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by George ALTER, Muriel NEVEN and Michel ORIS

Recent developments in demography and epidemiology have focused attention on the links between events in early life and mortality later in life. Processes developing over the life course can only be studied with long-run longitudinal data, which is quite difficult to obtain. Historical demography is unusually rich in such data. Indeed, one might say that any longitudinal data set describing complete life histories (e.g. more than fifty years) must be viewed in a historical perspective, because changing epidemiological, economic, and social contexts may affect the impacts of early life conditions on later health. This article is a preliminary attempt to link together demographic events and economic characteristics across the life course from childhood to old age. We are motivated by a particular interest in the effects of early life conditions on old age mortality, but we also want to know whether experiences in childhood can be mediated by experiences in midlife.

Demographers have long suspected that health and mortality in later life can be linked to earlier experiences (e.g. Derrick, 1927; Kermack *et al.,* 1934; Finch and Crimmins, 2004; Doblhammer, 2004). Recently Barker's "fetal origins" hypothesis (Barker, 1994; Barker and Osmond, 1986) has attracted attention and debate in the bio-medical community (Whincup and Cook, 1997; Järvelin *et al.,* 1998; Kannisto *et al.*, 1997; Stanner *et al.*, 1997) and stimulated research in epidemiology and demography (e.g., Elo and Preston, 1996; Leon *et al.*, 1998; Lundberg, 1993; Östberg and Vågerö, 1991; Preston *et al.*, 1998; Vågerö and Leon, 1994; Vaupel *et al.*, 1998). While Barker focuses on conditions *in utero*, other researchers highlight conditions in early childhood. Bengtsson and Lindstrom (2000) emphasize exposure to disease in infancy. They found that the level of infant mortality in the year of birth predicted mortality at older ages, while food prices did not. Robert Fogel (1993, 1996) has drawn attention to the implications of historical trends in stature. Height in adulthood is strongly linked to nutrition and disease in early childhood, and Waaler's (1984) study showed that height

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is inversely correlated with mortality in late adulthood.

Research in this area has had difficulty disentangling the persistent effects of early life conditions from other determinants of health. On one hand, the configuration of economic, social, and epidemiological conditions that cause poor health in early childhood are likely to be correlated with conditions in later life. Individuals who are born into poor families are more likely to be economically deprived in adulthood as well. On the other hand, poor health in childhood can contribute to lower socio-economic achievement. Ben Shlomo and Smith (1991) argue that associations between early life environments and late adult mortality may be due to the persistence of childhood differentials during adolescence and adulthood. Smith (Smith *et al.*, 1998), however, found that the effects of childhood background were not removed by controls for adult conditions.

Kuh and Ben-Shlomo (2004) expand the links between early-life and later morbidity and mortality to include the accumulation of risk throughout the life course. This notion differs from Barker's approach by emphasizing a greater range of experiences over a wider range of ages. In describing results from the British MRC 1946 birth cohort study, Wadsworth and Kuh (1997) write: "Associations between childhood and poor adult health in this investigation were evidently the products of continuing social disadvantage, of the effects of illness in childhood, adolescence and early adulthood, and the effects in adult life of gaining no educational qualifications." Thus, even when correlations between early life conditions and health or mortality in old age are observed, it is not clear whether these correlations are due to the physiological effects of childhood or to contemporaneous conditions that are correlated with childhood health for other reasons.

Historical demography can play a special role in this area, as the recent contribution of Bengtsson and Lindstrom (2000) shows. Historical sources can provide information about complete lives so that experiences in early, middle and later life can be considered simultaneously. Recent work with population registers (Bengtsson, Campbell and Lee, 2004) and event history methods (Alter, 1998) have expanded the range of questions that can be asked with historical demographic data. In addition, historical demographers have become increasingly adept at enhancing demographic sources with information on socio-economic status from taxes, successions, and other documents.

In this paper we look at the long-run effects of early life conditions on health by viewing the life course in a multi-period framework. We use indicators of health in childhood and parental wealth to predict both adult wealth and the likelihood of marriage. Then, we use a combination of measures from childhood and early adulthood to predict longevity. In this way, we look for both direct and indirect pathways leading from childhood experiences to health in old age.

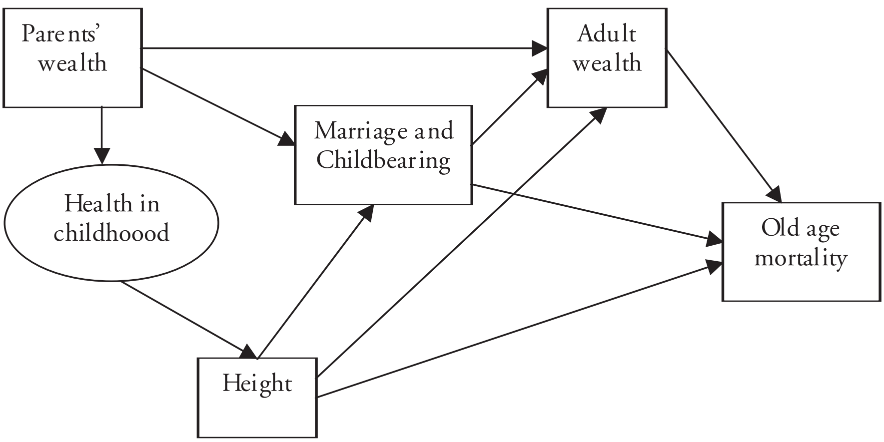
Wealth, Health, and Mortality: A Multi-period Approach

A simplified model of interrelations between wealth and health over the life course is illustrated in Figure 1. The arrows in the diagram indicate causal pathways linking outcomes in mid- and later life to earlier conditions. The model describes four outcomes. First, we hypothesize that health in childhood is strongly affected by parents' wealth (Aïach 1996; Power, Manor and Fox, 1991). We cannot measure health directly, of course, but the heights of men who were examined for military service provide a summary indicator of health and nutrition in childhood. While height is not a measure of health, it is strongly correlated with conditions that lead to good health. Height reflects cumulative experiences of both diet and diseases in childhood. Poor diet has a direct effect on adult stature, and diseases, like diarrhea, also prevent children from absorbing nutrients from the food that they do eat. Haines (1998) found that the heights of nineteenth-century American soldiers were strongly related to epidemiological conditions in their home communities.

Second, we examine the transition to marriage, and we hypothesize that marriage is affected by both parents' wealth and height. Nineteenth-century writers, who were usually inspired by Malthus, often stressed the link between economic self-sufficiency and marriage. In a rural setting, such as the one examined here, wealthy parents could transfer property to their children, allowing them to marry earlier. Height is both a measure of health and a potential indicator of potential work effort, both of which would have mattered in the marriage market (Baten and Murray, 1998; Murray, 2000; Herpin, 2003; Hacker, 2004). Thus, we expect taller men to marry earlier.

Third, we look at the effects of parents' wealth, height, marriage, and number of children on wealth in midlife. We expect that wealth in midlife is affected by transfers of wealth from parents to children and by health and potential work effort, which are reflected in heights. Marriage was probably wealth enhancing in a nineteenth century context. In a time when work roles were often defined by gender, marriage was an economic as well as an emotional partnership. Children could contribute either positively or negatively to wealth. If childrearing was expensive, we might expect to find that children

Fig. 1 *Conceptual Model of Wealth, Health and Mortality in Three Periods of the Life Course*



depleted wealth. Children, especially older children, were also an important source of family labor, who might have increased wealth. It is also possible that marriage and family size will capture aspects of health and wealth in midlife that are not measured by the other two indicators, which are more strongly related to conditions in childhood.

Fourth, we use height, wealth at age 50, marriage, and number of children to predict mortality after age 50. Height is included to look for long-run effects of conditions in childhood, as discussed above. If height has measurable effects on old age mortality, it suggests that childhood experiences have permanent physiological consequences. Wealth at age 50 is a measure of current experiences. Marriage and family size also describe important aspects of the domestic environment, which can have important effects on health. Married men usually have lower mortality than bachelors or widowers, and children can provide support and care in old age.

A model like this is challenging to estimate even under the best circumstances, but historical research presents both special problems and unique opportunities. The creation and preservation of documents with relevant information are often due historical accidents. Administrative agencies in a number of societies collected information that we can use to examine health, wealth, and longevity, but the array of measures available for any specific time and place is the result of a chain of chance events. Historical sources, however, cover long periods of time, allowing us to study entire lives and even successive generations. Fortunately, our database on the Belgian commune of Sart includes comprehensive demographic information, several different measures of wealth, and the heights recorded for military conscripts.

Setting and Data

Data for this study come from the commune of Sart-lez-Spa, located in the Belgian Ardennes (See Alter, Neven and Oris, 2004a). Nineteenth-century Sart covered a large, sparsely populated area. In spite of its close proximity to the most advanced agricultural and industrial areas on the European continent, Sart was poor and relatively backward. The terrain is steep, soils are poor, and a peat bog covers a large area. At the beginning of the century swidden agriculture was still being practiced in Sart's extensive, communally-owned forests (Vliebergh and Ulens, 1912). All 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. 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. In addition to complete registers of births, marriages, and deaths, we have population registers describing household composition and migration from 1811 to 1900[1]. These documents allow us to reconstruct the biographies of everyone living in Sart during most of the nineteenth century. We know not only when they were born, married, and died, but also the lives of their parents, siblings, and children. The main weakness of these documents lies in the underreporting of migration. Out-migrants often failed to report their departures, and some short-term residents, like servants, are not counted. We have adjusted the data by randomly assigning exit dates where they were missing.

In this paper, we supplement the population history with measures of wealth and heights from the following sources.

Successions[2]

After the death of a property owner, the value of the estate and a list of heirs were recorded in the *Enregistrement des successions*. Accurate valuation of the estate was important, because few people left wills and the Belgian Civil Code, which was based on the Napoleonic Code, divided estates equally among the heirs. Successions were usually registered within three months of the date of death, but large and complicated estates might take longer to inventory. We have collected the estate valuations and the names of heirs for persons who died in Sart between 1818 and 1900, and these records have been linked to the population registers. Successions are available for less than 20 percent of those who died in nineteenth-century Sart (See Appendix). When no succession is available, we assume that the decedent had no wealth.

Tax registers of 1818 and 1822[3]

From 1818 to 1822 the commune of Sart imposed a special tax on all taxpayers. This was a period of extreme distress in much of Europe. The region had been annexed to France in 1794, and records from the French regime show frequent demands for military supplies and conscripts. Napoleon's defeat in 1815 was followed by harvest failures, high prices, and a major epidemic of typhus. In addition, Sart still had outstanding debts from loans contracted during the eighteenth century. The 1818 and 1822 tax registers show both "personal" taxes and business licenses (*patentes*), and individuals were assessed approximately 116% of the sum of those amounts. We use these tax assessments as indicators of wealth in 1818 and 1822.

Landholding in 1843[4]

The population register of 1843 includes the amount of land belonging to each household. We use the area (in hectares) listed with each household as an indicator of wealth in 1843.

Atlas Popp[5]

In the 1870s a map showing landowners and the value of each property was constructed from cadastral records for Sart. This process was conducted throughout Belgium and is known as the Atlas Popp. We use the total value of land and buildings associated with each property-owner as an indicator of wealth in 1870.

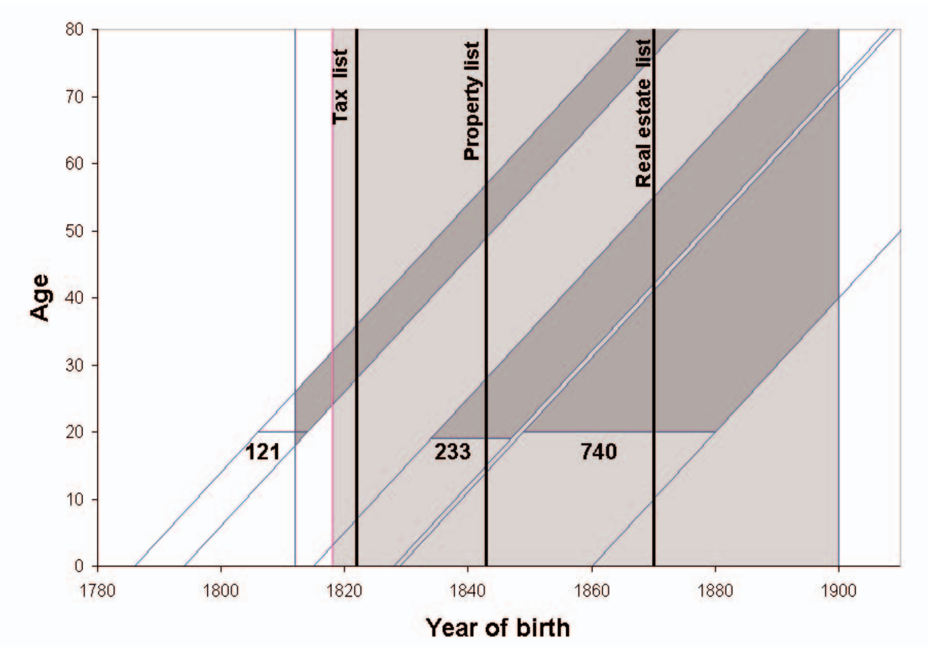
Height[6]

From the time that Eastern Belgium was under French control, all young men were required to report for military conscription when they reached age 20 (1794-1814 and 1849-1880) or age 19 (1816 to 1847). The conscription process included a medical examination at age 19 (1816-47) or 20 (1806- 1815 and 1848-1880). Men who were physically unfit or shorter than the minimum height (155 centimeters) could be excused from military service or required to appear for re-examination a year later. Military service could also be canceled or postponed for men who had brothers on active duty. We have linked records from military conscription lists beginning in 1834 to the population registers[7].

Since we are observing people over time, the number of subjects for any type of analysis will depend upon which variables are included. Figure 2 illustrates the availability of data from these various sources. For example, 1 165 men were present when the 1822 tax was taken, and 1 527 were there in the early 1870s when the Atlas Popp was constructed. But only 230 men were present for both, and we have heights for only 56 of them.

Since our measures of wealth come from four different types of sources, they are measured on different scales (taxes, land, estate values). We used the successions, which are the most comprehensive of these sources, to standardize the others to a common scale. The procedure assumes that there is a standard trajectory of wealth over the life course, which can be used to extrapolate from wealth at one age to wealth at any other age. We estimate a regression model predicting the value of the estate at the time of death based on each measure of mid-life wealth (taxes, land, estate values), age at the time when wealth was measured, and age at death. These regression models are then used to compute a predicted value of the logarithm of wealth at age 50 for use in the analysis. We use the logged values for all measures of wealth to reduce the effects of relatively large values. Details of the procedure are given in the Appendix.

Fig. 2 *Availability of Data for Sart, Belgium, 1812-1900*



Dark shading = Demographic data on cohorts in conscription lists
Light shading = Availability of successions

Height and Conditions in Childhood

Our previous research using military conscription lists from communities in Eastern Belgium suggested a strong link between childhood conditions and height (Alter, Neven and Oris, 2004b). We found several important patterns. First, at the beginning of the nineteenth century men from this region were very short by international standards (Alter, Neven and Oris, 2004b). The average height of men in Sart examined before 1850 was less than 163 centimeters (Table 4). In contrast, Quetelet (1869, 354) computed an average height of 164 centimeters for all Belgian men examined between 1842 and 1865, and even this is below the averages of other contemporary European countries[8]. Second, heights increased substantially, going from 161 for those measured in the 1820s to 165 around 1880 (Alter, Neven and Oris, 2004b, Table 5). The trend in heights in Sart is shown in Table 1. Third, heights were strongly related to conscripts' occupations. At the extremes, we found an average height of 157 for men working as day laborers compared to 164 and 167 for those who were still in students in rural and urban areas respectively (Alter, Neven and Oris 2004b, Table 8)[9]. Since occupation at age 20 is primarily a reflection of the economic position of the parental household, we interpret this as strong evidence that height reflected conditions in early life. Fourth, socio-economic differences in height narrowed after 1850. While heights among all groups increased, the increase was greatest among those who were shorter in earlier years. This suggests that the improving conditions after 1850 had the greatest impact on the nutrition and health of the poor.

Tab. 1 *Mean Heights of Men Examined for Military Service by Year of Birth, Sart, Belgium*

Year of birth	Mean height	Number
1810-9	160.4	48
1820-9	160.2	202
1830-9	161.1	222
1840-9	162.7	247
1850-9	164.3	229
1860-9	165.6	18

In Table 2 we look at the effect of parental wealth on the heights of men in Sart. Parents' wealth is measured in 1818, 1822, 1843, or 1870, but it is adjusted to a common standard by the method described in the Appendix[10]. We estimate separate models for men examined for military service from 1834 to 1847 (born 1815 to 1826) and for those examined 1849 to 1880 (born 1828 to 1860). There are two reasons for stratifying the data in this way. First, the earlier cohort was measured at age 19 and the later cohort at age 20. While growth is nearly completed at these ages in a well-nourished population, individuals who were severely malnourished in childhood can experience catch-up growth well into their twenties (Bogin 1999, 92). We have estimated that men grew an average of one and a half centimeters between age 19 and age 20 in our study population. Since this catch-up growth would have varied by

Tab. 2 *Regression Models of Height in Military Examinations, Males, Sart, Belgium, 1806-1880 (Dependent variable: Height at age 19 or 20)*

Covariate	Coefficient	p-value	Mean
A. Military examinations 1834 -47 (men born 1815 -28) (mean of dependent variable = 160.5)			
Parents' tax or property	2.54	0.00	3.1
Year of birth	0.59	0.00	123.0
Constant	225.37	0.00	
N	208		
R-squared	0.06		
F(2,213)	6.43		
p	0.06		
B. Military examinations 1849 -80 (men born 1829 -60) (mean of dependent variable = 162.8)			
Parents' tax or property	0.16	0.59	4.7
Year of birth	0.13	0.00	145.2
Constant	142.45	0.00	
N	649		
R-squared	0.03		
F(2,646)	10.84		
P	0.00		

social and economic status, it is risky to apply a single correction factor to all individuals in order to pool the data across cohorts. Second, we know that there were important social and economic changes in Sart around the middle of the nineteenth century. The first half century was characterized by backward agricultural techniques and growing population pressure. After 1850 new agricultural technologies were introduced, and out-migration to growing industrial areas reduced the total size of the population. Dividing the data into two cohorts highlights the effects of social and economic change.

The main lesson of Table 2 is that height was strongly related to parental wealth in the 1834-47 cohort of military conscripts but not in the 1849-80 cohort. In the earlier cohort the estimated coefficient for parental wealth is statistically significant and quite large (2.54). This implies that a ten percent increase in wealth would have increased height by almost one quarter of a centimeter[11]. In the later cohort, however, parents' wealth does not have any effect on height. As we noted above, socio-economic differences in height became much more attenuated after 1850 in Sart and several other communities in eastern Belgium. As the economy of Sart responded to the rapid growth of nearby industrial cities, the importance of wealth in determining childhood experiences decreased.

Marriage

To examine the timing of marriage we use a Cox proportional hazards model (Cox 1972) shown in Table 3. Relative risks estimated in this model show the effect of each covariate on the instantaneous rate of transition from single to married. A relative risk greater (less) than one means that a covariate increased (decreased) the probability of marriage. When the estimated relative risk does not differ from one, the covariate has no association with the timing of marriage. Models have been estimated for unmarried men observed between ages 18 and 50 in each cohort of military examinations.

Tab. 3 *Hazard Models of the Risk of Marriage (Ages 18-50), Sart, Belgium, 1811-1899*

Covariate	Relative risk	p-value	Mean
A. Military examinations 1834 -47 (men born 1815 -28)			
Parents' tax or property	1.31	0.04	3.14
Height	1.04	0.00	160.63
Year of birth	0.96	0.23	123.10
Subjects	203		
Deaths	103		
Time at risk	2743.74		
Log likeliho od	-450.73		
Chi-squared	18.11		
p-value	0.00		
B. Military examinations 1849 -80 (men born 1829 -60)			
Parents' tax or property	0.96	0.48	4.50
Height	1.02	0.00	162.75
Year of birth	0.99	0.33	145.21
Subjects	645		
Deaths	296		
Time at risk	9064.16		
Log likelihood	-1679.36		
Chi-squared	11.07		
p-value	0.01		

Parents' wealth has a large effect on marriage in the first cohort, but no effect in the second cohort. The estimated relative risk for parents' wealth in the first cohort is 1.31. This means that a ten percent increase in parents' wealth increased the relative risk of marriage by about 2.5 percent. Since the model assumes that unmarried men are continuously exposed to the risk of marriage, this increase in the relative risk of marriage has a cumulative effect over time. The estimated relative risk in the second cohort is .96, and the associated p-value implies that it may differ from the null hypothesis (no effect of wealth on marriage, i.e. relative risk=1.0) only by chance.

Height has a strong effect on the marriages of men in both cohorts. In the first cohort the estimated relative risk for a one-centimeter increase in height is 1.04. This is a large effect at a time when wealthy men were ten centimeters taller than unskilled laborers. A ten centimeter increase in heights would have increased the risk of marrying by about fifty percent. The estimated relative risk is only half as large in the second cohort, 1.02, but this is still a substantial and statistically significant effect.

These results imply that the marriage market in Sart changed significantly during the nineteenth century. Family wealth, which was very important in the first half of the century, had little effect on the timing of marriage after 1850. The changing economy of the region and increasing out-migration from Sart appear to have reduced the importance of inherited wealth in determining the timing of marriage. Height, as an indicator of health or physical ability or both, continued to have a large effect on the timing of marriage, but it was twice as important before 1850 as it was after 1850.

Wealth in Adulthood

In Table 4 we ask whether parents' wealth, height, or marital status affected wealth in mid-life. The dependent variable is our estimate of wealth at age 50 constructed by the method described in the Appendix.

The only variable that appears to make a difference in Table 4 is whether the subject was ever married. The estimated coefficients for having been married (67 and .62) imply that married men were almost twice as wealthy as those who remained unmarried. Children, however, made no difference.

Although parents' property and height do not appear to have direct effects on mid-life wealth, they do have indirect effects. As we saw above, parents' wealth and height strongly affected the likelihood of marriage, and marriage appears to have mediated the effects of childhood conditions on socio-economic status in mid-life. When we estimate the regression model without the marriage and family size variables (results not shown), the coefficients of parents' wealth and height are larger, which also suggests that they affect mid-life wealth indirectly through marriage.

Survival after age 50

We use the Cox partial likelihood model shown in Table 5 to estimate the effects of early life conditions on old age mortality. Again, we find an important difference between the early and later cohorts. Mid-life wealth and height mattered a great deal in the early cohort and not at all in the later cohort. This suggests that a ten percent increase in wealth would have reduced the risk of dying by more than five percent; while each additional centimeter increase in height was associated with a six percent reduction in the risk of dying. These effects do not appear in the later cohort.

It is somewhat surprising not to find a clearly beneficial effect for either marriage or family size in these data. The estimated effect for marriage in the second cohort is actually quite large, but it is not statistically significant. Descriptive statistics from the full population (including men whose heights do not appear in the military conscription lists) do show much higher mortality among men who never married. The absence of that pattern here points to the relationships among the variables included in the model. We showed above that marriage was strongly affected by both height and wealth, both of which affect old age mortality in the earlier cohort. Indeed, when we omit height and wealth from the model, marriage has a strong negative effect on mortality (results not shown). This suggests that married men had lower mortality, because they were already more healthy before they married. This does not mean that marriage did not have beneficial effects on health, but marriage was also a selective process that favored men with better health and more wealth.

Tab. 4 *Regression Models of Predicted Wealth at Age 50, Males, Sart, Belgium, 1806-1880 (Dependent variable: Logarithm of predicted wealth at age 50) (Men observed until age 40 or older)*

Covariate	Coefficient	p-value	Mean
A. Military examinations 1834 -47 (men born 1815 -28)			
(mean of dependent variable = 4.70)			
Parents' tax or property	0.14	0.33	3.23
Height	0.00	0.81	161.26
Children ever born	0.00	0.95	4.81
Ever married	0.67	0.06	0.85
Year of birth	-0.12	0.00	3.23
Constant	18.41		
N	104		
R-squared	0.16		
F(5,98)	3.60		
p	0.00		
B. Military examinations 1849 -80 (men born 1829 -60)			
(mean of dependent variable = 2.42)			
Parents' tax or property	-0.03	0.65	4.61
Height	0.00	0.80	162.15
Children ever born	0.02	0.27	3.82
Ever married	0.62	0.00	0.74
Year of birth	-0.18	0.00	4.61
Constant	28.02	0.00	
N	187		
R-squared	.63		
F(5,18)	62.54		
P	0.00		

Tab. 5 *Hazard Models of the Risk of Dying after Age 50, Sart, Belgium, 1811-1899*

Covariate	Relative risk	p-value	Mean
A. Military examinations 1834-47 (men born 1815-28)			
Predicted wealth at age 50	0.54	0.00	4.87
Height	0.95	0.04	160.71
Children ever born	0.94	0.20	5.10
Ever married	1.14	0.80	0.87
Year of birth	0.91	0.04	122.61
Subjects	93		
Deaths	54		
Time at risk	1791.81		
Log likelihood	-196.19		
chi2(5)	27.43		
p-value	0.00		
B. Military examinations 1849-80 (men born 1829-60)			
Predicted wealth at age 50	0.87	0.48	2.49
Height	1.00	0.96	161.96
Children ever born	1.05	0.51	4.34
Ever married	0.42	0.17	0.79
Year of birth	0.92	0.15	140.59
Subjects	160		
Deaths	30		
Time at risk	1368.72		
Log likelihood	-117.74		
chi2(5)	4.93		
p-value	0.42		

Conclusion

We have emphasized both the long-run effects of conditions early in life and the mediating effects of conditions in mid-life. The interactions between health and wealth over the life course sometimes make it difficult to separate their effects. Wealthier families have more resources to invest in the health of their children. Healthier adults are more likely to marry, and married couples have advantages in accumulating additional wealth. Wealth, marriage, and a healthy childhood all contribute to longer life in old age. The multi-period, longitudinal model used here helps to show these overlapping and reinforcing effects.

Our results also illustrate the importance of historical context. In general, we found much clearer and stronger effects in the cohort that reached adulthood before 1850 than among those born later, even though our sample of the later cohort is larger. This difference may be partly due to changes in the quality of our sources, but we are generally reassured by the fact that some results, like the effect of height on marriage, were very similar in both cohorts. It is more likely that these differences are due to the economic and social transformation of Sart as it was drawn into the new industrial world. Wealth in land meant something quite different after 1850 when jobs in factories, mills, and mines were available nearby. Migration, moreover, often drew the healthiest young men away from home, and this selective process may have reduced the apparent relationship between height and old age mortality in the later cohort (Oris and Alter, 2001).

Since the samples used here are small, the conclusions drawn here must be preliminary. We believe, however, that these results do demonstrate the value in taking a life course approach to the analysis of demographic and socio-economic events.

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NOTES

1. Archives de l'État à Liège, Communes, Sart-lez-Spa, Registres de population n° 27-34 (1811-1866) et Administration communale de Sart-lez-Spa, Registres de population n° 1-9 (1867-1900).

2. Archives de l'État Liège, Déclarations de successions. Bureau de Spa. Série 187: 187/4 à 187/82 (1819-1900).

3. Archives de l'État Liège, Communes, Sart-lez-Spa, Fiscalité, Correspondance, n° 26.

4. Archives de l'État à Liège, Communes, Sart-lez-Spa, Registres de population n° 28 (1843).

5. Archives de l'État à Liège, Collection des Plans Popp. Sart-lez-Spa.

6. Conscription lists are found in the Archives de l'État à Liège in the Fonds Francais, Fonds Hollandais, and Communes under the heading Miliciens.

7. Some military conscriptions lists also exist from the Napoleonic period. Those records are not included here, because we are unsure of the quality and completeness of recording during that period.

8. For a survey of the anthropometric history and the historical anthropometric data, see Coll and Komlos 1998.

9. These estimates come from regression models using data from conscripts examined between 1816 and 1847.

10. We adjust the parents' wealth to wealth at age 50 by assuming that parents were 30 years old when the subject was born.

11. Logarithms are used for all wealth variables. In this case ln(1.1)(2.542) = 0.242.

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APPENDIX: WEALTH BY AGE AND TIME

This appendix explains how we adjust measurements of wealth of different kinds to a common standard and age. We begin with a simple model of the growth of wealth over the life course:

$$\log(W_x) = \log(W_0) + ß_1 x + ß_2 t_0 \quad (1)$$

in which,
x represents age,
t_0 is the individual's year of birth,
and W_x is wealth at age x.

This is an exponential growth model in which each individual begins with an initial endowment of wealth (W_0) that increases at a constant rate with age. Year of birth is included in the model to capture exogenous conditions affecting the value of wealth, such as changes in technology and markets.

Tables A1 and A2 indicate that this model captures basic features of wealth at the time of death in nineteenth-century Sart. Table A1 shows that wealth did rise with age. Whether we look at average wealth for all decedents or at the average of those who left inheritance records, wealth increases with age. There is also a suggestion that wealth accumulation ended in old age. In Table A2 we see that the average value of estates rose dramatically during the nineteenth century. Since there was little inflation and prices actually fell after 1870, increased property values must have been due to improvements in agriculture and rising incomes.

Tab. A1 *Value of Estate by Age at Death*

	Non-zero estates		All decedents		
Age at death	Mean	Number	Mean	Number	Percent with no estates
0-9	245	44	13	850	94.8
10-9	932	26	258	94	72.3
20-9	1 177	34	328	122	72.1
30-9	1 277	34	457	95	64.2
40-9	3 110	39	1 123	108	63.9
50-9	2 940	94	1 607	172	45.3
60-9	4 545	107	2 123	229	53.3
70-9	4 492	100	1 936	232	56.9
80-9	4 284	47	1 830	110	57.3
90-9		0	0	3	100.0

Tab. A2 *Value of Estate by Year of Death*

	Non-zero estates		All decedents		
Year of death	Mean	Number	Mean	Number	Percent with no estates
1810-9	713	19	64	213	91.1
1820-9	2 948	21	333	186	88.7
1830-9	867	19	72	229	91.7
1840-9	1 329	58	393	196	70.4
1850-9	2 308	96	818	271	64.6
1860-9	2 986	100	1 176	254	60.6
1870-9	4 095	104	1 717	248	58.1
1880-9	5 202	63	1 413	232	72.8
1890-9	4 575	46	1 125	187	75.4

Although we have measurements of age at death throughout the nineteenth century, we only have indicators of wealth of the living population at three points in time: 1822, 1843, and 1870. Since our subjects were at different ages when these records were collected, it is not possible to compare them without adjustment. We use a regression model based on Equation 1 to compute predicted wealth at age 50 for each person. Equation 1 implies that if we compare wealth at two ages, x and x+n, we get:

$$\log(W_{x+n}) = \log(W_x) + ß_1 n \qquad (2)$$

In other words, the log of wealth at any age can be described by wealth at an earlier age plus the product of the rate of growth for age (?$_1$) and the number of years between these ages. Estimated values of the rate of growth can be used to predict wealth at any other age.

Tab. A3 *Regression Models of Wealth at Death with Three Measures of Wealth, Males, Sart, Belgium, 1811-1899 (Dependent variable: Logarithm of value of estate at death)*

Covariate	Coefficient	t	p-value	Mean
A. Tax in 1818 (mean of dependent variable = 3.2)				
Tax in 1818	0.64	2.61	0.01	0.39
Year of birth [a]	0.01	1.12	0.26	91.7
Year of death - 1818	0.06	8.53	0.00	33.5
Constant	-0.16	-0.18	0.86	
N	603			
R-squared	0.15			
F(3,599)	34.25			
p	0.00			
B. Tax in 1822 (mean of dependent variable = 3.3)				
Tax in 1822	0.71	2.81	0.01	0.3
Year of birth [a]	0.01	1.04	0.30	95.1
Year of death - 1822	0.07	8.01	0.00	33.7
Constant	-0.14	-0.15	0.88	
N	596			
R-squared	0.15			
F(3,617)	33.73			
p	0.00			
C. Land in 1843 (mean of dependent variable = 3.9)				
Land in 1843	0.73	3.29	0.00	0.4
Year of birth [a]	-0.02	-2.67	0.01	110.3
Year of death - 1843	0.04	3.96	0.00	25.5
Constant	5.16	5.27	0.00	
N	646			
R-squared	0.06			
F(3,642)	13.93			
p	0.00			
D. Real estate value in 1870 (mean of dependent variable = 3.6)				
Real estate value in 1870	0.24	5.54	0.00	3.6
Year of birth [a]	-0.05	-7.32	0.00	127.9
Year of death - 1870	-0.06	-3.45	0.00	12.2
Constant	9.14	10.76	0.00	
N	575			
R-squared	0.17			
F(3,571)	39.82			
p	0.00			

We estimate models like Equation 2 by regressing each of our measures of the wealth of the surviving population on the values of estates in the inheritance records. These results are shown in Table A3. Each of these regression models includes an indicator of wealth (taxes in 1822, land in 1843, value of real estate in 1870) and the time between the wealth measure and the date of death. Unlike Equation 2 the regression models include a constant. We also include the year of birth. Equation 2 implies that year of birth should have no effect when we include wealth at an earlier age, but it is included in the model to detect unforeseen trends in the data. We arbitrarily add one franc to each estate, so that we can calculate the logarithm of estates with no reported property.
The estimated coefficients of all the wealth measures in Table A3 are positive and statistically significant as we expect. The estimated coefficients for the time between death and the measurement of wealth are positive in the equation for 1822 and 1843 but negative in the equation for 1870. The latter seems to capture a decline in land prices during the years of deflation after the 1874.[1] The coefficient for year of birth is close to zero in the 1822 model, but negative and statistically significant in the later years. The coefficients of determination (R^2) for the models are low (.15, .06, and .15), but our prediction of wealth at death is better when we use the tax or property indicator closest to the subject's death. The correlation coefficient between this synthetic predicted wealth and the observed estate is .40 (equivalent to R^2 = .16).
The estimated models in Table A3 are not intended to explain all of the variation in the estates, but they should be sufficient for converting our three different measures of wealth to a common standard. We compute predicted values of wealth at age 50 by substituting the difference between the individual's current age and age 50 into the regression model in place of the difference between current age and age at death. When an individual's wealth was observed more than once, we use the one closest to his 50th birthday.

1. We tried using series of agricultural prices to convert the estates to real value, but it made almost no difference.

SUMMARY

Epidemiologists and demographers have long suspected that childhood experiences affect mortality at later ages, but it has been very difficult to separate the persistent effects of early life conditions from other determinants of health. Individuals raised in poor families are more likely to be economically deprived in adulthood, and poor health can cause lower socio-economic achievement. We use life histories from a 19th century community to identify the long-term effects of deprivation in childhood. Heights derived from military conscription examinations provide a summary measure of childhood experiences of nutrition and disease. We find a complex pattern of relationships between wealth, height, marriage, and mortality across the life course. Parental wealth was related to height, which in turn affected the likelihood that a man would marry. Height and wealth in adulthood were strongly related to survival in old age in earlier cohorts, but this relationship weakened after 1850.

RÉSUMÉ

Les épidémiologistes et les démographes ont pendant longtemps suspecté les conditions de vie et de maladie au cours de l'enfance d'influencer la mortalité ultérieure, mais il a été difficile de faire la part entre les effets de ces conditions et les autres facteurs s'exerçant sur la santé. Les enfants élevés dans les familles pauvres connaissent plus fréquemment que les autres une situation économique très difficile au cours de leur âge adulte mais une mauvaise santé peut conduire à des difficultés socio-économiques. Un suivi longitudinal des membres d'une communauté du XIXe siècle permet ici d'identifier les effets de long terme des privations au cours des premières années de vie. La taille, appréciée lors du conseil de révision, fournit un indice des conditions de nutrition et de morbidité de l'enfance. Il ressort de l'analyse des relations complexes entre la richesse, la taille, le mariage et la mortalité tout au long de la vie. L'aisance des parents est corrélée avec la taille des enfants qui affecte à son tour la probabilité qu'un homme se marie. La taille et l'aisance au cours de l'âge adulte sont fortement corrélées à la survie dans la vieillesse en particulier pour les premières générations du siècle, la relation s'affaiblit pour celles nées après 1850.