The Legacy of Longevity: Persistent inequalities in UK life expectancy 1500-2016

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Introduction: That global life expectancy has more than doubled within the previous two centuries is–by any objective standard–something miraculous to behold, and the academic literature across the fields of economics, demography, public health and evolutionary biology have all contributed to our understanding of the mechanisms behind the regional variations in the demographic transitions in mortality. We focus on the effect of the income differential on health gradients through the life expectancies of the tertiary universe of descendants of the British aristocracy and the general population. We use a dataset of 127,523 offspring up to three generations deep, meticulously curated from 7,161 individual sources including 6,756 instances of direct correspondence with aristocratic families. Using this unstructured free-text data on date of birth and death and information on the general population, we develop lifetable based methodologies to provide five distinct findings. We first fail to replicate and generally rally against the so called 'peerage paradox': that lifespans between aristocrats (and their families) was equivalent to the general population until the turn of the 19th century. Secondly, the mortality transition of elites occurred around 100 years earlier than for the general public (with considerable relative improvements of approximately 30% during the industrial revolution(s)). Thirdly, male aristocratic offspring fared less well than the general population during both the Great War and the Second World War, consistent with the existing evidence base. Fourthly, life expectancies equalized at the same time as the introduction of the National Health Service Act 1946. Finally, tentative evidence suggests that this gap has, however, begun to re-emerge since the 1980s. These results appear endogenously out of Figures 1-3 (where Figures 1-2 also contain a robustness measure which controls for uncertainty in unobserved infant mortality and as yet unrecorded deaths). An extensive manual data-verification exercise confirms the validity of the data resource profile, and additional structural break tests are consistent with voting reforms and the introduction of key policies and legislation prior to the general decline of the power of privilege.

Data: Our unique dataset represents a genealogical survey of the constituent families of the peerage of Britain as well as the royal families of Europe manually curated over 19 years. It began with a copy of Debrett's Peerage 1949, and was subsequently merged with information from various other sources such as Donald Reid's Royal92.ged database and a number of the standard royalty books such as Eilers's Queen Victoria's Descendants and Louda's Lines of Succession. A large number of the unique sources are from direct e-mail correspondences. Information on each entry is meticulously checked and cross-referenced one family and title at a time. As of September 2019, the database contains information on 716,415 individuals. We clean the data-set for individuals from which we can infer and extract a unique year of birth or date of death (if deceased). For example, `'between july 1656 and july 1658'` is discarded, but `'circa july 1678'` is not. We then randomize over potential month-day and day values as (seldom) required, and analyze the effects of this randomization. While the site contains a wealth of information on Offices, Awards and Honours related to a multitude of (predominantly) European countries, we only focus on the index of the 'British Peerage', specifically; Dukes and Duchesses, Marquesses and Marchionesses, Earls and Countesses, Viscounts and Viscountesses, Barons and Baronesses (by letters patent), Barons and Baronesses (by writ), Life Peers, UK Law Lords, Scots Law Lords, Baronets, Jacobite

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A full repository containing further information and a corresponding code library in Python 3.7 can be found at http://github.com/crahal/elitemortality (this is presently a private repository, but can invite on request for review purposes).

Figure 1: Life Expectancy at Birth: 1541 to 1985 based on 5x5 Lifetables

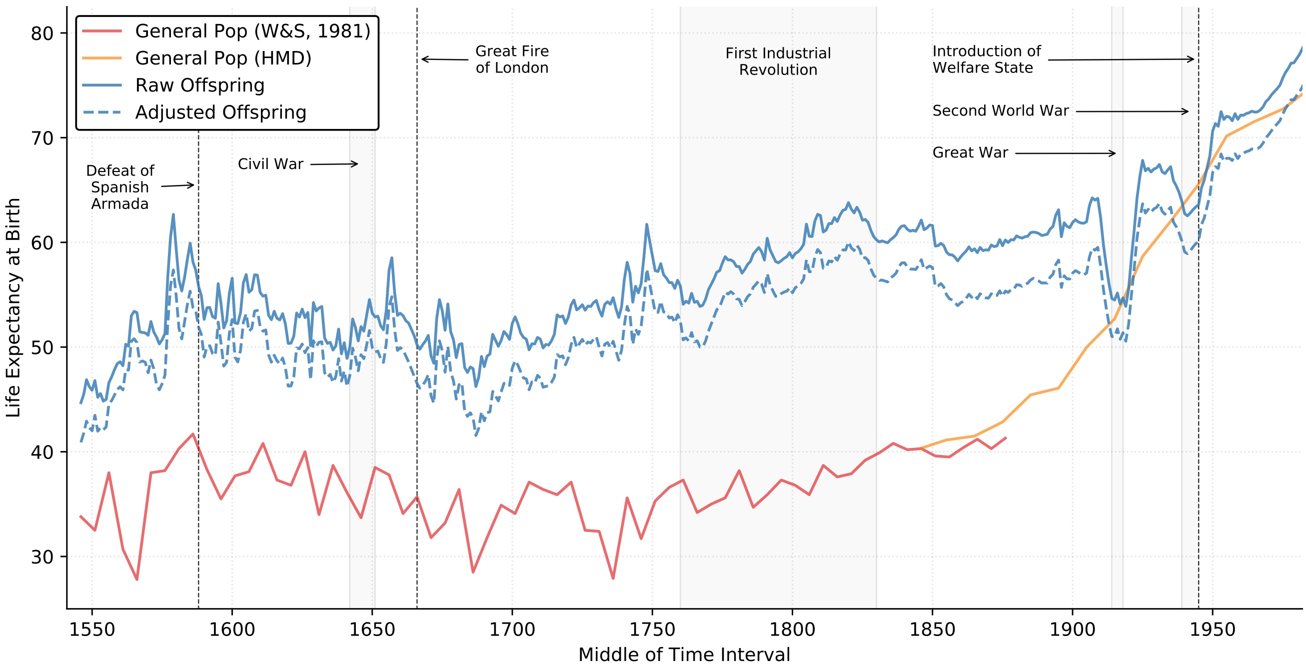


Figure Notes: The red line denoted 'Gen Pop (W&S, 1981)' indicates general population data from Wrigley and Scholfield's 1981 book entitled 'The population history of England 1541-1871: a reconstruction'. The orange line–General Pop (HMD)–indicates data from 1841 to the present day from the Human Mortality Database. The full blue line (Raw Offspring) represents our unadjusted peerage offspring life expectancy estimates, while the dashed blue line incorporates robustness adjustments.

titles, English feudal baronies and Scottish Chiefs of Clans. We exclusively use information on the first, second, or third generation descendants of a Peer or Noble to overcome a specific form of left truncation bias whereby those who ascend to the peerage must have survived to a specific age to reach ascension.[1] This leaves us with 127,523 elite offspring across three generations (the children, grandchildren and great-grandchildren of a specific Noble), with significant overlap between the generations due to the historically high coefficient of inbreeding (which we also compute). There are two important descriptive observations to make in terms of the filtered offspring dataset. The first is that eight of the ten most common exact days of death fall within the Great Wall, with the three most common being the Battle of Jutland on the 31st of May, 1916, the first day of The Battle of Flers–Courcelette on the 15th of September 1916, and the First Battle of the Aisne, 14th of September, 1914. The two the other most common dates of death are also military dates. One is the 9th of September 1513; The Battle of Flodden Flodden Field (a military combat in the War of the League of Cambrai between the Kingdom of England and the Kingdom of Scotland) and the other is the Battle of Inkerman (fought during the Crimean War on the 5th of November, 1854).

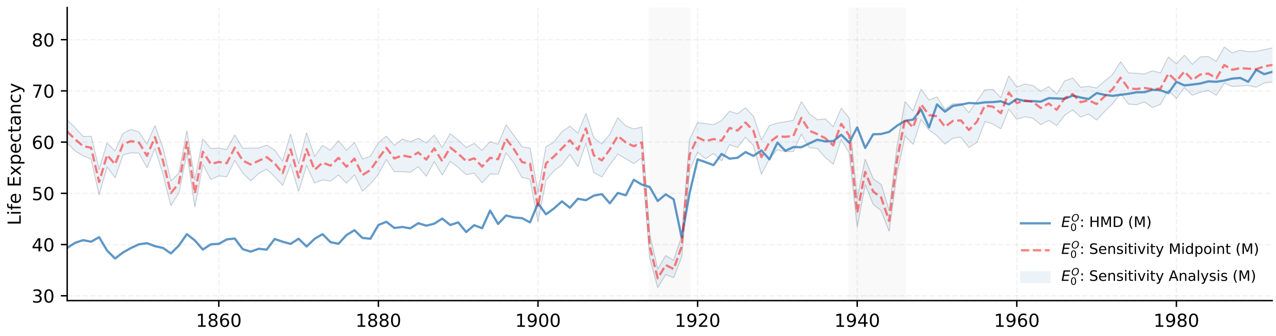
Methods: We develop software library (in Python 3.7) to construct (abridged) 5x1, 5x5 and 5x10 period life tables. The library takes as input the date of birth and date of death of each noble offspring to create a synthetic cohort to summarize and compare mortality experiences. It is largely based on the generally accepted approached summarized below and defined in more detail in Preston et al. (2001). The key assumption of the period (as opposed to a cohort) life table is that it shows what would happen to a cohort if it were subjected for all of its life to the mortality conditions of that specific period. In the following, n refers to the gap in years within an interval, and x to a specific age. The period life tables which we construct are created annually with five year age-ranges, apart from between the age ranges of 0-1 and 1-5. The open ended interval (x^*) in our tables is set to 110+, unless there are no remaining members of that synthetic cohort both living and dying in that interval.

We first calculate exposure to death for each specific age interval x to $x{+}n$, denoted ${}_nN_x$, and the corresponding number of deaths denoted ${}_nD_x$. This is then converted into the set of observed, period age specific death rates:

[1] We are able to quantify this bias, and estimate that males who are the first of their line to become a peer live on average 11.90 years longer than their direct male offspring.

Figure 2: Life Expectancies at Birth: Sensitivity to Unobserved Infant Mortality

(a) Male Life Expectancy at Birth (E$_0$)



(b) Female Life Expectancy at Birth (E$_0$)

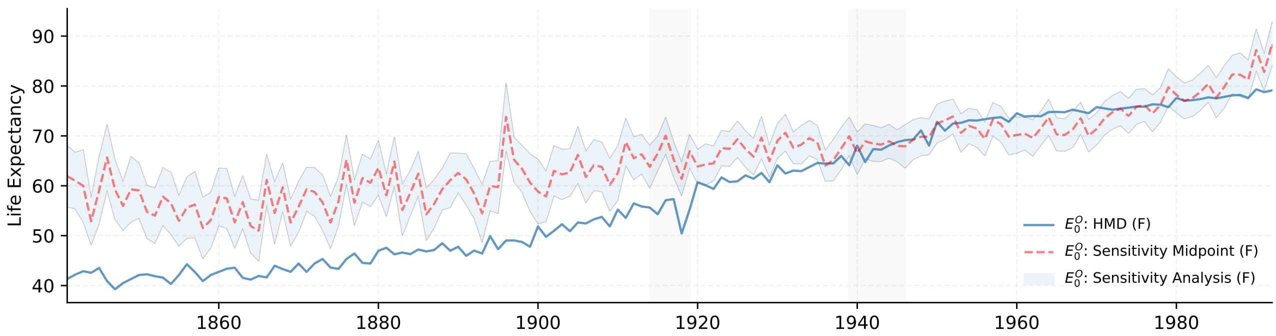


Figure Notes: E_0^O: HMD represents the population level estimates from the HMD. The shaded blue band represents a conservative sensitivity analysis regarding potential unobserved infant mortality, and the dashed red line represents the media point between the upper and lower bounds.

${}_nm_x = \frac{{}_nD_x}{{}_nN_x}$. We use Coale et al. (1983) equations for ${}_na_x$ for both of the intervals ${}_1a_0$ and ${}_4a_1$ and assume ${}_na_x = \frac{n}{2}$ for the remainder. For the transformation of observed period-specific death rates to a set of age specific probabilities of dying (${}_nq_x$), we use the following formula:

$$ {}_nq_x = \frac{n \cdot_n m_x}{1 + (n -_n a_x)_n m_x} \qquad \text{(Eq. 1)} $$

and for the open ended interval ${}_\infty q_{x^*} = 1.00$. The probability of surviving a specific age period is the complementary probability: ${}_np_x = 1 -_n q_x$. We then set an arbitrary radix (l_x) value of 100,000, and sequential values as $l_{x+n} = l_x \cdot_n p_x$. From this follows the formula for the number of deaths between ages x and $x+n$: ${}_nd_x = l_x \cdot_n q_x$. In order to derive the person-years lived between x and $x+n$ (denoted ${}_nL_x$): ${}_nL_x = n \cdot l_{x+n} +_n a_x \cdot_n d_x$, with the corresponding open ended interval derived as ${}_\infty L_{x^*} = \frac{l_{x^*}}{{}_nm_{x^*}}$. The total population aged x and over (T_x), working from the start of the life table, is defined as $T_x = \sum_{i=x}^{\infty} {}_nL_i$. Finally, we calculate the life expectancy of a person aged x simply as $e_x^O = \frac{T_x}{l_x}$. We calculate these life tables for each year annually between 1500 and 2016, independently for both genders, for each of the offspring in our peerage dataset and the exposure and death rates found in the Human Mortality Database (Boe et al. (2015)) for the general population. In order to analyze changes in life expectancy at birth, we also decompose what mortality differences in specific age groups contribute to the total difference in life expectancy. We follow the discrete approach of Arriaga (1984) to control for the interdependence among age groups, where the total effect (${}_n\Delta_x$) of a difference in mortality rates between x and $x+n$ on life expectancy at birth is expressed as:

$$ {}_n\Delta_x = \frac{{l_x}^1}{{l_0}^1} \cdot \left(\frac{{}_nLx^2}{{l_x}^2} - \frac{{}_n{L_x}^1}{{l_0}^1}\right) + \frac{T_{x+n}}{{l_0}^1} + \left(\frac{{l_x}^1}{l_x^2} - \frac{l_{x+n}^1}{l_{x+n}^2}\right) \qquad \text{(Eq. 2)} $$

and

$$ {}_\infty\Delta_x = \frac{{l_x}^1}{{l_0}^1} \cdot \left(\frac{{T_x}^2}{{l_x}^2} - \frac{{T_x}^1}{{l_x}^1}\right) \qquad \text{(Eq. 3)} $$

Figure 3: Age Decomposition of Differences in Life Expectancy at Birth based on 5x5 Lifetables

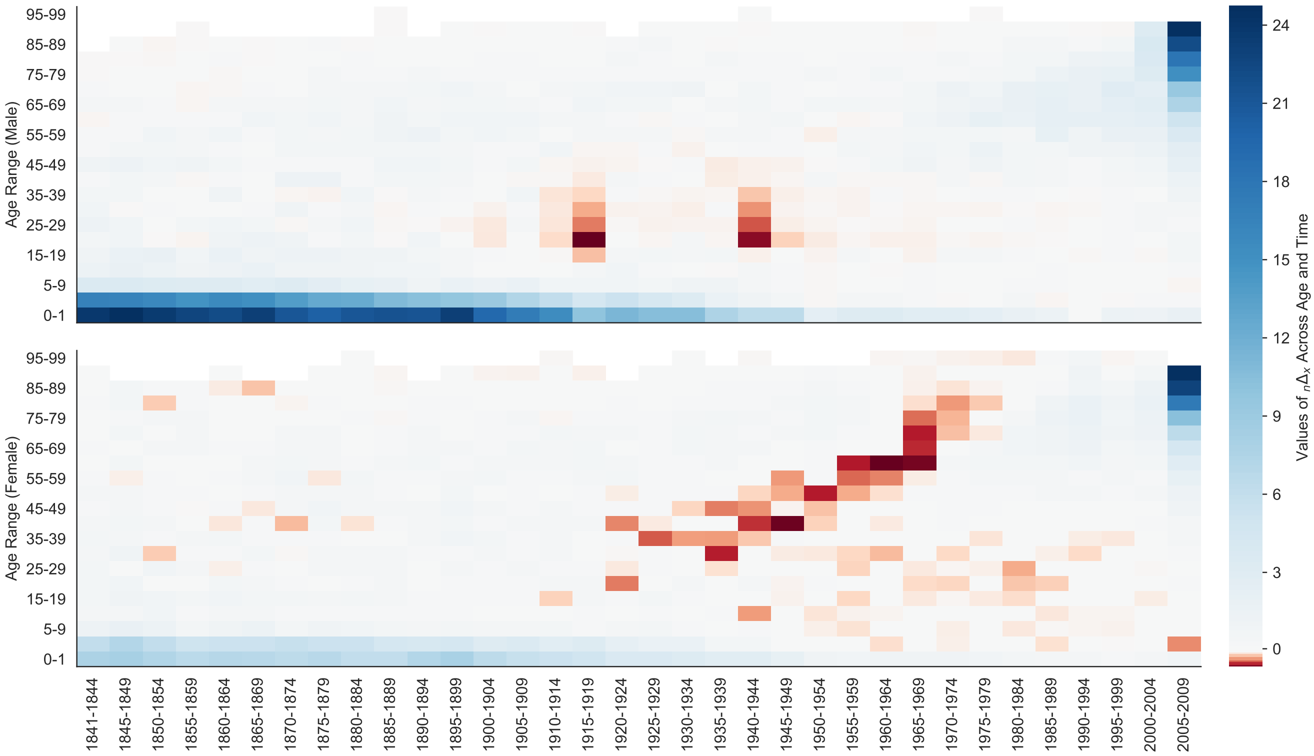


Figure Notes: Blue areas represent a lower morality rate at a specific age-year pair for the tertiary universe of peer and noble offspring, while red represents a comparative higher mortality rate.

where the superscripts '1' and '2' relate to Noble Offspring and the Total population respectively.

The results for this are shown in Figure 3 and a full set of results, analysis and description will be available in due course, but, as outlined in the Introduction, the five conclusions are:

Result One: There were substantial gaps between elite-group and general population mortality rates between the 16th to 18th century, contrary to our existing knowledge base.

Result Two: The demographic transition in mortality occurred earlier than previously estimated (for peers).

Result Three: That male elites offspring aged 18-45 disproportionately lost their lives during the major conflicts (the Great War and the Second World War) of the 20th century.

Result Four: A post-war equalization coincided with the introduction of the welfare state.

Result Five: A tentative gap has begun to re-emerge since the 1980s.

The appendices are reserved for robustness analyses (such as consideration of the 'distance' to a peerage) and the replication (or rather lack) of the original peerage paradox with identical assumptions and specifications.

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