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Gender convergence in human survival and the postponement of death

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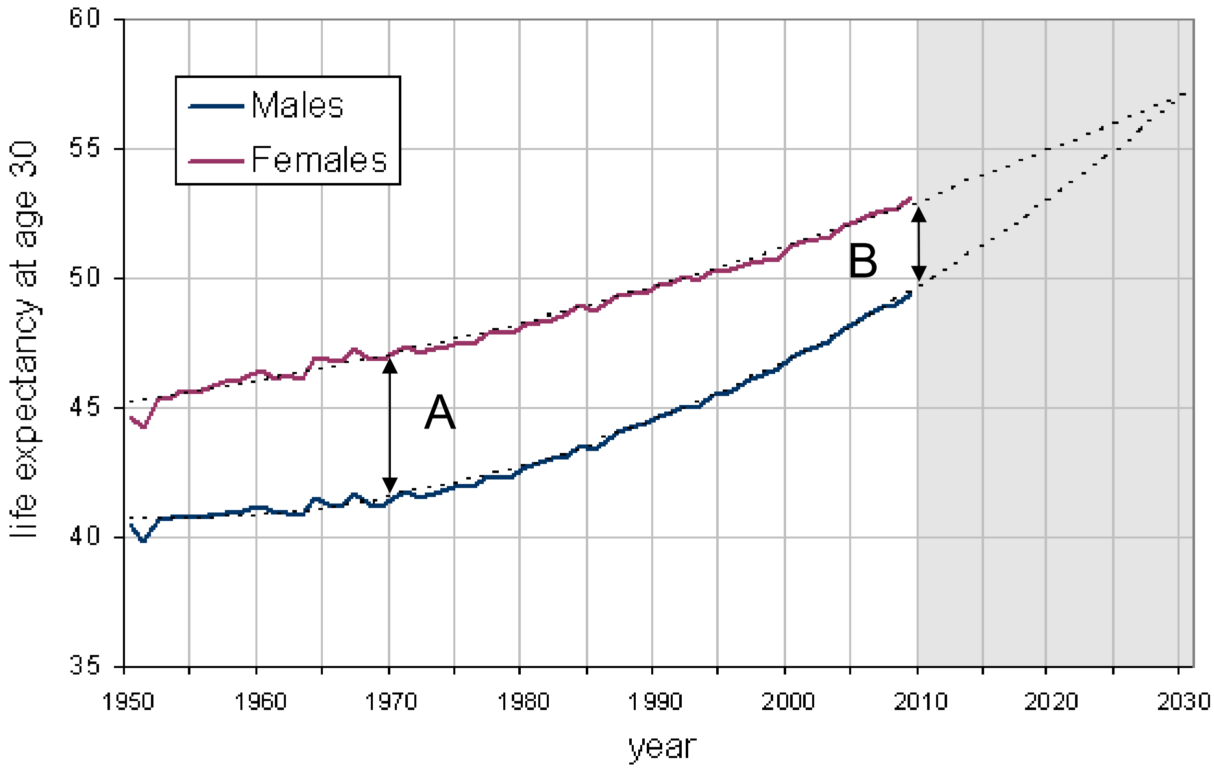
Gender convergence in human survival

- It is generally accepted that women live longer than men and people in general are living ever longer
- But are the improvements seen the same for both men and women?
- If death is being postponed which age groups are benefiting and are there gender differences?
- Can we identify reasons for the patterns observed and are they the same in each country?
- What are the social and other consequences

Life expectancy at age 30

- We concentrate on life expectancy for people aged thirty to remove the distortions of:
  - More boys than girls die in the first year of life which skews studies of life expectancy at birth
  - The male ‘mortality hump’ in early adult years caused by accidents and dangerous sports
- We find that tobacco consumption and related effects explain most of the gap
- Our main focus of results is on England and Wales but we cross-reference our findings with other countries
- A model is presented that quantifies convergence and provides forecasts of survivorship and death postponement

Life expectancy at age 30 in England and Wales– males and females



Long established trend with gap a maximum of 5.7 years in 1970 (A) compared with 3.8 years in 2009 (B). Trend lines suggest convergence in 2030 at 57.1 years

Comparative figures – four countries

	Life expectancy at 30 (yrs)	England and Wales	France	Japan	Sweden
A	Females 2009	53.2	55.1	57.9	55.1
	Males 2009	49.4	48.8	51.4	51.4
B	Gender gap (yrs)	3.8	6.3	6.5	3.7
	Gap as % of male life expectancy	*7.7*	*12.9*	*12.6*	*7.2*
	improvement relative to (C) (years)	-1.9	-1.2	0	-1.9
C	Maximum gender gap since 1950 (years)	5.7	7.5	6.7	5.6
	as % of male life expectancy	*13.3*	*16.4*	*13.3*	*10.9*
	year in which occurred	*1969*	*1987*	*2003*	*1983*
D	Minimum gender gap since 1900 (years)	2.5	2.6	3.1	0.5
	as % of male life expectancy	*7.1*	*7.2*	*7.8*	*1.3*
	year in which occurred	*1909*	*1903*	*1951*(1)	*1922*

Table 1: Comparative life expectancy at age thirty in selected countries by gender (source: HMD).(Note (1): Japanese data unavailable before 1947)

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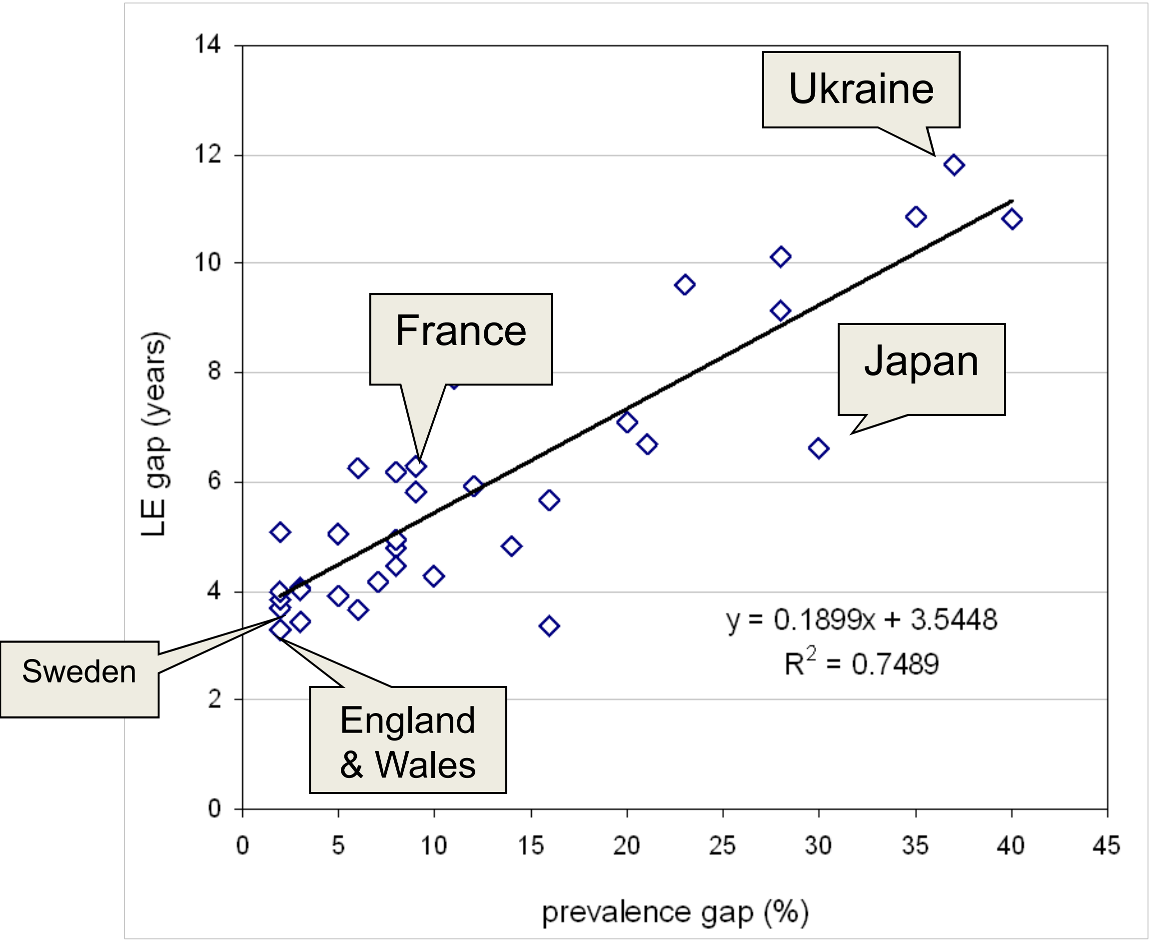
Relationship with smoking

- One in six of all deaths in E&W are smoking related - 60% of these men. Death takes form of COPD, heart disease and lung cancer
- In 1948, 82% of males smoked some form of tobacco, compared with 21% today. Female rates peaked at about 40% before declining to 20%
- Mortality rates depend on tobacco consumption, quitting rates and lifetime exposure. It is not inconsistent for mortality rates to continue rising whilst smoking prevalence is falling
- Death from Coronary heart disease (CHD) declining thanks to reductions in major risk factors, such as smoking, blood pressure and cholesterol.
- Effective treatments for heart disease such as coronary artery surgery, angioplasty, statins, and other medications
- Using data from 37 countries we found that the gender gap in life expectancy at age 30 was highly correlated with differences in smoking prevalence

Relationship between gap in life expectancy and gender difference in smoking prevalence



Sources: HMD and World Health Organisation Tobacco Free Initiative, 2011

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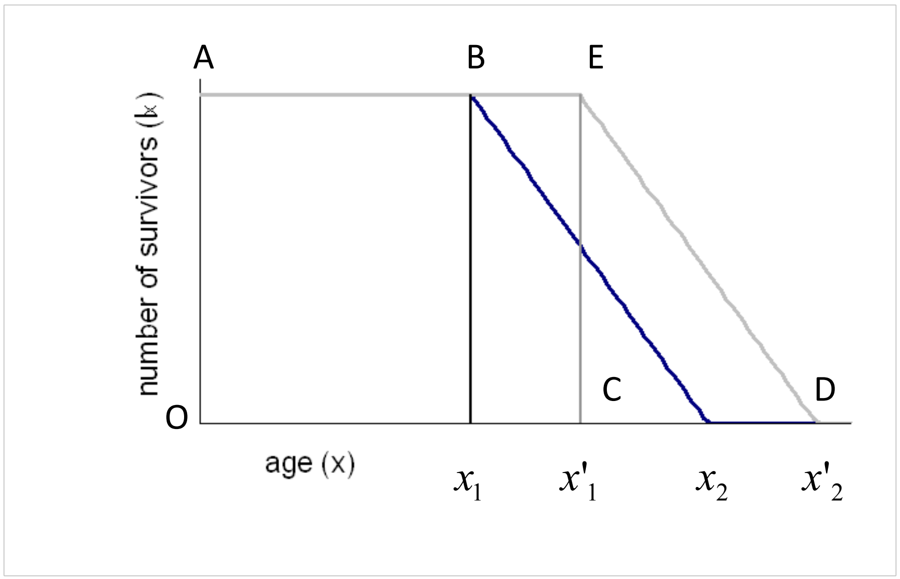
Swedish case

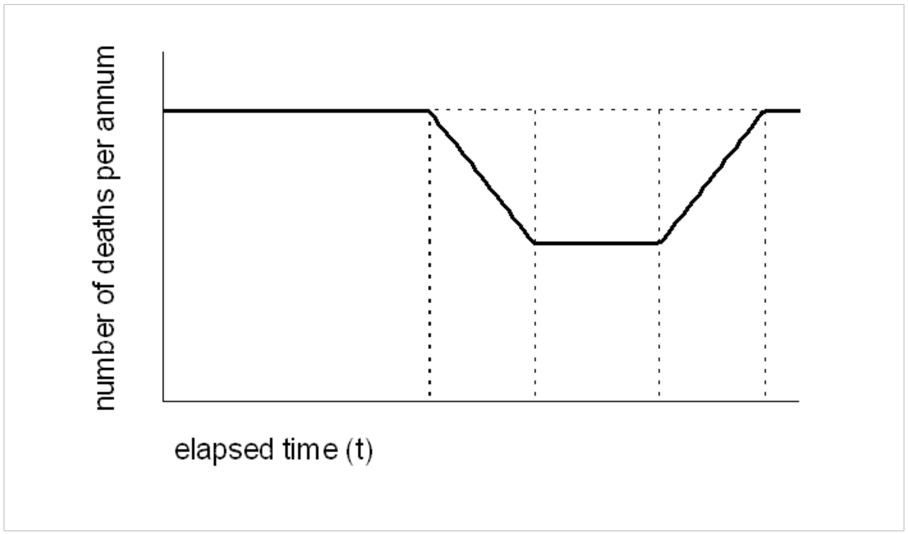
- Cigarette smoking in most European countries took off after the first world war and grew further in the second world war
- In Sweden tobacco was mainly consumed in the form of ‘snus’
- Sweden was neutral in both world wars and so fashion for cigarettes not established
- The gender gap fell over many decades and reached a low point of only 6 months in 1922

Can the gap be closed?

- A ceased smoker at age 30 can expect to live 10 years extra and at age 60 three years extra.
- If the remaining 20% of smokers ceased smoking then, crudely, this would add another two years to the life expectancy of the whole population
- Fewer people working in hazardous industry, fewer industrial or other accidents, increasing similarity in employment between genders and in other aspects
- Stubborn gaps remain, for example males lose more years living in deprived areas than females and so closure not guaranteed
- For this reason too early to say male life expectancy will converge with that of females but looks achievable

Simplified model of human survival





Simplified survival curve at two points in time

Change in pattern of deaths at either snapshot

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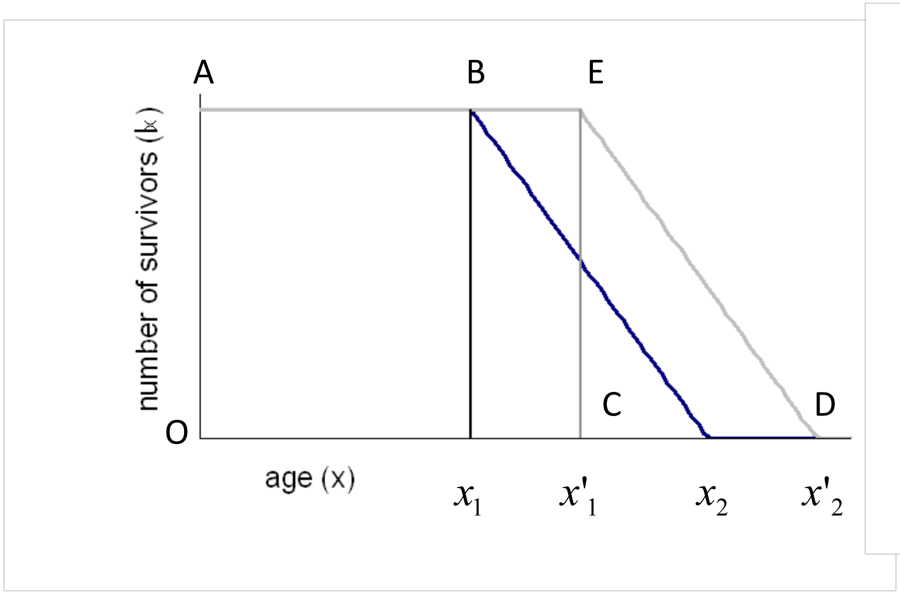
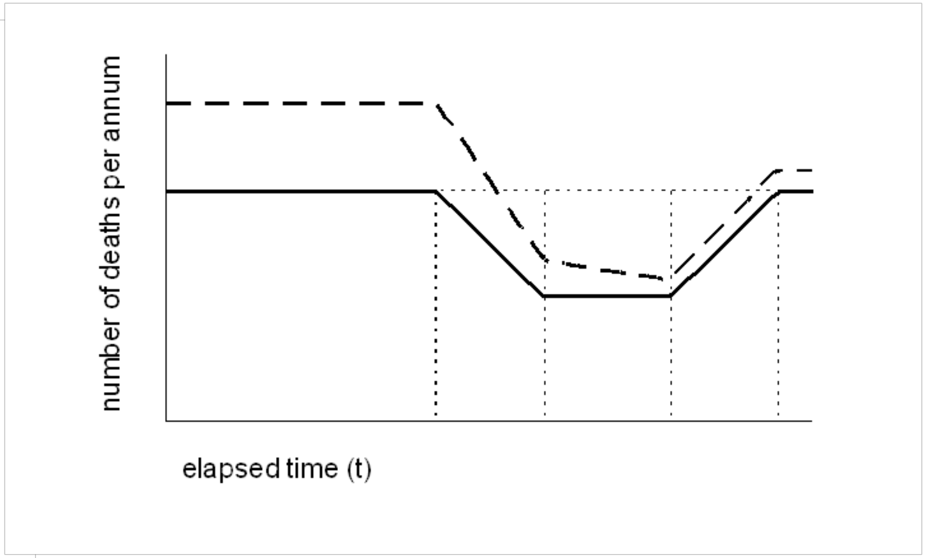
Simplified model of human survival





Simplified survival curve at two points in time

Change in pattern of deaths and mortality rate

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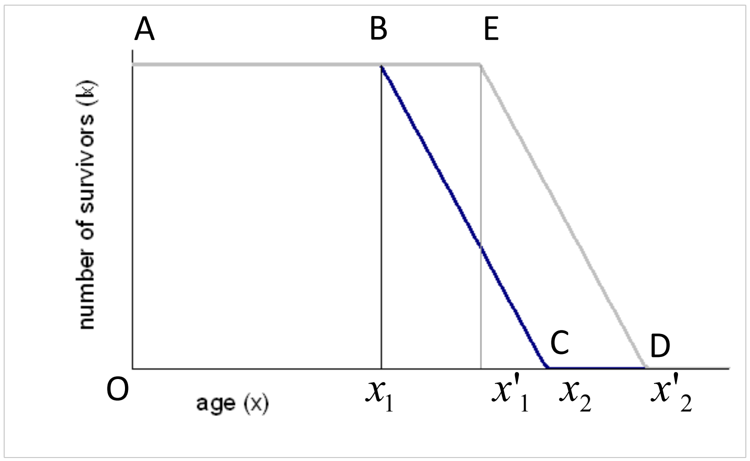
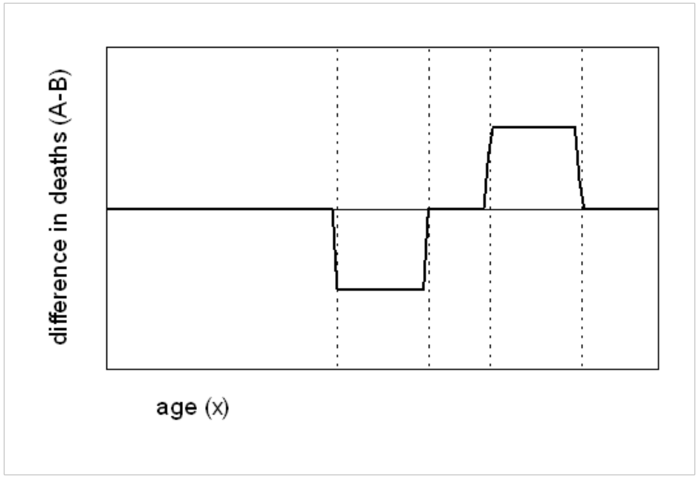
Simplified model of human survival



Simplified survival curve at two points in time



Change in pattern of deaths at either snapshot

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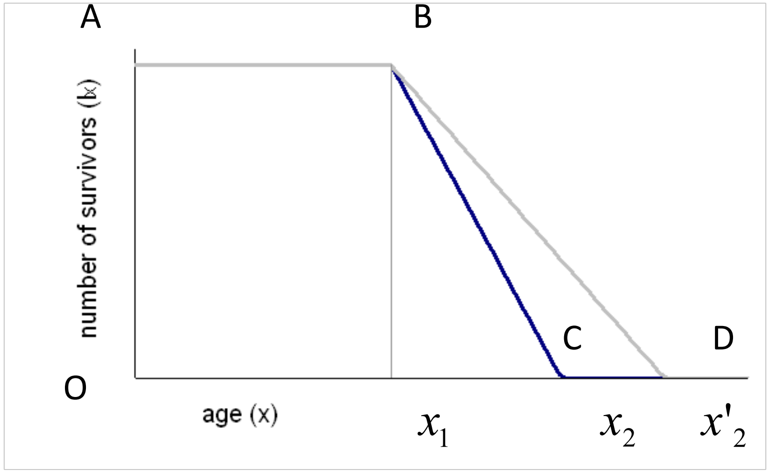
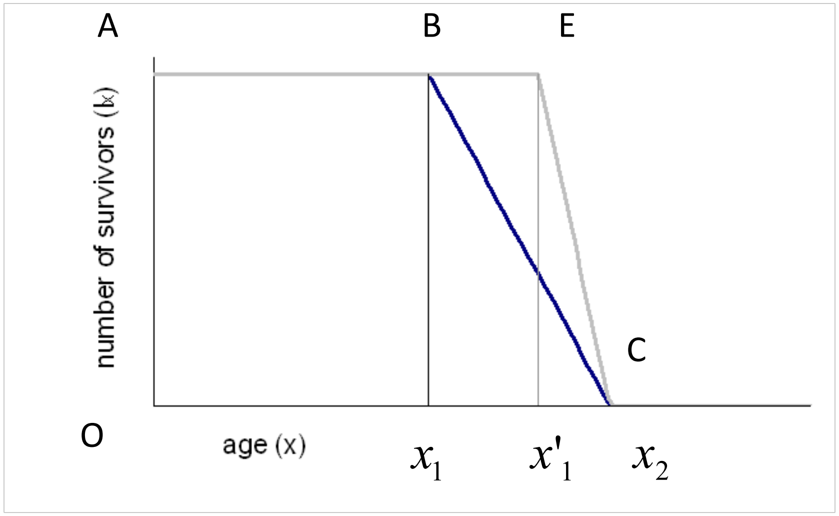
Other cases



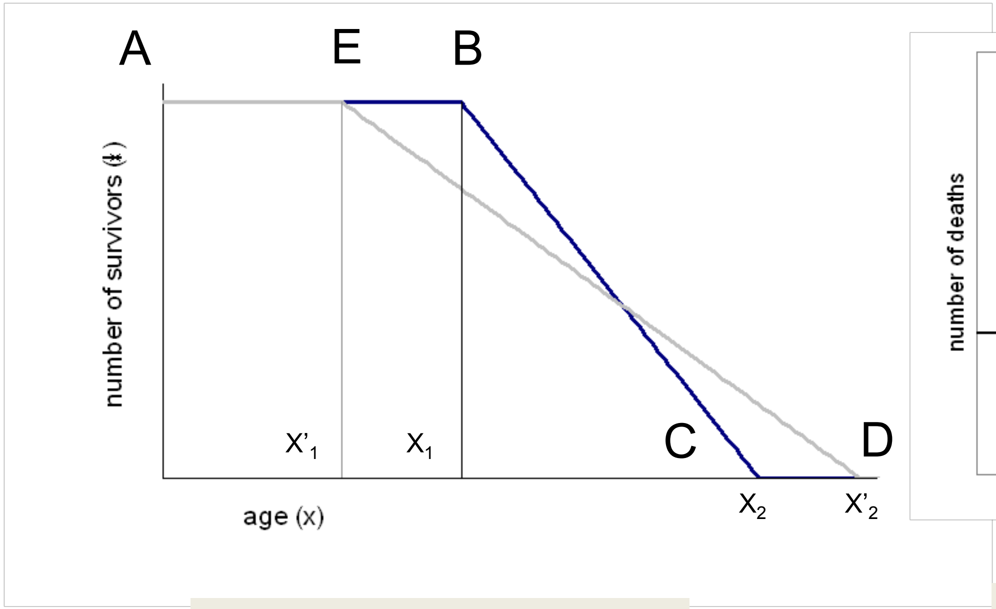


Divergent case

Convergent case

Regressive case

This regressive case occurs when x_1 falls and x_2 increases



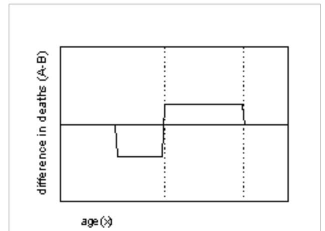
Regressive case

Change in pattern of deaths with double peak

Postponement of death

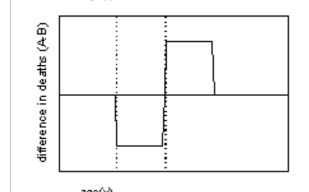
1. Divergent case:

$x_1' = x_1$ *and* $x_2' > x_2$



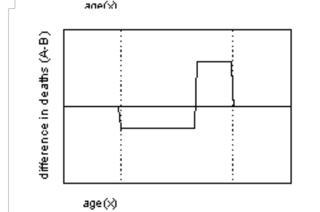
2. Parallel case:

$(x_1' - x_1) = (x_2' - x_2)$



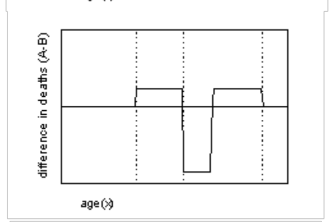
3. Convergent case:

$x_1' > x_1$ *and* $x_2' = x_2$



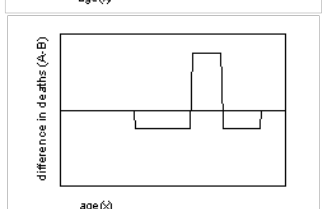
4. Regressive case (i)

$x_1' - x_{1,} < 0,\ \ x_2' - x_2 > 0,\ \ |x_1' - x_1| = |x_2' - x_2|$



5. Regressive case (ii)

$x_1' - x_{1,} > 0,\ \ x_2' - x_2 < 0,\ \ |x_1' - x_1| = |x_2' - x_2|$



<u>Definitions</u>

A. Trough - age at the lowest point in wave

B. Peak - age at the highest part of wave

C. Trough to peak age range - B minus A (years)

D. Pivot age - age at which difference in deaths is zero

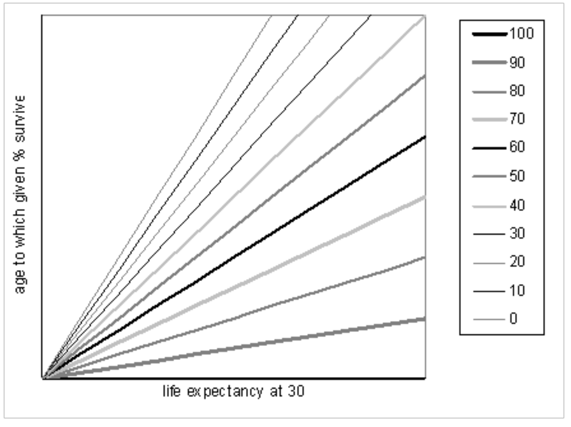
E. Pivot to peak - B minus D (years)

F. Trough to pivot- D minus A (years)

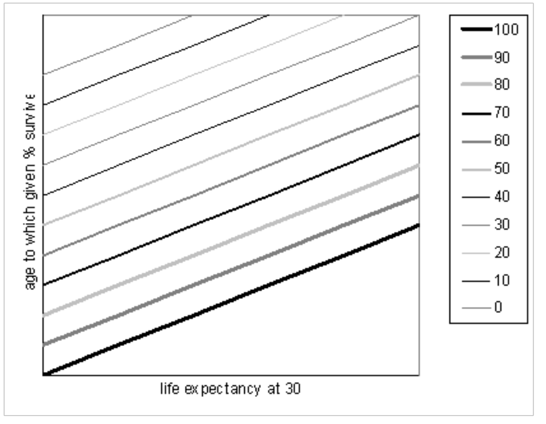
G. Amplitude below zero- difference in deaths at trough age

H. Amplitude at peak - difference in deaths at peak age

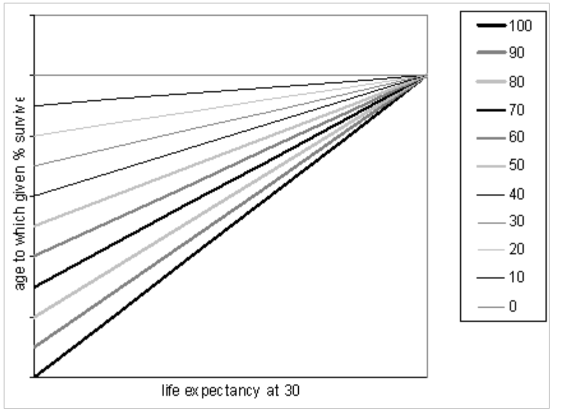
Survivorship patterns



Divergent case



Parallel case



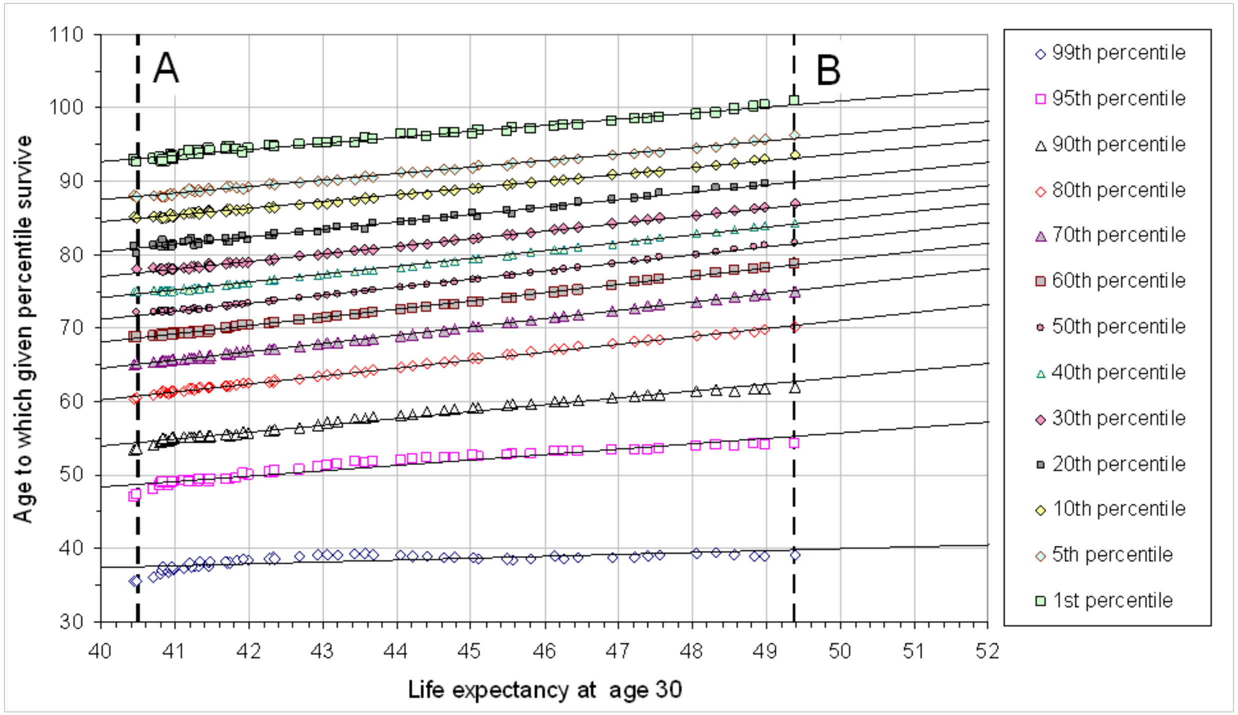
Convergent case

Theoretical model variants showing percentiles of population surviving to any given age as a function of life expectancy

Steps in our analysis

- Estimate and predict human survivorship using patterns in life tables
- Fit survival curves
- Derive future life tables based on trends in the above
- Produce results

Obtaining survival function at different points in time



We regress age to which each percentile lives on life expectancy at age 30 (1950 to 2009). We project the regression forward and extract data points. We then fit Gompertz-Makeham equation and extract projected survival curve

Gompertz-Makeham function

$$\mu_x = A + Be^{\gamma x} \quad \text{where } \gamma = \ln(c)$$

force of mortality

$$S(x) = \exp\left\{-\int_a^x \mu_s ds\right\}$$

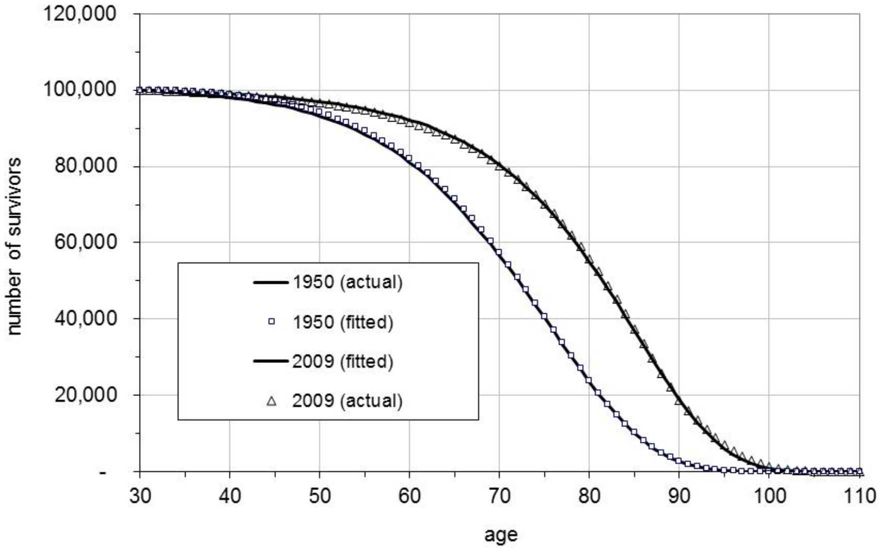
survival function

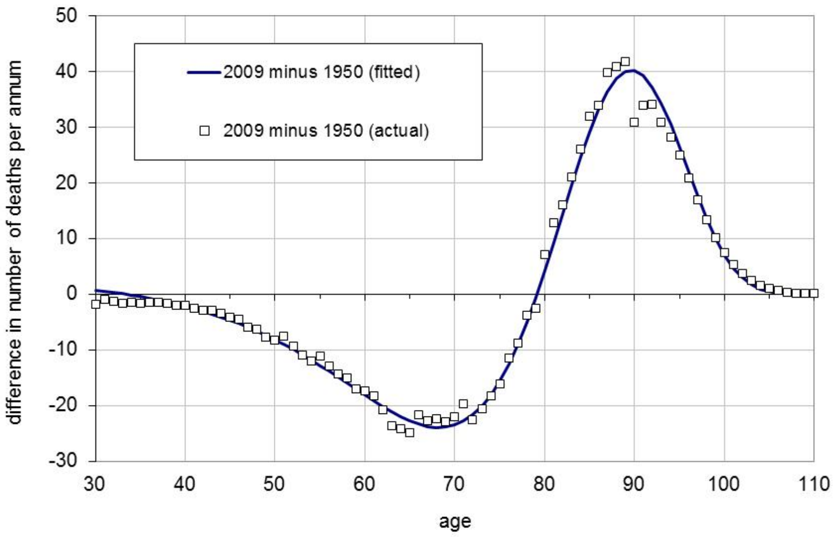
$$\hat{S}(x) = \exp\left[A(a-x) + \frac{B(e^{\gamma a} - e^{\gamma x})}{\gamma}\right]$$

Empirical function

A,B and c are unknowns which are determined by heuristic optimisation algorithm from the previous survival analysis

1950 to 2009 – fitted survival and death postponement





The example to the left is based on males in 1950 and 2009. The chart to the right shows the difference in deaths with age based on 100,000 lives. Actual data points and fitted curves shown.

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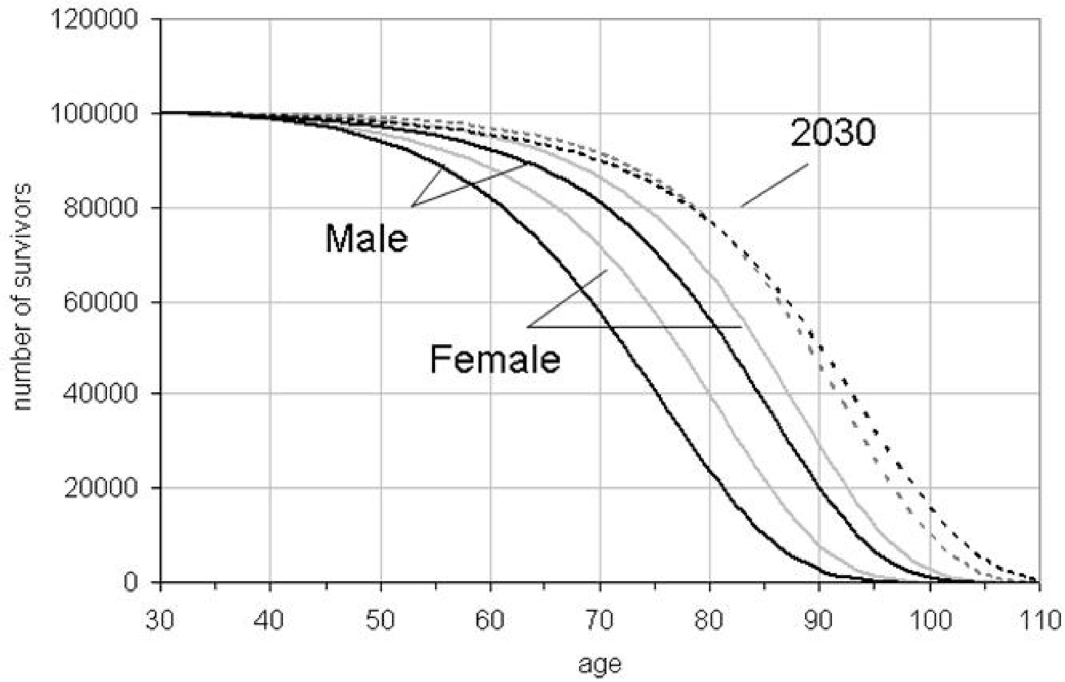
Trends in survival based on projected improvements in life expectancy



When we project survival forward the gap that is evident in 1950 is noticeably smaller by 2009 and almost vanishes by 2030

Remaining differences to 2030

(a) Males

year	mode	mean	standard deviation	median	IQR
1950	75	70.4	11.9	71	17
1960	75	70.5	11.9	71	16
1970	76	71.1	11.9	72	16
1980	77	72.3	11.9	73	16
1990	79	74.0	12.0	75	16
2000	82	76.2	12.2	78	15
2010	85	79.2	12.5	81	16
2020	89	82.6	12.8	84	15
2030	93	87.0	13.5	89	16

(b) Females

year	mode	mean	standard deviation	median	IQR
1950	80	74.7	12.3	76	16
1960	81	75.4	12.2	77	16
1970	82	76.4	12.2	78	16
1980	83	77.7	12.2	79	15
1990	85	79.1	12.1	81	15
2000	86	80.6	12.0	82	15
2010	88	82.1	11.9	84	15
2020	90	84.3	11.9	86	14
2030	92	86.5	11.9	88	15

Table 7(a) and (b): Modal age of death, mean and standard deviation, median and inter-quartile range (IQR) for each year by gender

- Mean, modal and median ages of age of death by gender converge with time
- By 2030 males marginally higher values but standard deviation and IQR based on age of death slightly greater

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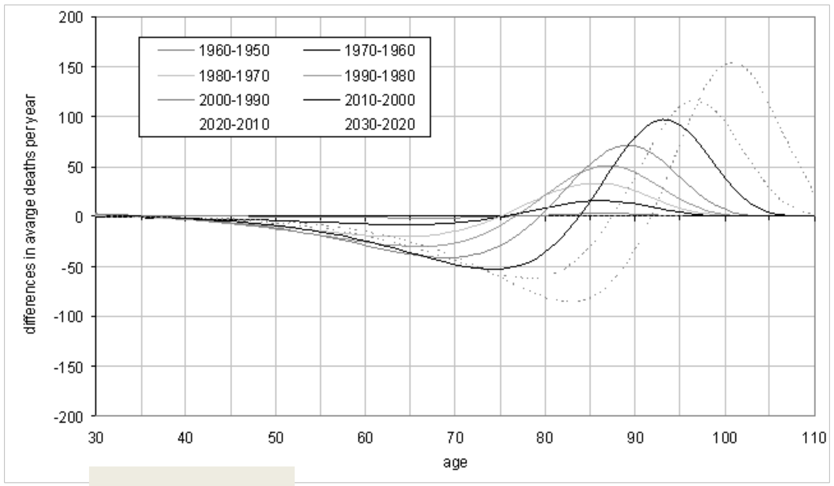
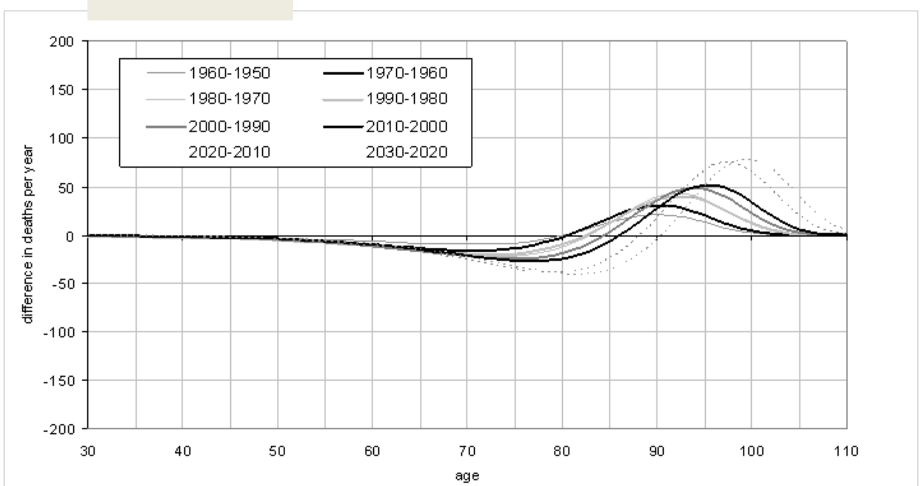
Characteristic waves showing postponement of death at 10 year intervals

males



females



Wave amplitude increasingly higher among males showing more and more deaths being postponed each decade

Greater shift in pivot age between decades in males compared with females (77 to 92 compared with 80 to 90)

Pace of change among females has been far more gradual but life expectancy started from a higher base

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Summary

- Smoking rather than genetic differences are a more important cause of differences in life expectancy at age 30
- At least 30m life-years lost as a result of smoking in England and Wales since 1950
- With reduction in smoking prevalence, gender differences are reducing as males catch up with females
- The savings to the health economy are significant: If smoking ceased HLE would increase by ~ two years. To achieve same by spending more on health care would cost ~£50bn a year
- Females start from a higher base and so progress slower. However, full convergence not guaranteed and nor what happens thereafter
- In countries where smoking prevalence is high and large differences between males and females, expect shorter lives and large gender differences (e.g. east Europe, middle-east, China, India)

Other considerations

- The emancipation of women may have led to life expectancy improving at a slower rate (e.g. due to adoption of some male habits such as alcohol consumption and the slower decline in smoking)
- Gender equality in life expectancy has significant implications for social policy and pensions, especially if fewer years spent living alone at end of life. It should be easier for insurers to set unisex annuity rates and help make more sense of sex equality legislation when it comes to pension age
- Smoking cessation services could be more effective than they are: people tend to seek help when the damage has been done. Particular problems in some segments of society
- However, threats to convergence taking place are persistent health inequalities, prolonged economic austerity, other social phenomena such as the rise in obesity

Some references

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