The Legacy of Longevity

Persistent inequalities in UK life expectancy 1500-2016

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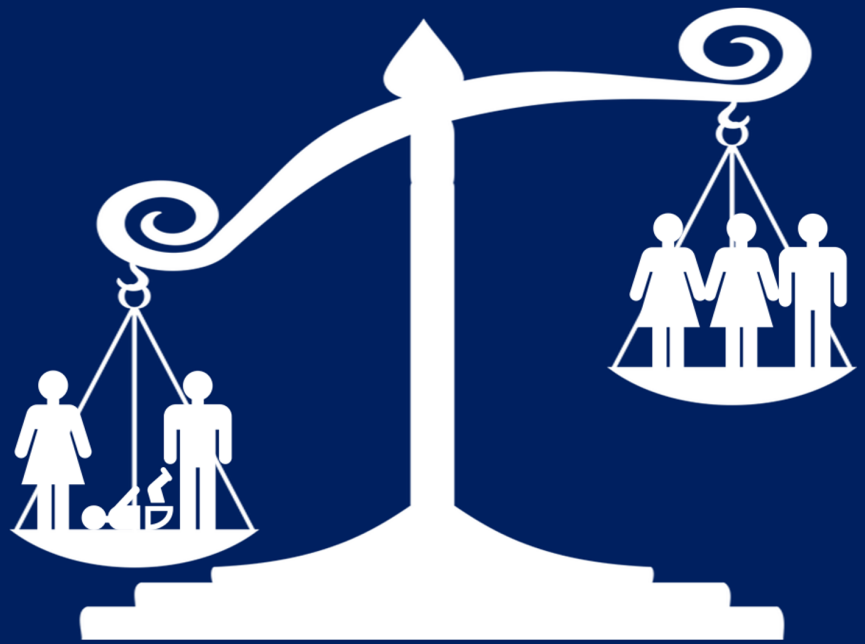

This paper is part of a larger theme of work...

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Analysis of 120 years of data in Who's Who shows those who went to top public schools are 94 times more likely to be in UK's 'elite'

▲ Harrow School's headmaster taking 'bill' or roll call on speech day in the 1980s. Photograph: Alamy

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- Primary feature: truly unique and original datasources.
- Past work has looked at inequalities arising from:
    1. Educational structures.
    2. Genomic studies.
- The next big project looks at housing inequalities.

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- Today's talk involves health inequalities (realised as mortality differentials) in the (very) long run.

We only have limited contemporary data …

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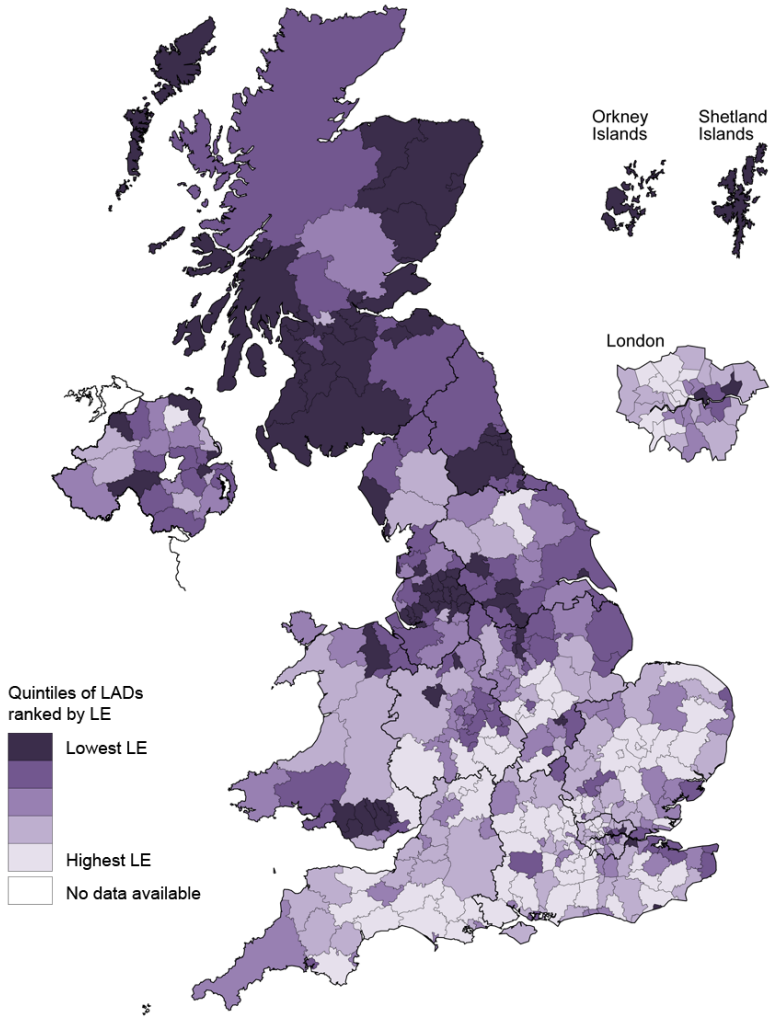
Reality Check

Can one mile take 10 years off your life?

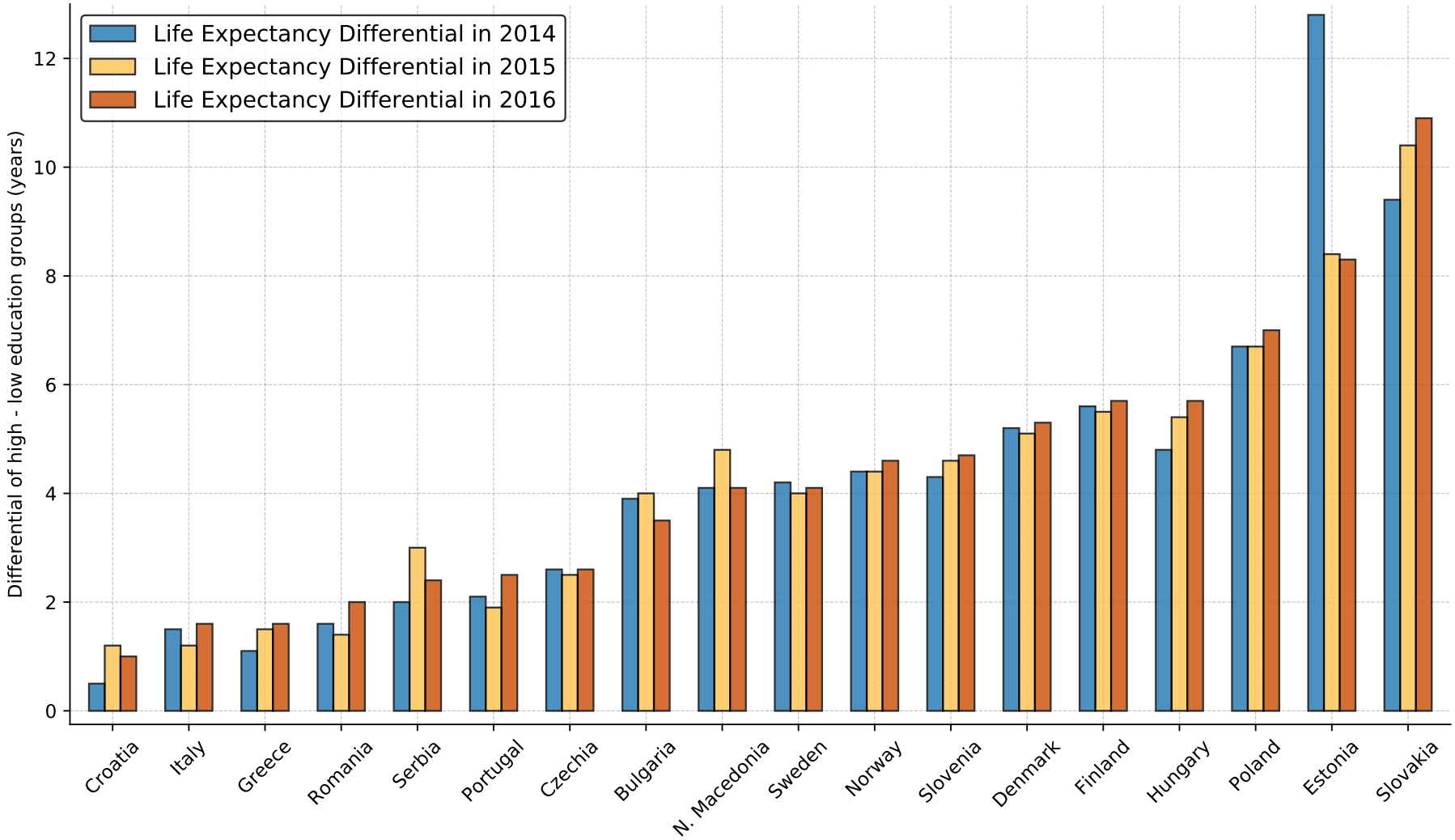
By Reality Check team
BBC News

20 January 2020 Share

Reality Check

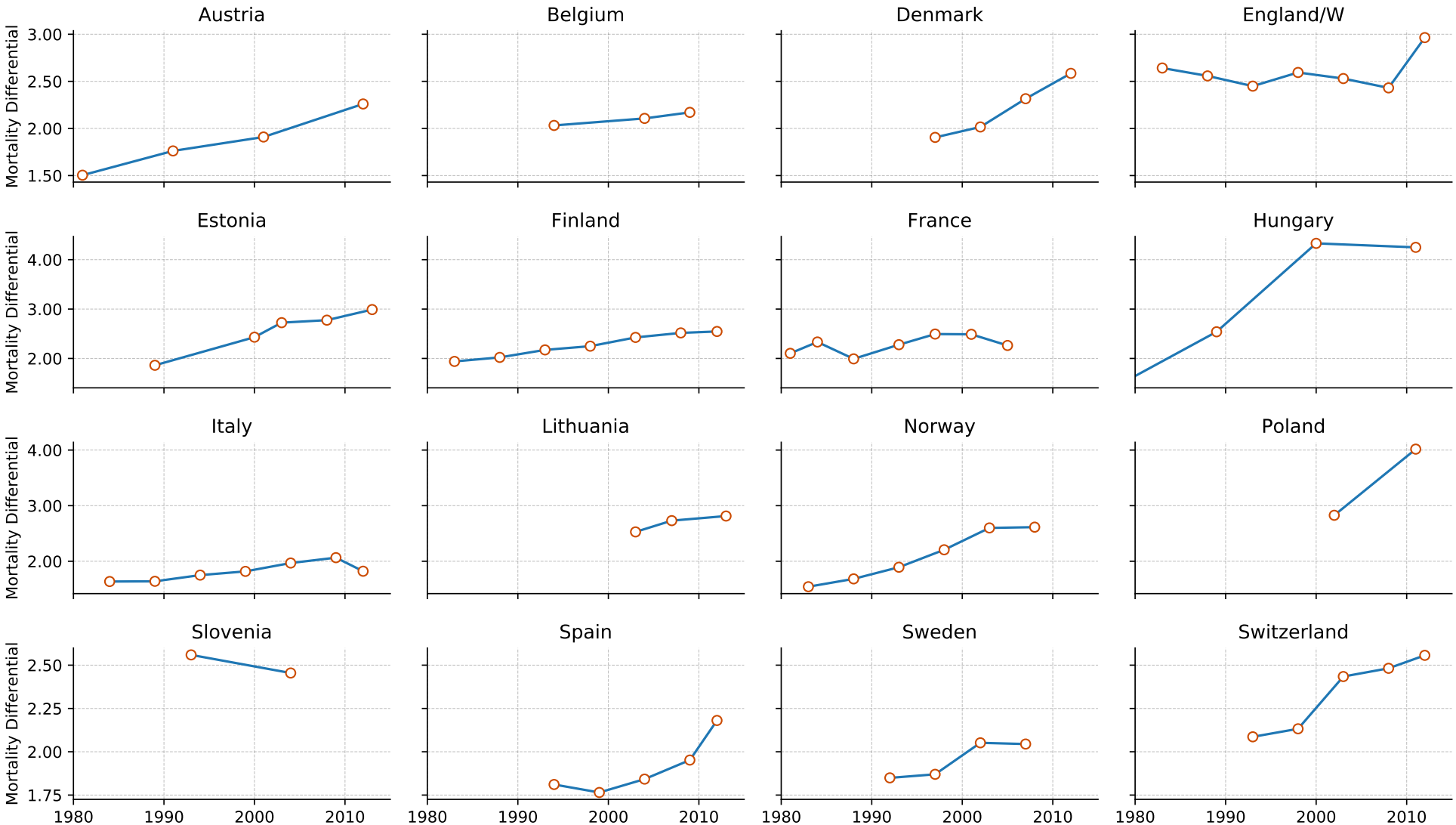


Inequalities in health are pervasive...



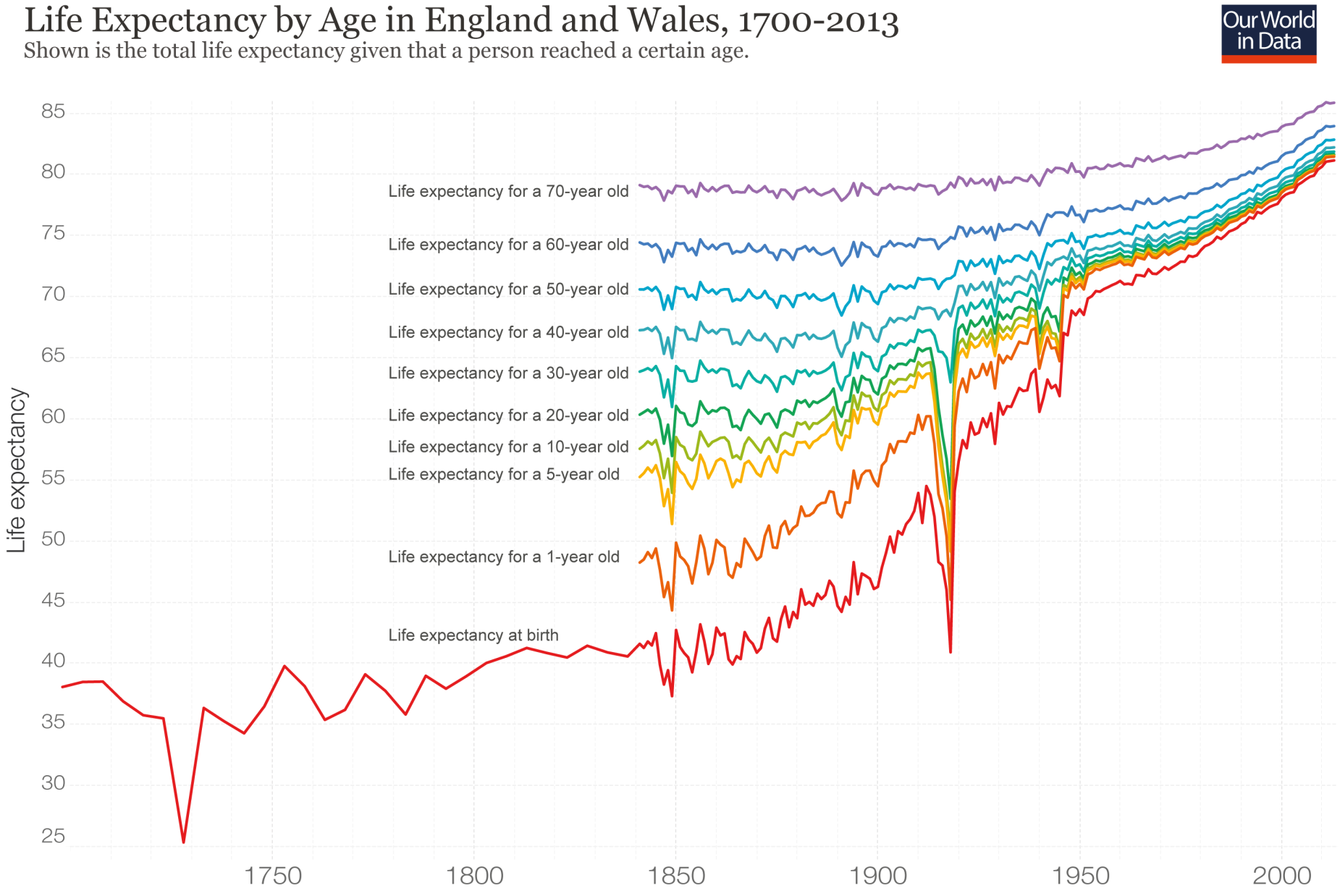
Source: Eurostat. Note: Not a selective subset – this is for **all** countries measured. Differential measured as life expectancy for those with 'Tertiary' education minus life expectancy of those with 'Less than primary, primary or lower secondary' education.

... and they are persistent



Source: Data from Mackenbach, Johan P. et al. 'Trends in Health Inequalities in 27 European Countries'. PNAS, 2018. Specifically: their 'Relative Index of Inequality', harmonized across countries to ISCED 1997 categories.

Historical health inequalities data are rare



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But WHY might there exist an association between SES and health disparities?

Theory of fundamental causes has four key components:

1. Multiple disease outcomes
2. Outcomes mediated through multiple risk factors
3. Access to resources allows risk avoision and minimizes consequences of disease
4. SES-mortality gradient persists and reproduces despite changing conditions

Key resources: knowledge, money, power, prestige, beneficial social connections.

(Link and Phelan, 1995)

BUT, THE HISTORICAL DATA IS COMPILED THROUGH LOTS OF SNAPSHOTS

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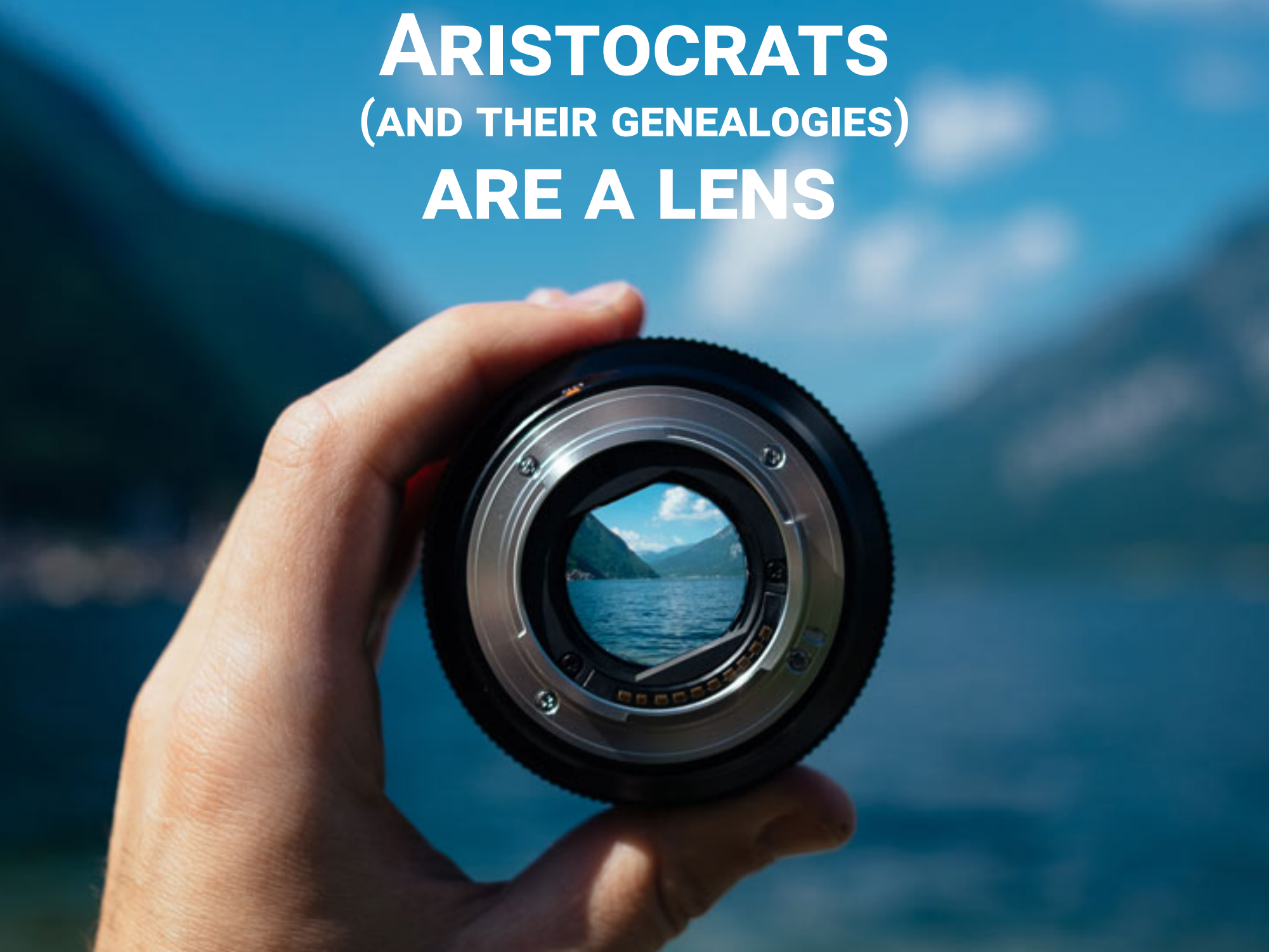
Chadwick (1842) in the Enquiry into the Sanitary Conditions of the Labouring Population. Average age at death in Liverpool (1840):

- 35 for professional persons
- 22 for tradesmen
- 15 for labourers, mechanics and servants.

Marmot (1994) analyzes the influential 'WhiteHall Study':

- Each hierarchical level of job seniority experienced a higher mortality rate than the group one step higher.

Aristocrats
(and their genealogies)
are a lens

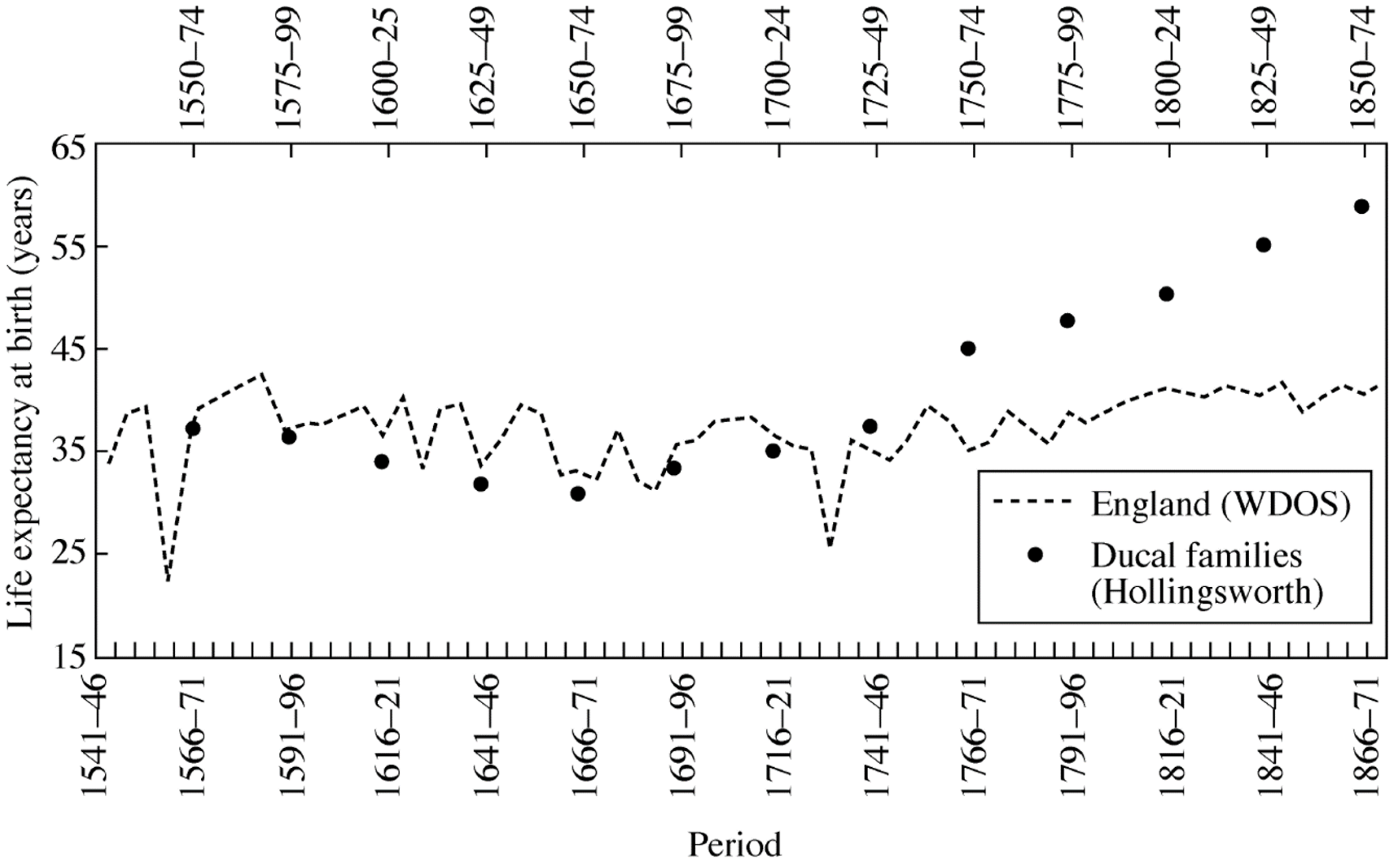


The 'Peerage Paradox'

The English peerage had virtually the same mortality as the general population until 1750

(Robert Fogel)

The emergence of health inequalities?



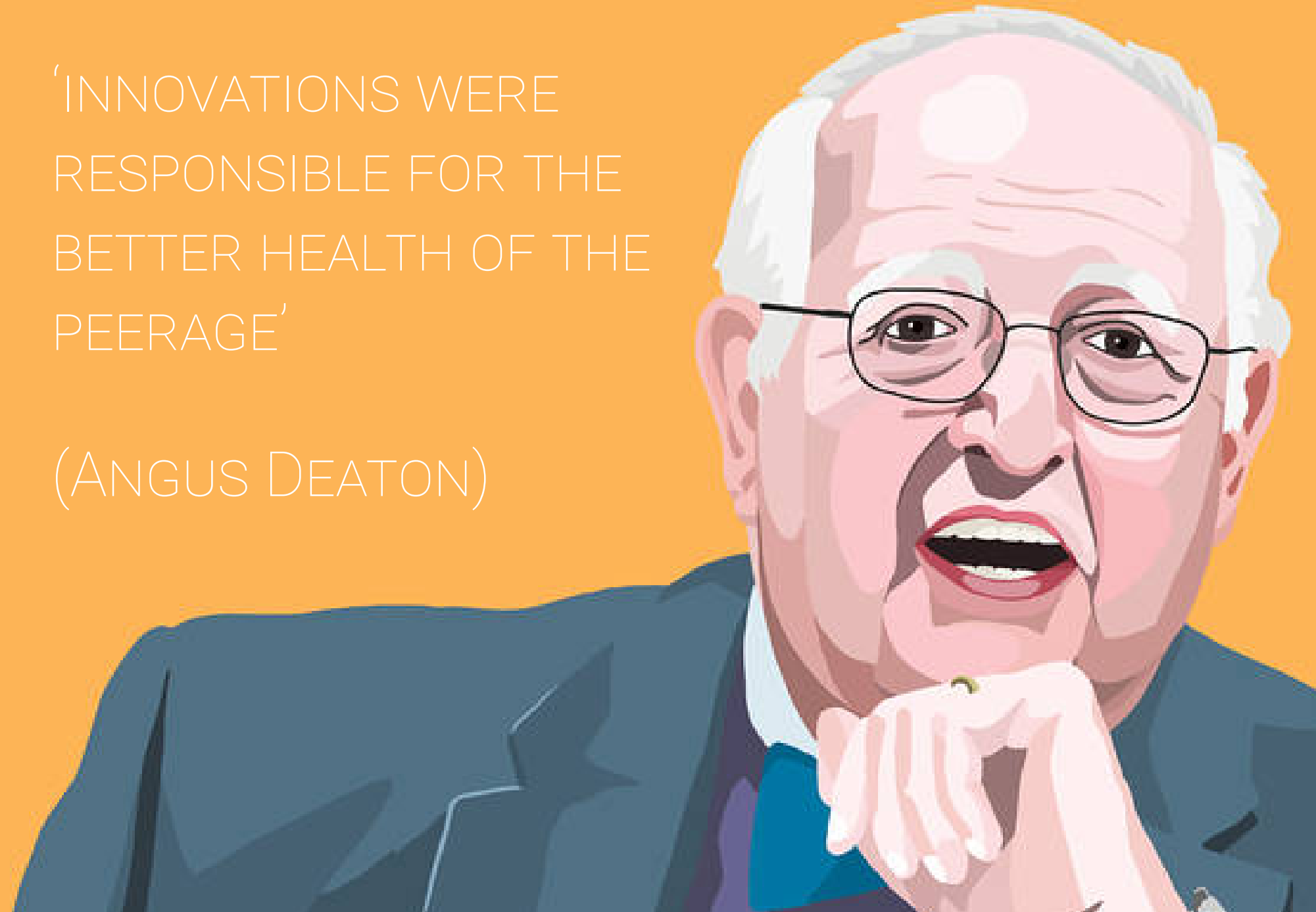
Harris, B., (2014), 'Public Health, Nutrition, and the Decline of Mortality: The McKeown Thesis Revisited'. Social History of Medicine.

‘the first lesson is that this "gradient" in health is not universal’

(Angus Deaton)

‘Innovations were responsible for the better health of the peerage’

(Angus Deaton)



IRON LUNGS FREE

GIFTS OF LORD NUFFIELD

LONDON, Thursday.

Thousands of "iron lungs" for combating infantile paralysis will be sent free to hospitals in all parts of the Empire as a result of a decision made by Lord Nuffield, the millionaire motor-car manufacturer and philanthropist.

Lord Nuffield announced to-day that he was ready to manufacture and supply "iron lungs" of the type designed by Mr. E. T. Both, a brilliant young scientist of the Adelaide University. This design is a modification of the Drinker respirator.

Mr. Both is at present in England. He told a representative of "The Argus" that he had received orders for 20 iron lungs from various hospitals in England. The machines were being sold for £98 each, compared with £240 for other types.

One of Mr. Both's respirators was recently rushed by plane from London to Alresford (Lincolnshire) for use in an urgent case of infantile paralysis.

Lord Nuffield chose Mr. Both's type of respirator from among several shown at a demonstration in London.

He said to-day:—"My offer will remain open until the last demand has been made. I do not think we shall need more than 5,000 machines. I shall be the sole judge of who gets them.

"Smaller hospitals may have to rely upon lungs presented to large hospitals nearby. On the other hand there may be small hospitals 800 miles from the nearest big town. I know of a few such instances in Australia. Each of these hospitals will receive a lung."

After Mr. Both had reached London from Adelaide in June, he assembled the first "iron lung" in a small workshop in North London. Then he arranged for the manufacture of the machines with D. and J. Fowler Ltd., of Adelaide and London.

One of his respirators was exhibited at the South Australian Agency General in London, and it attracted inquiries from all parts of the world.

It is understood that Lord Nuffield is prepared to produce the "iron lungs" by mass-production methods for about £15 each.

The gift of the respirators will bring Lord Nuffield's benefactions to charity to more than £12,000,000.

BRILLIANT PHYSICIST

Mr. Both, who is aged only 30 years, is one of the most brilliant young physicists yet produced by the University of Adelaide, where he did a distinguished course under Professor Kerr Grant. He began as an instrument maker. He has already many brilliant inventions to his credit, and some of these have attracted world-wide interest. He succeeded in developing an entirely new type of cardiograph, which permits instantaneous diagnosis of the heart.

Largest privately owned flying-boat in the world, the Consolidated PBY two-engined flying-boat Guba landed at Williamstown yesterday. The machine is owned by Mr. Richard Archbold, an American millionaire. The pictures of the interior show (left): The cook in his galley. Top right: The sleeping accommodation. The unusual design of the craft provides for plenty of space inside. Bottom right: The radio transmitter.

LUXURIOUS PLANE

£50,000 Flying Boat Here

After having circled three times to pick out the orange mooring-buoy, the luxurious flying boat Guba, the largest privately owned craft of her kind in the world, made a graceful landing off the Ann street pier, Williamstown, yesterday. She has flown from Papua.

The Guba reached Sydney on Tuesday after a non-stop flight from Port Moresby, Papua. She has been brought to Melbourne for overhaul of the automatic pilot equipment. After the repairs are made she will leave on Monday on the return flight to Papua.

With her beautifully streamlined hull and the birdlike lines of her wide spreading wings the Guba is one of the most shapely flying-ships ever to visit Melbourne. She is truly typical of the latest advances in aircraft design. The hull is smaller than that of the Empire flying-boats, but her lines are more graceful. One of her engineers pointed out that the Empire machines were designed for the comfort of passengers and with a heavy payload, while the Guba—a modern United States naval type—was designed for speed and long-range flying.

Centre of Interest

As the Guba was made fast to the mooring buoy a dozen inquisitive motor-launches hovered busily around her. For the first time in Melbourne it was necessary for Customs officers to board a flying-boat. They transferred from the large Customs launch to a smaller craft because of the possibility of damage to the aircraft's hull. The Customs formalities were quickly completed, and the Guba's happy crew of five and three passengers were taken ashore.

Throughout the day the Guba was the centre of great interest as she rode comfortably at her moorings. Experts and aviation enthusiasts who inspected her were impressed and delighted at her beauty, compactness, and obvious capabilities of sustained speed.

Valued at £50,000, the Guba is both the most palatial and largest privately owned machine of her kind in the world. Her wing span is 104ft. (no less than 30 men can stand on the wing); her length 68ft., and her weight 14,000lb. In test flights she has been loaded to 22,000lb., and she has taken off with ease with only one of the two motors running. Her fuel capacity is 1,700 gallons, and she has a flying range of 4,000 miles. The machine can remain in the air for 25 hours.

One of the most interesting of the Guba's technical features is the method by which the wing floats retract to form the wing tips while the machine is in flight. This gives reduced wind resistance and increased stability.

How does Fogel explain the paradox?

Fogel himself focus's on nutrition:

1. Alcoholic consumption much higher than in general public.
2. Adult peers ate well, but their children didnt.
3. A lot of food was salted.
4. Diseases mitigated by diet became more prevelant after 1750 (measels, Tuberculosis, leprosy).

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But what about *access* to a wide variety of (fresh) food?

"All I know is,

your carriage awaits

and my maid

is on her way up

with something

called a pineapple."

Olivia Coleman portraying Queen Anne in 'The Favourite', 2018

Other reasons to be cautious of earlier work

1. Not all earlier estimates of peerage mortality adjust for selection into the peerage
2. Studies which rely on aristocrats themselves are reliant on age at death only.
3. Men are over-represented in earlier periods
4. Mortality rates are upwardly biased for peers because not all deaths are recorded.
5. Small-N based dietary or parish records.

A NEW DATASET CREATED THROUGH DECADES OF ONE MAN'S HARD WORK MAKES A THOROUGH, COMPREHENSIVE ANALYSIS OF HEALTH INEQUALITY IN THE LONG RUN POSSIBLE.

Introducing **Darryl** and **thepeerage.com**

- 724,196 **manually** curated entries.
- 20-40 hours a week (since 1988).
- 7,275 unique sources.
- 5,792 direct correspondences.
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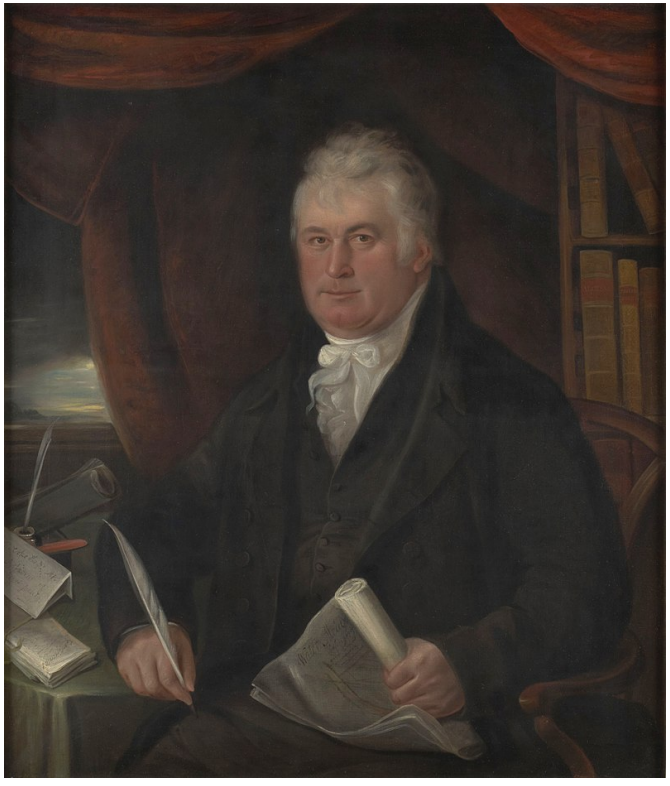
Why look at entire lineages?

"Peers themselves are a demographically biased group; they tend to die old, since entry into the group is unusual before middle age. The children of peers, however, are not."

Population Investigation Committee (1964)

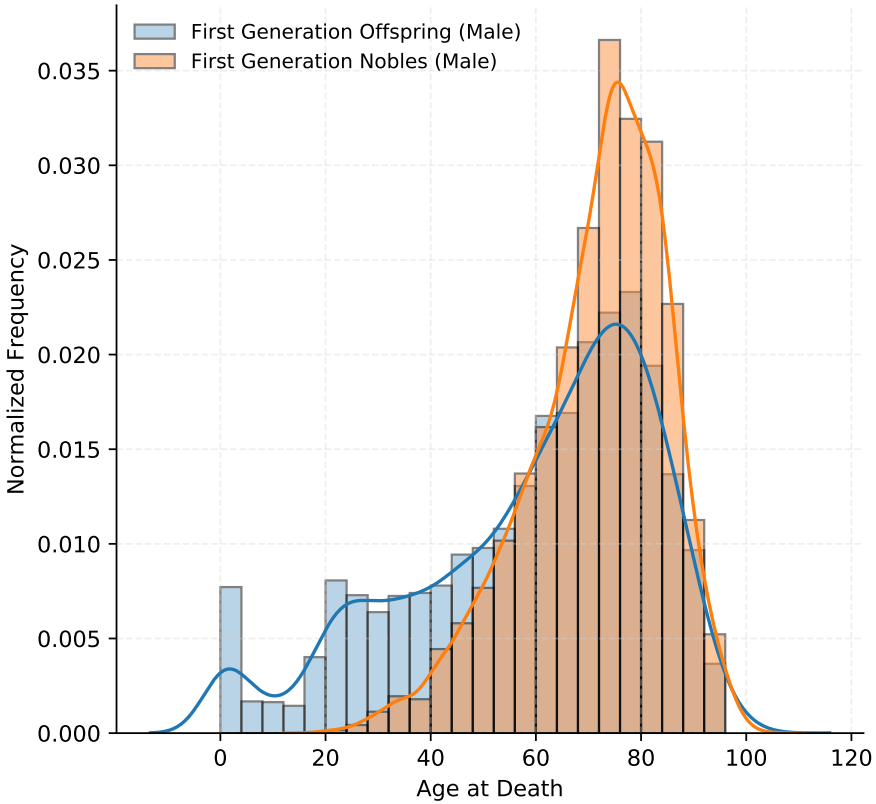
Thomas Coke, the First Earl of Leicester

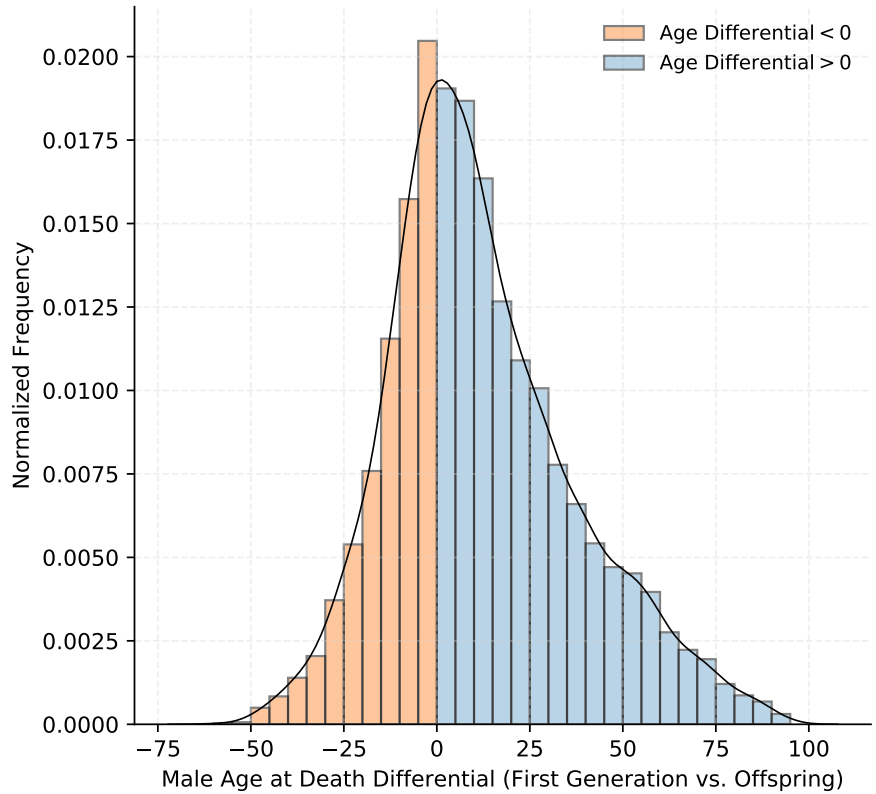


- A great example is Thomas Coke.
- An agricultural reformer, known as the 'greatest commoner'.
- Accepted an Earldom in 1837, aged 83, at the seventh offer.
- Died in 1842, aged 88.
- Earldom passed to son, Thomas, on death.

- If only analyzing peers, not only did Thomas (Snr) have to live to 83, Thomas (Jnr) had to live at least until fathers death.
- We call this 'Left Truncation Bias'

Quantifying the Left Truncation Bias





- Difference in age of death of 1st gen peers and their children: +11.90 years.

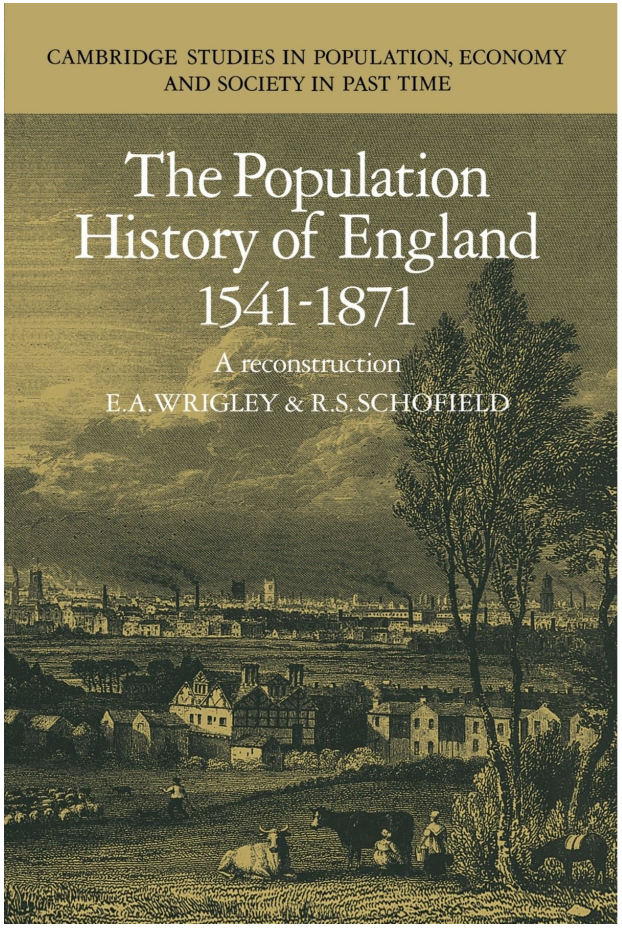
Data: Pre-processing the tertiary universe

- After pre-processing, we are left with:
  - 35,266 observations for aristocratic children.
  - 52,123 observations for aristocratic grand-children.
  - 65,477 observations for aristocratic great-grand-children.
- Note: an observation in our dataset can be both a child and a grandchild (and often is the case for hereditary peerages).
- This leaves us with 88,209 unique offspring observations (some of them can themselves be aristocrats).

Sanity Check: Groupby date of death

Date	Deaths	Event
15th September, 1916	17	Battle of Flers–Courcelette
14th September, 1914	17	The Battle of the Aisne
31st May 1916	17	Battle of Jutland
9th May, 1915	15	Battle of Aubers Ridge
5th November, 1854	12	Battle of Inkerman
25th of September, 1915	11	Battle of Loos
1st November, 1914	10	Battle of Coronel
30th October, 1914	10	First Battle of Ypres
25th September, 1916	9	Battle of Morval
29th October, 1914	9	Black Sea Raid

Historical population level data: 1500-1880



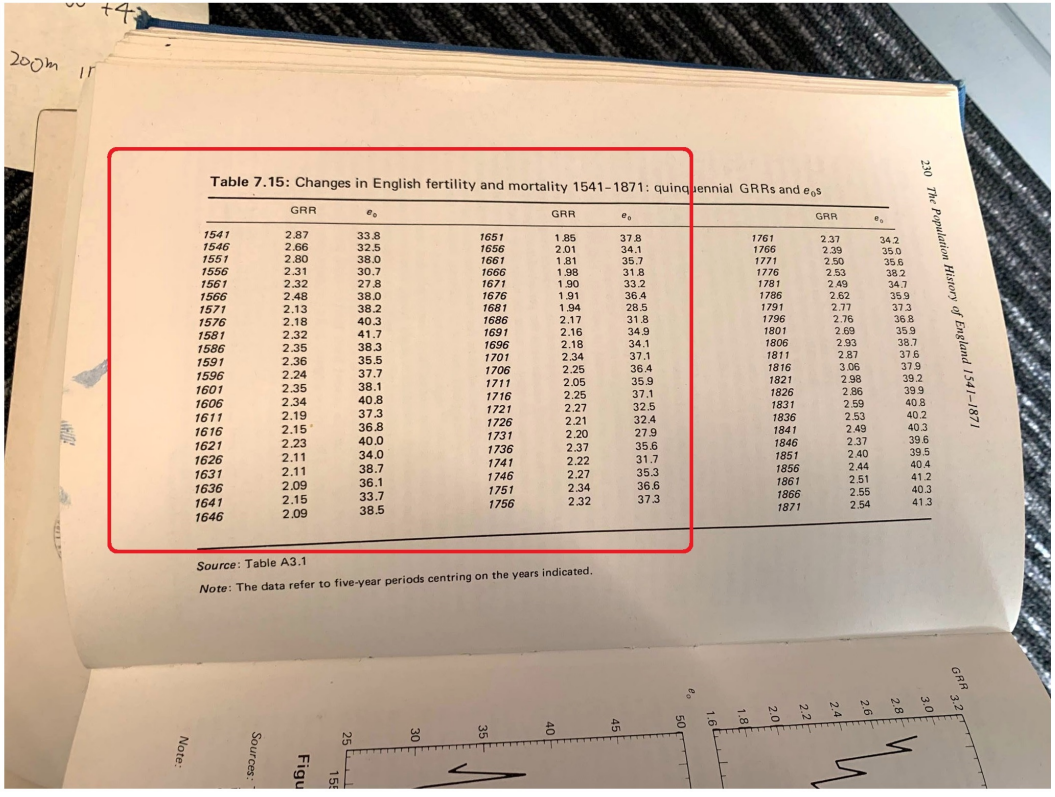


Table 7.15: Changes in English fertility and mortality 1541–1871: quinquennial GRRs and e_0s

	GRR	e_0		GRR	e_0		GRR	e_0
1541	2.87	33.8	*1651*	1.85	37.8	*1761*	2.37	34.2
1546	2.66	32.5	*1656*	2.01	34.1	*1766*	2.39	35.0
1551	2.80	38.0	*1661*	1.81	35.7	*1771*	2.50	35.6
1556	2.31	30.7	*1666*	1.98	31.8	*1776*	2.53	38.2
1561	2.32	27.8	*1671*	1.90	33.2	*1781*	2.49	34.7
1566	2.48	38.0	*1676*	1.91	36.4	*1786*	2.62	35.9
1571	2.13	38.2	*1681*	1.94	28.5	*1791*	2.77	37.3
1576	2.18	40.3	*1686*	2.17	31.8	*1796*	2.76	36.8
1581	2.32	41.7	*1691*	2.16	34.9	*1801*	2.69	35.9
1586	2.35	38.3	*1696*	2.18	34.1	*1806*	2.93	38.7
1591	2.36	35.5	*1701*	2.34	37.1	*1811*	2.87	37.6
1596	2.24	37.7	*1706*	2.25	36.4	*1816*	3.06	37.9
1601	2.35	38.1	*1711*	2.05	35.9	*1821*	2.98	39.2
1606	2.34	40.8	*1716*	2.25	37.1	*1826*	2.86	39.9
1611	2.19	37.3	*1721*	2.27	32.5	*1831*	2.59	40.8
1616	2.15	36.8	*1726*	2.21	32.4	*1836*	2.53	40.2
1621	2.23	40.0	*1731*	2.20	27.9	*1841*	2.49	40.3
1626	2.11	34.0	*1736*	2.37	35.6	*1846*	2.37	39.6
1631	2.11	38.7	*1741*	2.22	31.7	*1851*	2.40	39.5
1636	2.09	36.1	*1746*	2.27	35.3	*1856*	2.44	40.4
1641	2.15	33.7	*1751*	2.34	36.6	*1861*	2.51	41.2
1646	2.09	38.5	*1756*	2.32	37.3	*1866*	2.55	40.3
						1871	2.54	41.3

Source: Table A3.1

Note: The data refer to five-year periods centring on the years indicated.

Source: Wrigley, E.A and Schofield, R.S (1981), The Population History of England, Cambridge University Press, 1st Edition.

Rcent population level data: 1841-Present

- The Human Mortality Database: key goal of uniformity.
- The majority their sources are ONS, Registrar General and Jdanov et al. (2005) for wartime estimates.
- In particular, we use England and Wales, Total Population data.
- Data starts 1841 until present day.
- England & Wales Total Population (i.e. not 'civilian'): starts earlier than UK estimates (1841 vs 1922).
- Note: We do not make use of their lifetables, only exposures and death rates (for harmony).

Methods

- We have the following pipeline:
    1. Scrape and parse the entire thepeerage.com.
    2. Create dataframes of aristocrats and their descendant trees.
    3. Preprocess, particularly for dates of birth and death.
    4. Create lifetables.
    5. Calculate lifetables with robustness adjustments.
    6. Analyze and visualise.
- Everything is written in Python 3.7.x.
- TODO: Package the lifetables modules into a library for PyPI.

Methods: Pre-processing across fuzzy dates

- Naturally, not all dates of birth and death are exact.
- We follow a similar methodology to Cummins (2017).
- Build a RE function to find day, months and years:
    1. If no year present: discard observation.
    2. If no month present: randomise over month and date.
    3. If no date present: randomize over appropriate set of days.
- Randomisation is essential for exposure to death calculations.
- About 1 in 8 dates are randomised, and 1 in 9 months.
- No ‘heaping’ in either dates or months, raw or simulated.

Methods: Lifetables

- Yearly **abridged** 5x1, 5x5, 5x10 and 5x25 **period** lifetables.
- Mostly follow approach as outlined by Preston *et al.* (2001).
- Five year age ranges except for 0-1 and 1-5.
- We use a standard Kannisto-Thatcher smoothing technique.
- Calculations up until 110+, unless $P_x = 0$ `or` $D_x > P_x$.
- Period specific death rates are calculated as:

$$ {}_nM_x = \frac{{}_nD_x}{{}_nN_x} \tag{1} $$

- ${}_nD_x$ is number dying between $[x, x + n]$, and ${}_nN_x$ is cumulative person years exposed to death.

Methods: Lifetables (cont.)

- For $x = \{0, 1\}$, Coale and Demeny (1983) equations for ${}_n a_x$, otherwise $\frac{n}{2}$.
- No weighting based on P_x for gender i.e for 'Total' ${}_n a_x$:

$$ {}_n a_x^T = \frac{1}{2}({}_n a_x^M +_n a_x^F) \tag{2}$$

- Otherwise identical to the 'Preston' method of lifetable construction for ${}_n q_x$ (open ended interval ${}_\infty q_x^* = 1.00$), arbitrary radix (l_x=100,000) updated as $l_{x+n} = l_x \times (1 -_n q_x)$.
- . . . etc.

Methods: Lifetables (cont.)

Total 5x25 General Population Lifetable, Year 1600

range	Dx	Px	nMx	nax	nqx	ix	ndx	nLx	Tx	ex
0-1	5	502.825	0.010	0.081	0.010	100000	985	99095	5516982	55.17
1-4	8	1861.142	0.004	1.600	0.017	99015	1685	392014	5417887	54.72
5-9	8	2090.978	0.004	2.5	0.019	97330	1844	482037	5025873	51.64
10-14	0	1871.183	0.004	2.5	0.021	95485	2038	472332	4543836	47.59
15-19	8	1665.653	0.005	2.5	0.024	93447	2217	461694	4071504	43.57
20-24	13	1584.273	0.008	2.5	0.040	91230	3668	446981	3609810	39.578
25-29	15	1455.423	0.010	2.5	0.050	87562	4399	426814	3162830	36.12
30-34	8	1276.216	0.006	2.5	0.031	83163	2566	409401	2736016	32.90
35-39	15	1165.751	0.013	2.5	0.062	80597	5024	390426	2326615	28.87
40-44	15	968.981	0.015	2.5	0.075	75573	5632	363788	1936189	25.62
45-49	16	768.626	0.021	2.5	0.099	69942	6920	332410	1572401	22.48
50-54	16	633.615	0.025	2.5	0.119	63022	7485	296400	1239991	19.68
55-59	11	488.566	0.023	2.5	0.107	55538	5919	262891	943591	16.99
60-64	18	371.590	0.048	2.5	0.216	49619	10720	221294	680701	13.72
65-69	14	253.273	0.055	2.5	0.243	38899	9446	170881	459407	11.81
70-74	9	181.833	0.049	2.5	0.220	29453	6486	131051	288526	9.80
75-79	11	87.478	0.126	2.5	0.478	22967	10986	87369	157475	6.86
80-84	7	46.923	0.149	2.5	0.543	11981	6509	43631	70106	5.85
85-89	2	15.989	0.186	2.5	0.634	5472	3469	18686	26475	4.84
90-94	2	4.082	0.242	2.5	0.754	2003	1510	6237	7789	3.89
95-99	0	0.000	0.309	2.5	0.872	492	429	1389	1552	3.15
100-104	0	0.000	0.385	2.5	0.981	63	62	161	163	2.59
105-109	0	0.000	0.468	2.5	1.078	1	1	3	3	2.16
110+	0	0.000	0.552	2.5	1.000	0	0	0	0	1.81

Methods: Robustness

- We presently have three main robustness checks.
  1. Focus on the potential for unobserved infant mortality.
  2. Focus on gender differentials and unrecored deaths.
  3. Focus on the randomisation of non-exact dates.

- The first is applied to Male and Female lifetables to conservatively control for unobserved infant mortality:

$$ {}_1D_0^R = (1.5 \times_1 D_0) + (0.04 \times N_b) \tag{3} $$

$$ {}_4D_1^R = (1.25 \times_1 D_0) + (0.02 \times N_b) \tag{4} $$

- Where N_b is the number of children born in the relevant period.

Methods: Robustness

- The second method has two components and is applied to the 'Total' estimates for the long run (5x10).
- The first controls for gender bias (λ=0.25):

$$px_{\text{gend}} = 0.5 - \frac{px_f^0}{px_f^0 + px_m^0} \tag{5}$$

$$E_0^{\text{gend\_sens}} = E_0 - \lambda(px_{\text{gend}} \times E_0) \tag{6}$$

- The second controls for unrecorded deaths:

$$px_{\text{age}} = \frac{\sum_{i=80}^{110+} \text{px}_t}{\sum_{i=0}^{110+} \text{px}_t} \tag{7}$$

$$E_0^{\text{age\_sens}} = E_0 \times (1 - px_{\text{age}}) \tag{8}$$

Methods: Clarification

Lets make some clarifying points. We:

1. Use HMD exposures and deaths, *not* expectancy's.
2. Calculate gen pop life expectancy's from 1841-Present.
3. Calculate offspring life expectancy's from 1500-Present.
4. Calculate abridged 5x1, 5x5, 5x10 and 5x25 period life tables.
5. Repeat this for every year.

Methods: Direct Comparison

To compare l_x for gender at each year, follow Brass (1971):

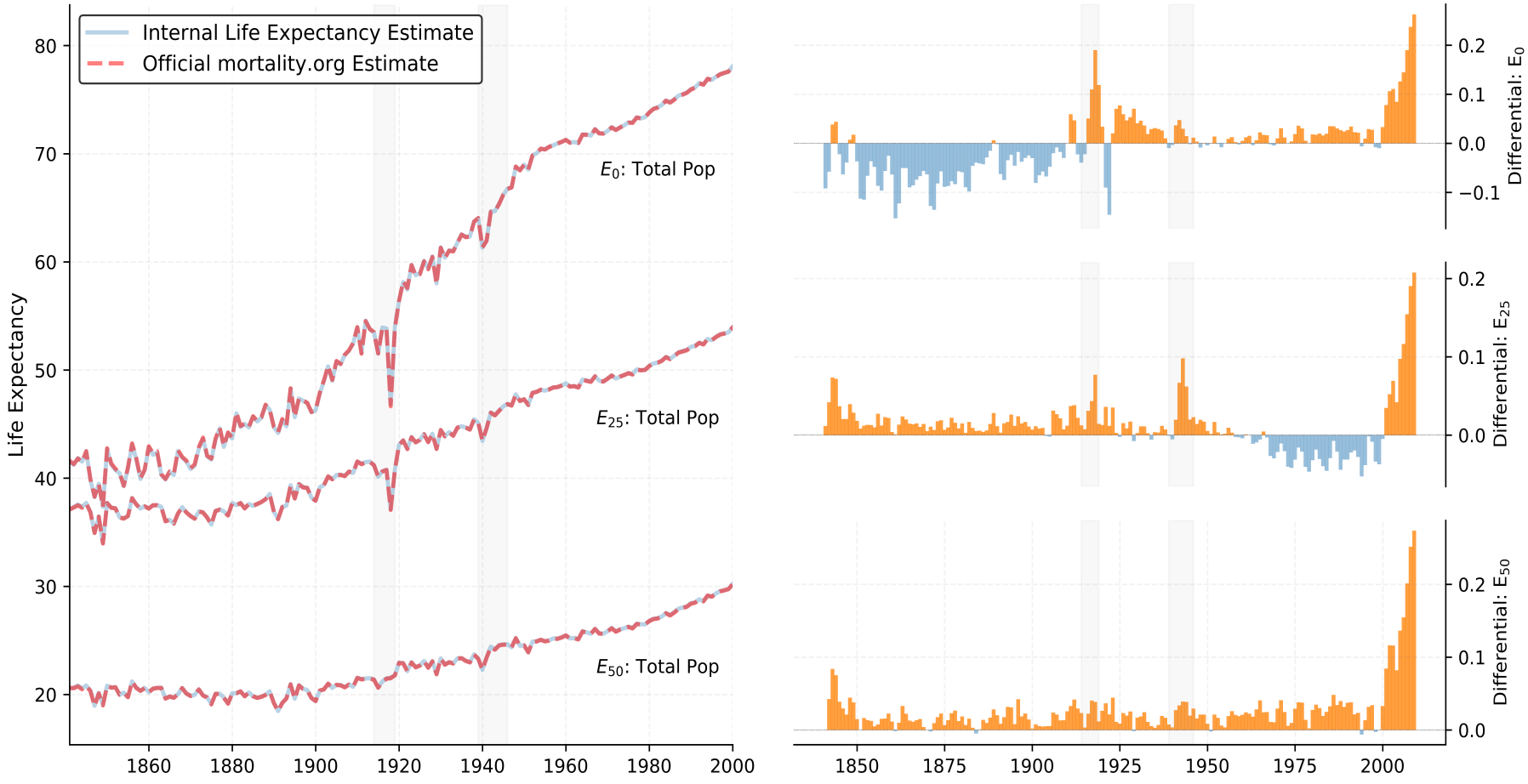
$$logit(\frac{l_x}{l_0}) = ln(\frac{1-\frac{l_x}{l_0}}{\frac{l_x}{l_0}}) \tag{9}$$

Allows us to compare in terms of intercept\slope. To analyze changes in life expectancy at birth, follow Arriaga (1984):

$$_n\Delta_x = \frac{l_x^1}{l_0^1} \times (\frac{_nL_x^2}{l_x^2} - \frac{_nL_x^1}{l_0^1}) + \frac{T_{x+n}}{l_0^1} + (\frac{l_x^1}{l_x^2} - \frac{l_{x+n}^1}{l_{x+n}^2}) \tag{10}$$

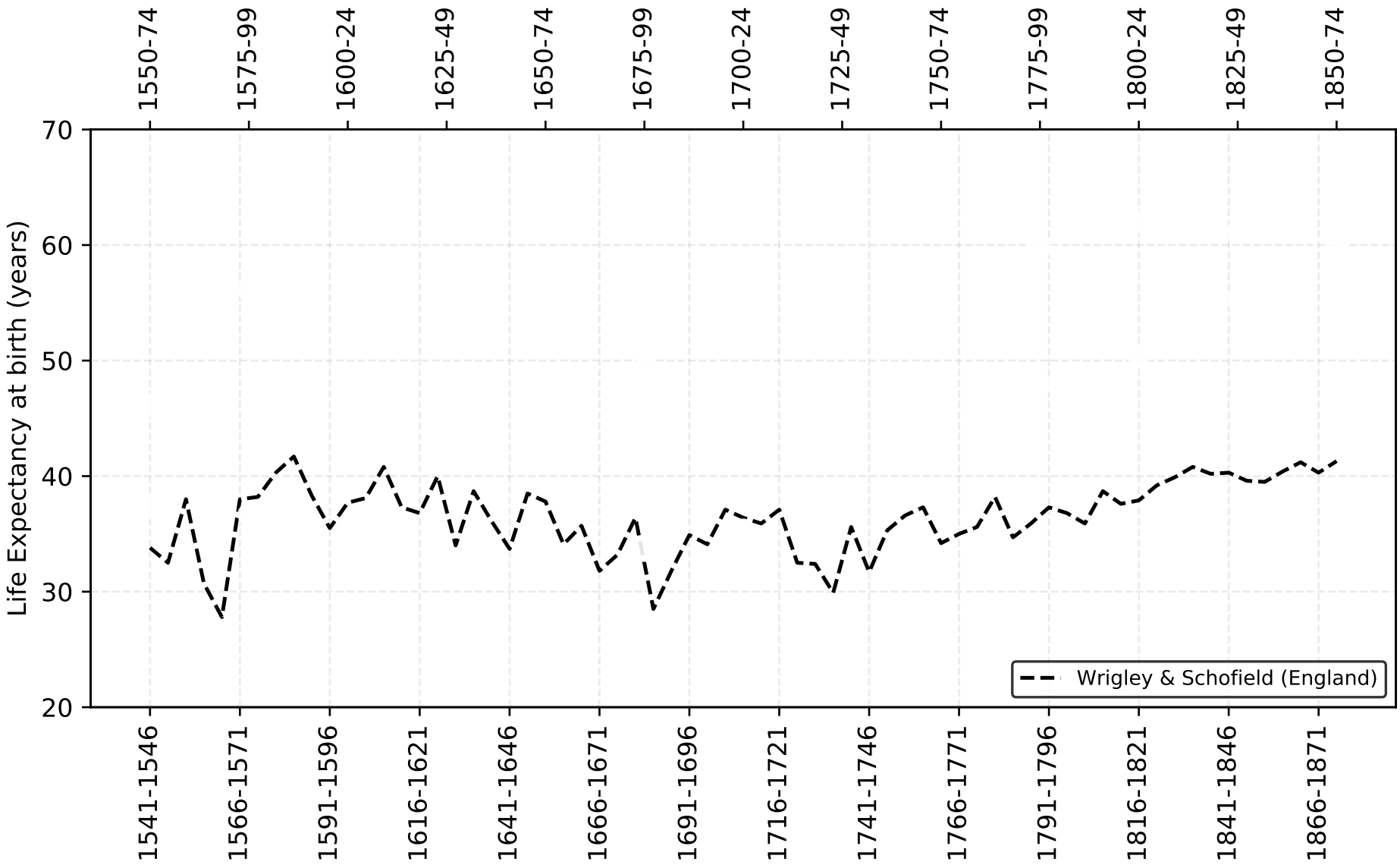
This allows us to analyse contributions of mortality differences across various ages to total difference in E_0^O.

Robustness: Compare E_0^o with full HMD E_0^o

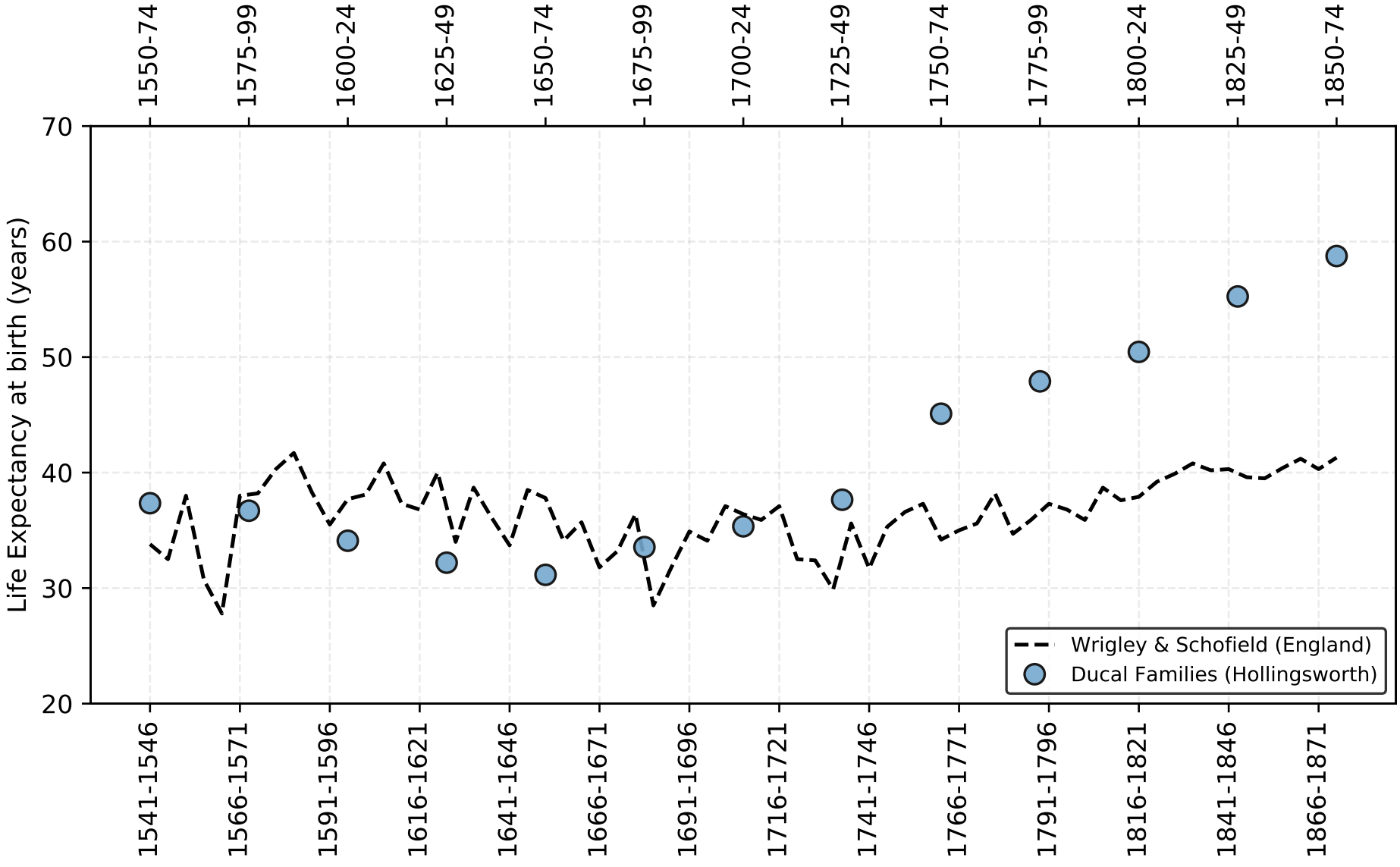


- A difference of -0.01 years for males, and +0.01 years for females between our gen pop estimates vs HMD E_0.

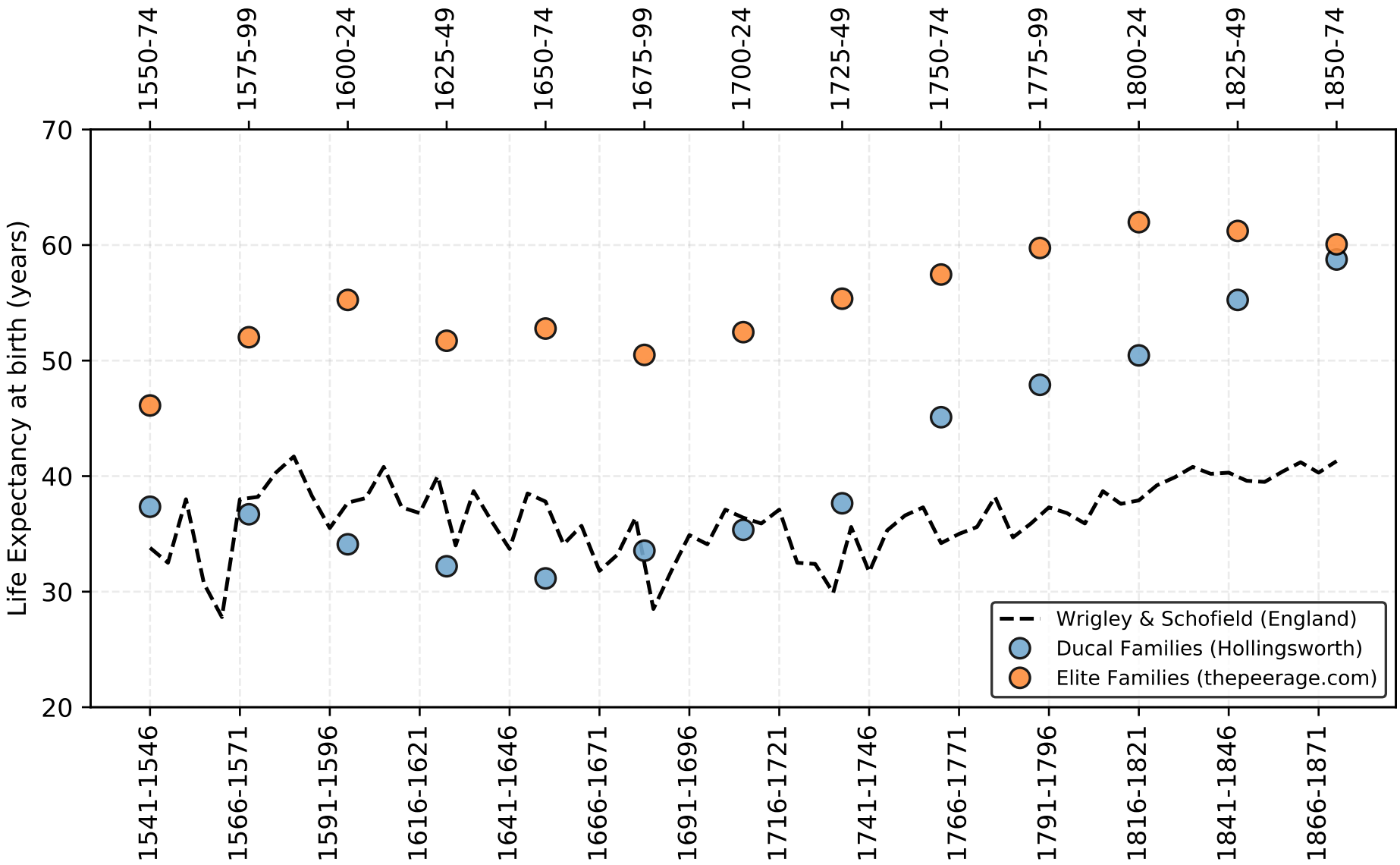
Health (In)Equality in the Very Long Run (5x25)



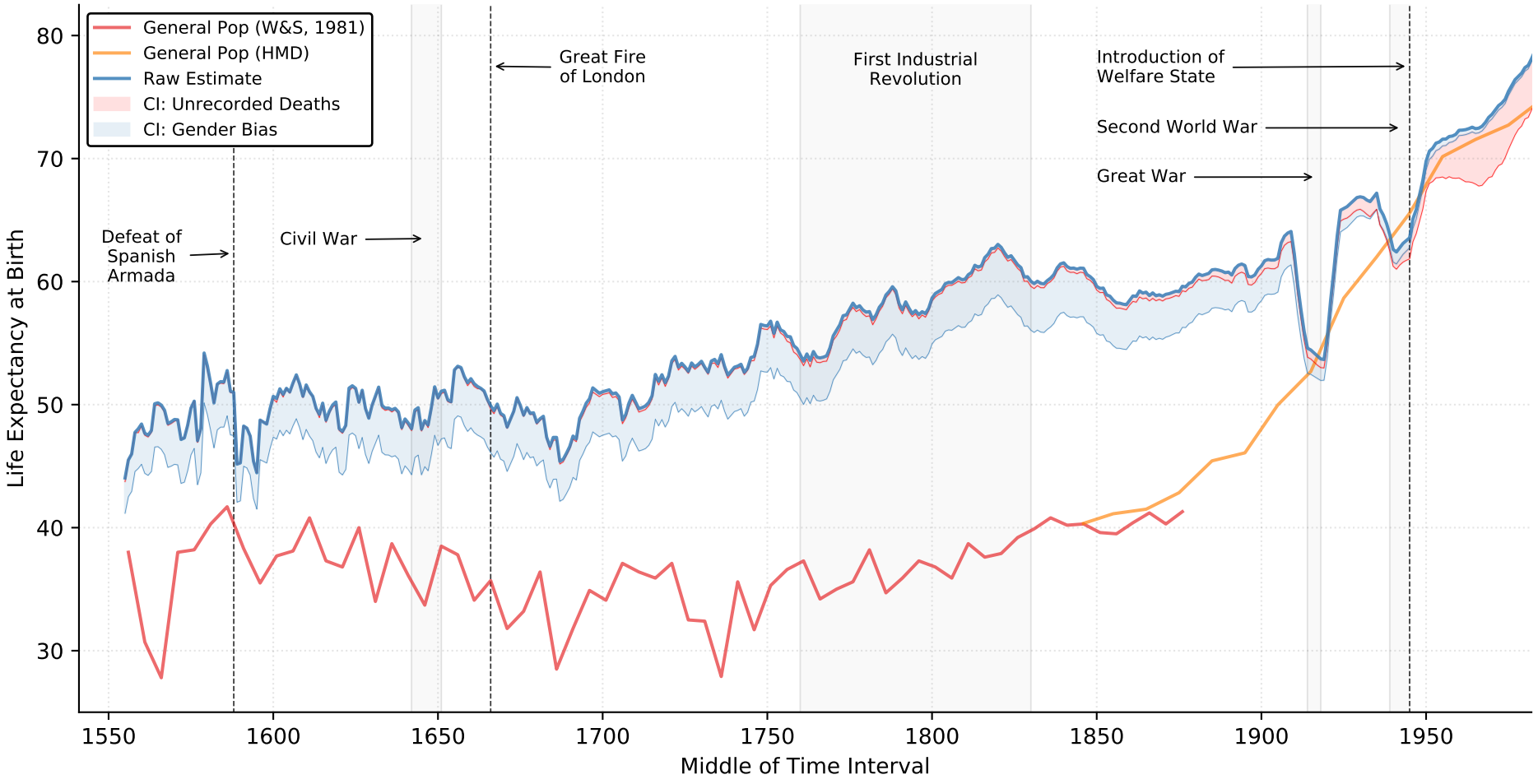
I taught the MPhil 'Replication Project' module...



Health (In)Equality in the Very Long Run (5x25)

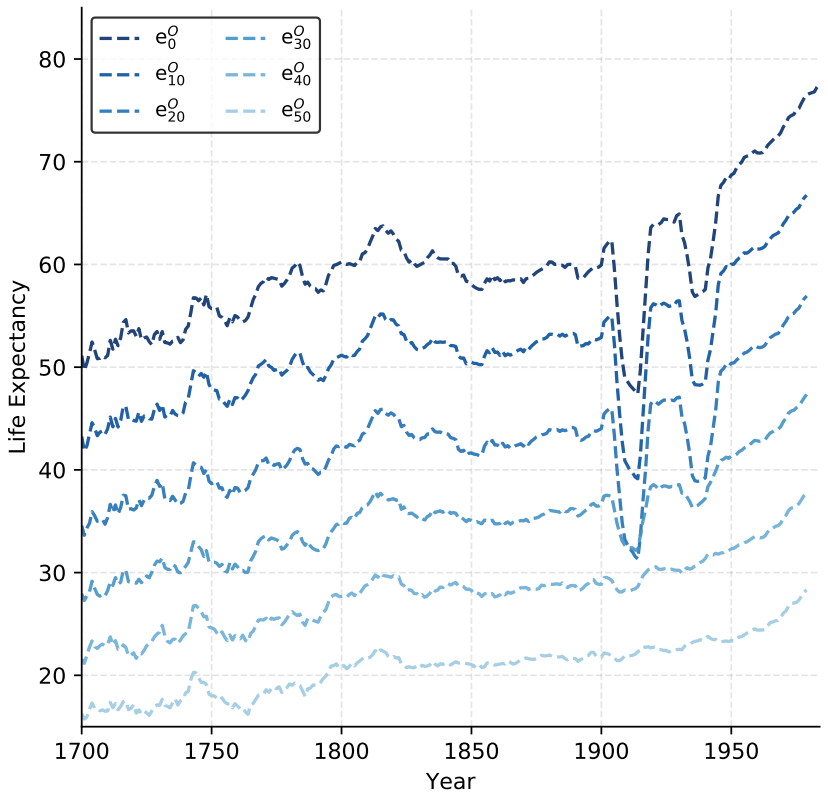


Health (In)Equality in the Very Long Run (5x10)

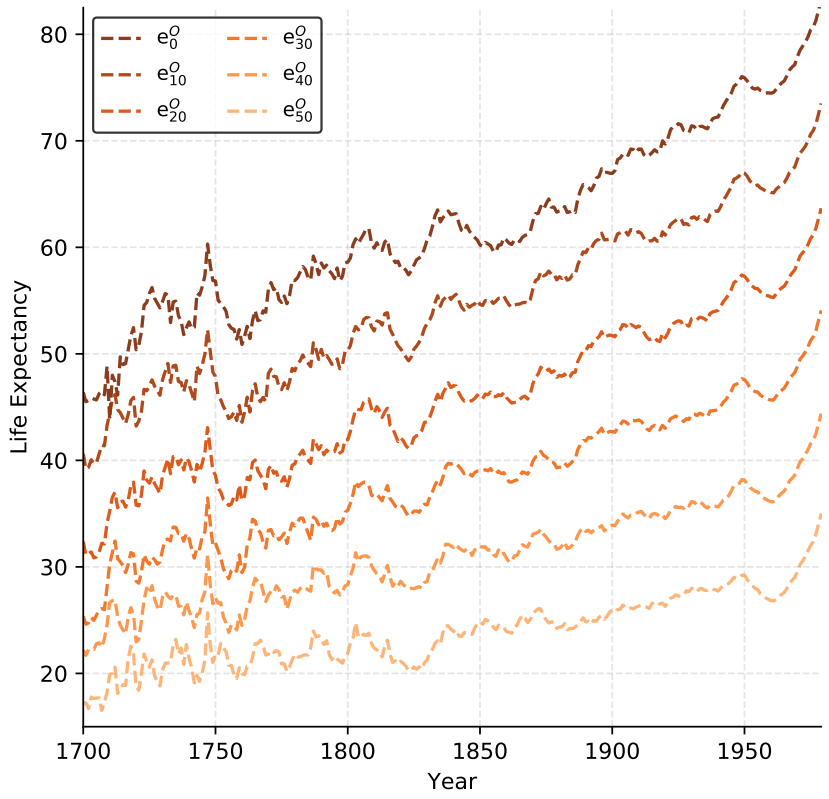


Raw life expectancy calculations (5x10)

(a) Males

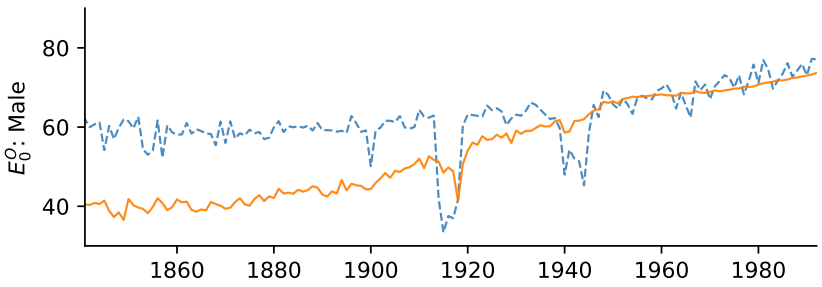


(b) Females

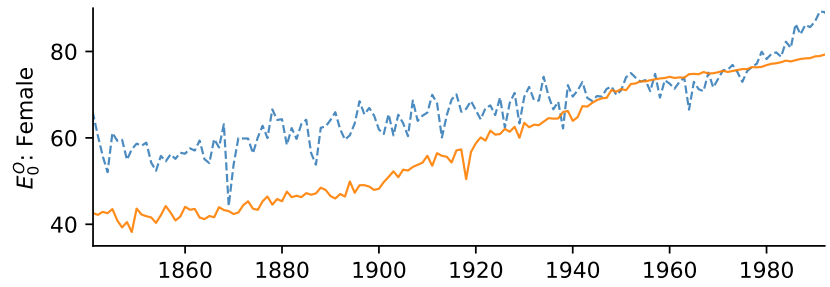


Note: All x-axes are prospective (i.e. for 5xn lifetables, x-axis tick label represent [YYYY-YYYY+n-1]).

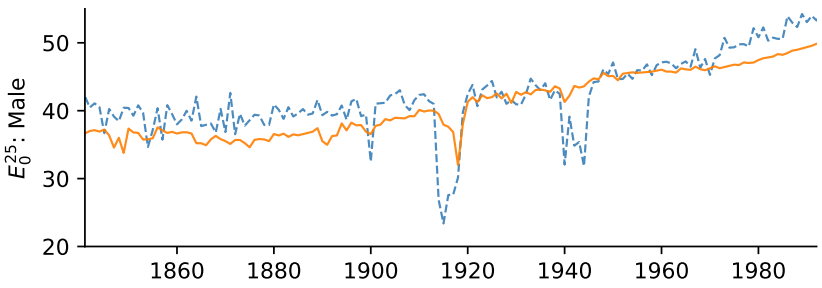
Various 5x1 comparisons: males and female



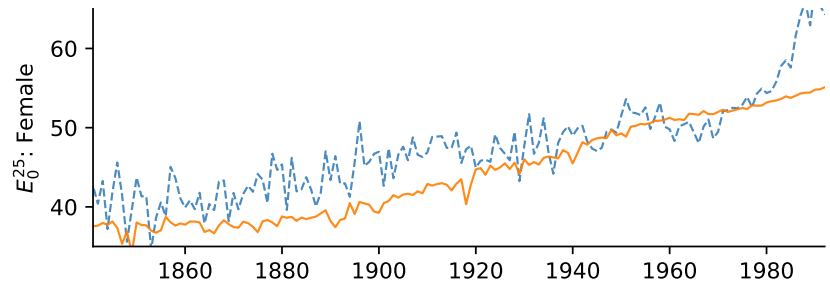
(a) Males, E_0



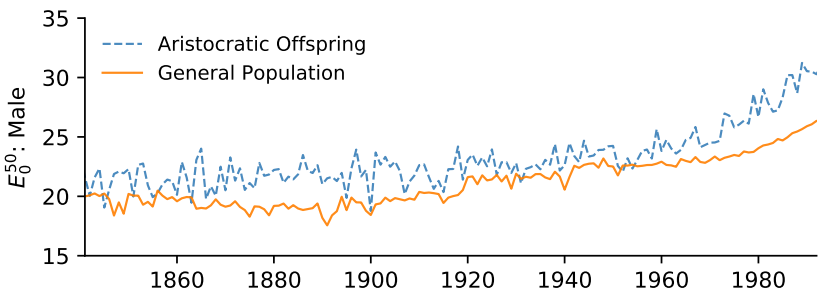
(b) Females, E_0



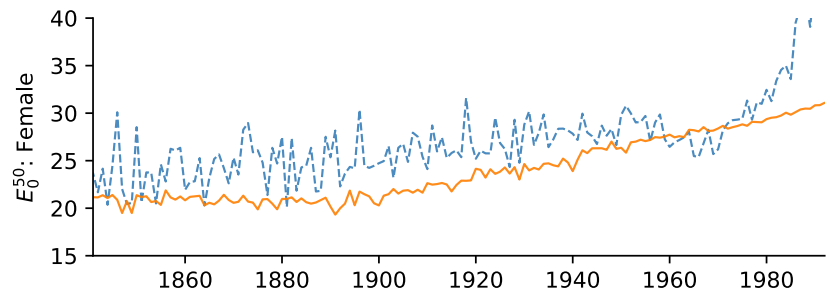
(c) Males, E_{25}



(d) Females, E_{25}

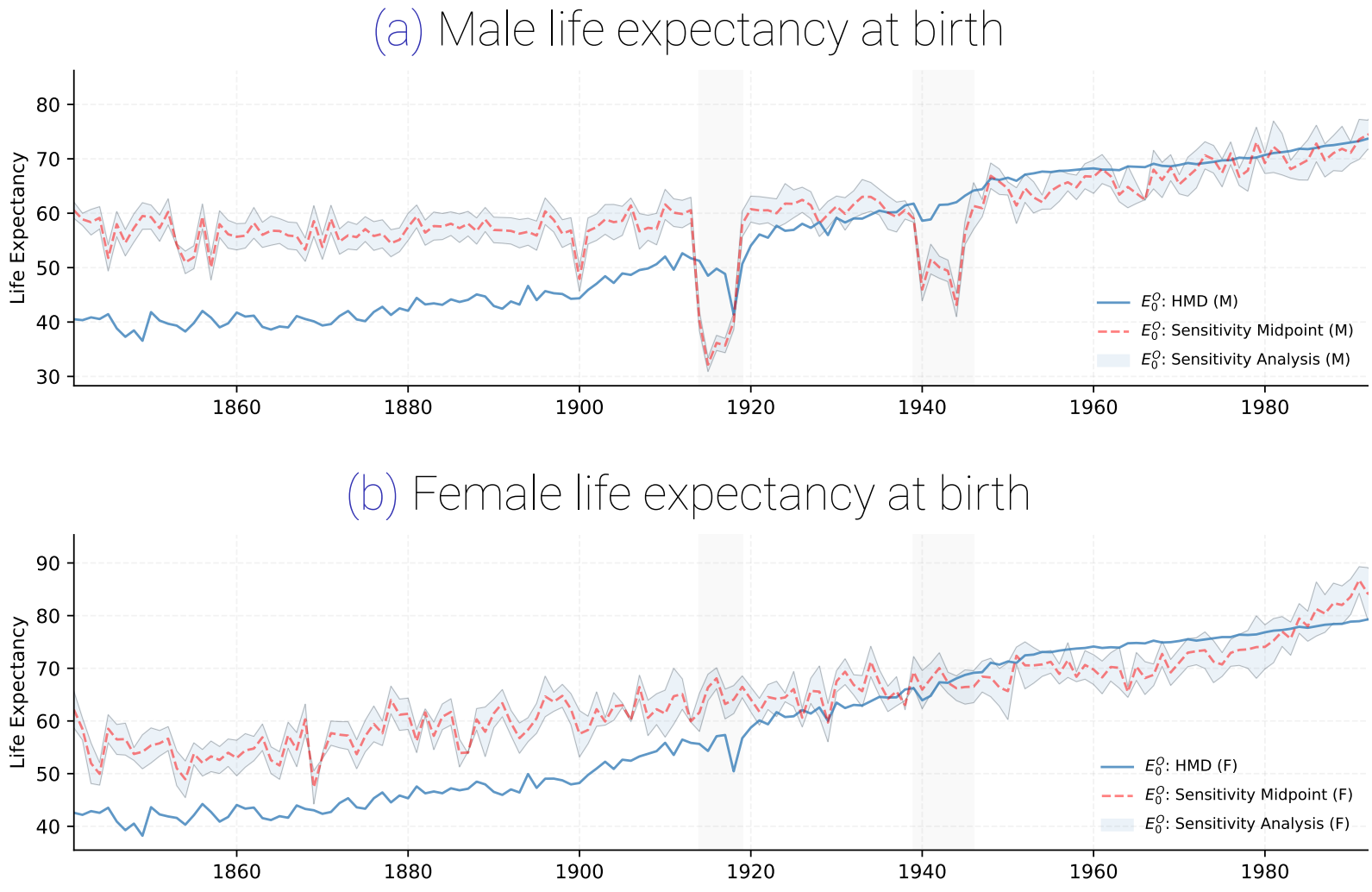


(e) Males, E_{50}



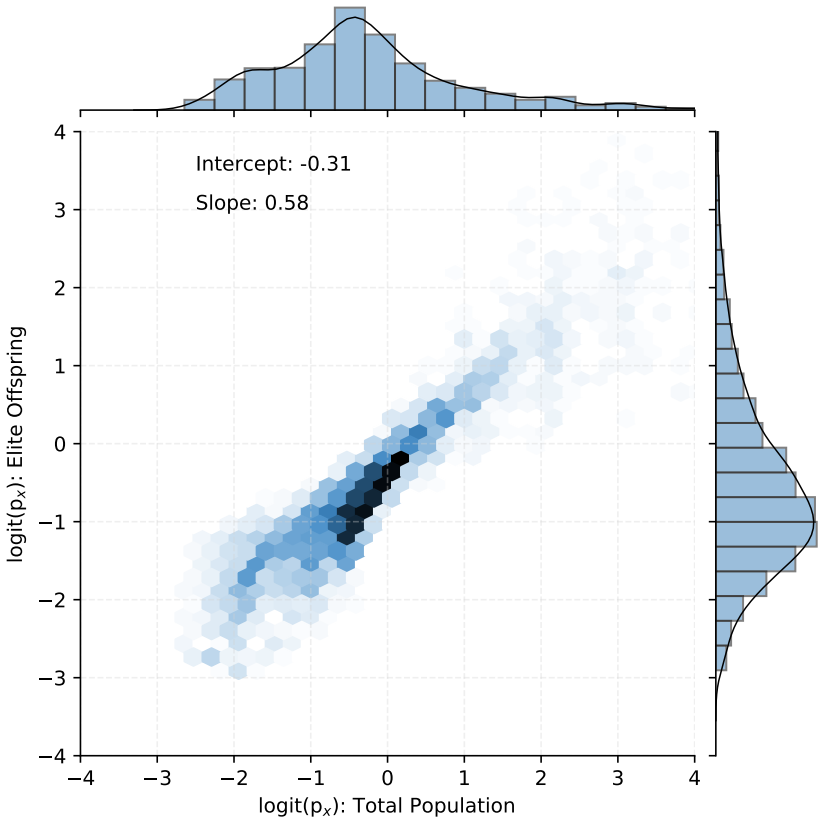
(f) Females, E_{50}

5x1 Lifetables with sensitivity bands

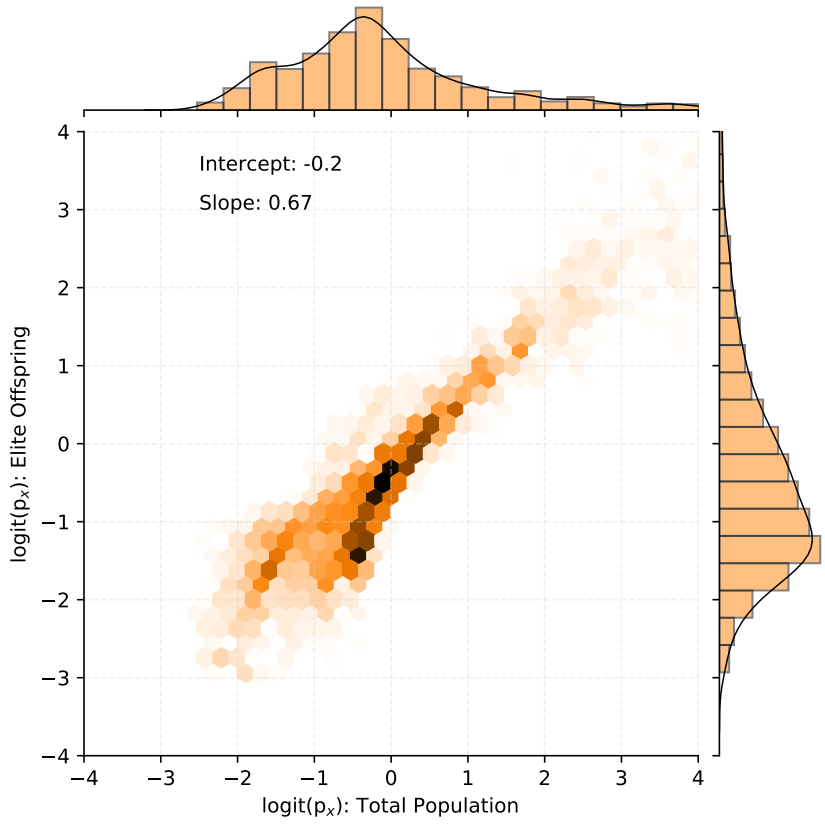


Logit Plots (5x10)

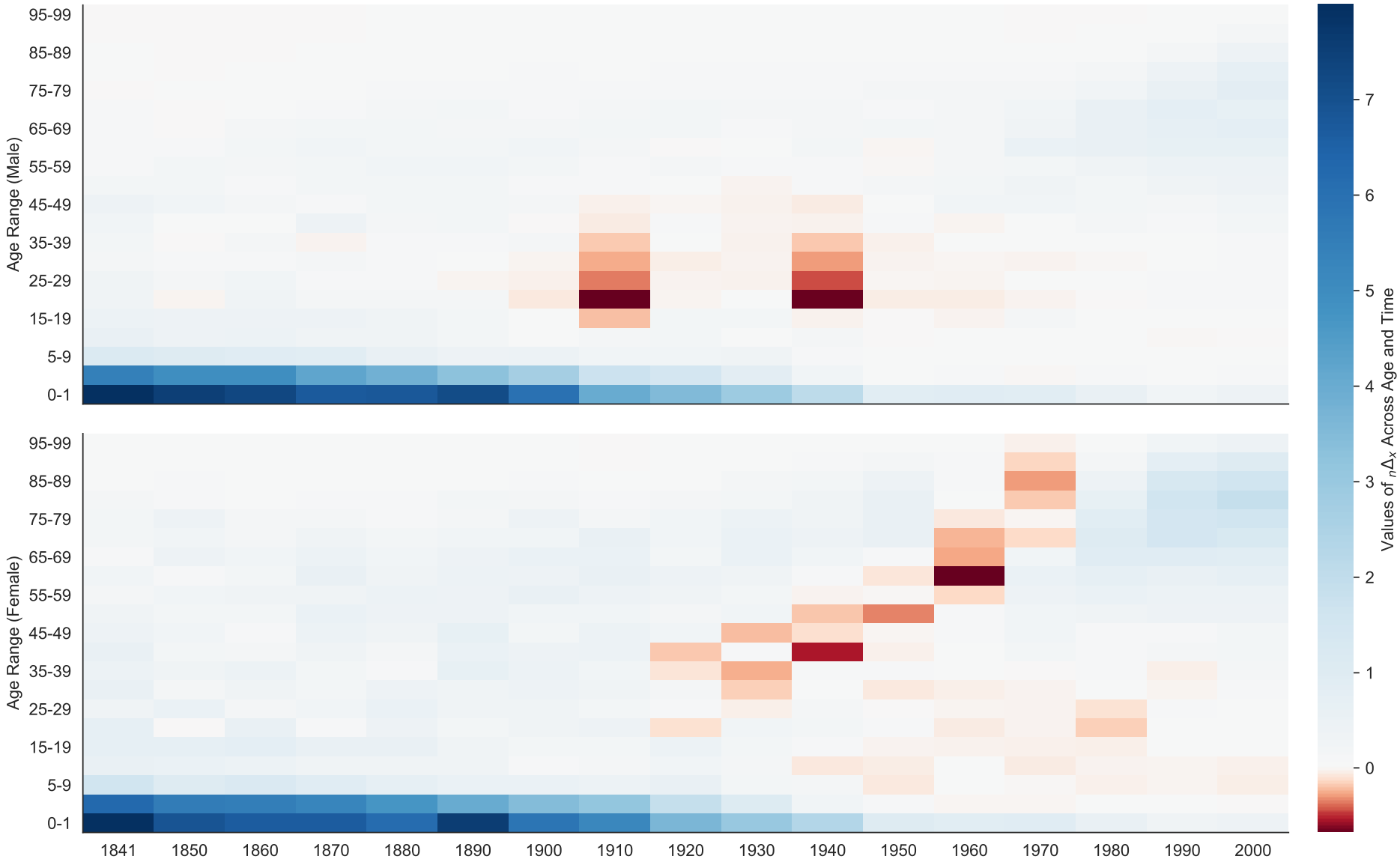
(a) Males



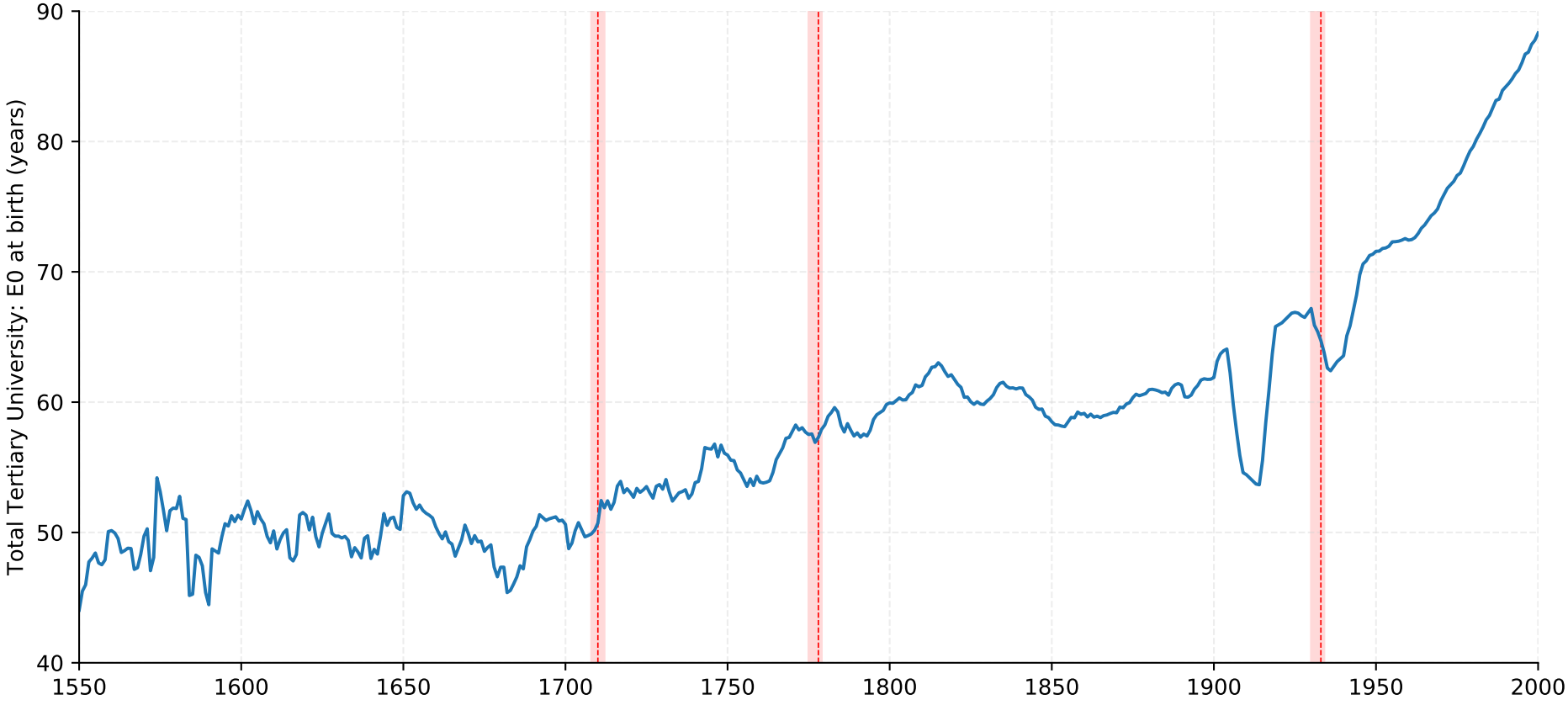
(b) Females



A granular heatmap based approach



Structural Break Tests



- Bai and Peron (2003) breakpoint tests, maximum of 5 breaks.
- Estimates three *endogenous* breakpoints: 1710, 1778 and 1933.

Conclusion: Key findings and future directions

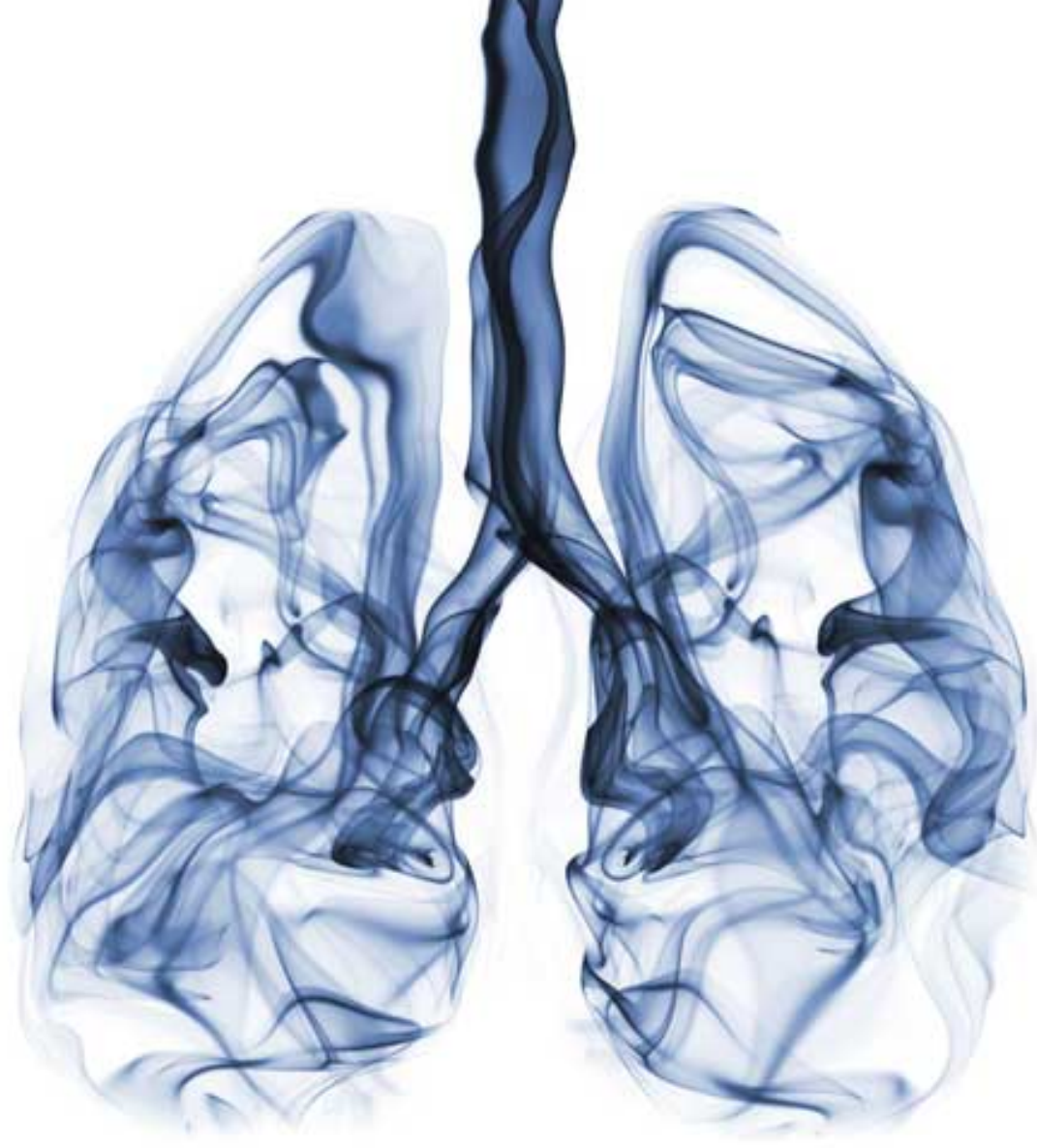
Our five key observations are:

- 1. Contest Peerage Paradox
- 2. Rise ahead of Ind Rev.
- 3. Contribution to wars.
- 4. Public health interventions.
- 5. Recent re-emergence.

In terms of future direction, we are:

- Looking at how we define the tertiary universe.
- Analyzing the effect of generational distance to an aristocrat.
- Compare Darrly's database with Hollingsworth's earlier work.

PUBLIC HEALTH IN A HIGH INFORMATION SETTING



The Legacy of Longevity

Persistent inequalities in UK life expectancy 1500-2016

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