to newly-opened parishes along the St. Lawrence River, thereby keeping adult sons often in close proximity to other family members. For boys in the Krummhörn region, the stark inequality meant that for most there was no land to inherit. Nevertheless, having older same-sex siblings, and in some cases opposite-sex siblings, was still associated with higher mortality, longer waiting times to marriage, and lower numbers of children ever born in both populations. Though new farmland in Quebec was relatively available during the French regime, developing new family farms entailed considerable work and occasioned delayed transitions. Thus, while Quebec family life was predicated on family solidarity, achieving this family solidarity required sacrifices by certain members of the family group. Setting across-family and within-family analyses side-by-side, we argue that sibling competition – or sacrifice – is manifested as an internal familial dynamic, but is obscured in non-fixed effects models by a broader trend of family cooperation. Thus, by comparing across-family and within-family models, we can reconcile family solidarity and sibling competition/sacrifice as co-existing phenomena.

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Tables

Table 1: Sample cohorts, Krummhörn region (1720-1824) and St. Lawrence Valley, Quebec region (1670-1799)

Cohort	**Krummhorn**		**Quebec**	
	Female	**Male**	**Female**	**Male**
	1	**2**	**3**	**4**
1670			234	195
1680			1,012	859
1690			1,862	1,763
1700			3,320	3,168
1710			3,984	3,888
1720	39	46	5,354	5,155
1730	420	407	7,816	7,590
1740	746	755	9,864	9,398
1750	817	821	11,564	11,351
1760	933	954	5,613	5,609
1770	1,086	1,169	1,192	1,178
1780	971	1,059	25	33
1790	997	967		
1800	1,140	1,201		
1810	1,101	1,185		
1820	1,325	1,273		
1830	1,347	1,284		
1840	1,275	1,241		
1850	488	510		
Total	12,685	12,872	51,840	50,187

Notes: The dates above correspond to when the individuals are born. The observation range lasts until 1874 for the Krummhörn region, and 1799 for the Quebec region. Thus individuals born in the final Krummhörn cohort are observed until age 24 and individuals born in the final Quebec cohort are observed until age 20. All individuals in the 1760, 1770, and 1780 cohorts in Quebec were born to marriages contracted before 1750.

Tables

Table 2: Summary statistics, infant and child mortality, proportions marrying, and age at marriage
Krummhörn region (1720-1824) and St. Lawrence Valley, Quebec region (1670-1799)

nber	# born between 1720 and 1849	# died in infancy	# died between ages 1 and 15	# married once	# never married	Age at first marriage		
						Average	Min	Max
mmhorn								
Female	12,685	1,532	2,062	4,266	2,723	26.6	15.4	65.4
Male	12,872	1,737	2,147	3,839	3,164	28.8	18.3	68.0
Total	25,557	3,269	4,209	8,105	5,887			
bec								
Female	51,840	10,739	6,142	30,671	3,954	22.8	15.0	65.5
Male	50,187	12,096	5,992	27,498	4,600	26.6	15.1	69.2
Total	102,027	22,835	12,134	58,169	8,554			

portion	# born between 1720 and 1849	# died in infancy	# died between ages 1 and 15	# married once	# never married	Age at first marriage		
						Average	Min	Max
mmhorn								
Female	49.63%	12.08%	16.26%	46.93%	29.95%			
Male	50.37%	13.49%	16.68%	42.71%	35.20%			
Total	100.00%	12.79%	16.47%	44.83%	32.56%			
bec								
Female	50.81%	20.72%	11.85%	87.73%	11.31%			
Male	49.19%	24.10%	11.94%	85.67%	14.33%			
Total	100.00%	22.38%	11.89%	86.74%	12.76%			

Notes: For adults in the Krummhoern region, 2,102 female and 1,985 males likely outmigrated and as such their marital status and possible timing of migration is unknown. For the Quebec population, marital status is unknown for 334 males and 1 female.

Tables

Table 3: Risk of infant mortality, Persons born in the Krummhörn region(1720-1824) and
Cox Proportional Hazard Model (with and without fixed effects)

Sex	Girls	Girls	Girls	Girls	Boys	Boys	Boys	Boys
Model	1	2	3	4	5	6	7	8
Age	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Population	KH	QUE	KH	QUE	KH	QUE	KH	QUE
Variables								
N elder brothers (alive)	__0.793**__	__0.874**__	1.129	1.015	__0.777**__	__0.885**__	__3.330**__	__1.983**__
	__(0.029)__	__(0.008)__	(0.094)	(0.020)	__(0.027)__	__(0.008)__	__(0.253)__	__(0.037)__
N elder sisters (alive)	__0.791**__	__0.895**__	__2.949**__	__2.139**__	__0.793**__	__0.864**__	__1.202*__	__1.002__
	__(0.030)__	__(0.008)__	__(0.233)__	__(0.042)__	__(0.028)__	__(0.008)__	__(0.089)__	__(0.018)__
Born in urban environment (Yes)		1.659**		1.588**		1.847**		1.417**
		(0.037)		(0.110)		(0.039)		(0.087)
Paternal Loss	1.399	1.654**	1.397	1.309+	1.443+	1.420**	1.000	1.263+
	(0.353)	(0.148)	(0.642)	(0.187)	(0.311)	(0.125)	(0.407)	(0.175)
Maternal Loss	5.138**	3.895**	3.089**	3.302**	5.033**	3.960**	2.916**	2.834**
	(0.617)	(0.253)	(0.913)	(0.429)	(0.628)	(0.256)	(0.964)	(0.362)
Paternal Age (Ref: 20-30)								
<20	0.591	0.902	0.746	1.240	0.623	1.082	0.542	1.222
	(0.592)	(0.251)	(1.059)	(0.480)	(0.624)	(0.281)	(0.618)	(0.432)
30-40	0.865+	0.899**	0.716*	0.954	0.978	0.926**	0.941	0.900*
	(0.069)	(0.026)	(0.101)	(0.045)	(0.073)	(0.025)	(0.122)	(0.040)
40-50	0.892	0.828**	0.731	0.992	0.824+	0.866**	0.942	0.907
	(0.102)	(0.032)	(0.161)	(0.076)	(0.093)	(0.031)	(0.196)	(0.066)
50-60	1.136	0.700**	1.095	1.048	0.791	0.842**	0.999	0.930
	(0.246)	(0.042)	(0.447)	(0.125)	(0.197)	(0.047)	(0.432)	(0.107)
>60	0.000	0.787	0.000	1.211	1.449	0.747+	1.379	0.925
	(0.000)	(0.118)	(0.000)	(0.299)	(1.453)	(0.111)	(2.047)	(0.234)
unknown	0.902	0.884	0.380	1.000	0.957	1.017	2.134	1.000
	(0.069)	(0.075)	(0.250)	(0.000)	(0.070)	(0.079)	(1.483)	(0.000)
Family fixed effects	N	N	Y	Y	N	N	Y	Y
N IDs (aged 0 or 1)	12,685	51,840	12,685	51,840	12,872	50,187	12,872	50,187
N deaths	1,532	10,739	1,532	10,739	1,737	12,096	1,737	12,096
Observations	26,177	105,304	26,177	105,304	26,420	101,161	26,420	101,161

Notes: Standard errors clustered at the household level are in parentheses

** p<0.01, * p<0.05, + p<0.1

Tables

Population samples are those indicated in Table 1 and discussed in sections 3.1 (Krummhörn) and 3.2 (Quebec)

Family fixed effects models are those which indicate “Family fixed-effects = Y” and are estimated using the stratified proportional Cox regression model, where each family is assumed to have its own baseline hazard model and separate likelihood functions are estimated for each household.
KH indicates estimates from the Krummhörn sample, QUE indicates estimates from the Quebec sample

Bolded hazard ratio estimates indicate those which are statistically different between the two populations. These differences are tested through pooling the two populations and estimating a model that includes the full set of covariates (save “Birth Cohort,” as the two populations do not completely overlap) as well as a full set of interactions for all of the different independent variables with an indicator for whether an individual was in the Quebec population. When the coefficients on these interaction terms are statistically significant at the 5 percent level, we consider the effects between the populations to be statistically significantly different.

Table 3 continued: Risk of infant mortality, Persons born in the Krummhörn region(1720-1824) and Cox Proportional Hazard Model (with and without fixed effects)

Sex	Girls	Girls	Girls	Girls	Boys	Boys	Boys	Boys
Model	1	2	3	4	5	6	7	8
Age	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1	0 to 1
Population	KH	QUE	KH	QUE	KH	QUE	KH	QUE
Maternal Age (Ref: 20-30)								
<20	1.712*	1.256**	0.956	1.273**	2.075**	1.335**	1.673	1.549**
	(0.403)	(0.060)	(0.387)	(0.089)	(0.454)	(0.058)	(0.617)	(0.098)
30-35	1.066	0.945+	1.040	1.022	1.030	0.914**	1.060	0.951
	(0.090)	(0.027)	(0.139)	(0.045)	(0.081)	(0.025)	(0.132)	(0.040)
35-45	1.071	0.902**	1.002	1.166*	1.009	0.887**	1.015	1.078
	(0.104)	(0.033)	(0.170)	(0.077)	(0.092)	(0.030)	(0.166)	(0.068)
>45	0.867	0.844	1.335	1.666**	1.032	0.847	1.822	1.498**
	(0.319)	(0.097)	(0.770)	(0.272)	(0.409)	(0.090)	(1.009)	(0.229)
unknown	1.057	1.041	1.857	1.000	0.935	1.078	0.241*	1.000
	(0.074)	(0.158)	(1.682)	(0.000)	(0.062)	(0.143)	(0.155)	(0.000)
Birth cohort (decades)	0.958**	1.126**	1.217+	0.925*	0.947**	1.112**	1.285*	0.963
	(0.008)	(0.006)	(0.139)	(0.035)	(0.008)	(0.006)	(0.132)	(0.034)
Birth Rank (ascending order)	1.156**	1.139**	0.705**	0.899**	1.185**	1.137**	0.658**	0.937**
	(0.023)	(0.006)	(0.032)	(0.010)	(0.022)	(0.006)	(0.027)	(0.010)
Next elder sibling has died	0.797**	1.165**	0.543**	0.802**	0.996	1.131**	0.630**	0.762**
	(0.065)	(0.027)	(0.055)	(0.022)	(0.071)	(0.025)	(0.057)	(0.020)
Family fixed effects	N	N	Y	Y	N	N	Y	Y
N IDs (aged 0 or 1)	12,685	51,840	12,685	51,840	12,872	50,187	12,872	50,187
N deaths	1,532	10,739	1,532	10,739	1,737	12,096	1,737	12,096
Observations	26,177	105,304	26,177	105,304	26,420	101,161	26,420	101,161

Notes: Standard errors clustered at the household level are in parentheses

** p<0.01, * p<0.05, + p<0.1

Population samples are those indicated in Table 1 and discussed in sections 3.1 (Krummhörn) and 3.2 (Quebec)

Family fixed effects models indicated by “Family fixed-effects = Y” and are estimated using the stratified proportional Cox regression model, where each family is assumed to have its own baseline hazard model and separate likelihood functions are estimated for each household.
KH indicates estimates from the Krummhörn sample, QUE indicates estimates from the Quebec sample

Tables

Bolded hazard ratio estimates indicate those which are statistically different between the two populations. These differences are tested through pooling the two populations and estimating a model that includes the full set of covariates (save “Birth Cohort,” as the two populations do not completely overlap) as well as a full set of interactions for all of the different independent variables with an indicator for whether an individual was in the Quebec population. When the coefficients on these interaction terms are statistically significant at the 5 percent level, we consider the effects between the populations to be statistically significantly different.

Tables

Table 4: Risk of child mortality (age 1 to 15), Persons born in the Krummhörn region(1720-1824) and Quebec (1670-1799), Cox Proportional Hazard Model (with and without fixed effects)

Sex	Girls	Girls	Girls	Girls	Boys	Boys	Boys	Boys
Model	1	2	3	4	5	6	7	8
Age	1 to 15	1 to 15	1 to 15	1 to 15	1 to 15	1 to 15	1 to 15	1 to 15
Population	KH	QUE	KH	QUE	KH	QUE	KH	QUE
Variables								
N elder brothers (alive)	0.866**	0.916**	**1.464****	**1.110****	0.874**	0.911**	**7.808****	**3.853****
	(0.028)	(0.012)	**(0.124)**	**(0.036)**	(0.028)	(0.012)	**(0.700)**	**(0.138)**
N younger brothers (alive)	0.980	1.040*	0.883	0.910**	**0.956**	**0.990**	1.532**	1.471**
	(0.040)	(0.021)	(0.075)	(0.032)	**(0.038)**	**(0.021)**	(0.112)	(0.048)
N elder sisters (alive)	0.894**	0.924**	**6.669****	**3.843****	0.869**	0.906**	**1.483****	**1.140****
	(0.029)	(0.012)	**(0.576)**	**(0.132)**	(0.028)	(0.012)	**(0.128)**	**(0.038)**
N younger sisters (alive)	1.003	1.017	1.267**	1.451**	**0.991**	**0.984**	0.858+	0.840**
	(0.041)	(0.020)	(0.090)	(0.043)	**(0.039)**	**(0.020)**	(0.074)	(0.030)
Born in urban environment (Yes)		1.948**		1.776**		2.163**		1.555**
		(0.059)		(0.166)		(0.066)		(0.155)
Maternal Loss	1.483**	1.481**	1.274	1.388**	1.507**	1.498**	1.697**	1.875**
	(0.120)	(0.077)	(0.261)	(0.150)	(0.119)	(0.081)	(0.342)	(0.214)
Paternal Loss	1.179+	1.217**	1.205	1.272*	1.069	1.159*	1.255	1.118
	(0.103)	(0.068)	(0.237)	(0.133)	(0.091)	(0.068)	(0.235)	(0.127)
Paternal Age (Ref: 20-30)								
<20	1.019	0.447	0.475	0.320	0.000	0.946	0.000	0.745
	(0.723)	(0.224)	(0.611)	(0.254)	(0.000)	(0.359)	(0.000)	(0.464)
30-40	1.158*	1.034	1.184	0.937	1.012	1.069+	0.854	0.904
	(0.082)	(0.038)	(0.156)	(0.062)	(0.069)	(0.040)	(0.111)	(0.062)
40-50	1.134	1.028	1.188	0.956	0.994	1.010	0.846	0.798*
	(0.112)	(0.052)	(0.245)	(0.106)	(0.097)	(0.051)	(0.177)	(0.090)
50-60	1.003	0.923	0.614	0.700*	0.750	1.078	1.115	0.859
	(0.227)	(0.074)	(0.266)	(0.120)	(0.175)	(0.087)	(0.491)	(0.154)
>60	0.000	0.928	0.000	0.386*	0.978	1.081	5.192e+15	0.912
	(0.000)	(0.208)	(0.000)	(0.144)	(0.981)	(0.220)	(4.928e+23)	(0.340)
unknown	1.066	1.235*	0.956	1.000	1.011	1.426**	0.933	1.000
	(0.075)	(0.121)	(0.424)	(0.000)	(0.067)	(0.141)	(0.541)	(0.000)
Family fixed effects	N	N	Y	Y	N	N	Y	Y
N IDs (aged 0 or 1)	11,153	41,101	11,153	41,101	11,135	38,091	11,135	38,091
N deaths	2,062	6,142	2,062	6,142	2,147	5,992	2,147	5,992
Observations	69,946	348,904	69,946	348,904	69,606	321,832	69,606	321,832

Notes: Standard errors clustered at the household level are in parentheses

Tables

** p<0.01, * p<0.05, + p<0.1

Population samples are those indicated in Table 1 and discussed in sections 3.1 (Krummhörn) and 3.2 (Quebec)

Family fixed effects models indicated by “Family fixed-effects = Y” and are estimated using the stratified proportional Cox regression model, where each family is assumed to have its own baseline hazard model and separate likelihood functions are estimated for each household.
KH indicates estimates from the Krummhörn sample, QUE indicates estimates from the Quebec sample

Bolded hazard ratio estimates indicate those which are statistically different between the two populations. These differences are tested through pooling the two populations and estimating a model that includes the full set of covariates (save “Birth Cohort,” as the two populations do not completely overlap) as well as a full set of interactions for all of the different independent variables with an indicator for whether an individual was in the Quebec population. When the coefficients on these interaction terms are statistically significant at the 5 percent level, we consider the effects between the populations to be statistically significantly different.

Table 4 continued: Risk of child mortality (age 1 to 15), Persons born in the Krummhörn region(1720-1824) and Quebec (1670-1799), Cox Proportional Hazard Model (with and without fixed effects)

Sex	Girls	Girls	Girls	Girls	Boys	Boys	Boys	Boys
Model	1	2	3	4	5	6	7	8
Age	1 to 15	1 to 15	1 to 15	1 to 15	1 to 15	1 to 15	1 to 15	1 to 15
Population	KH	QUE	KH	QUE	KH	QUE	KH	QUE
Maternal Age (Ref: 20-30)								
<20	1.473+	0.977	0.952	1.136	1.040	0.967	0.898	1.080
	(0.345)	(0.063)	(0.410)	(0.117)	(0.304)	(0.063)	(0.482)	(0.116)
30-35	1.014	1.053	1.057	0.907	1.133+	1.040	0.992	0.846**
	(0.074)	(0.039)	(0.130)	(0.056)	(0.080)	(0.039)	(0.123)	(0.053)
35-45	1.085	0.992	1.035	0.811*	1.124	1.009	0.941	0.762**
	(0.091)	(0.048)	(0.162)	(0.077)	(0.093)	(0.049)	(0.154)	(0.074)
>45	0.775	0.916	0.774	0.774	0.976	1.098	0.467	0.790
	(0.282)	(0.153)	(0.413)	(0.181)	(0.382)	(0.175)	(0.278)	(0.195)
unknown	1.097	1.634**	2.151+	1.000	1.082	1.496*	1.622	1.000
	(0.067)	(0.250)	(0.998)	(0.000)	(0.065)	(0.237)	(1.006)	(0.000)
Child's birth cohort	0.961**	1.131**	1.054	1.026	0.961**	1.112**	0.948	0.952
	(0.007)	(0.008)	(0.112)	(0.054)	(0.007)	(0.008)	(0.102)	(0.053)
Birth Rank (ascending order)	1.099**	1.057**	0.564**	0.774**	1.100**	1.059**	0.592**	0.800**
	(0.020)	(0.008)	(0.028)	(0.014)	(0.019)	(0.008)	(0.030)	(0.016)
Next elder sibling has died	0.938	1.004	0.836+	0.992	0.956	1.006	0.977	0.956
	(0.064)	(0.033)	(0.084)	(0.044)	(0.065)	(0.034)	(0.101)	(0.044)
Family fixed effects	N	N	Y	Y	N	N	Y	Y
N IDs (aged 0 or 1)	11,153	41,101	11,153	41,101	11,135	38,091	11,135	38,091
N deaths	2,062	6,142	2,062	6,142	2,147	5,992	2,147	5,992
Observations	69,946	348,904	69,946	348,904	69,606	321,832	69,606	321,832

Notes: Standard errors clustered at the household level are in parentheses

** p<0.01, * p<0.05, + p<0.1

Population samples are those indicated in Table 1 and discussed in sections 3.1 (Krummhörn) and 3.2 (Quebec).

Family fixed effects models indicated by “Family fixed-effects = Y” are estimated using the stratified proportional Cox regression model, where each family is assumed to have its own baseline hazard model and separate likelihood functions are estimated for each household.

KH indicates estimates from the Krummhörn sample, QUE indicates estimates from the Quebec sample

Bolded hazard ratio estimates indicate those which are statistically different between the two populations. These differences are tested through pooling the two populations and estimating a model that includes the full set of covariates (save “Birth Cohort,” as the two populations do not completely overlap) as well as a full set of interactions for all of the different independent variables with an indicator for whether an individual was in the Quebec population. When the coefficients on these interaction terms are statistically significant at the 5 percent level, we consider the effects between the populations to be statistically significantly different.

Tables

Table 5: Waiting time to marriage, Persons born and married in the Krummhörn region(1720-1824) and Quebec (1670-1799), Cox Proportional Hazard Model (with and without fixed effects)

Sex	Women	Women	Women	Women	Men	Men	Men	Men
Model	1	2	3	4	5	6	7	8
Age	15+	15+	15+	15+	15+	15+	15+	15+
Population	KH	QUE	KH	QUE	KH	QUE	KH	QUE
Variables								
N elder brothers (alive)	**0.868****	**0.986***	**0.726****	**0.926****	0.912**	0.953**	**0.744****	**0.989**
	(0.020)	**(0.006)**	**(0.079)**	**(0.022)**	(0.023)	(0.006)	**(0.065)**	**(0.022)**
N younger brothers (alive)	0.932**	0.970**	0.768*	0.921**	**0.953****	**1.009+**	**0.823***	**1.067****
	(0.015)	(0.005)	(0.082)	(0.020)	**(0.016)**	**(0.005)**	**(0.082)**	**(0.024)**
N elder sisters (alive)	**0.863****	**0.961****	0.867+	0.986	0.936*	0.987*	0.782*	0.964
	(0.020)	**(0.006)**	(0.067)	(0.019)	(0.024)	(0.006)	(0.089)	(0.024)
N younger sisters (alive)	0.947**	1.001	1.005	1.081**	**0.932****	**0.977****	0.832	0.943*
	(0.015)	(0.005)	(0.088)	(0.020)	**(0.015)**	**(0.005)**	(0.094)	(0.023)
Born in urban environment (Yes)		0.806**		1.046		0.783**		0.986
		(0.013)		(0.053)		(0.014)		(0.058)
Maternal Loss	0.977	1.077**	1.181	1.290**	1.023	0.994	1.370*	1.025
	(0.033)	(0.015)	(0.158)	(0.058)	(0.036)	(0.014)	(0.174)	(0.048)
Paternal Loss	1.017	1.112**	1.456**	1.283**	0.971	1.031*	1.484**	1.129**
	(0.033)	(0.015)	(0.175)	(0.050)	(0.034)	(0.014)	(0.185)	(0.045)
Paternal Age (Ref: 20-30)								
<20	0.322+	0.856	0.862	0.724	0.522	0.935	0.234	0.531+
	(0.186)	(0.117)	(1.223)	(0.181)	(0.302)	(0.152)	(0.256)	(0.177)
30-40	1.050	0.888**	0.976	1.037	0.930	0.828**	0.915	1.009
	(0.050)	(0.014)	(0.101)	(0.034)	(0.045)	(0.014)	(0.097)	(0.036)
40-50	1.032	0.863**	0.987	1.119*	0.775**	0.768**	0.893	1.138*
	(0.072)	(0.020)	(0.163)	(0.063)	(0.058)	(0.018)	(0.155)	(0.069)
50-60	1.161	0.837**	1.351	1.168+	0.660*	0.732**	0.600	1.284*
	(0.169)	(0.030)	(0.459)	(0.103)	(0.116)	(0.029)	(0.215)	(0.125)
>60	1.425	0.829*	2.072e+12	0.982	1.025	0.673**	2.244e+12	1.480*
	(1.011)	(0.078)	(2.738e+18)	(0.175)	(0.595)	(0.069)	(2.989e+18)	(0.286)
unknown	1.014	0.839**	1.044	1.000	0.949	0.795**	1.828	1.000
	(0.046)	(0.039)	(0.386)	(0.000)	(0.045)	(0.041)	(0.867)	(0.000)
Family fixed effects	N	N	Y	Y	N	N	Y	Y
N IDs (aged 15 and over)	6,989	34,625	6,989	34,625	7,003	32,098	7,003	32,098
N marriages	4,266	30,671	4,266	30,671	3,839	27,498	3,839	27,498
Observations	21,454	98,802	21,454	98,802	22,770	114,702	22,770	114,702

Notes: Standard errors clustered at the household level are in parentheses

Tables

** p<0.01, * p<0.05, + p<0.1

Population samples are those indicated in Table 1 and discussed in sections 3.1 (Krummhörn) and 3.2 (Quebec).

Family fixed effects models indicated by “Family fixed-effects = Y” and are estimated using the stratified proportional Cox regression model, where each family is assumed to have its own baseline hazard model and separate likelihood functions are estimated for each household.
KH indicates estimates from the Krummhörn sample, QUE indicates estimates from the Quebec sample.

Bolded hazard ratio estimates indicate those which are statistically different between the two populations. These differences are tested through pooling the two populations and estimating a model that includes the full set of covariates (save “Birth Cohort,” as the two populations do not completely overlap) as well as a full set of interactions for all of the different independent variables with an indicator for whether an individual was in the Quebec population. When the coefficients on these interaction terms are statistically significant at the 5 percent level, we consider the effects between the populations to be statistically significantly different.

Table 5 cont.: Waiting time to marriage, Persons born and married in the Krummhörn region(1720-1824) and Quebec (1670-1799), Cox Proportional Hazard Model (with and without fixed effects)

Sex	Women	Women	Women	Women	Men	Men	Men	Men
Model	1	2	3	4	5	6	7	8
Age	15+	15+	15+	15+	15+	15+	15+	15+
Population	KH	QUE	KH	QUE	KH	QUE	KH	QUE
Maternal Age (Ref: 20-30)								
<20	0.847	1.193**	0.521+	1.184**	1.267	1.047+	1.060	1.081
	(0.159)	(0.031)	(0.181)	(0.054)	(0.263)	(0.029)	(0.398)	(0.053)
30-35	0.921+	0.933**	1.020	0.981	0.990	0.986	1.013	1.037
	(0.046)	(0.016)	(0.099)	(0.031)	(0.051)	(0.018)	(0.101)	(0.035)
35-45	0.894+	0.954*	0.867	1.031	0.979	1.021	1.003	1.140*
	(0.054)	(0.021)	(0.111)	(0.051)	(0.062)	(0.024)	(0.135)	(0.060)
>45	0.822	0.980	0.820	1.137	1.272	1.090	0.909	1.239
	(0.217)	(0.076)	(0.430)	(0.141)	(0.398)	(0.092)	(0.429)	(0.176)
unknown	0.990	0.972	2.011+	1.000	0.991	0.988	0.709	1.000
	(0.041)	(0.081)	(0.806)	(0.000)	(0.044)	(0.093)	(0.309)	(0.000)
Birth cohort (decades)	1.064**	1.019**	1.117	1.027	1.093**	1.036**	1.031	1.010
	(0.007)	(0.003)	(0.097)	(0.028)	(0.007)	(0.003)	(0.092)	(0.030)
Birth Rank (ascending order)	1.032**	1.019**	1.000	1.002	1.007	1.034**	0.994	1.002
	(0.012)	(0.004)	(0.046)	(0.010)	(0.013)	(0.004)	(0.050)	(0.011)
Family fixed effects	N	N	Y	Y	N	N	Y	Y
N IDs (aged 15 and over)	6,989	34,625	6,989	34,625	7,003	32,098	7,003	32,098
N marriages	4,266	30,671	4,266	30,671	3,839	27,498	3,839	27,498
Observations	21,454	98,802	21,454	98,802	22,770	114,702	22,770	114,702

Notes: Standard errors clustered at the household level are in parentheses

** p<0.01, * p<0.05, + p<0.1

Population samples are those indicated in Table 1 and discussed in sections 3.1 (Krummhörn) and 3.2 (Quebec).

Family fixed effects models indicated by “Family fixed-effects = Y” are estimated using the stratified proportional Cox regression model, where each family is assumed to have its own baseline hazard model and separate likelihood functions are estimated for each household.
KH indicates estimates from the Krummhörn sample, QUE indicates estimates from the Quebec sample.

Bolded hazard ratio estimates indicate those which are statistically different between the two populations. These differences are tested through pooling the two populations and estimating a model that includes the full set of covariates (save “Birth Cohort,” as the two populations do not completely overlap) as well as a full set of interactions for all of the different independent variables with an indicator for whether an individual was in the Quebec population. When the coefficients on these interaction terms are statistically significant at the 5 percent level, we consider the effects between the populations to be statistically significantly different.

Tables

Table 6: Number of children born, Persons born and married in the Krummhörn region(1720-1824) and Quebec (1670-1799), Poisson Regression model (with and without fixed effects)

Sex	Women	Women	Women	Women	Men	Men	Men	Men
Model	1	2	3	4	5	6	7	8
Age	15+	15+	15+	15+	15+	15+	15+	15+
Population	KH	QUE	KH	QUE	KH	QUE	KH	QUE
Dependent Variable	N births	N births	N births	N births	N births	N births	N births	N births
Variables								
N brothers at birth (alive)	0.971*	1.010**	0.946+	1.002	0.997	1.006+	0.926**	0.972**
	(0.012)	(0.003)	(0.028)	(0.006)	(0.013)	(0.003)	(0.025)	(0.005)
N sisters at birth (alive)	0.978+	1.001	0.973	0.980**	1.013	1.015**	0.938+	1.017**
	(0.012)	(0.003)	(0.024)	(0.005)	(0.013)	(0.003)	(0.032)	(0.006)
N brothers at 15 (alive)	1.002	1.017**	0.986	0.980+	1.017*	1.013**	0.959	0.889**
	(0.008)	(0.003)	(0.036)	(0.011)	(0.008)	(0.003)	(0.028)	(0.009)
N sisters at 15 (alive)	1.006	1.022**	0.870**	0.834**	1.002	1.021**	0.995	1.028*
	(0.008)	(0.003)	(0.023)	(0.009)	(0.008)	(0.003)	(0.041)	(0.013)
Paternal Age (Ref: 20-30)								
<20	0.829	0.979	1.465	0.989	0.762	0.922	1.161	0.985
	(0.166)	(0.049)	(0.794)	(0.076)	(0.191)	(0.052)	(0.804)	(0.095)
30-40	0.841	0.952**	1.435	1.010	0.829	0.952**	1.230	0.952**
	(0.169)	(0.006)	(0.777)	(0.011)	(0.208)	(0.006)	(0.849)	(0.011)
40-50	0.793	0.935**	1.310	1.023	0.776	0.926**	1.278	0.914**
	(0.161)	(0.008)	(0.715)	(0.019)	(0.196)	(0.008)	(0.888)	(0.018)
50-60	0.950	0.902**	1.318	1.030	0.861	0.939**	1.056	0.899**
	(0.201)	(0.013)	(0.739)	(0.030)	(0.226)	(0.013)	(0.749)	(0.027)
>60	1.000	0.951	5.788	1.054	0.638	0.873**	2609108.432	0.873*
	(0.389)	(0.033)	(7.131)	(0.062)	(0.257)	(0.033)	(1.868e+09)	(0.054)
unknown	0.807	0.917**	1.253	1.000	0.790	0.867**	0.861	1.000
	(0.162)	(0.016)	(0.704)	(0.000)	(0.198)	(0.017)	(0.625)	(0.000)
Family fixed effects	N	N	Y	Y	N	N	Y	Y
Observations	4,704	26,274	2,889	22,321	4,089	22,994	2,393	19,077
Number of families			1,175	6,919			987	6,145

Notes: Standard errors clustered at the household level are in parentheses
** p<0.01, * p<0.05, + p<0.1

Population samples are those indicated in Table 1 and discussed in sections 3.1 (Krummhörn) and 3.2 (Quebec).

Family fixed effects models indicated by "Family fixed-effects = Y" are estimated using the conditional Poisson model, where estimates for each individual are conditioned on all the counts of their household.

Tables

KH indicates estimates from the Krummhörn sample, QUE indicates estimates from the Quebec sample.

Table 6 cont.: Number of children born, Persons born and married in the Krummhörn region(1720-1824) and Quebec (1670-1799), Poisson Regression model (with and without fixed effects)

Sex	Women	Women	Women	Women	Men	Men	Men	Men
Model	1	2	3	4	5	6	7	8
Age	15+	15+	15+	15+	15+	15+	15+	15+
Population	KH	QUE	KH	QUE	KH	QUE	KH	QUE
Dependent Variable	N births	N births	N births	N births	N births	N births	N births	N births
Maternal Age (Ref: 20-30)								
<20	1.282**	1.042**	1.335*	1.006	1.142	0.999	0.953	0.957**
	(0.118)	(0.010)	(0.193)	(0.014)	(0.125)	(0.010)	(0.181)	(0.014)
30-35	1.275**	0.970**	1.292+	0.992	1.199	0.975**	1.033	1.011
	(0.120)	(0.007)	(0.196)	(0.011)	(0.133)	(0.007)	(0.202)	(0.011)
35-45	1.162	0.954**	1.253	1.007	1.143	0.989	0.968	1.022
	(0.111)	(0.009)	(0.199)	(0.017)	(0.129)	(0.009)	(0.196)	(0.017)
>45	1.397*	0.916*	1.281	0.986	0.839	0.758**	0.647	0.779**
	(0.215)	(0.032)	(0.337)	(0.045)	(0.174)	(0.031)	(0.211)	(0.041)
unknown	1.212*	0.867**	1.379	1.000	1.130	0.902**	0.874	1.000
	(0.112)	(0.029)	(0.299)	(0.000)	(0.125)	(0.032)	(0.249)	(0.000)
Birth cohort (decades)	0.976**	0.998	1.046	1.005	0.980**	0.997**	0.911*	1.007
	(0.003)	(0.001)	(0.039)	(0.009)	(0.003)	(0.001)	(0.034)	(0.009)
Birth Rank (ascending order)	1.010	1.004**	0.972+	0.993*	0.994	1.002	1.042*	1.004
	(0.007)	(0.002)	(0.017)	(0.003)	(0.007)	(0.002)	(0.020)	(0.003)
Constant	295.696**	8.968**			185.320**	12.921**		
	(163.690)	(1.671)			(112.208)	(2.453)		
Family fixed effects	N	N	Y	Y	N	N	Y	Y
Observations	4,704	26,274	2,889	22,321	4,089	22,994	2,393	19,077
Number of families			1,175	6,919			987	6,145

Notes: Standard errors clustered at the household level are in parentheses
** p<0.01, * p<0.05, + p<0.1

Population samples are those indicated in Table 1 and discussed in sections 3.1 (Krummhörn) and 3.2 (Quebec).

Family fixed effects models indicated by “Family fixed-effects = Y” are estimated using the conditional Poisson model, where estimates for each individual are conditioned on all the counts of their household.

KH indicates estimates from the Krummhörn sample, QUE indicates estimates from the Quebec sample.