DEMOGRAPHIC RESEARCH
A peer-reviewed, open-access journal of population sciences

DEMOGRAPHIC RESEARCH

VOLUME 31, ARTICLE 38, PAGES 1167–1198
PUBLISHED 13 NOVEMBER 2014
http://www.demographic-research.org/Volumes/Vol31/38/
DOI: 10.4054/DemRes.2014.31.38

Research Article

Rivalry, solidarity, and longevity among siblings: A life course approach to the impact of sibship composition and birth order on later life mortality risk, Antwerp (1846–1920)

Robyn Donrovich

Paul Puschmann

Koen Matthijs

Table of Contents

Demographic Research: Volume 31, Article 38
Research Article

Rivalry, solidarity, and longevity among siblings: A life course approach to the impact of sibship composition and birth order on later life mortality risk, Antwerp (1846–1920)

Robyn Donrovich[1]

Paul Puschmann[2]

Koen Matthijs[3]

Abstract

BACKGROUND
Family composition and household dynamics, both in early and in later life, influence individual health and longevity. Both positive and negative effects can be expected in terms of sibling size and composition. On one hand, siblings compete with each other, which may lead to resource dilution and increased adult mortality risks. On the other hand, siblings protect and care for each other, which may have a positive impact on longevity.

OBJECTIVE
To investigate the way in which sibling composition (with respect to sibship size, sex, and birth order) in the family of orientation and the proximity of siblings in later life relates to adult mortality risks at ages 50+.

METHODS
Life courses of 258 men and 275 women from the Antwerp COR*-database were 'reconstructed' and analyzed by way of event history analysis using Gompertz shared frailty models.

RESULTS
Being higher in birth order related to significantly higher mortality risk after age 50 for men. Having older brothers, particularly those present in later life, was associated with very high excess mortality risk for both sexes, though men were more strongly disadvantaged. Having (more) younger sisters present at RP (research person) age 50 was related to significantly lower relative mortality risk for women.

[1] Centre for Sociological Research, KU Leuven, Belgium. E-Mail: RobynNicole.Donrovich@soc.kuleuven.be.
[2] Centre for Sociological Research, KU Leuven, Belgium. E-Mail: Paul.Puschmann@soc.kuleuven.be.
[3] Centre for Sociological Research, KU Leuven, Belgium. E-Mail: Koen.Matthijs@soc.kuleuven.be.

CONCLUSIONS
Our findings highlight the complex relationships between sibling and gender dynamics and mortality risk in later life. Evidence of a lasting impact of sibling competition on mortality risk over age 50 is found; and competition is only replaced by solidarity in critical times (e.g., widowhood), wherein older sibling presence dissimilarly impacts different social groups.

1. Introduction

A growing number of medical, epidemiological, and historical demographic studies find a relationship between early life conditions and later life mortality (Oris 2005; Bengtsson and Mineau 2009; Ben-Shlomo and Kuh 2002; Smith et al. 2009). Although the discussion on the causal mechanisms behind this link continues, it is clear that exposure to various risk factors in childhood has major negative effects on health and life expectancy in later life. For example, exposure to famines, smoke, toxins, and infectious diseases in childhood is associated with higher post-reproductive mortality (Elo and Preston 1996; Hayward and Gorman 2004; Ben-Shlomo and Kuh 2002). It is also accepted that the moment at which individuals are exposed to risk factors is important, as certain periods in the life course are identified as critical or sensitive. Moreover, risk factors operate at different levels of aggregation: the country, the municipality, the neighborhood, the household, the family, and the individual (Ben-Shlomo and Kuh 2002). In this article, we focus on individual level mortality risk within the context of the family.

A family's role in the survival of its members is crucial, particularly for infants and young children who spend most of their time within the home, and accordingly, are highly dependent on individual family members to be their primary caretakers. While it is clear that the presence or absence of certain family members has a direct influence on the health, well-being, and survival chances of infants and children, there is also evidence of long-term effects of family composition and internal family dynamics on mortality outcomes in later life. Whereas parental and grandparental influence on infant and child survival has been a primary focus of researchers, siblings' effect on survival has not been studied as extensively. In this study we investigate whether the sibling composition in the family of orientation and the proximity of siblings in later life have an effect on longevity (in this study defined as survival past age 50). We use data from the Antwerp COR*-database to 'reconstruct' life courses and to link individuals to family members both in and outside of the household. This is one of the few historical demographic databases that allow us to study the life course of individuals in relation to

the life course of their family members. We focus on the effect of sibship composition, birth order, and sex on post-reproductive mortality, using cohorts born in the Belgian district of Antwerp in the 19th century. We follow 258 men and 275 women from age 50 on, in order to determine their mortality risks in relation to the family configuration both in which they grew up, and in later life, controlling for other important factors.

2. Historical context

From a family perspective, the 19th and early 20th centuries witnessed important change. First, the Western European marriage pattern was gradually beginning to disappear, as the number of lifetime singles decreased and men and women started to marry earlier in their life (Matthijs 2002). Simultaneously, a transition towards age homogamy began, suggesting that egalitarian relations between husband and wife were gradually becoming the new norm and that love became a necessary condition for marriage (Van de Putte and Matthijs 2001; Coontz 2005). The fact that marriage witnesses were increasingly sought among family members, especially siblings, could suggest that the family was becoming a more important institution than it had been previously (Bras 2011; Matthijs 2003, 2006). Mortality decline strengthened family ties, as both parents and children died less often prematurely, lengthening the time that they spent together. Within the private sphere of the household, children had more time to play together, thanks in part to industrialization and the decline of child labor, which strengthened the bonds between brothers and sisters (Sanders 2002); and family members began to participate more in joint leisure activities during weekends, especially on Sundays (Gillis 1996).

The breadwinner–housewife model began to take root, which may have strengthened family relationships, as women now had more time to spend with their children. Overall during the course of the 19th century, the transition from proto-industry to modern industry, made a clearer distinction between work and family life, underlining the emotional bonds between family members and weakening the functional aspect of family relations.

3. Theoretical background and previous research

Life course studies on health propose that adult morbidity and mortality can be explained, at least partly, by exposure to risk factors earlier in life (Ben-Shlomo and Kuh 2002). Although researchers have been able to identify many risk factors in early life which lead to higher mortality risk in later life, the causal link between and the

mechanisms behind the two are often debated. In fact, many different pathways between in utero, infant, and early childhood conditions and adult morbidity and mortality have been suggested (Ben-Shlomo and Kuh 2002).

According to the *critical period model*, the health of individuals is biologically pre-programmed in the womb and directly affects an individual down the line, as the onset of chronic diseases manifest later in life (Barker 1994). Damage in critical periods is believed to be irreversible, but life expectancy might be (further) shortened by later life effect modifiers. Other researchers believe that outcomes in health and mortality in later life are the result of an accumulation of risk during the life course. According to the *accumulation of risk* model, an individual's experiences lead to cumulative damage to the human body. Exposure to risks might be independent of each other and have additive effects, or they may also be clustered where one risk acts as a trigger to other risks (Ben-Shlomo and Kuh 2002). Contrary to the critical period model, health and later life outcomes in the accumulation of risk approach are not so much pre-programmed biologically, but are instead the outcome of a wide range of biological and social factors from different stages of the life course (Kuh and Ben-Shlomo 1997). Within the accumulation of risk paradigm, the *life-style model* argues that risky behavior in adulthood is related to the socialization process of children. Whether adults smoke, drink alcohol, eat unhealthily, or regularly exercise or not, can be traced back to the prevalent behavior in the family of orientation, as children pick up habits and behaviors from parents, siblings, and other relatives (Kuh and Ben-Shlomo 1997; Hayward and Gorman 2004). According to the *deprivation model*, longevity differences between individuals can be (partially) traced back to differences in the environmental conditions in utero, in infancy, and in childhood. Forsdahl (1978) showed, for example, that Norwegian adults born in regions with high infant mortality in the past had higher incidence of cardiovascular diseases. Variations in cholesterol levels among men and women in the age category 35–49 were linked to infant mortality rates at the time of their birth. At the time the research was conducted, the differences in infant mortality rates between regions in Norway had largely disappeared. He concluded that "poverty in childhood and adolescence, followed by later prosperity, results in high cholesterol values [in later life]" (Forsdahl 1978: 34).

The terms *scarring, acquired immunity, and selection* have been used to describe the direct or indirect positive/negative relationship between disease exposure in childhood and adult mortality (Preston, Hill, and Drevenstedt 1998). Some historical studies have found a strong relationship between high disease load and old age mortality in rural parishes in southern Sweden in the 18th and 19th centuries (Bengtsson and Lindström 2000, 2003). Results showed that exposure to airborne diseases during the birth year (measured by use of yearly infant mortality rates) related to an increase in older adult mortality risk. Other empirical research using the same database, Quaranta

(2013), also highlighted the importance of infant mortality rates during the first year of life as a predictor of adult mortality. These previous studies illustrate a scarring effect from exposure to a high disease load in early life, in that being born during years with a high infant mortality rate and prevalence of epidemics left a permanent 'scar' on the health of the individual affecting him or her down the line. However, exposure to epidemics in early life could also yield a positive selection effect, meaning that those who were able to survive these poor conditions in infancy and childhood acquired immunity and were less likely to die from them in later life. Lee (1997) found some evidence of this in Union army soldiers during the American Civil War. Troops from healthier areas were more vulnerable to disease than those from harsher environments. Surviving the adverse environment, in general, and reaching adulthood also suggests that these individuals were 'selected' from their frail peers who did not survive similar poor conditions. Accordingly, these survivors benefitted from a health advantage in later life.

Given the importance of early life conditions, the number and composition of siblings one has may have implications on his or her health and longevity in later years; further, the effect may be different for women and men. One hypothesis that can address the way in which gender and sibships relate to the above life course models is the *resource dilution hypothesis* (Blake 1981). This theory suggests that the more siblings one has, the less family resources he or she will receive in infancy and childhood. In other words, when there is an increasing number of children present in a household, the overall *quality* of an individual child declines, as parental investments relatively decrease per child. Given that the early years of life are deemed critical according to life course epidemiology, sibling composition in childhood may have a lasting influence on health and mortality in later life.

Some empirical studies have looked into the effect of sibship size on other outcomes, since having more siblings means that more children needed to share the same pool of resources (Blake 1987; Hertwig, Davis, and Sulloway 2002; Marks 2006). Compared to those from smaller families, several researchers have found that those born into larger families often have poorer educational outcomes, in terms of school achievement (Rosenzweig and Wolpin 1980; Blake 1981; Hauser and Sewell 1986; Hanushek 1992; Hill and O'Neill 1994) or development of cognitive functions (Belmont and Marolla 1973; Wolf 1982). Male and female infants and children were most likely affected differently during resource competition. As there has been some evidence of parental favoritism toward male offspring, females may have been 'neglected' comparatively, in terms of developmental resources (Lloyd and Gage-Brandon 1994). Accordingly, excess female mortality has been found in historical European populations in certain age groups, particularly in younger ages (Devos 2000; Eggerickx and Tabutin 1994; Kennedy 1973). During times of scarcity, adult women

(in particular, mothers) in working class families may have put their husband's nourishment ahead of their own (and their children's) thereby lowering their own nutritional status, which can partly explain the excess female mortality risk in adulthood in some historical populations (Humphries 1991; Klasen 1998). In addition to sibling size and sex, the birth order of the individual may have also played a role. Children born first or earlier in succession may have received more benefits than those born later, as resources may have been exhausted on earlier children (Coall et al. 2009; Van Bavel 2006). Furthermore, the amount of medical care, such as vaccinations, had been shown to decline for each successive child within a family (Hertwig, Davis, and Sulloway 2002), and girls were less likely to have received vaccinations compared to boys (Van Poppel 2000). The effect may have been more pronounced for those in larger families, especially for females, for reasons described above.

Even though sibling competition for resources may have an impact on investment during childhood, sibling ties are also some of the longest lasting social relationships an individual has in life. Bonds can be ever-changing (in strength or direction) throughout the life course, but may become increasingly important in later adulthood and for the elderly, particularly when one's own children are grown and one's spouse is gone (Cumming and Schneider 1961). In the absence of children or spouse, aside from providing companionship, siblings may have had to step in financially, as the social welfare system in Belgium had not yet been fully established (Lamberts 2006). Given the very long duration and importance of siblings ties, essentially lasting from cradle to grave, we expect that sibling relationships or lack thereof will have had a strong positive or negative effect on the later-life mortality risk of individual family members, as poor social support is related to increased morbidity and mortality risk (House, Landis, and Umberson 1988).

In light of these frameworks, we developed three hypotheses:

- **(H1)** *Sex*: men will have higher mortality risk at ages 50+ compared to women, but may fare better during resource competition.
- **(H2)** *Early life*
  - **A.** *Birth order*: firstborns will be relatively better off than later-born siblings.
  - **B.** *Sibling composition*: accordingly, having many older siblings (mostly brothers) will leave the research person (from here abbreviated as RP) especially vulnerable.
- **(H3)** *Later life*: sibling presence in later life will be beneficial for RP's mortality risk. Having younger siblings, in particular, will lower RP's mortality risk.

4. Materials and methods

4.1 Database and study group

Data stems from the COR*-database, which contains linked micro level demographic data on individual life courses in the Antwerp district from the period 1846–1920. The data is a letter sample consisting of individuals whose surname began with "COR" and their co-residents (kin or non-kin) within a household. The database includes population registers and vital registration records, containing information on births, deaths, and marriages (Matthijs and Moreels 2010).

We performed a data retrieval from the Antwerp COR*-database, which is stored in a series of tables in Microsoft Access 2010. The tables contain characteristics of individuals, families, households, and life events for each RP. From these tables, we 'reconstructed' individual life courses, producing a final 'episode' file for analysis. We linked individuals through a mother-identifier in order to construct sibship sizes, composition, and birth orders, including only children, for our RPs. Our study group included men and women who had:

i) a mother still alive and present at the 1846 register in Antwerp (as we linked siblings through a mother identifier),
ii) birth date information,
iii) been born in the district of Antwerp, and
iv) whose birth dates fell between 1800 and 1859, so that the youngest cohorts would have been able to reach ages 60–70 by the end of the study period.

The earliest birth date included in the study was 11 June 1801 and the latest birth date recorded was 18 December 1859. Individuals were under risk from age 50 until 1920, the end of the last population register (1910) included in the COR*-database. Individuals were censored at emigration if they left Antwerp after age 50 (n=1) or at the start of the next population register (which is the end of the last population register in which they were recorded) for those who disappeared from the population registers without a recorded emigration date (n=97). In addition to these losses to follow-up, there were a few limitations with the data. Given the rather short timeframe of our data with reliable death certificates, more than half of the individuals in our study were still alive by the end of the observation period, as 41% of the original study group (n=533) died during the period of observation in the Antwerp district. Generated sibship size may have been underestimated for the two earliest cohorts (1800–1829 and 1830–1839), since the first population register in Antwerp did not begin until 1846. Given the time lapse between birth dates and register opening, siblings may have moved away

from Antwerp before register opening and had not been able to be linked to a mother in the database. However, as long as the siblings were born in Antwerp (all study participants were born in Antwerp) they should have been accounted for. We controlled for birth cohort in order to mitigate this potential bias, as well as by excluding migrants born outside of Antwerp, as we did not have full information on their siblings. According to these criteria, our final study sample is 533 (275 women and 258 men).

4.2 Variables

Sex is coded as male and female. Birth cohort was grouped as 1800–1829, 1830–1839, 1840–1849, and 1850–1859. We included two variables occurring in early life as proxies for potential health implications during development. The first is mother's age at birth which has been associated with child health even in the long-term (Kemkes-Grottenthaler 2004; Smith et al. 2009). We categorized it as ages 15–24, 25–34, and 35+. The variable disease exposure notes whether an epidemic occurred in the Antwerp region during RP's critical years of development. Epidemics included cholera, malaria, measles, small pox, and typhus. The variable was constructed using information collected from Kruithof (1964). Since we only have the year in which the epidemic took place, we coded this as a dummy variable, noting whether the epidemic took place in the calendar year before, during, or after RP's birth year. Both father's and RP's occupations are based on HISCO coding (Historical International Standard Classification of Occupations). We used a HISCLASS classification system that takes into account skill degree, supervision level, and whether the occupation was manual or non-manual (Van Leeuwen and Maas 2005). Father's occupation (at birth) was grouped into 4 categories: professionals, foremen, and skilled; farmers; unskilled and day laborers; and a missing category if no information was found in the sources. We took RP's occupation from the population register in which a person was 50 years old (start of observation). We categorized occupations into 5 groups, representing somewhat hierarchal levels: professionals, consisting of higher managers and professionals, lower managers and professionals, clerical and sales personnel; foremen, skilled and lower skilled workers; farmers, both skilled and unskilled; unskilled workers and day laborers; and an unknown category if no occupation was found. Birth order was grouped into 5 categories: only child (first and only born), 1st, 2nd, 3rd or higher and unknown if a sibling did not have a birthdate recorded. The composition of siblings is measured in 8 variables based on the number of younger brothers, younger sisters, older brothers, and older sisters. The first set of the 4 sibling variables measured in childhood ("ever-born" siblings) are used in Part I of the analysis and coded as 0, 1, 2, 3+. The second set of sibling variables is measured at RP age 50 (Part II of the analysis), coded

as 0, 1, 2+, and reflects whether or not the siblings were alive and residing in Antwerp. RP's number of children ranged from 1–23 and is categorized as 1–4, 5–9, 10+, and 0 or "unknown," if they were not linked to any children in the sample. Marital status – unmarried, married, widowed, and unknown was a time-varying covariate starting from age 50, constructed from marriage certificates, vital registrations, and population registers. While present in the registers, there were no divorces in our study group.

Table 1 displays the variable distributions and time-at-risk for the study group.

Table 1: Time-at-risk distribution in days for men and women (both only-children and those with siblings) 50+ in Antwerp, 1846–1920

Variable	Person-time (days)	%	Events
Sex			
Male	5223	52.8	118
Female	4654	47.1	98
Birth cohort			
1800–1829	3637	39.4	85
1830–1839	2560	25.0	54
1840–1849	2185	20.0	43
1850–1859	1493	15.7	34
Mother's age at birth			
15–24	969	11.5	25
25–34	5471	49.5	107
35+	3437	38.9	84
Disease exposure			
No	4710	54.2	117
Yes	5167	45.8	99
Father's occupation			
Professionals, foremen, and skilled	3523	31.5	68
Farmers	1442	19.4	42
Unskilled and day laborers	2591	25.0	54
Missing/ unknown	2321	24.7	52
Number of older brothers (ever-born)			
0	4429	49.1	106
1	2921	24.5	52
2	1357	14.8	33
3+	1168	11.6	25
Number of older sisters (ever-born)			
0	4646	50.0	108
1	2480	25.0	54
2	1507	15.3	33
3+	1242	9.7	21

Table 1: (Continued)

Variable	Person-time (days)	%	Events
Number of younger brothers (ever-born)			
0	3073	38.4	83
1	2556	24.1	52
2	1825	16.7	36
3+	2423	22.2	48
Number of younger sisters (ever-born)			
0	3323	37.0	80
1	2291	24.1	52
2	1804	16.7	36
3+	2458	20.1	48
Number of older brothers (alive at RP age 50)			
0	7291	70.8	153
1	2047	23.1	50
2+	538	6.0	13
Number of younger brothers (alive at RP age 50)			
0	6295	59.3	128
1	1984	28.2	61
2+	1597	12.5	27
Number of older sisters (alive at RP age 50)			
0	7141	74.5	161
1	2021	15.7	34
2+	714	9.7	21
Number of younger sisters (alive at RP age 50)			
0	5841	63.8	138
1	2625	22.2	48
2+	1411	13.9	30
Birth order			
Only child	410	5.1	11
1	1869	19.4	42
2	1958	24.1	52
3 or higher	5072	43.1	93
Unknown	565	8.3	18
Number of children			
1–4	1415	27.7	60
5–9	1444	27.3	59
10+	775	8.3	18
0 or unknown	6242	36.6	79
Marital status (time-varying)			
Unmarried	806	13.9	30
Married	2834	44.4	96
Widowed	960	15.3	33
Unknown	5275	26.4	57

Table 1: (Continued)

Variable	Person-time (days)	%	Events
Own occupation			
Professionals	1102	13.0	28
Foremen and skilled	1669	28.2	61
Farmers	1183	17.6	38
Unskilled and day laborers	2118	23.1	50
Missing/ unknown	3805	18.1	39
Total person-time, rounded	**9877**	**100%**	**216**

4.3 Methods

We conducted event history analysis using Gompertz proportional hazard models with age as baseline, given their strength in fitting adult human mortality and allowing for either increasing or decreasing hazard rates over time (Cleves et al. 2008). Our outcome variable was death at ages 50+ and we analyzed hazard ratios in order to estimate the relationships between our key variables, while controlling for other related explanatory variables. Analysis was conducted using Stata12.

The general proportional hazard model is defined as:

$$h(t \mid x_j) = h_o(t)\exp(x_j \beta_x).$$

The Gompertz model is expressed as:

$$h_o(t) = \exp(\alpha)\exp(\gamma t)$$

where α and γ are supplementary parameters (Cleves et al. 2008).

We ran our models including a shared frailty option in order to account for unobserved family-level risk for siblings who were included in our study. There were 275 families represented in the final study group of 533, ranging from 1 family representative (only child or those who had no siblings who met the criteria of the study) up to 9 siblings who all entered the study.

We separated our analysis into two main parts. In Part I we analyze the effect of sibship composition in early life on the basis of RP's number of siblings in childhood (Table 2, Figures 1–2), in order to capture the long-term effect of sibship in childhood on later life mortality. Table 2 displays the results from the main effects model for both only children and those with siblings, which includes: early life control variables (mother's age at birth, birth cohort, disease exposure, father's occupation); RP's sibling

composition in early life (number of older brothers, younger brothers, older sisters, and younger sisters); and later life control variables (time-varying marital status, number of children, and occupation). In order to see how risk varies by birth order and sex, and to test hypothesis H2a, we interact these terms in Figure 1. Because of the positive relationship found in Table 2 of having older brothers on mortality risk, Figure 2 presents the results from the interaction between number of older brothers and RP's sex.

In Part II we investigate the effect of the composition of surviving siblings who were living in Antwerp at the start of the study (RP age 50), in order to test our hypothesis H3 on the effect of sibling presence in later life (Tables 3–5, Figure 3a, 3b). We included number of older brothers, younger brothers, older sisters, and younger sisters at the start of observation for each study member (at age 50). Results from the fully adjusted model are shown in Table 3 for our main sibship variables (full nested models in the Appendix). Relative risks from the interaction between sex and number of older brothers at RP's age 50 are shown in Figure 3a, and sex and number of younger sisters in Figure 3b, in order to distinguish sex differences according to the number of older brothers and younger sisters present in later life. Given that the presence of older siblings in later life might have very different meaning (protective/ adverse/ none) for those in different marital statuses (a strong mortality indicator), we interacted these terms. Tables 4 and 5 present the results from the interaction between marital status and number of older sisters and marital status and number of older brothers, respectively, separately for men and women in the study.

5. Results

5.1 Part I: Sibling composition in early life

5.1.1 Main effects

Relative mortality risks from age 50+ are displayed in Table 2 for men and women during our study period in Antwerp. Of the 533 men and women in our study, there were 216 deaths (118 men and 98 women) by the end of the study period, 1920.

Table 2: Relative risks of mortality and standard errors for men and women in the Antwerp region in multiplicative hazard models, n=533

Sex		
Women	1	
Men	1.409*	[0.210]
Mother's age at birth		
15–24	1.254	[0.304]
25–34	1	
35+	0.924	[0.182]
Birth cohort		
1800–1829	1	
1830–1839	0.933	[0.179]
1840–1849	0.754	[0.169]
1850–1859	1.152	[0.294]
Disease exposure (~age 1)		
No	1	
Yes	0.692*	[0.111]
Father's occupation		
Professionals, foremen, and skilled	1	
Farmers	1.634^{+}	[0.495]
Unskilled and day laborers	1.043	[0.264]
Missing/ unknown	1.762*	[0.427]
Number of older brothers (ever-born)		
0	1	
1	1.101	[0.204]
2	1.454^{+}	[0.326]
3+	1.428	[0.372]
Number of younger brothers (ever-born)		
0	1	
1	0.818	[0.162]
2	0.819	[0.185]
3+	0.796	[0.190]
Number of older sisters (ever-born)		
0	1	
1	0.985	[0.178]
2	1.038	[0.226]
3+	0.747	[0.196]
Number of younger sisters (ever-born)		
0	1	
1	1.132	[0.221]
2	0.959	[0.225]
3+	0.967	[0.228]

Table 2: (Continued)

Number of children		
1–4	1	
5–9	1.049	[0.210]
10+	0.525*	[0.158]
0 or unknown	0.364***	[0.092]
Marital status (time-varying)		
Unmarried	2.013*	[0.561]
Married	1	[0.214]
Widowed	0.720	[0.193]
Unknown	1.483	[0.356]
Occupation		
Professionals	1	
Foreman and skilled	1.483	[0.356]
Farmers	0.795	[0.269]
Unskilled and day laborers	1.008	[0.302]
Missing/ unknown	0.423**	[0.130]
Observations	676	

Notes: Controlled for age
Exponentiated coefficients; Standard errors in brackets
+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

Men have significantly higher mortality risk than women with more than 40% excess risk (RR=1.41). Having any number of younger brothers or sisters (with the exception of having 1 younger sister) relates to lower mortality risk or risk differing only marginally from baseline. Having many older brothers is associated with considerably higher mortality risk, as having 2 or 3+ older brothers related to a significant 45% and 43% higher mortality risk, respectively.

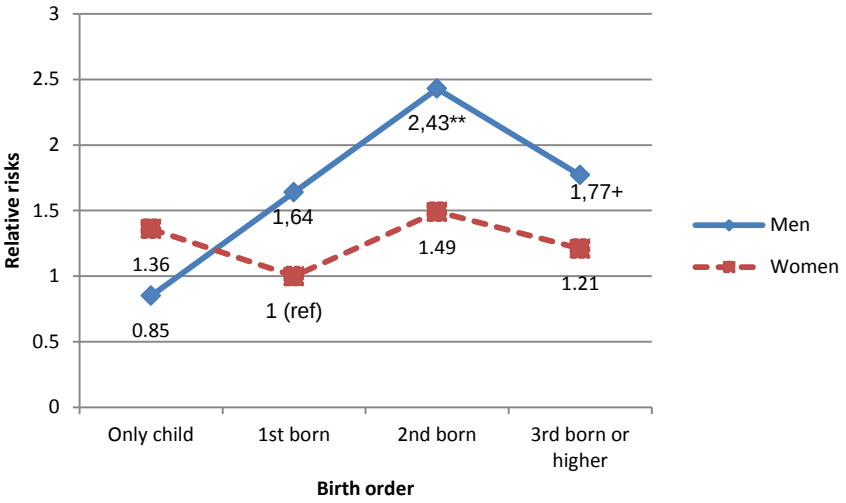
In addition to our key family variables, we used two variables as health proxies, mother's age at birth and disease exposure. While there was no significant effect from mother's age at birth, being born around the time of an epidemic during development resulted in significantly lower mortality risk compared to those never exposed to one (RR=0.69). We also controlled for social class at birth (father's occupation) and found that those born to a family in which the father worked as a farmer had significantly higher mortality risk compared to the reference group (1.63). Birth cohort had no statistical impact and limited influence on mortality risk in this study.

In terms of later life control variables, having very many children (10 or more) related to much lower mortality risk, with a significant 0.5 times the mortality risk of those with less than 5 children. While being widowed did not relate to a significant difference in mortality compared to the married, those who were unmarried experienced double the risk (RR=2.01).

5.1.2 Interaction effects

We tested two interactions with sex: birth order and number of older brothers, in order to see how these key variables relate to any differences for men and women.

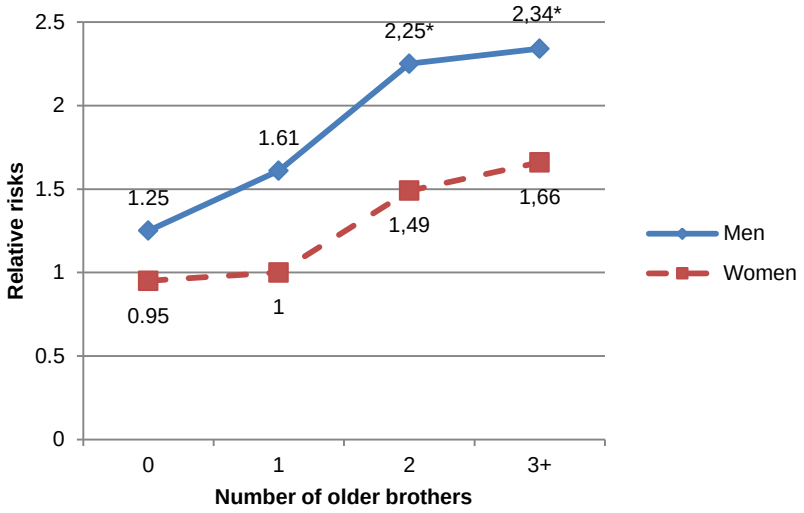
Figure 1: Relative risks of mortality by sex and birth order in the Antwerp region, both only children and those with siblings, n=533



Standardized for age, mother's age at birth, birth cohort, disease exposure, father's occupation, number of ever-born siblings, number of children, marital status, and occupation.
+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

For the interaction between sex and birth order presented in Figure 1, relative to first-born women, women had higher relative mortality risk in all other birth order categories. The only category with marginally lower relative mortality risk was men with no siblings (RR=0.85). Both men and women were at the highest risk when born second; men had a significant 2.4 times higher risk and women had 49% higher risk, relative to the reference group. Being born 3rd or higher also related to increased risk for both men and women, with 21% higher risk for women and a significant 77% higher risk for men.

Figure 2: Relative risks of mortality by sex and number of older brothers in the Antwerp region, both only children and those with siblings, n=533



Standardized for age, mother's age at birth, birth cohort, disease exposure, father's occupation, number of younger brothers, number of older sisters, number of younger sisters, number of children, marital status, and occupation.
+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

The interaction in Figure 2 between sex and number of older brothers ever-born overall suggests that having any number of older brothers relates to increased relative mortality risk for both sexes. With each higher category there was an increase in relative mortality risk, as having 3 or more is the highest risk group for both sexes. Men in particular were strongly affected by older brothers, as having 2 or having 3+ older brothers relates to a significant more than double the risk for men (RR=2.3).

5.1.3 Part I: Discussion

Part I of our analysis focused on the relationship between the composition of siblings in early life and mortality past age 50 for our RPs. Using both main effects and interaction models, we tested two hypotheses, based on sex, birth order, and composition, that related to this part of the analysis.

For our first hypothesis (H1), we believed that men would have higher mortality risk than women, but would fare better during sibling competition in early life. In all

main effects models, men had higher mortality risk, confirming the first part of our hypothesis. However, the second part of our hypothesis was not confirmed, as men seem even more negatively affected by being higher in order of birth, or having many older brothers in early life, compared to women.

We hypothesized (H2a) that being higher in birth order would also relate to increased mortality risk in later life, compared to only children or firstborns, as by the time of RP's birth, one or more siblings has/have already been consuming parental resources. Further, beyond resource scarcity, birth order has also been linked to several social factors that influence one's life course, such as professional opportunities, reproductive behavior, decisions about emigration, and personality (Sulloway 2001). Being born first is most advantageous; and given that we find this relationship for mortality over 50, this advantage appears to be life-long. Because the positive effect of being a firstborn may have been linked to a younger mother's age at birth, which has its own implications for the health and development of the fetus and future offspring, we controlled for this separately. Accordingly, we suspect that firstborns received preferential treatment from their parents, and/or lived a less risky lifestyle than their later-born siblings, in order to be an example for their younger brothers and sisters. This could also help explain why those born second are the most disadvantaged group for both men and women, as younger siblings tend to rebel, and firstborns tend to be more accepting of parental values or responsibility (Sulloway 1996).

We expected (H2b) that having a greater number of older siblings, particularly brothers, would have a negative impact on RP's survival chances in later life, due to the effect of resource dilution during early development, given that having a larger number of siblings has been theoretically linked to lower investment in childhood (Blake 1987; Hertwig, Davis, and Sulloway 2002; Marks 2006) and empirically shown to relate to worse health in adulthood (Lundberg 1993). Our findings suggest that having a larger number of older siblings does relate to lower survival chances after age 50. We found that this was largely influenced by sibling sex, as having many older brothers was related to a much higher significant mortality risk for members of our study group. In order to further analyze this finding, we were interested in whether not only sibling sex mattered, but also if the sex of the RP did. We interacted these variables and found that both men and women had higher risk from having any number of older brothers, though men were significantly more affected with very high excess risk at more than double.

5.2 Part II: Sibling presence in later life

5.2.1 Main effects

In order to examine our results through a life course perspective, Part II of the analysis accounts for the composition of siblings in later life, factoring in whether siblings were still alive and present in the Antwerp region at RP age 50. Table 3 displays relative mortality risks for men and women by number of brothers and sisters residing in Antwerp when RP is age 50. Of the 506 men and women with at least 1 sibling ever born, there were 205 deaths. Full results are presented in the Appendix.

Table 3: Relative risks of mortality and standard errors for men and women in the Antwerp region by presence of siblings in later life (RP age 50), n=506

	Full Model IV	
Number of older brothers at RP age 50		
0	1	
1	1.540*	[0.292]
2+	2.064*	[0.678]
Number of younger brothers alive at RP age 50		
0	1	
1	1.339	[0.239]
2+	0.887	[0.215]
Number of older sisters alive at RP age 50		
0	1	
1	0.926	[0.201]
2+	0.881	[0.252]
Number of younger sisters alive at RP age 50		
0	1	
1	0.655*	[0.124]
2+	0.719	[0.172]

Notes: Standardized for age, sex, mother's age at birth, birth cohort, disease exposure, father occupation, number of children, occupation, and marital status. Exponentiated coefficients; Standard errors in brackets.
+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In Table 3, having any number of older or younger sisters relates to lower mortality risk; and having exactly 1 younger sister is associated with a significant 0.7 times the risk of having none. Whereas having 1 younger sister is associated with a

lower relative mortality risk, having 1 younger brother has the opposite effect with approximately 34% higher risk compared to having none (RR=1.34). However, the highest risks belong to those having any number of older brothers. There is a significant 54% higher risk for having 1 and significant 2 times higher risk of having 2+ compared to those having no older brothers present in later life.

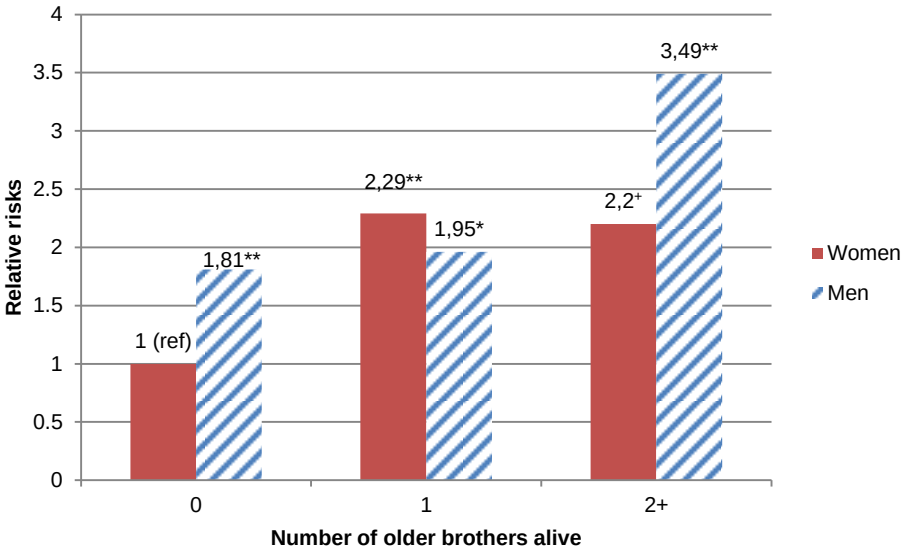
5.2.2 Interaction effects

We performed four interactions based on sibling presence in later life: sex and number of older brothers and younger sisters (Figure 3a and 3b) and RP's marital status and number of older sisters (Table 4) and older brothers (Table 5).

In order to gauge any sex differences in the strong, positive relationship between number of older brothers and mortality after age 50, and the inverse relationship between younger sisters and mortality, we interacted these terms in Figures 3a and 3b, respectively.

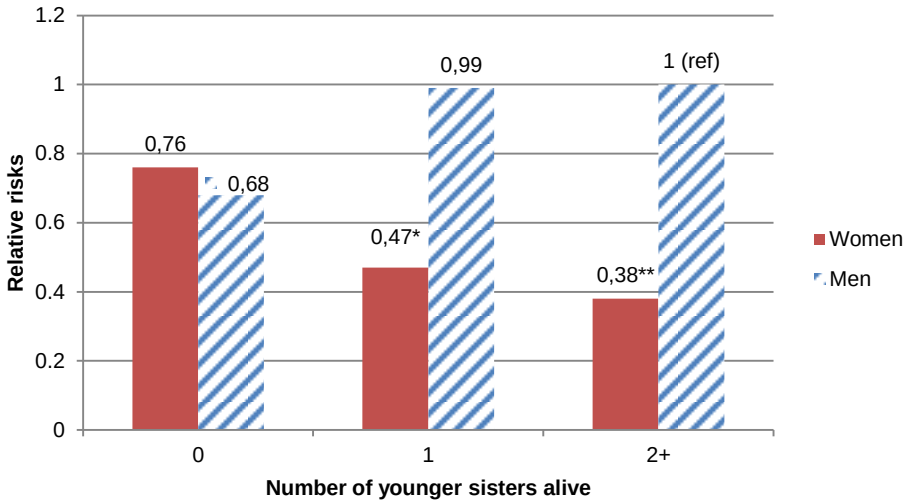
In Figure 3a, relative to women with no older brothers, all other categories have higher mortality risk. Men with 2+ older brothers are the most vulnerable group with 3.5 times the mortality risk of the reference category. Compared to having no brothers, women with older brothers have significantly higher mortality risk, at more than two-fold, for those with 1 brother (RR=2.3) and those with 2 or more (RR=2.2). For both men and women, having older brothers alive and residing in Antwerp in later life had a strong, negative relationship with their survival chances after age 50 with all relative risks significantly much higher than 1.

Figure 3a: Relative mortality risks from the interaction between sex and number of older brothers alive at RP age 50



Standardized for age, mother's age at birth, birth order, birth cohort, disease exposure, father occupation, number of younger brothers (at age 50), number of older sisters (at age 50), number of younger sisters (at age 50), number of children, marital status, and occupation.
+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Figure 3b: Relative mortality risks from the interaction between sex and number of younger sisters alive at RP age 50



Standardized for age, mother's age at birth, birth order, birth cohort, disease exposure, father occupation, number of younger brothers (at age 50), number of older sisters (at age 50), number of older brothers (at age 50), number of children, marital status, and occupation.
+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

In Figure 3b, compared to men with 2+ younger sisters, women are consistently better off in all other categories with relative risks substantially less than 1. Risk decreases with each additional higher number of younger sisters, with a significant 0.5 times the risk for having 1 younger sister and 0.4 times the risk for having 2 or more. There are no significant findings for men, but having no younger sisters relates to the lowest risk and having 1 only marginally differs from the reference group.

Further investigating the effect of older siblings present in later life, we tested the interaction between RP's marital status and number of older sisters and older brothers in separate models for men and women in Tables 4 and 5.

Table 4: Relative risks of mortality by RP marital status and number of older sisters alive and living in Antwerp at RP age 50, n=506

	Men						**Women**					
	Number of older sisters alive						Number of older sisters alive					
	0		1		2+		0		1		2+	
RP's Civil status	HR	SE	HR	SE	HR	SE	HR	SE	HR	SE	HR	SE
Unmarried	0.57	[.34]	0.46	[.54]	.82	[.65]	1.96	[1.2]	1.35	[.1.2]	2.45	[2.2]
Married	0.48	[.23]	1 (ref)		0.24*	[.17]	0.74	[.34]	1 (ref)		0.85	[.55]
Widowed	0.51	[.33]	0.83	[.60]	0.06*	[.07]	0.94	[.46]	1.23	[.80]	–	–
Unknown	2.16	[1.2]	0.37	[.33]	0.12+	[.14]	0.33*	[.18]	0.22*	[.16]	1.26	[1.03]

Standardized for age, mother's age at birth, birth order, birth cohort, disease exposure, father's occupation, number of younger brothers (at age 50), number of younger sisters (at age 50), number of older brothers (at age 50), number of children, and occupation.

Notes: Hazard ratios and standard errors are displayed.

+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

The interaction between RP's marital status and number of older sisters alive at RP age 50 produces some differing results for men and women. Unmarried women have consistently high mortality risk regardless of presence of older sisters, though having 2+ is associated with the highest risk (RR=2.45). Men in any marital status who have 2 or more older sisters have lower relative mortality risk, significant for the married and widowed (RR=.24 and RR=.06, respectively).

The interaction between RP's marital status and number of older brothers alive at RP's age 50 is displayed in Table 5.

Table 5: Relative risks of mortality by RP marital status and number of older brothers alive and living in Antwerp at RP age 50, n=506

	Men						**Women**					
	Number of older brothers alive						Number of older brothers alive					
	0		1		2+		0		1		2+	
RP's Civil status	HR	SE	HR	SE	HR	SE	HR	SE	HR	SE	HR	SE
Unmarried	1.01	[.51]	1.72	[1.1]	2.70	[3.0]	0.86	[.52]	2.29	[1.7]	7.67^{+}	[9.4]
Married	0.72	[.26]	1 (ref)		4.08*	[2.5]	0.38*	[.16]	1 (ref)		0.96	[.68]
Widowed	0.89	[.45]	0.52	[.45]	–		0.41^{+}	[.20]	2.20	[1.3]	0.63	[.70]
Unknown	2.19^{+}	[1.0]	1.95	[1.3]	1.32	[1.5]	0.18**	[.10]	0.33^{+}	[.20]	0.82	[.94]

Standardized for age, mother's age at birth, birth order, birth cohort, disease exposure, father's occupation, number of younger brothers (at age 50), number of younger sisters (at age 50), number of older sisters (at age 50), number of children, and occupation.

Notes: Hazard ratios and standard errors are displayed.

+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

Across all marital statuses for women, having 0 older brothers alive residing in Antwerp relates to lower mortality risk, with approximately a significant 0.4 times lower mortality risk for both the married and widowed. Having 2+ older brothers varied across marital statuses; there was minimal effect on married women (RR=.96), more than a significant 7 times the risk for unmarried women (RR=7.67), and 0.6 times the risk for the widowed (RR=.63). Having 2+ older brothers for men related to more than 2.5 times the risk for the unmarried (RR=2.70) and a significant 4 times the risk for married (RR=4.08), compared to the reference category.

5.2.3 Part II: Discussion

Part II of our analysis focused on the impact of sibling composition in later life on mortality past age 50. We believed that the presence of siblings in later life could lead to better insights into the relationship between sibships and longevity, as siblings may become close again in advancing ages. For our third hypothesis (H3), we expected that having younger siblings would be beneficial to RP's survival chances. We did find that having younger sisters, particularly 1, is beneficial to RP's survival. However, it becomes clear in the interaction between RP sex and number of younger sisters that this effect is not the same for both RP sexes; rather, it is very strong and positive for female RPs' survival, but not for male RPs'. If we believed that having younger siblings would be positive, having older siblings in later life would indicate the opposite effect. In fact, we do find that having older brothers (but not older sisters) in later life relates to very high excess mortality risk, for both male and female RPs. Overall our results suggest that both the sex of the sibling(s) and the sex of the RP matter, as having any number of sisters (both older and younger) in later life is mostly beneficial to RP's longevity, having any number of brothers elevates or has minimal effect on RP's mortality risk, and results often vary by RP sex.

6. Conclusions

Our findings suggest that sibling competition does not end in childhood, but rather that sibling competition carries on into later adulthood and has a strong relationship with mortality risk in advancing ages. Competition for sibling resources (financial, relationships, caretaking, etc.) may replace that of competition for parental resources occurring in early life. The complexity between sibling and gender dynamics in a life course perspective is also highlighted. In particular, we found that having any number of older brothers is a strong disadvantage for an individual, regardless of the sex of the

RP. This could suggest long-term effects of limited resources during developmental years, the 'burden' of caring for a dependent sibling later in life, or some combination of the two. We also found that certain social groups were even more affected by sibling composition than others. The interactions in Tables 4 and 5 (between sibling compositions and RP's marital status) could help explain why having older siblings had such a strong relationship with mortality risk. Unmarried women, for example, were severely disadvantaged by having any number of older brothers, and men were also to a somewhat lesser degree. Additionally, regardless of marital status, women who had no older brothers in Antwerp in later life were almost always consistently better off. However, the widowed represented a unique social group. Becoming widowed, in both contemporary as well as historical times, is a very stressful, life-changing event that could have profound, negative impact on health and longevity. Widows, in particular, often faced very harsh circumstances after spousal death, leading to poorer economic conditions and long-term effects on their health (Lillard and Waite 1995), particularly for those with younger children (Alter, Dribe, and Van Poppel 2007). Our study suggests that solidarity replaces competition among siblings when one becomes widowed, as the only time it was greatly beneficial for a woman's longevity to have any older siblings was in the case of widowhood, wherein having 2+ older brothers was related to greatly reduced mortality risk (.63 times the risk) though this finding was not significant. This finding was also mirrored for widowed men, to a far greater degree, who had greatly reduced mortality risk when having 2+ older sisters (a significant .06 times the risk). We see that risk is completely mitigated in this vulnerable social group, and even has positive effects on the widowed RP's longevity. This is interesting for several reasons. The first is that this is found for mixed-sex siblings, as same-sex siblings tend to have the strongest relationships, particularly for sister-sister pairings (Cicirelli 1994). It is also interesting that having many older siblings is beneficial when one is widowed, but certainly not when he or she is unmarried (both vulnerable social groups compared to the married). We believe this may suggest the inclination to protect a sibling in times of grief, but not when they were unmarried due to the inability to find a marriage partner. Widowhood represents a change in the status quo (from marriage to widowhood) while never marrying is simply a long-term unchanging status. It also suggests that being society's outcasts, and accordingly, undesirable on the marriage market, led to a harder life and very high excess mortality, which was particularly detrimental to unmarried women. It may also relate to the idea that singles (especially sisters) would be expected to care for their older or elderly siblings, since they did not have a family of their own and it would be practical for single women to assume this responsibility. The negative impact on singles could be twofold: an increased risk due to the stress of caretaking responsibility and also the negative effect of not having a partner. Being single was a burden in its own right, since there was no one to take care

of you or with whom to share caretaking responsibilities. We suspect this may have become burdensome, leading to increased mortality risk. We believe, in turn, that men were also negatively affected by having many older siblings, but perhaps this was due more to an increased competition for the support of their sister(s), since older siblings may have taken up most of the time and attention of these sister caretakers. Another issue could relate to the financial implications of supporting additional family members, since the welfare system was only in its initial phase of construction until the very end of the study period (Lamberts 2006).

In relation to life course studies on health, we find no direct evidence of a critical period effect during development (using our two proxies for health), as there was no negative effect from disease exposure in early life (actually a strong, positive effect) and no strong relationship to maternal age at birth. The positive effect of being born during the time of an epidemic could be explained in that these individuals were healthy enough to survive the epidemic. This could suggest that the exposure to epidemics during critical times did not leave them more susceptible in the long run, but rather, perhaps, strengthened their immune system, leading to lower mortality in later adulthood. There was some evidence of an accumulation of risks during the life course, in terms of sibling composition, as overall, the negative effects on longevity of having older brothers, and a higher birth order, carries on into late adulthood. We do, however, find some evidence of a critical period in later life, as having many older siblings present in later life relates to a much lower mortality risk for the widowed.

7. Acknowledgements

We would like to thank Hilde Bras, Isabelle Devos, Angelique Janssens, Jan Kok, Ward Neyrinck, Jan Van Bavel, and Mattijs Vandezande for their comments on an earlier version of this manuscript. We also greatly appreciate the valuable feedback that we received from the Editor and three anonymous reviewers.

References

Alter, G., Dribe, M., and Van Poppel, F. (2007). Widowhood, family size, and post-reproductive mortality: a comparative analysis of three populations in nineteenth-century Europe. *Demography* 44(4): 785–806. doi:10.1353/dem.2007.0037.

Alter, G. and Oris, M. (2005). Childhood conditions, migration, and mortality: Migrants and natives in 19th-century cities. *Biodemography and Social Biology* 52(3–4): 178–191. doi:10.1080/19485565.2005.9989108.

Barker, D.J.P. (1994). *Mothers, babies and health in later life*. Edinburgh, UK: Churchill Livingston.

Belmont, L. and Marolla, F.A. (1973). Birth order, family size, and intelligence. *Science* 182(4117): 1096–1101. doi:10.1126/science.182.4117.1096.

Bengtsson, T. and Lindström, M. (2000). Childhood misery and disease in later life: The effects on mortality in old age of hazards experienced in early life, southern Sweden, 1760–1894. *Population Studies* 54(3): 263–277. doi:10.1080/713779096.

Bengtsson, T. and Lindström, M. (2003). Airborne infectious diseases during infancy and mortality in later life in southern Sweden, 1766–1894. *International Journal of Epidemiology* 32(2): 286–294. doi:10.1093/ije/dyg061.

Bengtsson, T. and Mineau, G.P. (2009). Early-life effects on socio-economic performance and mortality in later life: A full life-course approach using contemporary and historical sources. *Social Science & Medicine* 68(9): 1561–1564. doi:10.1016/j.socscimed.2009.02.012.

Ben-Shlomo, Y. and Kuh, D. (2002). A life course approach to chronic disease epidemiology: Conceptual models, empirical challenges and interdisciplinary perspectives. *International Journal of Epidemiology* 31(2): 285–293. doi:10.1093/ije/31.2.285.

Blake, J. (1981). Family size and quality of children. *Demography* 18(4): 421–442. doi:10.2307/2060941.

Blake, J. (1987). Differential parental investment: Its effects on child quality and status attainment. In: Lancaster, J.B., Altmann, J., Rossi, A.S., and Sherrod, L.R. (eds.). *Parenting across the life span*. New York: Aldine de Gruyter: 351–375.

Bras, H. (2011). Intensification of family relations? Changes in the choice of marriage witnesses in the Netherlands, 1830–1950. *Tijdschrift voor Sociale en Economische Geschiedenis* 8(4): 102–135.

Cicirelli, V.G. (1994). Sibling relationships in cross-cultural perspective. *Journal of Marriage and the Family* 56(1): 7–20. doi:10.2307/352697.

Cleves, M., Gould, W., Gutierrez, R., and Marchenko, Y. (2008). *An introduction to survival analysis using Stata*. 2nd ed. College Station, TX: Stata Press.

Coall, D.A., Meier, M., Hertwig, R., Wanke, M., and Hopflinger, F. (2009) Grandparental investment: The influence of reproductive timing and family size. *American Journal of Human Biology* 21(4): 455–63. doi:10.1002/ajhb.20894.

Coontz, S. (2005). *Marriage, a history: How love conquered marriage*. New York: Penguin Books.

Cumming, E. and Schneider, D. (1961). Sibling solidarity: A property of American kinship. *American Anthropologist* 63(3): 498–507. doi:10.1525/aa.1961.63.3.02a00030.

Devos, I. (2000). Te jong om te sterven. De levenskansen van meisjes in België omstreeks 1900. *Tijdschrift voor Geschiedenis* 1: 55–75.

Eggerickx, T. and Tabutin, D. (1994). La surmortalité des filles vers 1890 en Belgique: Une approche régionale. *Population* 49(3): 657–684. doi:10.2307/1533962.

Elo, I.T. and Preston, S.H. (1996). Educational differentials in mortality: United States, 1979–85. *Social Science & Medicine* 42(1): 47–57. doi10.1016/0277-9536(95)00062-3.

Forsdahl, A. (1978). Living conditions in childhood and subsequent development of risk factors for arteriosclerotic heart disease. The cardiovascular survey in Finnmark 1974-75. *Journal of Epidemiology and Community Health* 32(1): 34–37. doi:10.1136/jech.32.1.34.

Gillis, J. (1996). Making time for the family: The invention of family time(s) and the reinvention of family history. *Journal of Family History* 21(1): 4–Y 21. doi:10.1177/036319909602100102.

Hanushek, E.A. (1992). The trade-off between child quantity and quality. *Journal of Political Economy* 100(1): 84–117. doi:10.1086/261808.

Hauser, R.M. and Sewell, W. (1986). Family effects in a simple model of education, occupation status, and earnings: findings from Wisconsin and Kalamazoo studies. *Journal of Labor Economics* 4(3): S83–S120. doi:10.1086/298122.

Hayward, M.D. and Gorman, B.K. (2004). The long arm of childhood: the influence of early-life social conditions on men's mortality. *Demography* 41(1): 87–107. doi:10.1353/dem.2004.0005.

Hertwig, R., Davis, J.N., and Sulloway, F.J. (2002). Parental investment: How an equity motive can produce inequality. *Psychological Bulletin* 128(5): 728–745. doi:10.1037/0033-2909.128.5.728.

Hill, M. and O'Neill, J. (1994). Family endowments and the achievement of young children with special reference to the underclass. *The Journal of Human Resources* 29(4): 1064–1100. doi:10.2307/146134.

House, J.S., Landis, K.R., and Umberson, D. (1988). Social relationships and health. *Science* 241(4865): 540–545. doi:10.1126/science.3399889.

Humphries, J. (1991). 'Bread and a pennyworth of treacle': excess female mortality in England in the 1840s. *Cambridge Journal of Economics* 15(4): 451–473.

Kemkes-Grottenthaler, A. (2004). Parental effects on offspring longevity—evidence from 17th to 19th century reproductive histories. *Annals of Human Biology* 31(2): 139–158. doi:10.1080/03014460410001663407.

Kennedy, R.E. (1973). *The Irish: emigration, marriage, and fertility*. Berkeley, CA: University of California Press.

Klasen, S. (1998). Marriage, bargaining, and intrahousehold resource allocation: Excess female mortality among adults during early German development, 1740–1860. *Journal of Economic History* 58(2): 432–67. doi:10.1017/S002205070002057X.

Kruithof, J. (1964). De demografische ontwikkeling in de XIXde eeuw. In: Genootschap voor Antwerpse Geschiedenis (ed.). *Bouwstoffen voor de geschiedenis van Antwerpen in de XIXde eeuw*. Antwerpen: Algemene Drukkerijen LLoyd Anversois: 508–543.

Kuh, D. and Ben-Shlomo, Y. (1997). *A life course approach to chronic disease epidemiology*. Oxford: Oxford University Press.

Lamberts, E. (2006). Belgium since 1830. In: Blom, J. and Lamberts, E. (eds.). *History of the Low Countries.* Oxford: Berghahn: 319–392.

Lee, C. (1997). Socioeconomic background, disease, and mortality among Union Army recruits: Implications for economic and demographic history. *Explorations in Economic History* 34(1): 27–55. doi:10.1006/exeh.1996.0661.

Lillard, L. and Waite, L. (1995). 'Till death do us part: Marital disruption and mortality. *American Journal of Sociology* 100(5): 1131–1156. doi:10.1086/230634.

Lloyd, C.B. and Gage-Brandon, A.J. (1994). High fertility and children's schooling in Ghana: Sex differences in parental contributions and educational outcomes. *Population Studies* 48(2): 293–306. doi:10.1080/0032472031000147806.

Lundberg, O. (1993). The impact of childhood living conditions on illness and mortality in adulthood. *Social Science & Medicine* 36(8): 1047–1052. doi:10.1016/0277-9536(93)90122-K.

Marks, G.N. (2006). Family size, family type and student achievement: Crossnational differences and the role of socioeconomic and school factors. *Journal of Comparative Family Studies* 37: 1–24.

Matthijs, K. (2002). Mimetic appetite for marriage in nineteenth-century Flanders: Gender disadvantage as an incentive for social change. *Journal of Family History: Studies in Family, Kinship and Demography* 27(2): 101–127. doi:10.1177/036319900202700203.

Matthijs, K. (2003). Demographic and sociological indicators of privatisation of marriage in the 19th century in Flanders. *European Journal of Population* 19(4): 375–412. doi:10.1023/A:1026361006200.

Matthijs, K. (2006). Changing patterns of familial sociability: Family members as witnesses to (re)marriage in nineteenth-century Flanders. *Journal of Family History: Studies in Family, Kinship and Demography* 31(2): 115–143. doi:10.1177/0363199005284871.

Matthijs, K. and Moreels, S. (2010). The Antwerp COR*-database: A unique Flemish source for historical-demographic research. *The History of the Family* 15(1): 109–115. doi:10.1016/j.hisfam.2010.01.002.

Preston, S.H., Hill, M.E., and Drevenstedt, G.L. (1998). Childhood conditions that predict survival to advanced ages among African–Americans. *Social Science & Medicine* 47(9): 1231–1246. doi:10.1016/S0277-9536(98)00180-4.

Quaranta, L. (2013). Scarred for Life. How conditions in early life affect socioeconomic status, reproduction and mortality in Southern Sweden, 1813–1968. [Ph.D. Thesis]. Lund: Lund University.

Rosenzweig, M.R. and Wolpin, K.I. (1980). Testing the quantity-quality fertility model: the use of twins as a natural experiment. *Econometrica* 48(1): 227–240. doi:10.2307/1912026.

Sanders, V. (2002). *The brother-sister culture in nineteenth century literature. From Austen to Woolf*. Basingstoke and New York: Palgrave.

Smith, K.R., Gagnon, A., Cawthon, R.M., Mineau, G.P., Mazan, R., and Desjardins, B. (2009). Familial aggregation of survival and late female reproduction. *Journal of Gerontology: Biological Sciences* 64A(7): 740–744. doi:10.1093/gerona/glp055.

Sulloway, F.J. (1996). *Born to rebel: Birth order, family dynamics, and revolutionary genius*. New York: Pantheon.

Sulloway, F.J. (2001). Birth order, sibling competition, and human behavior. In: Holcomb, H.R. (ed.) *Conceptual Challenges in Evolutionary Psychology: Innovative Research Strategies*. Dordrecht and Boston: Kluwer Academic Publishers: 39–83.

Van Bavel, J. (2006) The effect of fertility limitation on intergenerational social mobility: The quality-quantity trade-off during the demographic transition. *Journal of Biosocial Science* 38(4): 553–69. doi:10.1017/S0021932005026994.

Van de Putte, B. and Matthijs, K. (2001). Romantic love and marriage: A study of age homogamy in 19th century Leuven (Belgium). *Belgisch tijdschrift voor nieuwste geschiedenis-revue belge d histoire contemporaine* 31(3–4): 579–619. https://biblio.ugent.be/publication/443657/file/1038487.pdf.

Van Leeuwen, M.H. and Maas, I. (2005). *A short note on HISCLASS. History of Work Information System.* Amsterdam: International Institute of Social History. http://historyofwork.iisg.nl/docs/hisclass-brief.doc.

Van Poppel, F. (2000). Long-term trends in relative health differences between men and women. *European Journal of Obstetrics, Gynecology, and Reproductive biology* 93(2): 119–122. doi:10.1016/S0301-2115(00)00277-3.

Wolf, M. (1982). The word-retrieval process and reading in children and aphasics. In: Nelson, K. (ed.). *Children's language* (Vol. III). Hillsdale, NJ: Erlbaum.

Appendix

Table A1: Relative risks of mortality and standard errors for men and women who had siblings in the Antwerp region in nested multiplicative hazard models

	Model I		Model II		Model III		Model IV	
Sex								
Women	1		1		1		1	
Men	1.442*	[0.222]	1.428*	[0.221]	1.426*	[0.222]	1.490*	[0.235]
Mother's age at birth								
15–24	1.314	[0.326]	1.218	[0.310]	1.208	[0.307]	1.170	[0.298]
25–34	1		1		1		1	
35+	1.055	[0.183]	1.012	[0.177]	1.015	[0.178]	0.952	[0.171]
Birth cohort								
1800–1829	1		1		1		1	
1830–1839	0.917	[0.180]	0.915	[0.181]	0.910	[0.181]	0.909	[0.181]
1840–1849	0.833	[0.189]	0.857	[0.194]	0.852	[0.194]	0.870	[0.199]
1850–1859	1274	[0.327]	1264	[0.324]	1264	[0.324]	1236	[0.317]
Birth order								
1st born	1		1		1		1	
2nd born	1.328	[0.305]	1.270	[0.295]	1.296	[0.305]	1.216	[0.286]
3rd born or higher	0.927	[0.221]	0.928	[0.224]	0.979	[0.253]	0.850	[0.226]
Unknown	1.247	[0.393]	1.222	[0.395]	1.211	[0.392]	0.997	[0.330]
Disease exposure								
No	1		1		1		1	
Yes	0.701*	[0.116]	0.713*	[0.119]	0.711*	[0.119]	0.712*	[0.118]
Father's occupation								
Professionals, foremen, and skilled	1		1		1		1	
Farmers and farm workers	1.718^{+}	[0.520]	1.772^{+}	[0.535]	1.817^{+}	[0.556]	1.707^{+}	[0.519]
Unskilled and day laborers	0.986	[0.249]	1.078	[0.277]	1.095	[0.283]	1.072	[0.280]
Missing/ unknown	1.884**	[0.454]	1.917**	[0.462]	1.938**	[0.472]	1.894**	[0.467]
Number of older brothers alive								
0	1		1		1		1	
1	1.557*	[0.293]	1.533*	[0.289]	1.515*	[0.287]	1.540*	[0.292]
2+	1.925*	[0.627]	1.924*	[0.630]	1.948*	[0.640]	2.064*	[0.678]
Number of younger brothers alive								
0			1		1		1	
1			1.290	[0.227]	1.307	[0.232]	1.339	[0.239]
2+			0.817	[0.196]	0.823	[0.198]	0.887	[0.215]
Number of older sisters alive								
0					1		1	
1					0.894	[0.193]	0.926	[0.201]
2+					0.900	[0.251]	0.881	[0.252]
Number of younger sisters alive								
0							1	
1							0.655*	[0.124]
2+							0.719	[0.172]

Table A1: (Continued)

	Model I		Model II		Model III		Model IV	
Number of children								
< 5	1		1		1		1	
5 to 10	1.099	[0.227]	1.091	[0.227]	1.092	[0.228]	1.033	[0.216]
10+	0.571^{+}	[0.168]	0.580^{+}	[0.172]	0.580^{+}	[0.173]	0.539*	[0.161]
0 or unknown	0.362***	[0.0930]	0.369***	[0.0936]	0.374***	[0.0950]	0.345***	[0.0894]
Marital status (time-varying)								
Unmarried	2.164**	[0.601]	2.081**	[0.578]	2.066**	[0.573]	2.206**	[0.618]
Married	1		1		1		1	
Widowed	1.098	[0.237]	1.131	[0.248]	1.131	[0.248]	1.127	[0.249]
Unknown	0.695	[0.192]	0.674	[0.186]	0.665	[0.184]	0.695	[0.194]
Occupation								
Professionals	1		1		1		1	
Foreman and skilled	1.481	[0.362]	1.454	[0.358]	1.441	[0.356]	1.426	[0.355]
Farmers	0.690	[0.235]	0.678	[0.229]	0.676	[0.230]	0.700	[0.237]
Unskilled and day laborers	1.085	[0.329]	1.039	[0.315]	1.025	[0.313]	1.037	[0.319]
Missing/ unknown	0.450*	[0.144]	0.463*	[0.150]	0.456*	[0.149]	0.435*	[0.143]
Observations	641		641		641		641	

Notes: Adjusted for age. Exponentiated coefficients; Standard errors in brackets.+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001