Long Live the Family. Families' exceptional longevity in a changing disease environment, Sweden, 1880-2015

Dr. Ingrid K. van Dijk[1,2,] ingrid.van_dijk@ekh.lu.se

Dr. Niels van den Berg, N.M.A.van_den_Berg@lumc.nl [3,1]

Author affiliations

1 Centre for Economic Demography, Department of Economic History, Lund University, Sweden

2 Radboud Group for Family History and Historical Demography, Radboud University, Netherlands

3 Molecular Epidemiology, Leiden University Medical Centre

Abstract

Which families are aging in exceptional health, and how do social characteristics of families with a high clustering of exceptional survival change over time? In this paper, we take a closer look at families in which a large share of ancestors (father, mother, aunts, uncles and grandparents) belonged to the 10% longest-lived of their birth cohort (van den Berg et al. 2020). We use a unique dataset consisting of digitized and linked historical records for a region in Southern Sweden, reconstructing lives and families of individuals living in five rural parishes 1812-1967 and the town of Landskrona 1904-1967, with nationwide follow-up in the Swedish national registers of these individuals and their descendants 1968-2015. We show evidence that descendants from families that have a large number of long-lived ancestors have a mortality advantage across time. This advantage existed even before the rise of the modern social gradient in mortality by socioeconomic status and is remarkably stable across time. We present some evidence that low-mortality families may have had a more beneficial lifestyle or profited from treatment options before the general population, but given lower mortality for a range of types of causes of death, these families also appear to have done better across the board.

1. Introduction

Which families are aging in exceptional health, and how do social characteristics of families with a high clustering of exceptional survival change over time? In this paper, we take a closer look at families in which an increasing share of ancestors (father, mother, aunts, uncles and grandparents) belonged to the 10% longest-lived of their birth cohort (van den Berg et al. 2020). Exploring mortality patterns in families aging to exceptionally high ages and in exceptionally good health (Van den Berg, 2022) enables us to address social and lifestyle characteristics of these families. We use a unique dataset consisting of digitized and linked historical records for a region in Southern Sweden, reconstructing lives and families of individuals living in five rural parishes 1812-1967 and the town of Landskrona 1904-1967, with nationwide follow-up in the Swedish national registers of these individuals and their descendants 1968-2015. The structure of the data allows us to identify individuals who have several generations of ancestors who belonged to the longest-living individuals of their birth cohorts, thus indicating a family-shared survival advantage.

There exists a considerable gap in life expectancy between lower socioeconomic strata and the upper socioeconomic strata in contemporary societies. These differences in lifespan have increased in recent decades. It is often thought that such health differences were a historical given, but there is evidence that modern social differences in mortality are a relatively recent phenomenon, and were small, absent, and sometimes reversed in the early 20th century and 19th century. In Sweden, socioeconomic differences in mortality have risen only since about the 1940ies for women and 1960ies for men (see e.g. Bengtsson, Dribe & Helgertz 2020). Before then, the upper classes are thought to have had a generally unhealthy lifestyle, associated today with lower-SES individuals.

Although this is a plausible explanation for the absence of evidence for a social gradient in life expectancy in this period (Bengtsson, Dribe & Helgertz 2020), not much empirical evidence exists for such lifestyle-related differences in mortality. It is possible that a select subgroup of the higher classes benefited both from increased resources and a generally healthier lifestyle. Their descendants may also have profited from these family-shared advantages in health and resources. Focusing on long-lived families increases our understanding of the social and economic factors that may have contributed to the rise of life expectancy throughout the demographic transition, and the long roots of today's social differences in health. In this paper we explore differences between families in their all-cause mortality hazard and in causes of death across time, to determine a) similarities between relatives in life expectancy across time and b) the extent to which long-lived families may have been characterized by lower mortality due to lifestyle-related (preventable) causes of death in comparison to the general population.

In an earlier study, we found evidence based on nationwide hospital registers for Sweden that age-related disease onset was delayed in long-lived families in Scania (1990-2015) (Van den Berg et al. 2022). In a different study we found evidence that parental longevity is related to offspring increased survival in Utah and the Netherlands (Van den Berg et al. 2019). In this paper, we seek to determine if health advantages were already existent during and before the onset of the mortality transition (c. 1900). Before about 1900, adult mortality was much higher than today, and infectious diseases a much more prominent cause of death than today. During the rise of lifestyle-related diseases, circulatory and heart disease became an important cause of death. We address differences in infectious and circulatory disease mortality by ancestral longevity using information about causes of death for the SEDD region (1900-1967) and nationwide in Sweden (1968-2015).

The aim of this work is three-fold: First, to establish whether there exists a family-shared survival advantage across time and the magnitude of differences in mortality between individuals with and without a family-shared survival advantage in historical and contemporary Sweden. We investigate this using a family score based on ancestral lifespan percentiles in comparison to that of their birth cohort. For periods further back in time (1880-1920), we use parental survival only, as data on relatives is more limited than for periods closer to today. Second, we address the social gradient in mortality, and whether

families with an established survival advantage differ socioeconomically from families without such an advantage in historical and contemporary Sweden across time. Third, we address whether survival differences in families with a shared survival advantage apply specifically to preventable causes of death or extend to non-preventable causes of death. Specifically, we are interested in whether the survival advantage in all-cause mortality specifically applies to lifestyle-related mortality. Overall, this would lend support to the hypothesis that although socioeconomic resources benefited the potential survival of individuals across time, such benefits did not materialize due to the overall unhealthier lifestyle of upper class Swedes in history.

Preliminary results confirm that socioeconomic status is not significantly related to survival age 30-70 before about 1960, both in the entire sampled population as well as among individuals with known ancestry in the research region. At the same time, we find evidence for a family shared survival advantage from 1880. Having ancestors who belonged to the longest-lived of their birth cohort (a family-shared survival advantage among the previous generations) is significantly related to an individual survival advantage already from 1920, and in the period 1880-1920 effect sizes are similar although the confidence interval is wide and differences are not significant.

Before about 1960, individuals from families with a shared survival advantage are less often in blue-collar occupations, and relatively more often in farming and white collar occupations. After the second world war, the relative advantage of farmers declines and the socioeconomic gradient in the best performing families resembles more closely the modern social gradient in mortality. In this period, individuals from long-lived families are more often in white-collar occupations than blue-collar occupations and farming. With regard to cause-specific mortality, we find that infectious disease mortality is lower within families with a shared survival advantage across our entire study period (1880-2015). Circulatory disease mortality is lower from the 1960ies. At the same time, these differences do in these time periods also exist between non-manual and manual laborers. Both preventable and non-preventable mortality are lower within long-lived families and differences in preventable mortality arise before the general social gradient in preventable mortality rises. We thus find some evidence that low-mortality families may have had a more beneficial lifestyle or profited from treatment options before the general population, but given lower mortality in many ICD categories, these families also appear to have done better across the board.

2. Data

We benefit from a linkage between the national register data from Statistics Sweden covering the period 1968-2015, and a historical population database, the Scanian Economic Demographic Database (SEDD; Bengtsson et al 2021; Quaranta 2016; Dribe & Quaranta 2020) covering five rural parishes (1812-1967) and a town (1904-1967) in Scania, Southern Sweden. Individuals who resided in the SEDD region, as well as their children and grandchildren, were traced in the nationwide register data. The design of the study thus allows for the identification of a substantial number of ancestors for individuals living across Sweden from 1967. Before 1967, individuals live in a town and its rural hinterland in Scania, an area that is not statistically representative of Sweden in strict terms, but developments closely reflect those in Sweden as a whole (Bengtsson & Dribe 2021).

The SEDD was constructed using register-type data from catechetical examination registers and updated with information on births, marriages, and deaths from church books. The material is of high quality and considered to be complete regarding vital events (Dribe & Quaranta, 2020). Individuals are censored upon outmigration. Through name-based linking to the Swedish Death Index, ancestral death dates of linked individuals are obtained, even for individuals who migrate within Sweden before 1967, so that lifespan of ancestors can be reconstructed. In 1947, the person number was introduced in Sweden. If research persons leave the SEDD region after the introduction of the person number and remain alive and resident in Sweden in 1968 when the nationwide registers start, they can be followed in these registers. Individuals who left the research region before 1947 can, in a part of cases, be traced through a name-based linkage with the 1950 census which also provides person numbers.

We select research persons who are part of the SEDD sample or the national register data for the period 1880-2015, and whose parents and grandparents on at least one side of the family (maternal or paternal family line) are known and have an available date of death. We use the mortality information of the research persons' ancestors (parents' siblings, aunts and uncles, if known) to calculate the LRC (longevity relative count) score (van den Berg et al. 2020). The LRC score optimizes the difference in health and survival between long-lived families and the general population, by considering the share of long-lived ancestors weighted by genetic distance. The instrument was empirically tested and validated in earlier work (van den Berg et al., 2019). We include a linear measure of the share of ancestors who belonged to the top 10% survivors of their cohort ranging from 0-1. In a robustness check we replicated our findings using a cut-off of 0.4, implying that corrected for the closeness of the genetic relationship between the research person and his/her ancestors, 40% of the ancestors with a known lifespan belonged to the 10% longest-living members of their cohort.

We analyze both all-cause mortality using Cox proportional hazard models and cause-specific mortality due to infectious disease mortality and circulatory diseases. Causes of death for the historical part of the data (1904-1967) have been recoded to ICD-10 (Hiltunen & Edvinsson, 2017). Causes of death were recorded in ICD-8 and ICD-9 for part of the period 1968-2015 and have been recoded to ICD-10 using the official crosswalk provided by Statistics Sweden. We further include socioeconomic status using HISCLASS, based on occupational information. Occupations originate from parish registers and from the five-year tax census. Individuals are divided into groups by occupation, separating blue-collar workers (e.g., farm and industry laborers) from white-collar workers (e.g., teachers and priests) and farmers. We use the highest known occupation between age 30-60 and add a category for individuals for whom no occupation is ever registered, a group that is likely to consist of a mixture of upper-class individuals from the non-working groups and very poor individuals. The number of individuals without recorded occupations is small (range 1.72 in the period 1921-1960 to 7.95 in the period 1960-1980) and included separately in the analyses.

Preventable and non-preventable mortality is measured using the AMIEH index, following Ericsson (2019) and Debiasi (2020). We adjusted the index by adding a category for ill-defined causes of death next to preventable and non-preventable causes of death.

3. Results

Results are shown in Table 1-5 and Figure 1 and Figure 2.

We find that already in the period 1920-1960 there is a substantial survival advantage for individuals with ancestors who are among the longest living of their birth cohort. If the share of ancestors who were among the top 10% survivors of their cohort rises, their descendants have better survival age 30-90. The point estimate for the period 1880-1920 is suggestive that the same effect exists in that period, but due to small numbers of individuals with known ancestors the power in these analyses is low. Effect estimates are remarkable similar over time, so that the survival advantage for descendants of families with a shared survival advantage is sustained into the most recent periods. Effects apply both to preventable and non-preventable causes of death.

Regarding the social gradient in mortality, we replicate earlier findings from the literature that in Sweden and in the research region socioeconomic differences in mortality first rose after the second world war, from about the 1960ies onwards (Bengtsson, Dribe & Helgertz 2020) (Figure 1, middle panel). In the analyses presented here, we only included families with known ancestry, so that both the parents and at least one grandparent on maternal or paternal side was known. Survival does not differ significantly between white collar workers or farmers from survival among blue collar workers with known ancestry in the period 1880-1960. After that, we observe the rise of the social gradient in survival, with better survival among white collar workers than among blue collar workers.

We further investigate the distribution of socioeconomic status between individuals with known ancestry and by their share of long-lived ancestors measured using the LRC score. Our findings show that in the period 1960-2015 (1961-1980, 1981-2000) and 2001-2015) individuals from long-lived families are more often in a white-collar occupation. This mirrors the rise of socioeconomic differences in health in Sweden from about this period. From about the 1960ies, the modern social gradient with white collar workers consistently having lower mortality than blue-collar workers, farmers and the non-working appeared in Sweden. Around the second world war, there are no pronounced differences in socioeconomic status between individuals from long-lived families and population-average families (1921-1960). Before 1920 (1880-1920), individuals from long-lived families are more likely to be farmers or in white-collar occupations, and less likely to work in blue collar occupations.

A first exploration of cause-specific mortality shows that from 1961-1980, infectious disease mortality and circulatory disease mortality, indicative of lifestyle-related mortality, are lower among descendants from long-lived families with a larger number of long-lived ancestors (results not shown). Infectious disease as well as circulatory diseases appear to have been lower among descendants of families from long-lived families already in the period 1880-1960 (results not shown). However, due to small numbers of cases, the latter result is only significant for infectious disease mortality. We plan to extend these analyses using a larger sample from Swedish historical and contemporary register data (see below for further planned work).

4. Conclusion and Discussion

We presented evidence that, despite the absence of evidence for a social gradient in mortality in Sweden before the Second World War, there were already differences between long-lived families and families without a shared survival advantage in their level of adult mortality. Individuals from long-lived families already have a lower hazard of mortality in the first period we study (1880-1920). Before WWII, long-lived families were more often in farming an occupational group historically known for their relative wealth and access to nutrition, than families closer to the population average. After WWII, the socioeconomic pattern among long-lived families aligns closely with the modern socioeconomic gradient in health, whereby white-collar occupations are associated with longer and healthier lifespan.

We conclude that before the rise of general socioeconomic differences in mortality and survival in Sweden, members of long-lived families had an advantage in comparison to the general population. Part of that advantage appears to have been socioeconomic, as members of long-lived families were somewhat more often farmers and white-collar workers. But a large part of the advantage of these families doing well remains currently unexplained. Such resources could have had a different character: living in healthier places, access to larger kin networks in times of need due to better collective survival, and shared lifestyle or behavioral factors. For the latter type of mechanism only little evidence was found, as preventable and non-preventable causes of death appear to have been affected similarly. A familial health advantage thus appears to benefit survival of descendants broadly, and further research is necessary to pinpoint the factors that contribute to this family-shared advantage.

5. Selected References

Bengtsson, T., Dribe, M., & Helgertz, J. (2020). When did the health gradient emerge? social class and adult mortality in southern Sweden, 1813–2015. Demography, 57(3), 953-977.

Bengtsson, T., Dribe, M., Quaranta, L. & Svensson, P. (2021) The Scanian Economic Demographic Database, Version 7.2 (Machine-readable database). Lund: Lund University, Centre for Economic Demography.

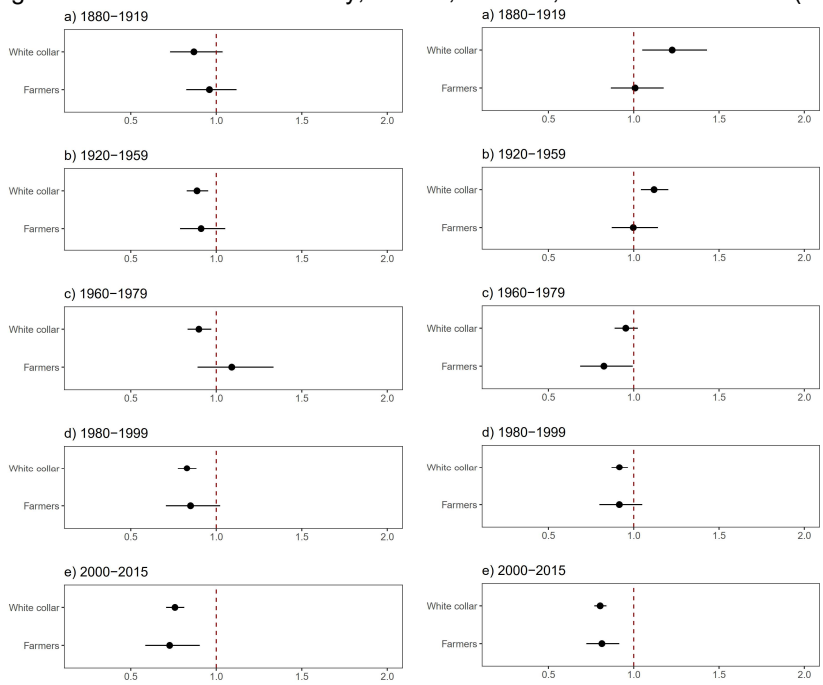
Bengtsson, T. & Dribe, M. (2021). The Long Road to Health and Prosperity, Southern Sweden, 1765-2015. Research Contributions From the Scanian Economic-Demographic Database (SEDD). Historical Life Course Studies, 11, 74–96.

Van den Berg, N., Rodriguez-Girondo, M., van Dijk, I. K., Slagboom, P. E., & Beekman, M. (2023). Increasing number of long-lived ancestors associates with up to a decade of healthspan extension and a healthy metabolomic profile in mid-life. Nature Communications.

Van den Berg, N., Rodríguez-Girondo, M., Mandemakers, K., Janssens, A. A., Beekman, M., & Slagboom, P. E. (2020). Longevity Relatives Count score identifies heritable longevity carriers and suggests case improvement in genetic studies. Aging Cell, 19(6), e13139.

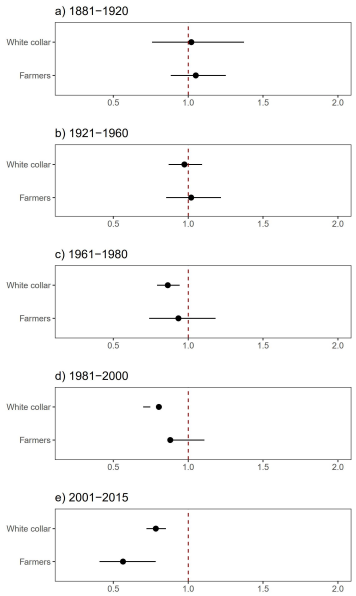
Dribe M., Quaranta L. The Scanian Economic-Demographic Database (SEDD). Historical Life Course Studies. 2020. Online first.

Figure 1. SES and adult mortality, Scania, Sweden, 1880-2015. Women (left) and Men (right)



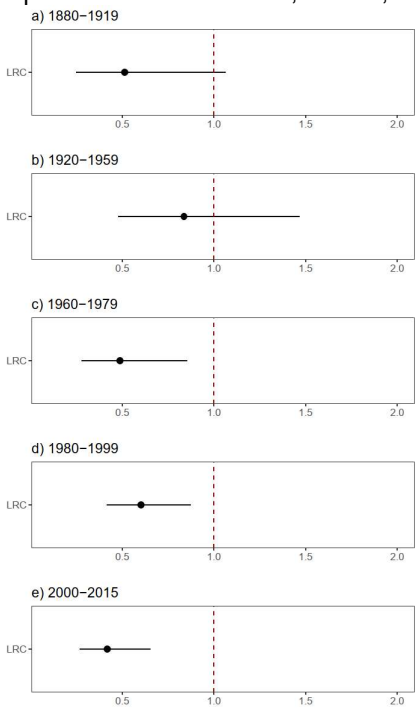
Source: SEDD and Swedish national register data, author's calculations. See Table A2. Socioeconomic status and all-cause mortality by period, Cox proportional hazard regression models. Reference category are blue collar workers. All models control for sex and birth year.

Figure 1b. SES and adult mortality, Scania, Sweden, 1880-2015, for individuals with known parental survival information



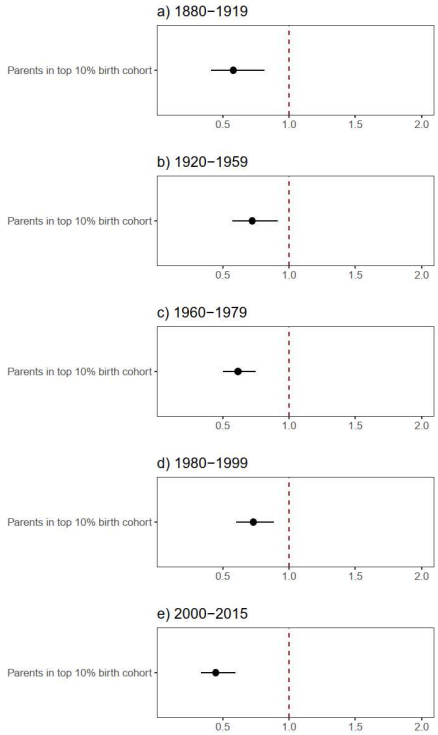
Source: SEDD and Swedish national register data, author's calculations. See Table 3.
Socioeconomic status and all-cause mortality by period, Cox proportional hazard regression models. Reference category are blue collar workers. All models control for sex and birth year. Women and men separately: see Table 3b.

Figure 2. Shared ancestral survival advantage (LRC score) and HR of adult all-cause mortality, Cox proportional hazard models, Scania, Sweden, 1880-2015



Source: SEDD and Swedish national register data, author's calculations. See Table 3. All-cause mortality age 30-70 by period, Cox proportional hazard regression models. All models control for sex, birth year, and socioeconomic status. LRC is a linear measure of the share of ancestors, corrected for genetic distance, who are among the 10% top survivors of their birth cohort.

Figure 2b. Shared ancestral survival advantage (parents belong to top 10% survivors) and HR of all-cause mortality, Cox proportional hazard models, Scania, Sweden, 1880-2015



Source: SEDD and Swedish national register data, author's calculations. See Table 3. All-cause mortality age 30-70 by period, Cox proportional hazard regression models. All models control for sex, birth year, and socioeconomic status.

Table 1a: Number of individuals age 30-90 per period

	All individuals	Observed deaths	Grandparents w death dates	Parents w death dates	Parents are long-lived	Parents w death dates & own death
1880-1919	23919	3671	1201	3792	295	757
1920-1959	47494	9349	3180	12043	674	1711
1960-1979	46974	8554	3336	14849	922	2689
1980-1999	52386	9895	3547	16410	1100	3261
2000-2015	57554	7448	2924	13465	684	2372
1880-2015	135660	38929	6689	31079	3676	10791

Table 1b. Cause-specific mortality for individuals with parental death dates, by period

Period	1840-1879	1880-1919	1920-1939	1940-1959	1960-1979	1980-1999	2000-2015
Cause of death group							
Infectious disease	49	114	107	99	102	183	94
Circulatory disease	2	46	161	428	1345	1627	891
Respiratory system and lung cancer	19	18	14	35	156	266	293
Other cancers	8	43	88	240	551	695	581
External causes	6	16	32	75	152	127	112
Other and ill-defined	63	278	170	259	372	346	369
Missing	181	242	4	0	11	17	32
Preventable causes of death							
Non-preventable	58	107	167	323	780	855	868
Preventable	46	173	311	698	1845	2358	1453
Ill-defined	43	235	94	115	53	31	19
Missing	181	242	4	0	11	17	32
N deaths	328	757	576	1136	2689	3261	2372
N individuals	1676	3792	6903	10267	14849	16410	13465

Table 1c. Descriptive statistics, 1840-2015, by period, for individuals with known parental death dates

		Age 30-90					
		1840-1879	1880-1919	1920-1959	1960-1979	1980-1999	2000-2015
SES	Nonmanual	2.6	11.64	31.3	45.15	54.34	59.06
	Manual	65.84	57.53	61.56	49.65	41.61	38.15
	Farmers	25.99	22.11	5.42	2.71	2.37	1.52
	Missing	5.57	8.72	1.73	2.49	1.69	1.26
Civil status	Never married	19.31	33.25	26.32	14.14	13.42	14.32
	Currently married	71.87	55.22	66.57	71.17	62.75	55.89
	Previously married	8.82	11.53	7.11	14.69	23.83	29.77
Parish of residence	Hög, Kävlinge	15.28	17.63	8.57	9.2	13.02	19.17
	Halmstad, Sireköpinge, Kågeröd	84.72	63	14.36	8.26	7.48	7.94
	Landskrona	NA	19.37	77.07	82.53	79.51	72.89
Birth year		1826	1864	1903	1922	1936	1945
Parents are long-lived	No information	NA	NA	NA	NA	NA	NA
	Neither	58.5	57.78	62.92	66.01	66.31	65.98
	Father	23.75	20.63	15.91	14.44	15.91	18.55
	Mother	11.86	16.4	16.82	15.79	14.44	12.35
	Both	5.89	5.19	4.34	3.76	3.34	3.12
Cause of death group	Infectious disease	49	114	206	102	183	94
	Circulatory disease	2	46	589	1345	1627	891
	Respiratory system and cancer	19	18	49	156	266	293
	Other cancers	8	43	328	551	695	581
	External causes	6	16	107	152	127	112
	Other and ill-defined	63	278	429	372	346	369
	Missing	181	242	4	11	17	32
Preventable causes of death	Non-preventable	58	107	490	780	855	868
	Preventable	46	173	1009	1845	2358	1453
	Ill-defined	43	235	209	53	31	19
	Missing	181	242	4	11	17	32
	N deaths	328	757	1712	2689	3261	2372
	N individuals	1676	3792	12043	14849	16410	13465
	Time at risk	23448	39746	192667	169277	195145	140155

Table 2. Socioeconomic status, long-lived ancestors, and hazard ratio of mortality by period. Individuals with known grandparental survival information on at least one side (maternal or paternal) and known parental death dates

	Age 30-90														
	1880-1919			1920-1959			1960-1979			1980-1999			2000-2015		
		95% CI			95% CI			95% CI			95% CI			95% CI	
	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper
SES (ref: Manual)															
Nonmanual	1.010	0.528	1.932	1.102	0.792	1.535	0.815	0.644	1.032	0.806	0.700	0.929	0.872	0.750	1.014
Farmers	0.960	0.710	1.298	1.101	0.863	1.406	1.479	1.050	2.084	0.843	0.587	1.212	0.620	0.389	0.988
Missing	1.333	0.776	2.291	0.940	0.577	1.532	4.015	2.888	5.582	1.319	0.887	1.960	2.072	1.045	4.109
LRC (linearly)	0.513	0.248	1.064	0.837	0.477	1.469	0.488	0.278	0.855	0.603	0.416	0.874	0.418	0.267	0.654
LRC (categorical) (ref: 0)															
0-.4	0.754	0.555	1.025	0.970	0.762	1.236	0.799	0.647	0.987	0.948	0.820	1.095	0.835	0.715	0.974
More than .4	0.648	0.428	0.982	0.863	0.626	1.190	0.667	0.485	0.916	0.814	0.658	1.008	0.646	0.504	0.829
N individuals	1201			3180			3336			3547			2924		
N deaths	238			384			445			907			761		
Time at risk	16412			39646			46509			46552			29813		

All analyses control for birth year, marital status (never married, currently married, previously married), parish (Hög & Kävlinge, Halmstad & Sireköpinge & Kågeröd, Landskrona), and migrant status. Analyses for influence of family on mortality control for SES. Grouped rows report results from separate analyses.

Table 3. Socioeconomic status, long-lived ancestors and hazard ratio of mortality by period. Individuals with known parental death dates

	Age 30-90														
	1880-1919			1920-1959			1960-1979			1980-1999			2000-2015		
		95% CI			95% CI			95% CI			95% CI			95% CI	
	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper
SES (ref: Manual)															
Nonmanual	1.021	0.759	1.373	0.975	0.870	1.093	0.864	0.792	0.943	0.804	0.747	0.865	0.784	0.721	0.852
Farmers	1.051	0.884	1.251	1.020	0.853	1.219	0.935	0.739	1.183	0.880	0.699	1.108	0.565	0.408	0.783
Missing	1.440	1.084	1.914	1.387	1.094	1.759	2.838	2.507	3.211	1.210	1.018	1.439	2.432	1.742	3.394
Parents long-lived (ref: neither)															
Father 10%	0.872	0.706	1.077	0.833	0.730	0.951	0.788	0.708	0.877	0.906	0.822	0.997	0.804	0.714	0.906
Mother 10%	0.721	0.598	0.869	0.881	0.775	1.002	0.805	0.722	0.899	0.927	0.839	1.025	0.803	0.712	0.907
Both 10%	0.580	0.412	0.817	0.723	0.573	0.913	0.615	0.504	0.751	0.731	0.604	0.884	0.448	0.335	0.599
Parents long-lived (ref: neither)															
Father 20%	0.943	0.768	1.158	0.800	0.704	0.909	0.749	0.679	0.827	0.836	0.765	0.913	0.868	0.781	0.965
Mother 20%	0.819	0.685	0.981	0.868	0.769	0.981	0.752	0.68	0.832	0.838	0.765	0.918	0.879	0.791	0.978
Both 20%	0.799	0.642	0.996	0.690	0.593	0.802	0.671	0.595	0.757	0.758	0.675	0.850	0.744	0.645	0.859
N individuals	3792			12043			14849			16410			13465		
N deaths	757			1712			2689			3261			2372		
Time at risk	39746			192667			169277			195145			140155		

All analyses control for birth year, marital status (never married, currently married, previously married), parish (Hög & Kävlinge, Halmstad & Sireköpinge & Kågeröd, Landskrona), and migrant status. Analyses for influence of family on mortality control for SES. Grouped rows report results from separate analyses.

Table 3b. Socioeconomic status, long-lived ancestors and hazard ratio of mortality by period. Individuals with known parental death dates, men and women separately

	Women age 30-90														
	1880-1919			1920-1959			1960-1979			1980-1999			2000-2015		
		95% CI			95% CI			95% CI			95% CI			95% CI	
	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper
SES (ref: Manual)															
Nonmanual	0.757	0.480	1.194	0.880	0.749	1.034	0.875	0.768	0.995	0.819	0.735	0.914	0.769	0.681	0.868
Farmers	1.041	0.814	1.332	1.171	0.892	1.537	1.410	0.972	2.047	1.037	0.707	1.522	0.397	0.215	0.732
Missing	1.453	0.995	2.122	1.025	0.749	1.403	2.244	1.860	2.707	1.354	1.067	1.717	2.535	1.511	4.255
Parents long-lived (ref: neither)															
Father 10%	0.757	0.558	1.025	0.877	0.724	1.062	0.747	0.633	0.882	0.903	0.781	1.044	0.795	0.668	0.945
Mother 10%	0.718	0.552	0.935	0.954	0.795	1.145	0.782	0.661	0.924	0.995	0.854	1.158	0.903	0.759	1.075
Both 10%	0.604	0.382	0.956	0.568	0.389	0.830	0.588	0.440	0.784	0.692	0.516	0.929	0.426	0.259	0.699
Parents long-lived (ref: neither)															
Father 20%	0.806	0.603	1.077	0.844	0.696	1.024	0.709	0.608	0.827	0.855	0.749	0.977	0.821	0.702	0.960
Mother 20%	0.698	0.543	0.898	0.995	0.832	1.192	0.762	0.650	0.892	0.869	0.757	0.998	0.945	0.809	1.103
Both 20%	0.752	0.556	1.017	0.704	0.564	0.879	0.642	0.537	0.768	0.691	0.579	0.824	0.779	0.631	0.962
N individuals	1887			5710			7163			8111			6914		
N deaths	392			789			1132			1434			1088		
Time at risk	20165			92048			84027			101346			72833		
	Men age 30-90														
	1880-1919			1920-1959			1960-1979			1980-1999			2000-2015		
		95% CI			95% CI			95% CI			95% CI			95% CI	
	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper
SES (ref: Manual)															
Nonmanual	1.486	1.005	2.198	1.103	0.938	1.297	0.876	0.778	0.987	0.802	0.726	0.886	0.798	0.710	0.896
Farmers	1.081	0.844	1.384	1.038	0.817	1.317	0.837	0.619	1.133	0.808	0.606	1.078	0.675	0.458	0.996
Missing	1.629	1.05	2.529	2.107	1.466	3.029	3.512	2.979	4.139	1.097	0.849	1.416	2.35	1.512	3.65
Parents long-lived (ref: neither)															
Father 10%	1.005	0.748	1.349	0.781	0.648	0.942	0.834	0.725	0.958	0.910	0.800	1.035	0.814	0.690	0.959
Mother 10%	0.742	0.565	0.975	0.823	0.684	0.989	0.831	0.718	0.962	0.889	0.778	1.015	0.727	0.614	0.862
Both 10%	0.559	0.334	0.936	0.891	0.662	1.199	0.630	0.477	0.831	0.775	0.604	0.996	0.466	0.326	0.668
Parents long-lived (ref: neither)															
Father 20%	1.059	0.791	1.418	0.768	0.647	0.911	0.789	0.694	0.897	0.82	0.728	0.923	0.916	0.793	1.057
Mother 20%	0.944	0.729	1.223	0.779	0.658	0.922	0.755	0.662	0.862	0.821	0.727	0.928	0.826	0.713	0.956
Both 20%	0.837	0.606	1.155	0.697	0.567	0.857	0.687	0.583	0.809	0.822	0.706	0.956	0.724	0.595	0.881
N individuals	1905			6333			7686			8299			6551		
N deaths	365			923			1557			1827			1284		
Time at risk	19581			100618			85249			93799			67321		

All analyses control for birth year, marital status (never married, currently married, previously married), parish (Hög & Kävlinge, Halmstad & Sireköpinge & Kågeröd, Landskrona), and migrant status. Analyses for influence of family on mortality control for SES. Grouped rows report results from separate analyses.

Table 4. Socioeconomic status, long-lived ancestors and hazard ratio of preventable and non-preventable mortality by period. Individuals with known parental death dates

	Preventable														
	1880-1919			1920-1959			1960-1979			1980-1999			2000-2015		
		95% CI			95% CI			95% CI			95% CI			95% CI	
	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper
SES (ref: Manual)															
Nonmanual	1.025	0.613	1.713	0.924	0.796	1.073	0.839	0.756	0.930	0.804	0.738	0.876	0.758	0.681	0.844
Farmers	1.337	0.918	1.946	0.986	0.774	1.255	1.097	0.831	1.448	0.915	0.701	1.195	0.619	0.418	0.916
Missing	1.564	0.924	2.646	1.481	1.094	2.006	2.013	1.706	2.376	1.136	0.927	1.392	1.267	0.725	2.214
Parents long-lived (ref: neither)															
Father 10%	1.126	0.754	1.682	0.870	0.734	1.030	0.761	0.669	0.867	0.909	0.812	1.019	0.754	0.645	0.881
Mother 10%	0.769	0.512	1.156	0.888	0.751	1.050	0.780	0.683	0.892	0.998	0.890	1.119	0.807	0.691	0.942
Both 10%	0.857	0.432	1.704	0.562	0.399	0.793	0.617	0.484	0.786	0.667	0.528	0.843	0.541	0.386	0.759
Parents long-lived (ref: neither)															
Father 20%	1.222	0.796	1.875	0.794	0.673	0.937	0.740	0.658	0.832	0.834	0.751	0.925	0.794	0.692	0.911
Mother 20%	1.150	0.783	1.689	0.862	0.735	1.011	0.684	0.605	0.775	0.866	0.779	0.964	0.831	0.725	0.952
Both 20%	1.033	0.647	1.651	0.694	0.570	0.845	0.620	0.535	0.718	0.752	0.657	0.862	0.762	0.637	0.911
N individuals	3792			12043			14849			16410			13465		
N deaths	173			1009			1845			2358			1453		
Time at risk	39746			192667			169277			195145			140154		
	Non-preventable														
	1880-1919			1920-1959			1960-1979			1980-1999			2000-2015		
		95% CI			95% CI			95% CI			95% CI			95% CI	
	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper
SES (ref: Manual)															
Nonmanual	1.097	0.588	2.047	1.004	0.814	1.238	0.970	0.821	1.147	0.829	0.719	0.956	0.828	0.720	0.952
Farmers	1.117	0.688	1.813	0.994	0.696	1.421	0.637	0.395	1.029	0.835	0.522	1.337	0.428	0.225	0.815
Missing	1.095	0.519	2.310	1.579	0.999	2.498	5.633	4.624	6.861	1.358	0.961	1.918	4.284	2.726	6.731
Parents long-lived (ref: neither)															
Father 10%	0.995	0.601	1.648	0.760	0.588	0.982	0.818	0.673	0.995	0.879	0.728	1.062	0.854	0.705	1.035
Mother 10%	0.434	0.234	0.803	0.845	0.661	1.080	0.833	0.681	1.021	0.735	0.594	0.910	0.792	0.648	0.968
Both 10%	0.424	0.133	1.350	0.795	0.519	1.218	0.651	0.456	0.929	0.844	0.597	1.194	0.233	0.121	0.451
Parents long-lived (ref: neither)															
Father 20%	1.006	0.608	1.664	0.816	0.643	1.034	0.759	0.629	0.917	0.824	0.694	0.978	0.936	0.788	1.111
Mother 20%	0.539	0.320	0.909	0.911	0.726	1.144	0.910	0.758	1.093	0.769	0.642	0.922	0.935	0.786	1.111
Both 20%	0.874	0.505	1.513	0.712	0.535	0.946	0.797	0.642	0.989	0.717	0.571	0.901	0.663	0.515	0.853
N individuals	3792			12043			14849			16410			13465		
N deaths	107			490			780			855			868		
Time at risk	39746			192667			169277			195145			140155		

All analyses control for birth year, marital status (never married, currently married, previously married), parish (Hög & Kävlinge, Halmstad & Sireköpinge & Kågeröd, Landskrona), and migrant status.
Analyses for influence of family on mortality control for SES. Grouped rows report separate analyses.

Table 4b. Socioeconomic status and hazard ratio of cause-specific mortality by period.

	Infectious disease														
	1880-1919			1920-1959			1960-1979			1980-1999			2000-2015		
	HR	Lower	upper	HR	lower	upper	HR	Lower	upper	HR	lower	upper	HR	lower	upper
SES (ref: Manual)															
Nonmanual	0.491	0.231	1.043	0.528	0.358	0.778	0.838	0.538	1.305	0.685	0.500	0.939	0.489	0.314	0.761
Farmers	1.727	1.087	2.744	1.398	0.868	2.252	0.998	0.400	2.494	0.839	0.321	2.188	0.987	0.325	3.000
Missing	0.959	0.485	1.897	1.777	0.959	3.294	0.666	0.240	1.848	0.81	0.391	1.679	3.545	1.045	12.027
Parents long-lived (ref: neither)															
Father 20%	1.014	0.593	1.732	0.855	0.593	1.233	0.605	0.366	1.001	0.616	0.412	0.921	1.032	0.623	1.709
Mother 20%	1.151	0.725	1.826	0.947	0.669	1.341	0.581	0.344	0.980	0.871	0.601	1.264	0.668	0.372	1.200
Both 20%	0.897	0.499	1.612	0.673	0.430	1.054	0.478	0.252	0.909	0.781	0.494	1.236	0.836	0.421	1.658
N individuals	3792			12043			14849			16410			13465		
N deaths	114			206			102			183			94		
Time at risk	39746			192667			169277			195145			140155		
	Circulatory disease														
	1880-1919			1920-1959			1960-1979			1980-1999			2000-2015		
	HR	Lower	upper	HR	lower	upper	HR	Lower	upper	HR	lower	Upper	HR	lower	Upper
SES (ref: Manual)															
Nonmanual	1.437	0.568	3.637	0.878	0.719	1.072	0.916	0.811	1.035	0.836	0.754	0.928	0.873	0.762	1.000
Farmers	0.835	0.386	1.810	0.983	0.728	1.327	1.140	0.830	1.564	0.93	0.675	1.280	0.514	0.295	0.896
Missing	2.044	0.767	5.450	1.312	0.890	1.935	2.395	2.004	2.863	0.978	0.767	1.249	0.911	0.373	2.223
Parents long-lived (ref: neither)															
Father 20%	2.137	1.030	4.435	0.788	0.633	0.982	0.675	0.588	0.776	0.804	0.71	0.911	0.737	0.618	0.880
Mother 20%	0.645	0.273	1.519	0.879	0.713	1.082	0.634	0.548	0.734	0.811	0.712	0.923	0.832	0.699	0.990
Both 20%	0.978	0.386	2.473	0.681	0.527	0.881	0.625	0.529	0.738	0.704	0.598	0.830	0.778	0.622	0.974
N individuals	3792			12043			14849			16410			13465		
N deaths	46			589			1345			1627			891		
Time at risk	39746			192667			169277			195145			140155		
	Respiratory disease and cancer														
	1880-1919			1920-1959			1960-1979			1980-1999			2000-2015		
	HR	Lower	upper	HR	lower	upper	HR	Lower	upper	HR	lower	Upper	HR	lower	Upper
SES (ref: Manual)															
Nonmanual				1.636	0.873	3.067	0.689	0.466	1.020	0.671	0.520	0.868	0.684	0.539	0.868
Farmers				0.808	0.258	2.534	0.300	0.071	1.264	0.468	0.168	1.303	0.519	0.188	1.434
Missing				1.614	0.364	7.161	4.456	2.860	6.943	0.953	0.443	2.049	2.533	1.009	6.361
Parents long-lived (ref: neither)															
Father 20%				0.687	0.331	1.426	0.866	0.585	1.281	1.033	0.760	1.403	0.809	0.599	1.093
Mother 20%				0.591	0.278	1.258	0.820	0.546	1.233	1.065	0.781	1.453	0.754	0.555	1.024
Both 20%				0.547	0.219	1.363	0.388	0.209	0.723	0.779	0.507	1.196	0.562	0.359	0.879
N individuals	3792			12043			14849			16410			13465		
N deaths	18			49			156			266			293		
Time at risk	39746			192667			169277			195145			140155		
	Other cancers														
	1880-1919			1920-1959			1960-1979			1980-1999			2000-2015		
	HR	lower	upper	HR	lower	upper	HR	Lower	upper	HR	lower	Upper	HR	lower	upper
SES (ref: Manual)															
Nonmanual	2.480	0.994	6.186	1.171	0.916	1.497	0.989	0.821	1.192	0.924	0.790	1.080	0.893	0.753	1.060
Farmers	1.359	0.620	2.977	0.849	0.539	1.339	0.760	0.423	1.365	0.705	0.404	1.230	0.795	0.437	1.448
Missing	3.198	1.218	8.394	1.411	0.772	2.578	3.489	2.642	4.606	1.481	0.994	2.207	2.775	1.345	5.726
Parents long-lived (ref: neither)															
Father 20%	0.636	0.225	1.799	0.904	0.676	1.208	0.838	0.673	1.043	0.980	0.810	1.185	0.972	0.787	1.200
Mother 20%	0.988	0.461	2.118	0.999	0.755	1.323	0.872	0.698	1.091	0.934	0.766	1.139	0.991	0.802	1.223
Both 20%	1.477	0.656	3.327	0.854	0.608	1.198	0.884	0.685	1.142	0.945	0.742	1.204	0.816	0.612	1.088

N individuals	3792	12043	14849	16410	13465
N deaths	43	328	551	695	581
Time at risk	39746	192667	169277	195145	140155

All analyses control for birth year, marital status (never married, currently married, previously married), parish (Hög & Kävlinge, Halmstad & Sireköpinge & Kågeröd, Landskrona), and migrant status. Analyses for influence of family on mortality control for SES. Grouped rows report separate analyses. Individuals with known parental death dates

Table 5. Long-lived parents (top 10%) and socioeconomic status, by period. Individuals with known parental death dates

	Age 30-90				
	1880-1919	1920-1959	1960-1979	1980-1999	2000-2015
Long-lived mother					
SES (ref: Manual)					
Nonmanual	-.006 (0.003)*	.005 (0.002)*	.015 (.004)***	.029 (.002)***	.018 (.002)***
Farmers	.030 (0.005)***	.019 (0.006)***	.001 (.008)	-.003 (.007)	-.009 (.007)
Adjusted R squared	.016	.008	.007	.011	.024
Long-lived father					
SES (ref: Manual)					
Nonmanual	.000 (0.003)	0.003 (0.002)	.003 (.002)	.013 (.002) ***	.017 (.002)***
Farmers	.0538 (0.005)***	0.037 (0.005)***	.006 (.007)	.014 (.008) ***	.026 (.009)**
Adjusted R squared	.020	.008	.007	.008	.015
LRC score > .4					
SES (ref: Manual)					
Nonmanual	-.000 (0.0038)	0.006 (0.003)*	.015 (.003)***	.030 (.003)***	.023 (.992)***
Farmers	.054 (0.006)***	0.032 (0.007)***	-.001 (.001)	.007 (.009)	.012 (.010)
Adjusted R squared	.021	.011	.011	.014	.029
N	23,919	46,494	47,974	52,386	57,554

Analyses control for birth year, marital status (never married, currently married, previously married), parish (Hög & Kävlinge, Halmstad & Sireköpinge & Kågeröd, Landskrona), and migrant status. SES includes a category "missing". Grouped rows report separate analyses.

* significant at p=0.10 level; ** significant at p=0.05 level; *** significant at p=0.01 level

Table A1. Main causes of death by period

Men, age 30-90 Period	1880-1919	1920-1959	1960-1979	1980-1999	2000-2015
Preventable					
1.	A16 (Respiratory tuberculosis)	I25 (Atherosclerotic cardiovascular disease)	I20 (ischaemic heart diseases)	I20 (ischaemic heart diseases)	I21 (Acute myocardial infarction)
2.	J18 (Pneumonia)	I51 (Complications and ill-defined descriptions of heart disease)	I25 (Atherosclerotic cardiovascular disease)	I25 (Atherosclerotic cardiovascular disease)	I25 (Chronic ischaemic heart disease)
3.	I61 (Intracerebral haemorrhage)	I61 (Intracerebral haemorrhage)	I62 (intracranial haemorrhage)	I62 (intracranial haemorrhage)	C34 (Malignant neoplasm of bronchus and lung)
4.	C16 (Malignant neoplasm of stomach)	C16 (Malignant neoplasm of stomach)	I21 (Acute myocardial infarction)	I21 (Acute myocardial infarction)	J44 (Chronic obstructive pulmonary disease)
Non-Preventable					
1.	I70 (Atherosclerosis of aorta)	I70 (Atherosclerosis of aorta)	I30 (Other heart disease)	C61 (Malignant neoplasm of prostate)	C61 (Malignant neoplasm of prostate)
2.	C80 (Malignant neoplasm)	N40 (Hyperplasia of prostate)	C61 (Malignant neoplasm of prostate)	I30 (Other heart disease)	C25 (Malignant neoplasm of pancreas)
3.	N11 (Chronic tubulo-interstitial nephritis)	C61 (Malignant neoplasm of prostate)	C25 (Malignant neoplasm of pancreas)	I00 (Other diseases of the circulatory system)	F03 (Dementia)
4.	J98 (Other respiratory disorders)	C80 (Malignant neoplasm)	K70 (Cirrhosis)	C25 (Malignant neoplasm of pancreas)	I71 (Aortic aneurysm)
Women, Age 30-90					
Preventable					
1.	A16 (Respiratory tuberculosis)	I51 (Complications and ill-defined descriptions of heart disease)	I20 (ischaemic heart diseases)	I20 (ischaemic heart diseases)	I21 (Acute myocardial infarction)
2.	J18 (Pneumonia)	I25 (Atherosclerotic cardiovascular disease)	I25 (Atherosclerotic cardiovascular disease)	I25 (Atherosclerotic cardiovascular disease)	C34 (Malignant neoplasm of bronchus and lung)
3.	I61 (Intracerebral haemorrhage)	I61 (Intracerebral haemorrhage)	I74 (Arterial embolism and thrombosis)	C50 (breast cancer)	I25 (Chronic ischaemic heart disease)
4.	I25 (Chronic ischaemic heart disease)	J18 (Bronchopneumonia)	I21 (Acute myocardial infarction)	I60 (Cerebrovascular diseases)	I50 (Heart failure)
Non-Preventable					
1.	I70 (Atherosclerosis of aorta)	I70 (Atherosclerosis of aorta)	I30 (Other heart disease)	C56 (Malignant tumor of the ovary)	F03 (Dementia)
2.	C80 (Malignant neoplasm)	C55 (Malignant neoplasm of uterus)	C25 (Malignant neoplasm of pancreas)	I30 (Other heart disease)	I48 (Atrial fibrillation)
3.	N11 (Chronic tubulo-interstitial nephritis)	S72 (Fracture of femur)	I25 (Atherosclerotic cardiovascular disease)	I00 (Other diseases of the circulatory system)	C25 (Malignant neoplasm of pancreas)
4.	J98 (Other respiratory disorders)	C80 (Malignant neoplasm)	I26 (Pulmonary heart disease)	C25 (Malignant neoplasm of pancreas)	G30 (Alzheimer disease)

Preventable and non-preventable causes of death following Ericsson (2019) and Debiasi (2020). We adjusted the index by adding a category for ill-defined causes of death next to preventable and non-preventable causes of death. The table shows most common causes of death coding among men and women within the categories of non-preventable and preventable causes of death.

Table A2. Socioeconomic status and hazard ratio of mortality by period, all individuals

	Age 30-90														
	1880-1919			1920-1959			1960-1979			1980-1999			2000-2015		
			95% CI		95% CI			95% CI			95% CI			95% CI	
	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper
SES main groups (ref: Manual)															
Nonmanual	1.034	0.921	1.160	0.995	0.946	1.046	0.916	0.869	0.965	0.803	0.768	0.840	0.757	0.721	0.794
Farmers	0.968	0.869	1.078	0.938	0.850	1.035	0.915	0.798	1.050	0.813	0.722	0.915	0.760	0.654	0.883
Missing	2.147	1.959	2.352	1.433	1.340	1.532	2.194	2.076	2.320	1.052	0.986	1.124	1.171	1.049	1.308
N deaths	23919			47494			46974			52386			57554		
N individuals	3672			9350			8555			9907			7449		
Time at risk	195738			602844			478622			575235			529550		

All analyses control for birth year, marital status (never married, currently married, previously married), parish (Hög & Kävlinge, Halmstad & Sireköpinge & Kågeröd, Landskrona), and migrant status.

Table A3. Long-lived parents and mortality hazard by period. Observations after parental death

	Age 30-90														
	1880-1919			1920-1959			1960-1979			1980-1999			2000-2015		
	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper	HR	lower	upper
SES main groups (ref: Manual)															
Nonmanual	0.828	0.548	1.250	0.971	0.846	1.115	0.893	0.812	0.982	0.821	0.759	0.887	0.796	0.728	0.870
Farmers	0.977	0.808	1.180	1.107	0.915	1.339	0.964	0.756	1.229	0.837	0.653	1.073	0.566	0.404	0.792
Missing	1.373	0.945	1.994	1.231	0.909	1.667	2.673	2.344	3.048	1.043	0.865	1.259	2.238	1.489	3.364
Parents long-lived (ref: neither)															
Father 10%	1.027	0.780	1.351	1.034	0.857	1.248	0.886	0.777	1.009	0.914	0.816	1.025	0.841	0.730	0.968
Mother 10%	0.744	0.601	0.921	1.037	0.883	1.218	0.838	0.741	0.946	0.939	0.842	1.046	0.815	0.713	0.931
Both 10%	0.613	0.409	0.916	0.973	0.734	1.289	0.704	0.569	0.872	0.749	0.609	0.921	0.459	0.334	0.632
Parents long-lived (ref: neither)															
Father 20%	1.035	0.814	1.317	1.014	0.857	1.199	0.833	0.745	0.932	0.851	0.771	0.939	0.915	0.813	1.029
Mother 20%	0.810	0.665	0.986	1.031	0.893	1.191	0.766	0.686	0.855	0.850	0.772	0.937	0.893	0.799	0.999
Both 20%	0.857	0.665	1.104	0.926	0.773	1.110	0.742	0.652	0.844	0.793	0.702	0.896	0.753	0.644	0.881
N individuals	1477			5183			7063			8385			10141		
N deaths	595			1202			2285			2850			2100		
Time at risk	18508			66774			81413			89188			86951		

All analyses control for birth year, marital status (never married, currently married, previously married), parish (Hög & Kävlinge, Halmstad & Sireköpinge & Kågeröd, Landskrona), and migrant status. Analyses for influence of family on mortality control for SES. Grouped rows report results from separate analyses.