Published in final edited form as:
Soc Sci Med. 2009 May ; 68(9): 1641–1648. doi:10.1016/j.socscimed.2009.02.017.

Long-Term Mortality Consequences of Childhood Family Context in Liaoning, China, 1749-1909

Cameron Dougall Campbell and
UCLA, Los Angeles, CA UNITED STATES

James Z Lee, PhD
University of Michigan

Abstract

We examine the effects on adult and old age mortality of childhood living arrangements and other aspects of family context in early life. We focus on features of family context that have already been shown to be associated with infant or child mortality in historical and developing country populations. We apply discrete-time event-history analysis to longitudinal, individual-level household register data for a rural population in northeast China from the eighteenth and nineteenth centuries. Loss of a mother in childhood, a short preceding birth interval, and high maternal age were all associated with elevated mortality risks later in life. Such effects persist in a model with fixed effects that account for unobserved characteristics of the community and household. An important implication of these results is that in high mortality populations, features of early life family context that are associated with elevated infant and child mortality may also predict adverse mortality outcomes in adulthood.

Keywords

China; early life; mortality; family; historical; life course; childhood

Before the twentieth century, high levels of adult mortality meant that loss of one or both parents in childhood was a common experience. According to a variety of studies carried out in historical European and Asian populations, recent loss of a parent was associated with a substantial elevation in infant or child mortality (Beekink, van Poppel & Liefbroer 1999, 2002; Breschi & Manfredini, 2002; Campbell & Lee, 2002, 318; Högberg & Broström, 1985; Tsuya & Kurosu, 2002). While the specific mechanisms underlying this relationship have yet to be delineated, possibilities include reduced consumption associated with the loss of a caregiver and household laborer, physiological effects of psychological stress, or a common disease environment or genetic endowment that raised the mortality risks of parents and children.

We examine the long-term mortality consequences of the loss of a parent and other features of childhood family context that have been shown or suggested to affect infant and child mortality

Corresponding Author: Cameron Dougall Campbell, UCLA, Los Angeles, CA UNITED STATES, E-Mail: E-mail: camcam@ucla.edu.

Author Comments: A previous version of this paper was presented the conference “Longevity: Early-life Conditions, Social Mobility and Other Factors that Influence Survival to Old Age,” International Union for the Scientific Study of Population, Committee on Historical Demography, Lund, Sweden, 8-10 June, 2006.

in historical populations and contemporary developing countries. These include short preceding birth interval, birth order, family size, and maternal age. Based on the existing literature on associations between childhood conditions and health and mortality at later ages, we hypothesize that features of early life family context already known to be associated with elevated infant and child mortality in high mortality populations may also have implications for health and mortality in adulthood and old age.

We make use of longitudinal household register data on one-quarter million people who lived in more than 600 largely rural communities in Liaoning province in northeast China from 1749 to 1909. We compare male mortality outcomes in adulthood and old age according to the age at loss of parent, the length of the preceding birth interval, family size, birth order, and maternal age and other features of household context in childhood. For this comparison, we carry out a discrete-time event-history analysis (Allison, 1984). This is analogous to Cox regression but as we discuss in detail later more appropriate to data organized like ours (Allison, 1984). To control for unobserved characteristics of the community and household, we also estimate fixed-effects models (Allison & Christakis, 2006; Hoffman & Duncan, 1988).

Even though the emphasis in this study is more on the documentation of substantively interesting relationships than on their explanation, it has at least two distinguishing features. It is one of a relatively small number of studies of the long-term health consequences of early life conditions that considers the influence of parental survival, preceding birth interval, and other features of household and family structure. As detailed later, most published studies focus on the long-term implications of socioeconomic status, health conditions, and community context. It is also one of a very small number of studies of which we are aware that examines a non-Western population, the others being Khang's (2006) study of South Korea and Zeng et al.'s (2007) study of twentieth-century China.

We organize the remainder of the paper into five sections. The first motivates our expectations for the consequences of household context in childhood for adult mortality and clarifies the contribution of this study through a brief review of relevant findings on health effects of conditions in early life. The second introduces the data, focusing on strengths and weaknesses that facilitate or constrain analysis. The third introduces the statistical methods and models, motivating each of the variables included in the analysis. The fourth presents empirical results. We conclude in the fifth section with an assessment of the implications of these results.

Background

A large literature describes and seeks to explain associations between conditions in childhood and health and mortality in later life (Blackwell, Hayward & Crimmins, 2001; Davey Smith et al. 1998; Forsdahl, 2002; Guralnik et al., 2006; Kuh & Ben-Shlomo, 2004; Kuh et al., 2002; Haas 2008; Hayward & Gorman 2004; Leon & Davey Smith, 2000; Moody-Ayers et al., 2007; Palloni, 2006; Preston, Hill & Drevenstedt, 1998; Schwartz et al., 1995). The emphasis has generally been on the long-term implications of parent and child health, family socioeconomic status, and community context in childhood. A variety of relationships have been reported and a number of mechanisms have been proposed to account for them.

Only a few studies of which we are aware have considered the effects of childhood family structure, including of the presence or absence of parents. Results suggest that males who lived with both parents in childhood had a mortality advantage in adulthood and old age, even after controlling for socioeconomic status and community context. Preston, Hill, & Grevenstedt (1998) find that in a sample of African-Americans, childhood residence in a two-parent household increased the chances of surviving to old age. Similarly, Hayward & Gorman (2004) report based on an analysis of the 1966 cohort of the National Longitudinal Study that men who reported that they lived with both biological parents at age 15 had lower mortality risks than men who reported other living arrangements. An analysis of contemporary data from a survey of elderly Chinese found that reported loss of a parent in childhood was associated with worse health and higher mortality risk in old age, but the relationship was not statistically significant (Zeng, Gu, & Land, 2007, 512).

There is strong reason to consider the long term health effects of early loss of a parent, at least in preindustrial populations. In historical populations, loss of a parent was associated with elevated infant, child and early adolescent mortality. As mentioned earlier, boys aged 1 to 15 *sui* in Liaoning who lost their mother experienced a 33 to 40 increase in the risk of dying (Campbell & Lee 2002, 318; Campbell & Lee, 2004). Similarly strong effects of loss of parent have been reported for a number of other historical European and Asian communities (Beekink, van Poppel and Liefbroer 1999, 2002; Breschi & Manfredini, 2002; Högberg & Bröström, 1985; Tsuya & Kurosu, 2002).

There are a number of reasons to expect the early loss of a parent to have longer-term consequences. In a preindustrial setting like eighteenth- and nineteenth-century northeast China, household context was a key determinant of individual wellbeing. When a parent died, their child suffered in a variety of ways. Their nutritional intake may have declined, their work load may have increased, they may have experienced increased psychosocial stress, and other important relevant features of living conditions like clothing, hygiene, and housing may have deteriorated. Adversity during this sensitive period led to poor health later in life by causing disruptions in growth and development from which individuals do not recover (Fogel, 1994; Kuh & Wadsworth 1993). Infections contracted during this period may have led to chronic conditions that later increased morbidity and eventually mortality (Elo & Preston, 1992; Mosley & Gray, 1993). There may also be more complex and indirect effects in which childhood conditions affect or interact with aspects of adult status such as lifestyle and occupation that in turn affect health and mortality (Kuh & Ben-Shlomo, 2004; Costa, 2000). Parent-child correlations in health and mortality attributable to common community or household environment, genetic factors, and parent-child transmission of infection may have been important as well, and we discuss those later in the context of our statistical methods.

Examination of the long-term consequences of loss of a parent in childhood is substantively important because it was a relatively common experience in high-mortality populations. In northeast China in the eighteenth and nineteenth centuries, nearly one-third of children lost one or both of their parents by the time they reached age 15 (Campbell & Lee, 2002, 316). In Venice in the middle of the nineteenth century, the figures are nearly identical (Derosas, 2002, 423). In Casalguidi, Italy, in the early nineteenth century, more than one-fifth of children lost at least one parent by the time they reached age 12 (Breschi & Manfredini, 2002, 374). In the Netherlands in the last half of the late nineteenth century, around 10 percent of people aged less than 20 had lost at least one parent (Beekink, van Poppel, & Liefbroer 2002).

Other features of family context are also of interest because they have been shown to be associated with elevated infant and child mortality. Studies using historical German data suggest a J- or U-shaped relationship between child mortality and maternal age (Knodel & Hermalin, 1984). Birth order and family size may also be associated with infant and child mortality (Kaunitz et al., 1985; Knodel & Hermalin, 1985). Studies in a variety of historical populations and developing countries indicate that a short preceding birth interval raises mortality risks for the child (Curtis, Diamond & McDonald, 1993; Knodel & Hermalin, 1984; Koenig et al. 1990; Miller et al. 1992) and possibly the mother (Conde-Agudelo & Belizan, 2000).

Most historical studies of the effects of conditions in early life on health and mortality in later life focus on childhood community context or socioeconomic status, not family structure. Preston & van de Walle (1978) showed that nineteenth-century urban French cohorts who experienced childhood after the improvement of the water supply enjoyed substantially reduced mortality risks for the remainder of their lives. Alter & Oris (2005, 2008) and Alter et al. (2004) examine effects of socioeconomic status, as reflected in occupation. At least two historical studies take an approach similar to the one in the contemporary studies by Forsdahl (2002) and Leon & Davey Smith (2000) and use infant mortality rates as a proxy for conditions in the community around time of birth. Bengtsson & Lindström (2000) finds that in southern Sweden, they are associated with elevated mortality in adulthood and old age. Costa (2000) finds that for Civil War veterans in the United States, they were associated with a higher risk of certain chronic conditions.

Based on our reading of the literature, we have several expectations about the results. Theory and evidence on the general importance of family context in childhood for health and mortality at later ages, especially the findings in Preston, Hill, & Grevenstedt (1998) and Hayward & Gorman (2004), suggests that childhood living arrangements should affect mortality in adulthood and old age. From the theory and evidence that suggests that children's development may have been more sensitive to health disruptions at some ages than at others, we expect that specific age at loss of a parent may have mattered (Kuh & Wadsworth, 1993). Based on previous findings that the mortality disadvantage in childhood associated with the loss of a mother was pronounced and persistent (Campbell & Lee, 2002), we expect the long-term effects of a loss of a mother to have been especially strong.

Data

We make use of triennial household register data for 1749 to 1909 for more than 600 villages in Liaoning province in northeast China. The original dataset comprises 1.4 million records describing approximately 250,000 people who lived in 28 administrative populations between 1749 and 1909. The origins of the registers as well as procedures for data entry, cleaning and linkage are described in Lee & Campbell (1997, 223-237). Features of the registers relevant to event history analysis are described in Campbell & Lee (1996, 2000, 2002, 2004, 2008). Overall, the Liaoning household registers provide far more comprehensive and accurate demographic and sociological data than other sources for China before the twentieth century (Lee & Campbell, 1997).

The geographic and economic contexts of these populations varied dramatically. As Figure 1 shows, the villages are spread over an area of 40,000 square kilometers. These regions include a commercialized coastal area around Gaizhou in south Liaoning, a farming region around Haizhou and Liaoyang in south central Liaoning, a farming area around the provincial capital in central Liaoning, and a remote agricultural area in the hills and mountain ranges in north Liaoning.

The registers resemble a triennial census in terms of format and organization. Entries were ordered by village and residential household. In contrast with most historical censuses, the registers allow for longitudinal linkage of the records of the same individual across the life course. Households and their members appeared in almost the same order in each register, even when they moved to another village. The extensive detail on household relationship, meanwhile, allows for location of kin and measurement of their characteristics. For each person in a household, the registers recorded relationship to household head; name(s) and name changes; adult occupation, if any; age; lunar year, month, day, and hour of birth; marriage, death, or emigration, since the last register, if any; and village of residence.

Ages were recorded in *sui*. In this traditional means of reckoning age, individuals were 1 *sui* at birth, and their age incremented every Lunar Year. On average, an age reckoned in *sui* is 1.5 higher than when reckoned according to Western practice. We are not confident that the recorded month and day of birth are reliable enough to allow for conversion to Western ages, thus we leave ages in *sui* for the analysis.

The registers are an excellent source of the study of the determinants of mortality (Campbell & Lee, 1996, 2002, 2004). Most importantly, entries into and exits from the population were rare and when they did occur they were annotated, largely avoiding problems associated with censoring (Lee & Campbell, 1997, 223-237). The registers also provide a measure of socioeconomic status in the form of salaried official positions held by adult males, and distinguish disabled adult males from other adult males (Lee & Campbell, 1997; Campbell & Lee 2003). The men who held salaried official positions represented the local elite in this otherwise rural population.

The most important feature of the registers relevant to our choice of method is that they only specify the interval between two registers during which death occurred, not the precise date of death. As discussed later, this leads us to apply discrete-time event-history analysis techniques that are analogous to Cox regression (Allison 1984). The absence of precise dates of death also affects the specification of the explanatory variables that indicate when individuals lost their parent. The measure of age at loss of a parent is actually age in the last register when the parent was still listed as alive. Since the registers followed individuals or families who moved from one village to another within the region, and departures from the region were extremely rare, we are confident that the absence of a parent in a register is a reliable indicator that they have passed away.

Other features of the registers imply additional limitations in the analysis. First, children who died in infancy or early childhood were omitted from the registers. We cannot reliably compute infant and early child mortality, thus are unable to follow the example of studies that used infant or child mortality rates around the time of birth as a proxy for health conditions in early childhood and showed that they were associated with mortality later in life (Fordahl, 2002; Leon & Davey Smith, 2000). Second, we restrict our analysis to males because we cannot follow women from childhood into adulthood and old age because we have not yet linked records of wives in one household back to their records as a daughter in another households. Third, daughters are especially prone to omission from the registers, even when they survived, thus variables intended to capture family size and composition effects are based on counts of sons, not counts of all children. Fortunately, women were recorded in detail after they married and appeared as wives in a household, allowing for measurement of the characteristics of mothers.

Methods

We apply discrete-time event-history or survival analysis via logistic regression (Allison 1984). This approach is most appropriate when the data only specify an interval in which an event occurred, not its precise timing. It is a discrete-time analogue to the Cox proportional hazards regressions applied to continuous-time data. Following previous studies of mortality that apply discrete-time event-history analysis (Curtis, Diamond & McDonald, 1993; Elo & Preston, 1996), we estimate a logistic regression in which a dichotomous outcome variable specifies whether or not a death between two registers, and right-hand side variables specify characteristics of the individual at risk of dying. Odds ratios estimated for the right-hand side variables measure their association with the risk of an event occurring, holding the values of the other variables constant, and are analogous to the hazard ratios yielded by Cox proportional hazards regressions.

We estimate three sets of logistic regressions. One is for boys aged 1-15 *sui*, another is for adult males aged 16-55 *sui*, and the last is for elderly males aged 56-75 *sui*. Each set consists of three regressions. The first, Model I, only includes as right-hand side variables the indicators of when each parent was last seen alive, and basic controls for age, region, and year. We specify age as a polynomial. Inclusion of age as a right-hand side variable is analogous to specification of age as the duration measure in a Cox proportional hazards model. Region is specified as a categorical variable to account for geographic differences in mortality (Campbell & Lee 2004; Lee & Campbell 2005). We distinguish between north, central, south central, and south Liaoning. We enter year directly to account for secular trends in mortality. To save space, we omit odds ratios from the presentation of results. To save space, we omit estimate odds ratios for age, year, and region from the presentation of results.

In the analysis of adult and old age mortality, age at loss of a parent is expressed as a categorical variable. One set of indicators expresses the subject's age when their mother was last seen alive: 1 to 5 *sui*, 6 to 10 *sui*, or 11 to 15 *sui*. The omitted reference category consists of men whose mother was still alive when they reached 16 *sui*. Odds ratios for a category compare the mortality risks of men whose mother was last observed when they were in the specified category to those of men whose mothers were still alive when they reached age 16 *sui*. A similar set of indicators expresses the subject's age when their father was last seen alive.

Model II adds other features of family context that may have affected infant and child mortality, and possibly maternal mortality. The additional variables are interesting not only in their own right, but their inclusion helps rule out the possibility that observed effects of age at loss of parent are the result of correlations between them, parental survival, and child health. Variables include maternal age (Knodel & Hermalin, 1984), the length of the preceding birth interval (Curtis, Diamond & McDonald, 1993; Knodel & Hermalin, 1984; Koenig et al. 1990; Miller et al. 1992), and parity based on previous male births (Kaunitz et al., 1985; Knodel & Hermalin, 1985). Maternal age at time of birth is measured categorically. An indicator identifies males who were born when their mothers were less than 20 *sui*, and another indicator identifies males who were born when their mother was more than 35 *sui*. To account for effects of a short preceding birth interval, another indicator variable identifies males who were born less than two years after an older sibling. Finally, we include a count of the boys previously born to the parents, including those who have already died, to account for possible birth order effects (Knodel & Hermalin, 1984).

Model III introduces additional measures of family and individual circumstances that may have been the same for brothers but differed between cousins. The first is a count of the total number of sons born to the parents, regardless of their current survival status (Knodel & Hermalin, 1984). Brothers may have affected health by increasing the frequency of exposure to infection, and may have been associated with a higher mortality risk for mothers because repeated pregnancies led to nutritional depletion and decreased resistance to disease. The second is an indicator of whether the father ever held a salaried official position with the state. Men in the study population who held such positions experienced elevated mortality, possibly as a result of unhealthy lifestyles or more frequent exposure to infection (Campbell & Lee, 1996, 2000, 2004). The third is an indicator of whether the father was ever identified in the registers as disabled. Disabled males were at higher risk of dying (Campbell & Lee, 2003). Model III accounts for the possibility that adult socioeconomic status and health mediated relationships between childhood conditions and adult mortality (Kuh & Ben-Shlomo, 2004; Costa, 2000) by including as right-hand side variables attainment of a salaried official position as an adult, and being listed as disabled.

To account for unobserved characteristics of the community or household that affect mortality risks and may be correlated with the included variables, we also estimate fixed-effect logistic regressions (Allison & Christakis, 2006; Duncan & Hoffman, 1988). In developing countries, mortality risks are clustered in the sense that even after controlling for measured characteristics of the community and household, mortality risks differ systematically across communities or households (Curtis et al. 1993; Sastry, 1997). Random effects or multilevel models are often used to account for such clustering, but require strong assumptions about the distribution of the intercepts, and their independence from the right-hand side variables. A fixed effects approach makes no assumption about the distribution of the intercepts, and do not require the right-hand side variables to be independent of the cluster-specific intercept. Conceptually, introduction of a fixed effect is equivalent to accounting for clustering by including a dichotomous indicator variable identifying the members for each cluster (Greene, 1997, 615-623). Estimated odds ratios reflect differences in mortality risk within a cluster, net of the effects of regional, community and household characteristics common to the members of the cluster.

We specify clusters to consist of male paternal cousins, that is, men with a common paternal grandfather. Men typically spent their childhood in the same households as their paternal cousins because most individuals lived in large households that consisted of married brothers or even cousins living together with their families (Lee & Campbell, 1997). Since paternal cousins experienced a common household environment as children, relationships of their mortality risks to right-hand side variables that remain after introduction of a fixed effect cannot be artifacts of a relationship to common features of the region, community or household. Defining clusters to consist of paternal cousins as opposed to siblings allows for comparisons of related children who grew up in the same household, but differed in terms of parental characteristics such as survival, total number of children born, and father's attainment of official position.

Differences according to the survival status of parents that persist after the introduction of fixed effects of common paternal grandfather may not only reflect differences in childhood context, but also differences in the health of brothers or their wives that were inherited by their children. Differences between paternal cousins according to their father's survival status could reflect genetic differences between the brothers who fathered their cousins, and differences according to mother's survival status could reflect genetic differences between the women who married into a household. Differences between paternal cousins could also reflect differential exposure within the household to infections like hepatitis B and H. pylori that are widespread in East Asia and are transmitted from mother to child (Elo & Preston, 1992; Rothenbacher et al., 2002). Finally, differences between paternal cousins could reflect differences in the health status of their mothers that predated their marriage and which affected their mortality and the intrauterine environment experienced by the son (Gluckman & Hanson 2006).

Results

We begin by confirming the importance of presence of parent for child mortality. The results in Table 1 confirm findings in Campbell & Lee (1996,2002,2004) that the loss of a mother was associated with higher child mortality. According to results for Model I in Table 1, boys who lost their mothers had odds of dying in the next three years that were 21.1 percent higher than those of boys who did not. In line with earlier findings (Campbell & Lee 2002), the loss of a father had no apparent effect on mortality. When unmeasured characteristics of the community and household are controlled in Model I for by introduction of a fixed effect of paternal grandfather, the effect of loss of a mother remained. Boys who lost a mother had odds of dying about 26.6 percent higher than those of their cousins whose mothers were still alive. Effects persist after the addition of additional controls in Models II and III.

The persistence of the effect of loss of mother after the inclusion of a fixed effect of grandfather indicates that associations in the mortality risks of mothers and their sons were not an artifact of community or household characteristics. The results are consistent with either a causal effect of loss of mother on child mortality, or an association between mother's and son's mortality attributable to genetic factors, an infection transmitted between mother and child, or maternal health that affected child health via the intrauterine environment.

Short preceding birth interval and seniority among brothers also influenced child mortality. According to results for Model II in Table 1, a short preceding birth interval raised the odds of dying by 17.2 percent. The adverse effect of being born after a short preceding birth interval persisted after the introduction of a fixed effect. When a fixed effect of grandfather is included in Model II, a short preceding birth interval raises the odds of dying by 20.9 percent. In the version of Model III that includes fixed effects, it is better to be a younger brother: every additional older brother lowers the odds of dying by about six percent.

The loss of a mother in childhood was associated with elevated mortality risks in adulthood. Table 2 presents results from the event-history analysis of adult mortality. In Model I without fixed effects, loss of either parent in childhood appears to affect adult mortality risks, but once fixed effects were introduced, only the effect of loss of mother remains. Men whose mother was last seen alive when they were aged 6 to 10 *sui* had odds of dying 15 percent higher than brothers and cousins whose mothers were still alive when they reached age 16 *sui*. The apparent effects of mother's survival is likely either to be causal, or attributable to one of the genetic or other mechanisms outlined earlier that would allow for a mother-son correlation in health above and beyond that attributable to a common household and community environment.

Other features of family context in childhood are associated with adult male mortality, even after the inclusion of fixed effects. According to results for models II and III in Table 2, men whose mothers were more than 36 *sui* old when they were born experienced elevated mortality risks in adulthood. The comparison in the fixed effect models includes brothers born to the same mother at different ages, suggesting either that this effect is causal in the sense that high maternal age had adverse health effects, or else that women who were still bearing children at such late ages differed in some way from brothers' and cousins' wives who were not. Men who had more brothers experienced lower mortality than cousins who had fewer brothers: every additional brother in the family lowered the odds of dying by 4.2 percent relative to other cousins. This may reflect correlations in health among brothers above and beyond associations attributable to their common community and household characteristics.

In old age, adverse effects of early loss of a parent are no longer apparent. Table 3 presents results from the event-history analysis of mortality between ages 56 and 75. Either the mechanisms that translated early loss of a mother into poor health and elevated mortality risk in adulthood worked through disease processes that were most important in middle age, or else selection allowed survival to old age only for the most robust of the men who experienced the early loss of a mother.

Other features of early life family context had strong associations with mortality risks in old age. Whereas according to Table 2 a short preceding birth interval had no influence on adult mortality after controlling for unobserved household and community characteristics, it led to a substantial mortality disadvantage in old age. Results in Table 3 for Model II with fixed effects indicate that elderly men born after a short preceding birth interval had odds of dying at least 40 higher than those of brothers and cousins whose birth followed a longer interval. Elderly men whose mothers were 36 *sui* or older when they were born also experienced a persistent mortality disadvantage. According to the results for Model II with fixed effects, their odds of dying were 18.7 percent higher than those of brothers and cousins who were born when their mothers were younger. Conversely, elderly men born when their mothers were relatively young, less than 20 *sui*, experienced lower mortality risks in old age than brothers or cousins who were born when their mothers were older. According to results for Model III, elderly men whose fathers had been listed as disabled at some point during their lives had much higher mortality than cousins whose fathers had never been listed as disabled.

Finally, the fixed effect models confirm the existence of the ‘price of privilege’ (Lee & Campbell, 1997): high socioeconomic status, in the form of attainment of an official position, was associated with a mortality disadvantage. According to the results for Model III with fixed effects, elderly men who held a salaried official position earlier in life had odds of dying 50.7 percent higher than those of brothers and cousins who had not. These results suggest that mortality disadvantages for men with salaried official position reported in Campbell & Lee (1996, 2004) were not an artifact of unmeasured community and household characteristics that simultaneously influenced attainment and mortality chances.

The pronounced disadvantage in old age associated with having a father who held a salaried official position is the reverse of associations reported for twentieth-century Asian populations (Khang, 2006; Zeng, Gu, & Land 2007). According to results in Table 3 for Model III with fixed effects, elderly men whose fathers had held official position had odds of dying 72.2 percent higher than those of their cousins whose fathers had not held official position. These associations may be the reverse of the ones typically observed in contemporary populations, but they are not inconsistent with associations observed in other preindustrial populations. Relationships between socioeconomic status and mortality were much less consistent in historical populations than in contemporary populations (Bengtsson, Campbell, & Lee et al., 2004; Kunitz, 1987). Campbell & Lee (1996, 2004) and Lee & Campbell (1997) speculated that the mortality disadvantage associated with high socioeconomic status was related to an unhealthy lifestyle or possibly more frequent exposure to infection.

Conclusions

The results raise the possibility that in high-mortality populations, historical or contemporary, features of early life context already known to influence infant and child mortality may have had longer-term effects on health and mortality in adulthood in old age. These conditions include early loss of one or both parents, short birth intervals, or very high or low maternal age at birth that are already known to influence. Differences in adult mortality by age at loss of mother persisted after controlling for characteristics of the individual and their family. Mortality differentials according to mother's age at birth, total number of brothers, preceding birth interval, father's socioeconomic and disability status were also apparent in adulthood or old age. Most importantly, mortality differentials according to early life family structure persisted in models that controlled for unobserved features of the community and household by inclusion of fixed effects.

The results for the effects of loss of mother are suggestive enough to be substantively interesting but not conclusive. Persistence of the effect of loss of mother after introduction of fixed effects rules out common community and household features as a source of the relationship, but does not distinguish between a causal effect of the early loss of the mother, and a mother-child correlation in mortality risks attributable to genetic factors, infections transmitted from mother to child at birth or early childhood, or poor maternal health transmitted to the son by effects on the intrauterine environment.

These results are suggestive rather than conclusive. At this point we have documented a number of substantively interesting relationships and ruled out common community and household characteristics as a source, but we have not explained them. Fortunately, other historical databases of individual life histories already exist and have been used to study long-term effects of conditions in early life (Alter & Oris 2005, 2008; Bengtsson, Campbell, & Lee et al., 2004; Bengtsson & Lindström, 2000). Whereas the focus of such studies has generally been on the long-term effects of community context and family socioeconomic status in childhood, the results here suggest that examination of other features of early life family context, in particular family structure, may also prove fruitful. While the results here do not illuminate the mechanisms by which features of early-life family structure affected mortality in later life, replication of this analysis in other contexts and comparison of results may be able to.

Acknowledgments

We are grateful to those who provided comments and suggestions. We are also grateful to Zheng Zhenmei, Dwight Davis and the anonymous reviewers for their comments and suggestions. The research on which this work was based was supported by NICHD 1R01HD045695-A2, “Demographic Responses to Community and Family Context.” The authors were also supported by fellowships from the John Simon Guggenheim Memorial Foundation.

References

Allison, Paul. Sage University Paper series on Quantitative Applications in the Social Sciences, 07-046. Sage Publications; Thousand Oaks, California: 1984. Event history analysis: Regression for longitudinal event data.

Allison P, Christakis N. Fixed-effects methods for the analysis of nonrepeated events. Sociological Methodology 2006;36(1):155–172.

Alter, George; Oris, Michel. Childhood conditions, migration, and mortality: migrants and natives in 19th-century cities. Social Biology 2005;52(34):178–191. [PubMed: 17619610]

Alter, George; Oris, Michel. Effect of inheritance and environment on the heights of brothers in nineteenth-century Belgium. Human Nature 2008;19:44–55.

Alter G, Neven M, Oris M. Stature in transition: A micro-level study from nineteenth-century Belgium. Social Science History 2004;28(2):23–147.

Beekink E, van Poppel F, Liefbroer AC. Surviving the loss of the parent in a nineteenth-century Dutch provincial town. Journal of Social History 1999;32:641–670.

Beekink, E.; van Poppel, F.; Liefbroer, AC. Parental Death and Death of the Child. In: Derosas, R.; Oris, M., editors. When Dad Died. Peter Lang; Bern: 2002. p. 233-260.

Bengtsson, T.; Campbell, C.; Lee, J., et al. Life Under Pressure: Mortality and Living Standards in Europe and Asia, 1700-1900. MIT Press; Cambridge, Massachusetts: 2004.

Bengtsson T, Lindström M. 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 2000;54:263–277. [PubMed: 11640213]

Blackwell D, Hayward M, Crimmins E. Does childhood health affect chronic morbidity in later life? Social Science and Medicine 2001;52(8):1269–1284. [PubMed: 11281409]

Breschi, M.; Manfredini, M. Parental Loss and Kin Networks. In: Derosas, R.; Oris, M., editors. When Dad Died. Peter Lang; Bern: 2002. p. 369-387.

Campbell C, Lee J. A death in the family: household structure and mortality in rural Liaoning, life-event and time-series analysis, 1792-1867. The History of the Family: An International Quarterly 1996;1 (3):297–328. [PubMed: 12347666]

Campbell, C.; Lee, J. Price fluctuations, family structure and mortality in two rural Chinese populations: Household responses to economic stress in eighteenth- and nineteenth-century Liaoning. In: Bengtsson, T.; Saito, O., editors. Population and the economy: From hunger to modern economic growth. Oxford University Press; Oxford: 2000. p. 371-420.

Campbell, C.; Lee, J. When husbands and parents die: widowhood and orphanhood in late imperial Liaoning, 1789-1909. In: Derosas, R.; Oris, M., editors. When Dad Died. Peter Lang; Bern: 2002. p. 313-334.

Campbell, C.; Lee, J. Disability, disease, and mortality in northeast China. California Center for Population Research Working Paper Series, CCPR-038-03. 2003. http://www.ccpr.ucla.edu/ccprwpseries/ccpr_038_03.pdf

Campbell, C.; Lee, J. Mortality and household in seven Liaoning populations, 1749-1909. In: Bengtsson, T.; Campbell, C.; Lee, J., et al., editors. Life Under Pressure: Mortality and Living Standards in Europe and Asia, 1700-1900. MIT Press; Cambridge MA: 2004. p. 293-324.

Campbell C, Lee J. Kinship, Employment and Marriage: The Importance of Kin Networks for Young Adult Males in Qing Liaoning. Social Science History 2008;32(2):175–214.

Conde-Agudelo A, Belizan J. Maternal morbidity and mortality associated with interpregnancy interval: a cross sectional study. British Medical Journal 2000;321(7271):1255–1259. [PubMed: 11082085]

Costa D. Understanding the twentieth-century decline in chronic conditions among older men. Demography 2000;37(1):53–72. [PubMed: 10748989]

Curtis S, Diamond I, McDonald J. Birth interval and family effects on postneonatal mortality in Brazil. Demography 1993;30(1):33–43. [PubMed: 8440397]

Davey Smith G, Hart C, Blane D, Hole D. Adverse socioeconomic conditions in childhood and cause specific adult mortality: prospective observational study. British Medical Journal 1998;316:1631–1635. [PubMed: 9603744]

Derosas, R. Fatherless families in 19th-century Venice. In: Derosas, R.; Oris, M., editors. When Dad Died. Peter Lang; Bern: 2002. p. 421-452.

Elo I, Preston S. Effects of early-life conditions on adult mortality: A review. Population Index 1992;58:186–212. [PubMed: 12285320]

Elo I, Preston S. Educational differences in mortality: United States, 1979-85. Social Science & Medicine 1996;42(1):47–57. [PubMed: 8745107]

Fogel, R. The relevance of Malthus for the Study of Mortality Today: Long-run Influences on Health, Mortality, Labour-force Participation and Population Growth. In: Lindahl-Kiessling, K.; Landberg, H., editors. Population, Economic Development, and the Environment: The Making of Our Common Future. Oxford University Press; Oxford: 1994. p. 231-284.

Forsdahl, Anders. Observations throwing light on the high mortality in the county of Finnmark. International Journal of Epidemiology 2002;31(2):302–308. [PubMed: 11980784]

Gluckman, P.; Hanson, M., editors. Developmental Origins of Health and Disease. Cambridge University Press; Cambridge: 2006.

Greene, W. Econometric Analysis. Vol. Third. Prentice Hall; New Jersey: 1997.

Guralnik JM, Butterworth S, Wadsworth M, Kuh D. Childhood socioeconomic status predicts physical functioning a half century later. Journal of Gerontology 2006;61A(7):694–701.

Haas S. Trajectories of functional health: The ‘long arm’ of childhood health and socioeconomic factors. Social Science and Medicine 2008;66:849–61. [PubMed: 18158208]

Hayward M, Gorman B. The long arm of childhood: The influence of early-life social conditions on men's mortality. Demography 2004;41(1):87–108. [PubMed: 15074126]

Hoffman S, Duncan G. Multinomial and conditional logit discrete-choice models in demography. Demography 1988;25(3):415–42. [PubMed: 3234576]

Högberg U, Bröström G. The demography of maternal mortality: Seven Swedish parishes in the 19th century. International Journal of Gynecology and Obstetrics 1985;23:489–497. [PubMed: 2868944]

Kaunitz A, Hughes J, Grimes D, Smith J, Rochat R, Kariffsen M. Causes of maternal mortality in the United States. Obstetrics & Gynecology 1985;65(5):605–12. [PubMed: 3982738]

Khang Y. Relationship between childhood socio-economic position and mortality risk in adult males of the Korea Labour and Income Panel Study (KLIPS). Public Health 2006;120(8):724–731. [PubMed: 16824564]

Knodel J, Hermalin A. Effects of birth rank, maternal age, birth interval, and sibship size on infant and child mortality: evidence from 18th and 19th century reproductive histories. American Journal of Public Health 1984;74(10):1098–1106. [PubMed: 6383084]

Koenig M, Phillips J, Campbell O, D'Souza S. Birth intervals and childhood mortality in rural Bangladesh. Demography 1990;27(2):251–265. [PubMed: 2332089]

Kuh, D.; Ben-Shlomo, Y., editors. A Life Course Approach to Chronic Disease Epidemiology. Vol. Second. Oxford University Press; Oxford: 2004.

Kuh D, Hardy C, Langenberg C, Richards M, Wadsworth M. Mortality in adults aged 25-64 years related to socioeconomic conditions in childhood and adulthood: post war birth cohort study. British Journal of Medicine 2002;325:1076–1080.

Kuh D, Wadsworth M. Physical health status at 36 years in a British national birth cohort. Social Science and Medicine 1993;37(7):905–16. [PubMed: 8211309]

Kunitz S. Making a long story short: a note on men's height and mortality in England from the first through the nineteenth centuries. Medical History 1987;31(3):269–280. [PubMed: 3306219]

Lee, J.; Campbell, C. Fate and Fortune in Rural China: Social Organization and Population Behavior in Liaoning, 1774-1873. Cambridge University Press; Cambridge: 1997.

Lee, J.; Campbell, C. Living standards in Liaoning, 1749-1909: Evidence from demographic outcomes. In: Allen, R.; Bengtsson, T.; Dribe, M., editors. Living Standards in the Past: New Perspectives on Well-Being in Europe and Asia. Oxford University Press; Oxford: 2005. p. 403-426.

Leon D, Davey Smith G. Infant mortality, stomach cancer, stroke, and coronary heart disease: ecological analysis. British Medical Journal 2000;320(7251):1705–1706. [PubMed: 10864546]

Miller J, Trussell J, Pebley A, Vaughan B. Birth spacing and child mortality in Bangladesh and the Philippines. Demography 1992;29(2):305–318. [PubMed: 1607054]

Moody-Ayers S, Lindquist K, Sen S, Covinsky KE. Childhood social and economic well-being and health in older age. American Journal of Epidemiology 2007;166:1059–67. [PubMed: 17720682]

Mosley, W.; Gray, R. Childhood precursors of adult morbidity and mortality in developing countries: Implications for health programs. In: Gribble, J.; Preston, S., editors. The Epidemiological Transition: Policy and Planning Implications for Developing Countries. National Academy Press; Washington: 1993. p. 69-100.

Palloni A. Reproducing inequalities: luck, wallets, and the enduring effects of childhood health. Demography 2006;43(4):87–615.

Preston S, Hill M, Drevenstedt G. Childhood conditions that predict survival to advanced ages among African Americans. Social Science & Medicine 1998;47(9):1231–1246. [PubMed: 9783866]

Preston S, van de Walle E. Urban French mortality in the nineteenth century. Population Studies 1978;32:275–97. [PubMed: 11630579]

Rothenbacher D, Winkler M, Gonser T, Adler G, Brenner H. Role of infected parents in transmission of Helicobacter pylori to their children. The Pediatric Infectious Disease Journal 2002;21(7):674–679. [PubMed: 12237602]

Sastry N. Family-level clustering of childhood mortality risk in Northeast Brazil. Population Studies 1997;51:245–261.

Schwartz J, Friedman H, Tucker J, Tomlinson-Keasey C, Wingard D, Criqui M. Sociodemographic and psychosocial factors in childhood as predictors of adult mortality. American Journal of Public Health 1995;85(9):1237–45. [PubMed: 7661231]

Tsuya, N.; Kurosu, S. The mortality effects of adult male death on women and children in agrarian household in early modern Japan: Evidence from two northeastern villages, 1716-1870. In: Derosas, R.; Oris, M., editors. When Dad Died. Peter Lang; Bern: 2002. p. 261-299.

Zeng Y, Gu D, Land K. The association of childhood socioeconomic conditions with health longevity at the oldest-old ages in China. Demography 2007;44(3):497–518. [PubMed: 17913008]

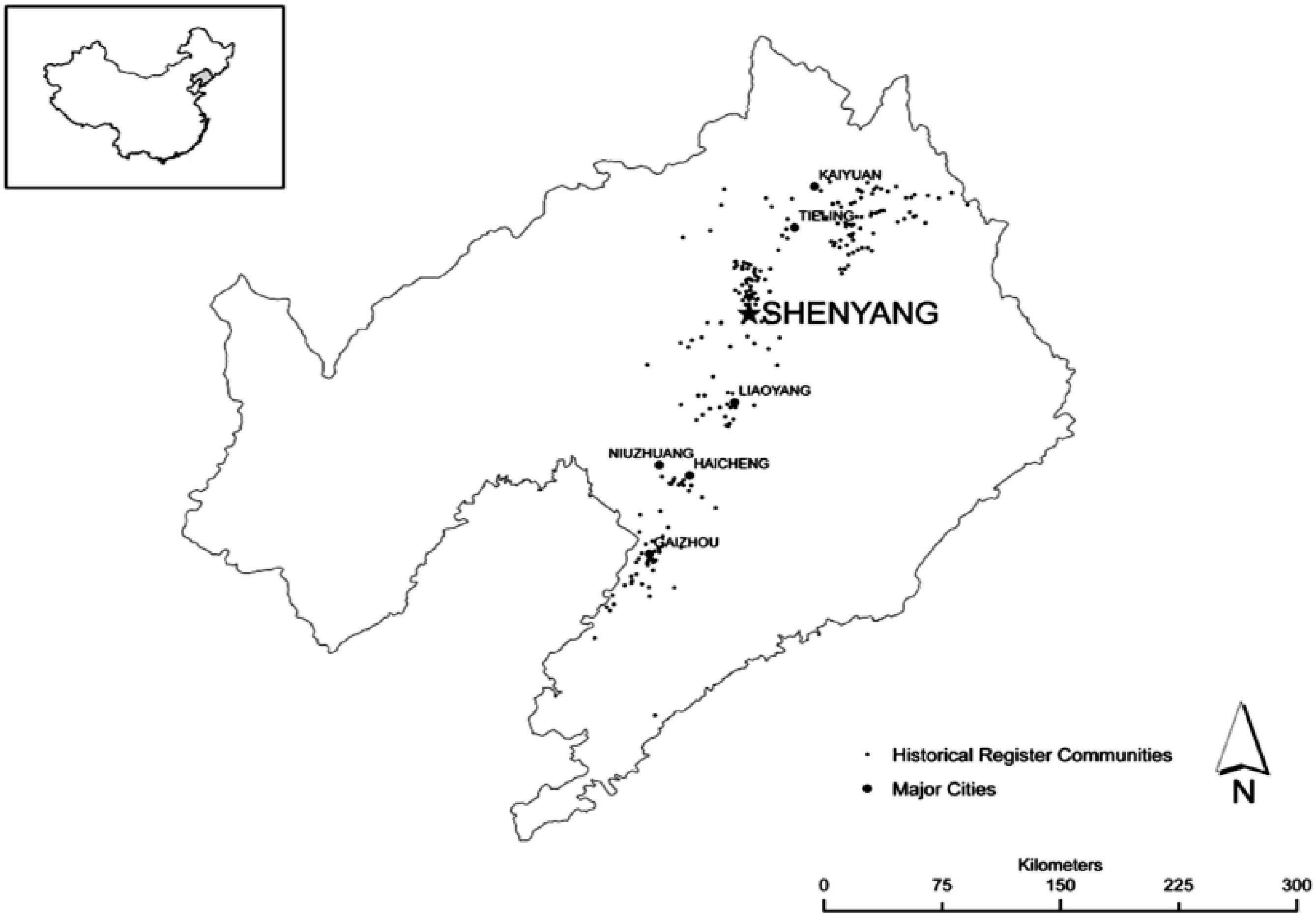

Figure 1. Communities Covered by Liaoning Household Register Data, 1749-1909

Table 1

Logistic Regression of Death in Next 3 Years, Males 1-15 sui

	Controls for region, age, year						Fixed effect of grandfather, with controls for age and year					
	Model I		Model II		Model III		Model I (w/fixed effect of grandfather)		Model II (w/fixed effect of grandfather)		Model III (w/fixed effect of grandfather)	
	Odds ratio	**p**	**Odds ratio**	**p**	**Odds ratio**	**p**	**Odds ratio**	**P**	**Odds ratio**	**p**	**Odds ratio**	**P**
Mother dead	1.211	0.00	1.237	0.00	1.243	0.00	1.266	0.01	1.262	0.01	1.270	0.01
Father dead	0.940	0.28	0.930	0.22	0.992	0.89	0.966	0.68	0.948	0.53	1.020	0.82
Birth order			1.017	0.08	0.978	0.08			0.921	0.00	0.939	0.00
P.B.I. <= 2 years			1.172	0.00	1.144	0.01			1.209	0.00	1.183	0.01
Mother <= 20 sui at birth			1.040	0.42	1.024	0.63			1.081	0.28	1.026	0.73
Mother >= 36 sui at birth			0.915	0.02	0.936	0.08			0.942	0.28	1.013	0.82
Total number of brothers					1.051	0.00					1.016	0.45
Father has official position					1.288	0.00					1.079	0.54
Father is disabled					0.993	0.92					0.906	0.47
N	120512		120512		120512		28301		28301		28301	
Groups							3236		3236		3236	

Note: To save space, results for controls for age, year, and region are not included. Age in *sui* was entered as a polynomial. Individuals are 1 *sui* at birth, and age by 1 sui every Lunar New Year. On average, ages reckoned in *sui* are 1.5 higher than ages reckoned according to Western practice. Year was entered directly. Region was entered as a set of dichotomous indicators, distinguishing between north, central, south central, and south Liaoning.

Table 2

Logistic Regression of Death in Next 3 Years, Males 16-55 sui

	Controls for region, age, year						Fixed effect of grandfather, controls for age and year					
	Model I		Model II		Model III		Model I		Model II		Model III	
	Odds ratio	**p**	**Odds ratio**	**p**	**Odds ratio**	**p**	**Odds ratio**	**p**	**Odds ratio**	**p**	**Odds ratio**	**P**
Age when mother last observed alive (Ref: 16+ sui)												
1-5 sui	1.097	0.06	1.085	0.10	1.085	0.11	1.077	0.38	1.071	0.41	1.062	0.47
6-10 sui	1.156	0.00	1.149	0.00	1.148	0.00	1.157	0.05	1.140	0.08	1.139	0.08
11-15 sui	1.089	0.09	1.083	0.12	1.083	0.11	1.066	0.41	1.061	0.45	1.053	0.51
Age when father last observed alive (Ref: 16+ sui)												
1-5 sui	1.068	0.11	1.061	0.16	1.056	0.21	0.852	0.03	0.931	0.34	0.857	0.04
6-10 sui	1.114	0.02	1.104	0.03	1.103	0.03	0.965	0.63	1.012	0.88	0.961	0.60
11-15 sui	1.032	0.50	1.024	0.61	1.022	0.64	0.923	0.26	0.954	0.51	0.922	0.26
Birth order			0.997	0.74	1.000	0.98			0.988	0.38	0.985	0.36
P.B.I. <= 2 years			0.881	0.01	0.884	0.01			1.021	0.73	1.046	0.48
Mother <= 20 sui at birth			0.991	0.82	0.994	0.88			0.943	0.32	0.980	0.74
Mother >= 36 sui at birth			1.074	0.02	1.074	0.02			1.166	0.00	1.113	0.02
Father ever held official position					0.985	0.78					0.825	0.09
Father ever disabled					0.990	0.83					1.161	0.16
Total number of brothers					0.993	0.50					0.958	0.03
Ever held an official position					1.229	0.00					1.172	0.13
Ever recorded as disabled					1.103	0.18					0.892	0.32
N	196851		196851		196851		75783		75783		75783	
Groups							5027		5027		5027	

See Notes to Table 1.

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Table 3

Logistic Regression of Death in Next 3 Years, Males 56-75 sui

	Controls for region, age, year						Fixed effect grandfather, controls for age and year					
	Model I		Model II		Model III		Model I		Model II		Model III	
	Odds ratio	**p**	**Odds ratio**	**p**	**Odds ratio**	**p**	**Odds ratio**	**p**	**Odds ratio**	**p**	**Odds ratio**	**p**
Age when mother last observed alive (Ref: 16+ sui)												
1-5 sui	0.952	0.51	0.938	0.39	0.943	0.43	0.723	0.07	0.710	0.03	0.703	0.06
6-10 sui	1.075	0.28	1.059	0.40	1.058	0.40	1.021	0.90	1.000	1.00	0.991	0.96
11-15 sui	1.001	0.99	0.993	0.93	0.997	0.97	0.910	0.58	0.895	0.52	0.874	0.44
Age when father last observed alive (Ref: 16+ sui)												
1-5 sui	1.064	0.29	1.049	0.43	1.071	0.27	0.699	0.02	0.710	0.03	0.728	0.05
6-10 sui	1.018	0.78	1.001	0.99	1.015	0.82	0.791	0.12	0.790	0.13	0.800	0.15
11-15 sui	1.058	0.39	1.052	0.44	1.056	0.41	1.014	0.93	1.026	0.86	1.009	0.95
Birth order			0.998	0.89	0.989	0.46			1.026	0.33	0.993	0.83
P.B.I. <= 2 years			1.116	0.08	1.105	0.11			1.418	0.00	1.458	0.00
Mother <= 20 sui at birth			0.950	0.34	0.949	0.34			0.785	0.05	0.797	0.06
Mother >= 36 sui at birth			1.172	0.00	1.176	0.00			1.187	0.07	1.152	0.15
Father ever held official position					1.001	0.99					1.722	0.01
Father ever disabled					1.126	0.03					1.640	0.01
Total number of brothers					1.009	0.47					1.004	0.83
Ever held an official position					1.240	0.01					1.507	0.03
Ever recorded as disabled					1.218	0.01					1.127	0.50
N	26942		26942		26942		12012		12012		12012	
Groups							2565		2565		2565	

See notes to Table 1.