WIDOWHOOD, FAMILY SIZE, AND POST-REPRODUCTIVE MORTALITY: A COMPARATIVE ANALYSIS OF THREE POPULATIONS IN NINETEENTH-CENTURY EUROPE*

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Researchers from a number of disciplines have offered competing theories about the effects of childbearing on parents' postreproductive longevity. The "disposable soma theory" argues that investments in somatic maintenance increase longevity but reduce childbearing. "Maternal depletion" models suggest that the rigors of childrearing increase mortality in later years. Other researchers consider continued childbearing a sign of healthy aging and a predictor of future longevity. Empirical studies have produced inconsistent and contradictory results. Our focus is on the experience of widowhood, which has been ignored in previous studies. We hypothesize that the death of a spouse is a stressful event with long-term consequences for health, especially for women with small children. Data are drawn from historical sources in Sweden, Belgium, and the Netherlands from 1766 to 1980. Postreproductive mortality was highest among young widows with larger families in all three samples. Age at last birth had little or no effect. We conclude that raising children under adverse circumstances can have long-lasting, harmful effects on a mother's health.

Researchers in several disciplines have recently focused on links between childbearing and postreproductive longevity. Some view childbirth and childrearing as stressful experiences with long-lasting consequences for the mother's health, especially in economically deprived populations (Dribe 2004; Hurt et al. 2004; Van de Putte, Matthijs, and Vlietinck 2004; Winikoff, Castle, and International Planned Parenthood Federation 1987; Winkvist, Rasmussen, and Habicht 1992). Others see childbearing as an indicator of good health, implying that women with later births will be more resistant to disease at later ages (Doblhammer and Oeppen 2003; Mueller 2004; Smith, Mineau, and Bean 2002). Another school suggests that human evolution resulted in a genetic trade-off between reproduction and longevity (Kirkwood and Westendorp 2001; Westendorp and Kirkwood 1998). Despite the attention that this topic has received, the nature and meaning of relationships between childbearing and longevity remain obscure. Empirical results often differ widely between studies, and the diversity of disciplinary and theoretical perspectives leads to different interpretations of similar results. For example, some studies have found strong correlations between number of children ever born (parity) and old-age mortality, whereas others have found no correlation (Gavrilov and Gavrilova 1999; Gavrilova and Gavrilov 2005; Hurt, Ronsmans, and Thomas 2006).

Our focus is on the experience of widowhood, which has been ignored in previous studies. We hypothesize that the death of a spouse is a stressful event with long-run

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consequences for health, especially for women with small children who could not rely on strong social support systems in the past. Widows were often in extreme economic distress in the populations born in eighteenth- and nineteenth-century Europe that we examine here. Working women were poorly paid, and widowed mothers worked harder and denied themselves to feed their children. Thus, we expect that the consequences of widowhood were greater for women with young children.

Most previous studies did not separate widowhood or divorce from other factors that end a woman's childbearing career. Age at last birth is usually treated as an indicator of a woman's health or of her biological ability to bear children. These interpretations are clearly problematic for women whose marriages ended in widowhood, and in some cases the socioeconomic consequences of widowhood may have been confused with biological processes. We argue that the poverty experienced by widows, which was intensified when they had young children to support, had physiological consequences at older ages.

Our data describe three historical populations from the mid-eighteenth to the mid-twentieth centuries. We find that mortality in the postreproductive years responded to the interaction between age at widowhood and children ever born. Women who had been young widows with large families had the highest mortality above age 50. Moreover, in an area where results have varied widely among studies, we obtain very similar results from three independent samples representing different periods and places. This suggests that stressful experiences during the childbearing years had long-run adverse consequences for survival in old age.

PREVIOUS RESEARCH ON CHILDBEARING AND POSTREPRODUCTIVE MORTALITY

In present-day populations, giving birth to additional children appears to have a negative impact on female longevity (e.g., Beral 1985; Friedlander 1996; Green, Beral, and Moser 1988; Kvåle, Heuch, and Nilsson 1994; Lund, Arnesen, and Borgan 1990). Some studies seem to suggest a more or less linear relationship, but others have found a U-shaped pattern (Doblhammer 2000; Green et al. 1988). This relationship may also be due to correlations with third factors, such as socioeconomic differences in living conditions and family limitation, rather than direct effects of childbearing on longevity. Since the poor often have both larger families and higher mortality, correlations between fertility and mortality may be spurious. For this reason, a number of researchers have turned to historical populations in which fertility was not controlled.

The results from historical studies have also been mixed. A number of studies failed to find a relationship between family size and mortality after the childbearing years (Bideau 1986; Gavrilov and Gavrilova 1999; Helle, Käär, and Jokela 2002; Knodel 1974; Le Bourg et al. 1993). The most common result in these studies is that women whose last births occurred at a higher age had lower postreproductive mortality (Helle, Lummaa, and Jokela 2005; Muller et al. 2002). Recent studies by Doblhammer and Oeppen (2003), Dribe (2004), Smith et al. (2002), and Westendorp and Kirkwood (1998), however, found a positive association between children ever born and postreproductive mortality.

It has become clear that the relationship between childbearing and postreproductive longevity may be quite complicated. Indeed, several recent papers (Beise and Voland 2002; Dribe 2004; Korpelainen 2000; Le Bourg 2001; Lycett, Dunbar, and Voland 2000) suggested that the relationship between longevity and number of children varies by socioeconomic status, with stronger effects among the poor. Others found that marital duration (Lycett et al. 2000) and even the sex composition of the children (Helle, Lummaa, and Jokela 2002; Van de Putte, Matthijs, and Vlietinck 2004) affect the relationship between childbearing and longevity.

Because various studies have found different empirical relationships between fertility and longevity, a diverse body of hypotheses has been offered to explain these findings.

These explanations fall under five main headings: biomedical models, evolutionary models, maternal depletion models, social support models, and selection models.

Biomedical Models

Medical researchers have linked postreproductive mortality from specific diseases to consequences of pregnancy and delivery. Pregnancy, delivery, and lactation activate a variety of physiological processes, some of which may have long-term implications. These processes may affect both the risk of contracting a disease and the risk of dying after diagnosis, sometimes in opposite directions. Research on breast cancer, for example, has focused on differences between childless (nulliparous) women and those with at least one child (parous), as well as differences in the timing of first and last births (Albrektsen, Heuch, and Kvåle 1995). The risk of breast cancer seems to be higher for childless women (Lambe et al. 1998), but their chances of surviving after diagnosis are also higher than for parous women (Korzeniowski and Dyba 1994). High fertility appears to be protective for some other forms of cancer (Egan, Quinn, and Gragoudas 1999; Lochen and Lund 1997; Salvesen et al. 1998), and the link between childbearing and cardiovascular disease differs among various studies (de Kleijn, van der Schouw, and van der Graaf 1999). Correlations between parity and the risks of some forms of cancer among men as well as women point to an important role for lifestyle factors in the relationship between childbearing and mortality (Kravdal 1995).

Evolutionary Models

Unlike most other species, human females survive many years after their ability to reproduce has ended. This trait has been viewed as a challenge to evolutionary theory, and a large literature offers potential explanations, such as the "grandmother hypothesis" (Hawkes 2004; Hawkes et al. 1998). Some of these evolutionary models have been used to describe possible genetic links between fertility and longevity. Genes can have multiple effects (pleiotropy), and a single gene may have both beneficial and harmful effects (antagonistic pleiotropy). Williams (1957) suggested that genes enhancing fecundity may have negative consequences on survival after the end of childbearing. Natural selection will tend to favor such genes because of their positive effect on reproduction, and their effects on postreproductive life span will be ignored. This leads to the hypothesis that higher fertility will be associated with higher mortality after the end of childbearing (see Gavrilov and Gavrilova 2002 and Le Bourg 2001 for reviews). Kirkwood (1977; Kirkwood and Westendorp 2001; Westendorp and Kirkwood 1999) posited a conflict between somatic investments in aging and in reproduction. The "disposable soma" theory (Kirkwood and Holliday 1979) sees a metabolic trade-off between fecundity and longevity, such that women who have more children are more likely to have shorter lives. A number of studies have examined this trade-off in nonhuman species (Kirkwood 2002; Kirkwood and Austad 2000; Kirkwood and Rose 1991; Kirkwood and Westendorp 2001), as well as in historical human populations (Doblhammer and Oeppen 2003; Gavrilova et al. 2004; Helle et al. 2005; Korpelainen 2000; Le Bourg et al. 1993; Lycett et al. 2000; Muller et al. 2002; Westendorp and Kirkwood 1998), with mixed results.

Maternal Depletion Models

Repeated childbearing may increase the likelihood that women will suffer poor nutrition, greater exposure to disease, and other physical and emotional stress, leading to higher mortality at later ages. These effects are mediated by the social and economic context, and the physiological costs of childbearing are expected to be more pronounced among the poor (Dribe 2004; Oris, Neven, and Alter 2004; Winikoff et al. 1987; Winkvist et al. 1992). For example, childbearing and lactation can have strong effects on a mother's nutritional status. Christensen et al. (1998) found that the Danish saying "one tooth per child" was very nearly true among twins born between 1893 and 1923. Tooth loss is a sign of protein deficiency, and observers often remark that women sacrifice their own health to feed their husbands and children (Alter, Manfredini, and Nystedt 2004). Van de Putte et al. (2004) suggested that mothers were at a greater disadvantage in the competition for resources within households when they had more sons. Maternal depletion may also be related to the pace of childbearing: women who experienced shorter birth intervals had less time to recover between pregnancies (see Higgins and Alderman 1997; Miller, Rodríguez, and Pebley 1993; Pebley and DaVanzo 1993). Short birth intervals and repeated childbearing also increase the amount of time that mothers must cope with more than one very young child simultaneously, intensifying the physical and emotional stress on mothers (Breschi and Derosas 2000; Imhof 1984; Lynch and Greenhouse 1994; Perrenoud 1981).

Social Support Models

Social networks that provide income, labor, and other forms of material and social support significantly improve health and increase longevity (House, Landis, and Umberson 1988; Hurt et al. 2004; Kawachi et al. 1996; Lindström 2000; Marmot and Wilkinson 1999). Even in wealthy societies, children often provide important forms of care and support. Thus, people with more children may receive better treatment in old age (Zeng and Vaupel 2004). In a preindustrial context, children were probably even more important for assuring security to their parents in old age, although they might well have constituted a net financial burden if viewed over the entire life cycle (see Lee 2000).

Selection Models

Associations between fertility and postreproductive mortality may be confounded by correlations with other factors related to childbearing and longevity. Differences in demographic behavior among social and economic groups tend to create an apparent negative correlation between fertility and mortality. If higher incomes and education are correlated with both family limitation and better health, women with smaller families will live longer. There is also a biological feedback from mortality to fertility. Infant deaths shorten lactation, which can reduce birth intervals and increase completed family size (Gutmann and Alter 1993). Consequently, women in high-mortality environments may have more children, implying a positive correlation between childbearing and subsequent mortality.

On the other hand, poor health may cause both lower fecundity and higher mortality, resulting in a positive correlation between family size and longevity. Women in poor health may be less likely to conceive, be less able to carry pregnancies to a successful conclusion, and live shorter lives after the childbearing years. Doblhammer and Oeppen (2003) recently argued that an unobserved positive correlation between fecundity and the risk of dying has concealed the effect of childbearing on mortality. In other words, women with large families lived longer than those with fewer births because they were healthier at the outset, even though repeated childbearing reduced the size of their advantage. Doblhammer and Oeppen (2003) found that modeling fertility and mortality in simultaneous equations revealed a positive effect of number of births on mortality. Thus, more children ever born or late ages at last birth may simply indicate better health rather than a direct link between childbearing or child rearing and postreproductive longevity (see also Mueller 2004).

DATA

We compare results from three samples of historical life histories.

Scania, Sweden

Life histories from eighteenth- and nineteenth-century Sweden are drawn from family reconstitutions carried out within the Scanian Demographic Database (Center for Economic

Demography 2006) for five parishes in western Scania in southern Sweden: Hög, Kävlinge, Halmstad, Sireköpinge, and Kågeröd (see Dribe [2000, 2004] for a description of the data). In 1766, the five parishes had 2,509 inhabitants, which increased to 5,539 by 1895. The family reconstitutions have also been supplemented with data from catechetical examination registers (a kind of population register) and poll-tax registers (showing, for example, type and size of landholding). The database contains all individuals born in, or migrating into, the parishes. Instead of sampling a certain stock of individuals—for example, a birth cohort—each individual is followed from birth or time of in-migration to death or out-migration.

The parishes were rural and dominated by agriculture until the final decades of the nineteenth century, when Kävlinge was transformed from a rural village into a small town following the building of a main railroad line through the village and the establishment of different industries, such as sugar, leather, and shoemaking. Kävlinge, Hög, Sireköpinge, and southern Halmstad were open-country farmland, while northern Halmstad and Kågeröd were more wooded. Kågeröd, Halmstad, and Sireköpinge were composed primarily of manorial land, while freehold and crown land predominated in Kävlinge and Hög. In the first decades of the nineteenth century, agriculture in Scania became increasingly commercialized as larger and larger quantities of agricultural goods were supplied to the market, both for internal sale in Sweden and for export.

Sart, Belgium

Our Belgian sample comes from the commune of Sart-lez-Spa, located in the Belgian Ardennes. Nineteenth-century Sart covered a large, sparsely populated area. In spite of its proximity to the most advanced agricultural and industrial areas on the European continent, Sart was poor and relatively backward at the beginning of the nineteenth century (Vliebergh and Ulens 1912). Contemporary accounts speak of the area's poverty, and there are signs of increasing Malthusian pressure as the population grew from 1,791 in 1806 to 2,380 in 1846 (Oris et al. 2004). Men measured in military conscription examinations reflect these conditions. Most men in Sart were shorter than the average for Belgium, which had a shorter average male height than neighboring countries (Alter, Neven, and Oris 2004b). After 1850, conditions in Sart improved dramatically. Rapidly expanding factories in the nearby city of Verviers drew migrants from Sart, reducing population pressure. More-advanced agricultural practices were introduced, including artificial fertilizers.

Sart was chosen for study not because it is in any way typical of Eastern Belgium, but because of its excellent population records (Alter, Neven, and Oris 2004a). In addition to complete registers of births, marriages, and deaths (Sart, Belgium 1800–1900), we have population registers describing household composition and migration from 1811 to 1900 (Sart, Belgium 1811–1890). These documents allow us to reconstruct the biographies of everyone living in Sart during most of the nineteenth century.

Historical Sample of the Netherlands (HSN)

The HSN is a national database with information on the complete life histories of a 0.5% random sample (76,700 birth records) of men and women born in the Netherlands between 1812 and 1922. Data for 3 of the 11 Dutch provinces—Zeeland, Utrecht, and Friesland—are used in this study, and these data are limited to women born between 1850 and 1889. Life histories of the sampled persons are reconstructed from the vital registration system (birth, death, and marriage certificates), decennial population registers, personal cards, and the Municipal Basic Administration (Historical Sample of the Netherlands 2005). This allows us to follow sampled persons from household to household and from place to place.

Zeeland is characterized by landscape, drainage, soil, and accessibility that had a profound effect on the types of settlement, reclamation methods, shapes of fields and farms, land use, and communications (Van Poppel, Jonker, and Mandemakers 2005). The province had (and still has) few industries and no large towns. In the second half of the nineteenth century, it remained a rural area with sea-clay grain-farming where agricultural modernization was eroding the position of the small farmer and farm laborer. After 1900, industrialization took place, but industrialization did not result in urbanization of the area.

Utrecht, located in the center of the country, is considered more or less representative of the Netherlands as a whole with respect to religious composition, income level, and demographic characteristics. The northeastern province of Friesland was also a mainly rural province, the only large town being Leeuwarden. The relatively prosperous agricultural economy was strongly commercialized, and an industrial breakthrough began in the early 1880s. Like Zeeland, it was heavily affected by the agrarian depression, leading to very high emigration in the period 1881–1915.

These three provinces illustrate the sharp divide between the high mortality of coastal and low-lying areas in the West and the low mortality in the East and South, which characterized the Netherlands until late in the nineteenth century. Until the 1880s, coastal and low-lying riverine municipalities in Zeeland and Utrecht were characterized by very high infant mortality, reaching levels of 350 deaths before age one per 1,000 live births. Infant mortality was much lower in Friesland, where fewer than 100 infants died per 1,000 live births.

SAMPLE AND VARIABLES

Women who remarried before age 50 have been dropped from the samples used in this analysis to avoid complicating the interpretation of children ever born. There were a small number of such women in each sample. Remarriages after age 50 are captured by a time-varying covariate for marital status. A small number of divorcees (three women in the HSN sample) are included among the widows because we believe that the economic consequences of divorce were similar to widowhood.

Table 1 shows means and distributions of the variables used in the analysis. There are basic similarities among the three data sets as well as some differences. Most of the differences between samples are due to timing. The average woman in the Scanian data was born in 1778, compared with 1811 in the Sart data and 1871 in the HSN. This difference in timing explains the higher death rate in Scania (48 per 1,000) and lower death rate in the HSN (36). Also, fewer of the women in the HSN sample were widowed before age 50 (7% compared with 18% in Scania and 19% in Sart). Marital status is measured as a time-varying covariate so that we can capture the effects of bereavement immediately after a spouse's death (Smith and Zick 1994; Thierry 1999). A significant portion of our observations (15% to 25%) occurred during the bereavement period, less than five years after the spouse's death.

The number of children ever born is very similar in all three samples: 5.2 in Scania, 5.7 in Sart, and 5.4 in the HSN. This similarity conceals an important difference because women in the HSN began and ended childbearing at earlier ages. Half of the HSN women had a first birth before age 25, compared with only 34% in Scania and 39% in Sart. It is also noteworthy that a higher proportion of the HSN women had their last births before age 35 (40% compared with 13% in Scania and 12% in Sart). This strongly suggests that some women in the HSN sample were practicing family limitation. The high ages at last birth in Scania and Sart indicate that little family limitation was practiced in those populations (see also Bengtsson and Dribe 2006).

We constructed an indicator of socioeconomic status for each sample. These scales are specific to each population, and they are intended to control for differences within samples, not for comparisons between samples. Since the samples include only women over the age of 50, these women tend to be in households with above-average wealth.

The data used in this study differ in important ways from most historical research on postreproductive longevity. Previous studies have been based on either genealogies or

Table 1. Means and Distributions of Variables

Variable	Scania 1766–1895	Sart 1812–1899	HSN 1850–2005
Number of Women	1,031	386	556
Deaths	768	252	479
Time at Risk	15,867	6,296	13,293
Deaths per 1,000 Person-Years	48.4	40.0	36.0
Number of Children Ever Born			
Mean	5.2	5.7	5.4
1–2	22.0	12.3	26.0
3–4	22.2	24.3	19.7
5–6	24.3	28.0	21.5
7–8	19.7	17.9	13.6
9+	11.8	17.5	19.3
All[a]	100.0	100.0	100.1
Age at First Birth			
Mean	27.2	27.3	25.8
< 25	34.2	38.5	50.0
25–30	37.7	34.8	33.4
30–35	18.4	19.0	13.2
> 35	9.7	7.7	3.3
All[a]	100.0	100.0	99.9
Age at Last Birth			
Mean	39.6	40.3	36.4
< 35	12.7	11.8	40.1
35–40	29.9	26.4	27.4
40–44	49.3	52.7	26.5
> 45	8.0	9.2	6.0
All[a]	99.9	100.1	100.0
Age at Widowhood if Widowed Before 50 (50 for currently married at age 50)	48.8	48.7	49.5
Age at Widowhood			
< 40	4.1	4.6	1.8
40–44	5.4	6.4	1.5
45–49	8.8	8.0	3.8
Married at age 50	81.7	81.1	92.8
All[a]	100.0	100.1	99.9
Year of Birth	1777.7	1811.8	1871.3
Marital Status			
Currently married	58.9	43.6	50.8
Widowed < 5 years	15.3	24.0	25.6
Widowed > 5 years	25.8	32.4	23.6
All	100.0	100.0	100.0

Note: Means of socioeconomic status and place of birth variables are available from the authors.

[a]Some totals do not sum to 100.0 because of rounding.

parish registers (baptisms, marriages, and burials). Since migration is not usually reported in those sources, only women with complete life histories can be studied, and migrants are often excluded. Our sources include information on migration and nominative lists of the current population at specific points in time. We can determine when subjects were under observation, even if their life histories are incomplete. For example, the population registers of Sart describe all residents of the municipality from 1812 until 1900. Consequently, we include women in the study who were alive in 1900. In this respect, our samples are more representative of their respective societies than most previous studies of historical populations. In addition, all three of these societies had well-established vital registration systems, and we are confident that the recording of births was as close to being complete as possible.

METHODS

Women are included in this study if they could be followed from first marriage until the age of 50 or older. Our analysis starts at age 50 and continues until the woman dies or observation of her life history ends. Because our data include incomplete life histories, we use a method for event-history analysis with censored data: the Cox partial-likelihood proportional hazards model (Cox 1972). The Cox model takes the form

$$h(t|\mathbf{x}_j) = h_0(t)\exp(\mathbf{x}_j\beta_x),$$

in which $h(t|\mathbf{x}_j)$ is the hazard rate or instantaneous rate of transition (also called the *force of mortality*) at age t for an individual with characteristics $\mathbf{x}_j$. This expression assumes that all hazard rates are proportional to a baseline hazard, $h_0(t)$, which describes variation by age in the transition rate for a standard individual.

We present four models describing the effects of childbearing and widowhood on postreproductive mortality.

$$h(t) = h_0(t)\exp(\beta_1 CEB + \beta_2 AgeLastBirth + \beta_3 AgeFirstBirth + \beta_4 Widowed{<}5years + \beta_5 Widowed{>}5years + \beta_6 SES) \quad (1)$$

$$h(t) = h_0(t)\exp(\beta_1 CEB + \beta_2 AgeLastBirth + \beta_3 CEB \times AgeLastBirth + \beta_4 AgeFirstBirth + \beta_5 Widowed{<}5years + \beta_6 Widowed{>}5years + \beta_7 SES) \quad (2)$$

$$h(t) = h_0(t)\exp(\beta_1 CEB + \beta_2 AgeWidowed + \beta_3 AgeFirstBirth + \beta_4 Widowed{<}5years + \beta_5 Widowed{>}5years + \beta_6 SES) \quad (3)$$

$$h(t) = h_0(t)\exp(\beta_1 CEB + \beta_2 AgeWidowed + \beta_3 CEB \times AgeWidowed + \beta_4 AgeFirstBirth + \beta_5 Widowed{<}5years + \beta_6 Widowed{>}5years + \beta_7 SES) \quad (4)$$

Model 1 tests biomedical and evolutionary models, which suggest that age at last birth is an indicator of other physiological processes linked to fecundity. Biomedical models and maternal depletion models are also consistent with Model 2, in which age at last birth interacts with number of children ever born. Social support models imply that women with fewer children or those widowed at younger ages will have higher old age mortality, as in Model 3, because they lack the social support provided by children. In Model 4, which is based on an alternative version of the maternal depletion model, the experience of widowhood is more stressful when women have young children.

All models include the number of children ever born (*CEB*) and age at first birth (*AgeFirstBirth*), two covariates to identify marital status (*Widowed<5years*; *Widowed>5years*), and indicators for socioeconomic status (*SES*). Marital status is modeled with time-varying covariates to allow for a period of high mortality following a spouse's death (Thierry 1999).

The reference category is currently married, and we use binary variables to distinguish between women who were widowed less than five years earlier and those who had been widows for more than five years. We use measures of socioeconomic status constructed specifically for each sample. Control variables are not shown in Tables 2, 3, and 4, but results are available from the authors.

We compare two measures of the end of childbearing: age at last birth (*AgeLastBirth* in Models 1 and 2) and age at widowhood (*AgeWidowed* in Models 3 and 4). The age at widowhood variable is set to the subject's age at the death of her first husband if her husband died before she reached age 50, or 50 if her first husband was still alive on her 50th birthday. This means that there is very little overlap with the marital status variable, which is a time-varying covariate beginning when a woman reached age 50. In each case, we estimate both additive models (Models 1 and 3) and multiplicative models (Models 2 and 4), which test for an interaction between children ever born and age at last birth or age at widowhood. Interactions are added by including the product of *CEB* and *AgeLastBirth* (Model 2) or *AgeWidowed* (Model 3) as a covariate. Several of the theories reviewed above suggest that an interaction should be present. For example, evolutionary theories imply that women with low fertility (fewer children ever born) and late ages at last birth should have the longest lives (Smith et al. 2002; Westendorp and Kirkwood 1998). Similarly, we argue that young widows with more children suffered more stress than those with fewer children or an older age at widowhood.

RESULTS

Table 2 presents the Cox models estimated with age at last birth. These results provide little evidence of a relationship between reproduction and longevity after age 50. The estimates for Scania are consistent with hypotheses that more births increased postreproductive mortality and that higher ages at last birth were beneficial, but the effects are small and not statistically significant. In a previous study with the Scanian data, Dribe (2004) found that number of children affected the old-age mortality of only poor women. The models for Sart and the HSN are similar. The addition of an interaction between children ever born and age at last birth in Model 2 does increase the sizes of the estimated relative risks for these covariates, but none of the estimates are close to statistical significance. Models 1 and 2 in Table 2 are similar to the models used by Smith et al. (2002) in their study of the Utah genealogical database. Our data differ from that study in the inclusion of widowed women—they included only women who were married at age 60. In Appendix Table A1, we show that limiting the sample to women currently married at age 50 to approximate the Utah data does not lead to stronger results.

In Models 3 and 4, shown in Table 3, we replace age at last birth with age at widowhood. Age at widowhood does not seem to matter (Model 3) until we add an interaction between children ever born and age at widowhood in Model 4, where the results are dramatic. The interaction effects in Model 4 are statistically significant in both Scania and Sart.[1] The results for the HSN are consistent with the other two samples but not statistically significant. This seems to be due to both the small number of widows and the later time period in that database. The small number of women widowed before age 50 makes it difficult to get statistically significant results in the HSN sample. Our hypothesis also suggests that the consequences of widowhood should have diminished in the twentieth century, when social welfare services improved. If we limit the HSN sample to women born before 1875, the estimated coefficient for the interaction effect in Model 4 is smaller (farther from 1.0), but

1. The main effects for children ever born and age at widowhood also change when the interaction effect is added in Model 4. These effects are difficult to interpret because of multicollinearity between main and interaction effects. The magnitudes and p values of the main effects change when the covariates are centered on their means. Centering the covariates has no effect on the estimated relative risk for the interaction effect, however. We are grateful to an anonymous reviewer and to Göran Broström for this insight.

Table 2. Relative Risks of Dying for Women Over Age 50 in Three Historical Communities: Cox Models Estimated With Age at Last Birth

	Scania (Ages 50–90)				Sart				HSN			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Covariate[a]	Relative Risk	*p* Value	Relative Risk	*p* Value	Relative Risk	*p* Value	Relative Risk	*p* Value	Relative Risk	*p* Value	Relative Risk	*p* Value
Children Ever Born	1.03	0.18	1.07	0.64	1.00	0.98	1.48	0.13	1.04	0.10	1.12	0.30
Age at Last Birth	0.98	0.07	0.98	0.35	1.00	0.85	1.04	0.23	0.98	0.11	0.99	0.42
Children Ever Born × Age at Last Birth			1.00	0.77			0.99	0.12			1.00	0.47
Women	1,031		1,031		386		386		556		556	
Deaths	768		768		252		252		479		479	
Time at Risk	15,490		15,490		6,296		6,296		13,293		13,293	
Maximum Log-Likelihood	–4,447.1		–4,447.0		–1,211.4		–1,210.1		–2,500.4		–2,500.1	
p Value	0.00		0.00		0.18		0.13		0.12		0.15	

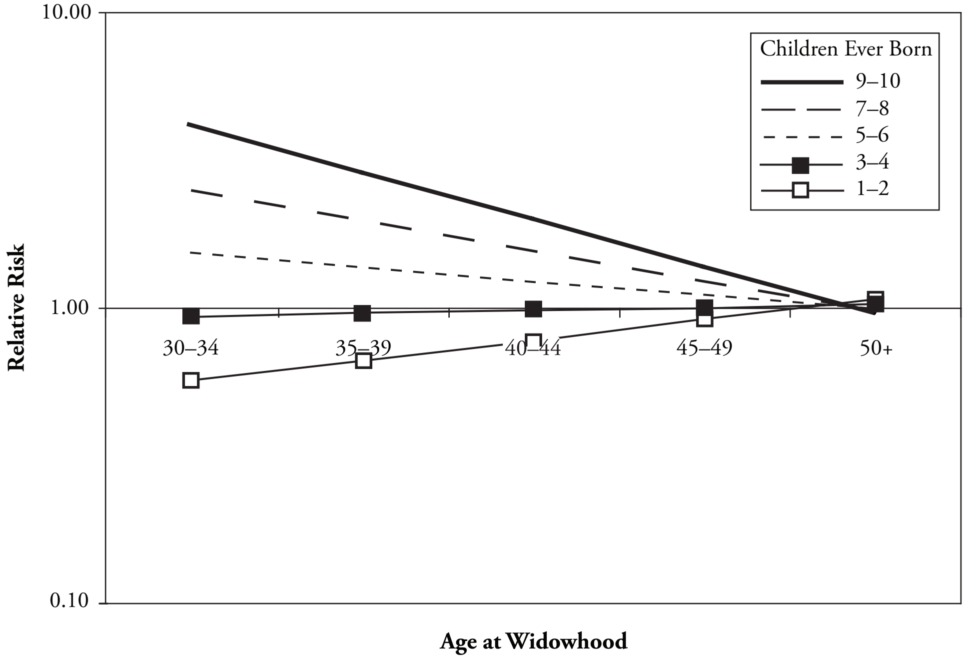
[a]Models also include controls for age at first birth, year of birth, marital status, socioeconomic status, and place of birth. Full models are available from the authors.

Table 3. Relative Risks of Dying for Women Over Age 50 in Three Historical Communities: Cox Models Estimated With Age at Widowhood

	Scania (Ages 50–90)				Sart				HSN			
	Model 3		Model 4		Model 3		Model 4		Model 3		Model 4	
Covariate[a]	Relative Risk	*p* Value	Relative Risk	*p* Value	Relative Risk	*p* Value	Relative Risk	*p* Value	Relative Risk	*p* Value	Relative Risk	*p* Value
Children Ever Born	1.01	0.64	1.96	0.00	1.00	0.98	3.48	0.00	1.01	0.58	1.27	0.39
Age at Widowhood or Age 50	0.99	0.55	1.05	0.04	1.01	0.52	1.10	0.01	1.01	0.52	1.03	0.32
Children Ever Born × Age at Widowhood			0.99	0.00			0.97	0.00			1.00	0.40
Women	1,031		1,031		386		386		556		556	
Deaths	768		768		252		252		479		479	
Time at Risk	15,490.0		15,490.0		6,296		6,296		13,293		13,293	
Maximum Log-Likelihood	–4,448.6		–4,444.1		–1,211.2		–1,206.4		–2,501.5		–2,501.1	
p Value	0.00		0.00		0.16		0.01		0.22		0.24	

[a]Models also include controls for age at first birth, year of birth, marital status, socioeconomic status, and place of birth. Full models are available from the authors.

Figure 1. Relative Risk of Dying for Women Over Age 50, by Age at Widowhood and Number of Children Ever Born, in Scania (from regression Model 4)



this result, which is based on only 46 women widowed before age 50, is not statistically significant either (results not shown).

The interaction effects in Model 4, which have estimated relative risks slightly less than 1, mean that the effect of children ever born on mortality after age 50 decreases as the age at widowhood increases. In other words, children had a big effect on the mortality of women who were widowed at young ages and much less effect on those widowed at older ages. This is shown graphically in Figure 1 using the results from Model 4 for Scania.

Since the effects of these variables could be even more complex, we also examined models in which children ever born, age at last birth, and age at widowhood are divided into categories rather than entered as continuous variables. The results for Scania are shown in Table 4 and Figures 2 and 3. In Scania, women with small families and younger ages at last birth had higher mortality (Model 5), consistent with what Dribe (2004) reported previously. These effects are weaker when we use age at widowhood in Model 7. The interactions with children ever born are important in both Models 6 and 8, however.

These results are easier to appreciate when they are expressed as net effects, which are shown in Figure 2 for age at last birth and Figure 3 for age at widowhood. Net effects are obtained by multiplying the estimated relative risks from the main effects for children ever born and age at last birth/widowhood by the estimated interactions. The relative risks for each combination should be compared with the omitted category, which is 5–6 children ever born and either last birth at ages 40–44 or currently married at age 50. Both figures suggest that the effects of children ever born were stronger when last birth or widowhood

Table 4. Relative Risks of Dying for Women Aged 50–90 in Scania

	Age at Last Birth				Age at Widowhood			
	Model 5		Model 6		Model 7		Model 8	
Covariate[a]	Relative Risk	*p* Value	Relative Risk	*p* Value	Relative Risk	*p* Value	Relative Risk	*p* Value
Children Ever Born								
1–2	0.71	0.01	0.74	0.11	0.82	0.08	0.90	0.42
3–4	0.88	0.22	0.92	0.59	0.96	0.68	1.02	0.86
5–6	1.00		1.00		1.00		1.00	
7–8	0.91	0.38	0.82	0.18	0.91	0.38	0.85	0.20
9+	1.03	0.84	0.97	0.86	1.02	0.89	0.97	0.83
Age at Last Birth								
< 35	1.47	0.01	1.54	0.13				
35–40	1.01	0.92	0.96	0.81				
40–44	1.00		1.00					
> 45	1.12	0.39	0.65	0.27				
Age at Widowhood								
< 40					1.22	0.29	0.98	0.95
40–44					1.01	0.97	1.23	0.50
45–49					0.73	0.03	0.96	0.89
Married at age 50					1.00		1.00	
Age at Last Birth × Children Ever Born								
< 35 × 1			0.82	0.59				
< 35 × 3			0.83	0.61				
< 35 × 7			1.96	0.17				
< 35 × 9			1.99	0.52				
35–39 × 1			1.07	0.80				
35–39 × 3			0.89	0.62				
35–39 × 7			1.96	0.17				
35–39 × 9			1.24	0.57				
45–49 × 1			1.92	0.22				
45–49 × 3			2.78	0.05				
45–49 × 7			1.87	0.18				
45–49 × 9			1.79	0.22				

(continued)

occurred earlier. These effects are attenuated among women whose last birth was after age 40 and those who were still married at age 50.

Since many of the categories produced by interacting children ever born with age at widowhood have few cases in them, it is remarkable that the pattern in Figure 3 (Model 8) is so consistent with the results in Model 4 (Figure 1). In Model 4, the effects of continuous

(Table 4, continued)

	Age at Last Birth				Age at Widowhood			
	Model 5		Model 6		Model 7		Model 8	
Covariate[a]	Relative Risk	*p* Value	Relative Risk	*p* Value	Relative Risk	*p* Value	Relative Risk	*p* Value
Age at Widowhood × Children Ever Born								
< 40 × 1							0.89	0.81
< 40 × 3							1.23	0.66
< 40 × 7							3.83	0.01
< 40 × 9							5.26	0.04
40–44 × 1							0.62	0.28
40–44 × 3							0.64	0.49
40–44 × 7							1.62	0.35
40–44 × 9							0.73	0.53
45–49 × 1							0.48	0.12
45–49 × 3							0.54	0.12
45–49 × 7							1.04	0.93
45–49 × 9							1.78	0.21
Number of Women	1,031		1,031		1,031		1,031	
Deaths	768		768		768		768	
Time at Risk	15,867.0		15,867.0		15,867.0		15,867.0	
Maximum Log-Likelihood	–4,546.6		–4,541.7		–4,547.9		–4,536.7	
p Value	0.00		0.01		0.00		0.00	

[a]Models also include controls for age at first birth, year of birth, marital status, socioeconomic status, and place of birth. Full models are available from the authors.

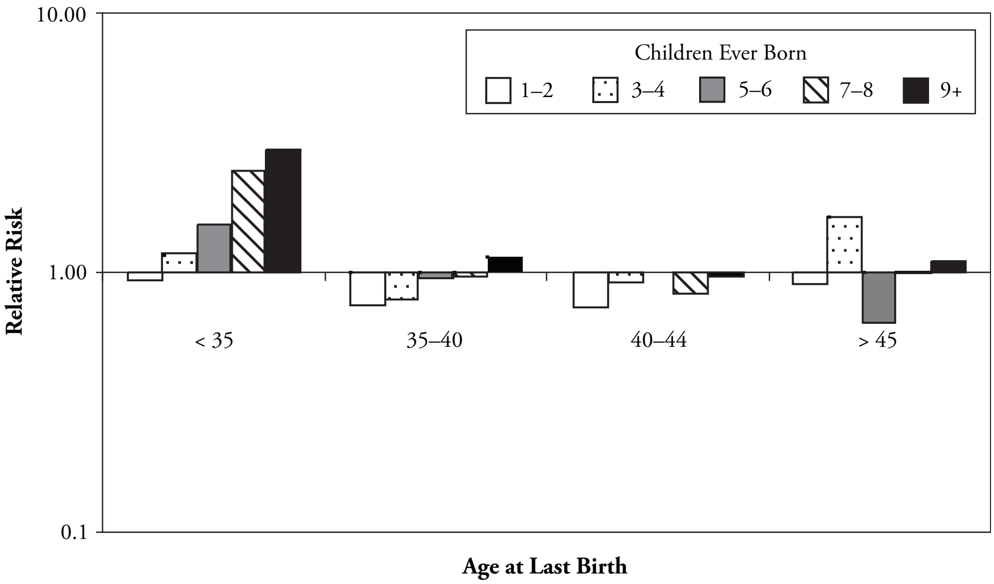
variables are constrained to be log linear. The effects shown in Figure 3 are not constrained, but they appear to be essentially linear anyway.

It is also worth noting that the net effects for women with 1–2 children in the reference categories (age 40–44 at last birth; currently married at age 50) in Models 6 and 8 are similar in size to the effects of family size when no interaction is included (Models 5 and 7). This suggests that even women who were in intact marriages when childbearing ended may have benefited from having small families.

CONCLUSION

Our results imply that female longevity was not affected by the number or timing of a woman's children, but by the circumstances in which she raised them. The sacrifices made by a widow with young children had long-term effects on her health. Several recent studies attributed much of the impact of widowhood on health to changes in economic circumstances (Lillard and Waite 1995; Zick and Smith 1991), and the economic consequences of losing a spouse would have been at least as great in the past. Women's wages were very low, and relief for the poor was minimal at best. Widows faced hunger and long hours of

Figure 2. Relative Risk of Dying for Women Over Age 50, by Age at Last Birth and Number of Children, in Scania



Note: The reference categories are age 40–44 at last birth and 5–6 children ever born.

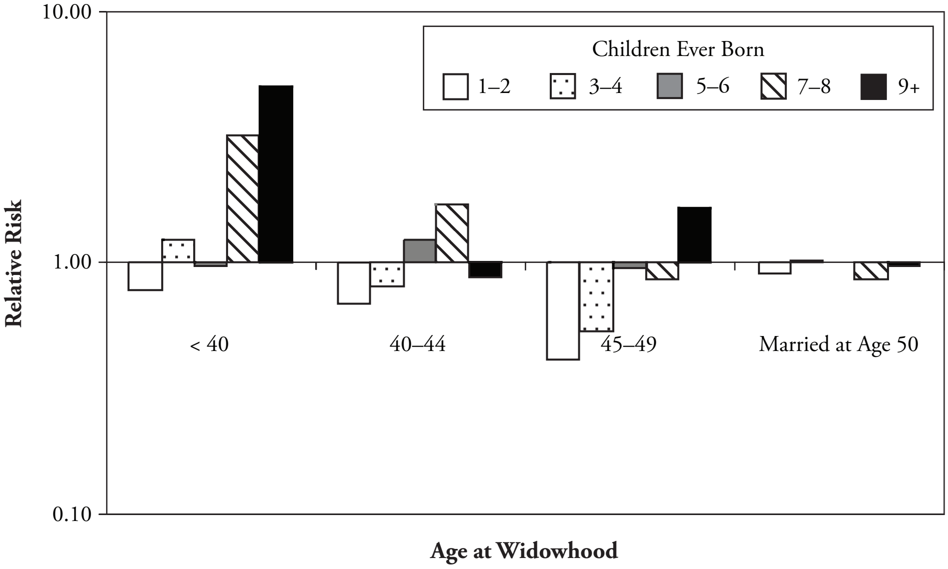
heavy labor, which would have compromised their health in the long run. We also find that large families were not as burdensome to women who were widowed at later ages, when their older children were already at work.

Higher mortality in later life could also have been due to the psychological stress suffered by widows with young families. A large and growing literature links psychological stress to poor health (McEwen and Stellar 1993; Rozanski, Blumenthal, and Kaplan 1999; Schulz and Beach 1999). Chronic stress affects the immune system and other physiological processes that contribute to higher rates of cardiovascular disease, diabetes, and other chronic conditions (Kiecolt-Glaser et al. 2003; Padgett and Glaser 2003; Seematter et al. 2004). This psychological mechanism cannot be separated from the economic consequences of widowhood. Anxiety caused by economic insecurity would have added to the emotional trauma of bereavement.

These findings complement Dribe's (2004) previous examination of the Scanian data. That analysis found that poor women benefited from having small families but wealthier women did not. Dribe suggested that "the higher mortality in old age of landless women with more children might well have been related to physical depletion and exhaustion of mothers arising from repeated pregnancies and deliveries in combination with hard physical labor" (2004:307). Our analysis suggests that the long-run consequences of another source of stress, loss of a spouse, were directly related to the number of children that a widowed woman had to support.

This interpretation is consistent with the "maternal depletion" model described above, which emphasizes the importance of socioeconomic circumstances, but our evidence

Figure 3. Relative Risk of Dying for Women Over Age 50, by Age at Widowhood and Children Ever Born, in Scania



Note: The reference categories are currently married at age 50 and 5–6 children ever born.

points to stresses associated with child rearing rather than the effects of pregnancy, childbirth, and lactation. We find little support for other hypotheses about childbearing and postreproductive longevity. The biomedical, evolutionary, and selection models link longevity to number of children ever born and the mother's age at last birth, but these factors had little or no association with old-age mortality in our data. The social support model, which emphasizes transfers from children to elderly parents, implies that women with more surviving children would have lower old-age mortality. Transfers from older children may help to explain why family size had little effect on the mortality of women who were widowed at older ages.

The consistency of our results in populations from three different times and places is important because results from previous studies have been contradictory. The interaction between age at widowhood and children ever born may explain some of these inconsistencies. Neither variable appears to matter in any of our samples when the interaction is not present. Few previous studies have tested for interactions, although some theories imply that they should exist.

Our results suggest that future studies should be careful about including widows when examining the relationship between the duration of reproduction and postreproductive mortality. Hypotheses derived from biological and selection models imply that women who gave birth at late ages had better than average health. This association is present in our data for a different reason: women had worse health when their spouses died at younger ages, especially if they had more children to support. We did not find an association between age at last birth and longevity when widows were excluded, but a relationship of this kind may be present in other times and places (Smith et al. 2002).

Appendix Table A1. Relative Risks of Dying for Women Over Age 50 in Three Historical Communities: Women Who Were Currently Married at Age 50 Only

	Scania (ages 50–90), Model 1		Sart, Model 1		HSN, Model 1	
Covariate	Relative Risk	*p* Value	Relative Risk	*p* Value	Relative Risk	*p* Value
Children Ever Born	0.96	0.80	1.19	0.52	1.12	0.32
Age at Last Birth	0.98	0.18	1.01	0.88	0.99	0.42
Children Ever Born × Age at Last Birth	1.00	0.83	1.00	0.54	1.00	0.48
Age at First Birth	1.00	0.86	1.03	0.25	1.02	0.26
Year of Birth	1.00	0.00	0.99	0.11	0.99	0.07
Marital Status						
Currently married	1.00		1.00		1.00	
Widowed < 5 years	1.40	0.00	1.28	0.25	0.92	0.63
Widowed > 5years	1.27	0.03	0.87	0.48	1.03	0.80
Social Status						
Freeholders	1.00					
Noble tenants	0.96	0.85				
Semilandless	1.04	0.84				
Landess	0.91	0.60				
Wealth						
No property			1.00			
Small property			1.09	0.69		
Large property			0.82	0.33		
Husband's Occupation						
Unskilled					1.00	
Semiskilled					0.79	0.19
Skilled					0.76	0.04
Nonmanual and supervisory					0.99	0.93
Parish						
Hög	1.00					
Kävlinge	1.13	0.54				
Halmstad	1.21	0.30				
Sireköpinge	1.25	0.21				
Kågeröd	1.28	0.12				
Born in Utrecht					1.16	0.22
Born in Friesland					1.01	0.96
Born in Zeeland					1.00	
Number of Women	842		306		503	
Deaths	632		197		435	
Time at Risk	12,655		5,009		12,074	
Maximum Log-Likelihood	–3,525.3		–902.3		–2,228.5	
p Value	0.00		0.18		0.28	

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