Cause of Death Mortality: International Trends by Socio-Economic Group

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Outline

- Motivation and long term goals
- Data
- Comparison of US, Denmark and England
- England: deeper dive

Purpose of looking at cause of death data

- What are the key drivers of all-cause mortality?
- How are the key drivers changing over time?
- Which causes of death have high levels of inequality:
  - by education;
  - by affluence?
- Can we point to specific causes of death as responsible for *growing inequality*?
- Leading to: insight into mortality underpinning life insurance and pensions

Drivers

- Medical advances
- Health spending
- Public health initiatives
- Individual risk factors:
  - Controllable

    e.g. smoking, diet, exercise, alcohol, sun, drugs, hygeine, risky sex, stress, environment...

    leading to cohort effects
  - Not (easily) controllable

    e.g. genetic, affluence, education, character/personality traits, ...

Socio-economic datasets

Cause of death data for:

- US (males and females)
  - by education level: low ($\leq$ high school); high
- Denmark (males only):
  - by education level: low; medium; high (cohorts $>$ 1920 only)
  - by individual affluence: 10 deciles
- England (males and females)
  - by small area *income deprivation*: 10 deciles
  - by region: 9 areas

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Cause of Death Groupings

US1.1	Infectious diseases excl. HIV/AIDS	US 1.2	HIV/AIDS
1	Infectious diseases	2	Cancer: mouth, gullet, stomach
3	Cancer: gut, rectum	4.1	Cancer: larynx
4.2	Cancer: trachea	4.3	Cancer: lung, bronchus
5	Cancer: breast	6.1	Cancer: uterus, cervix
6.2	Cancer: ovary	6.3	Cancer: other female genital
7.1	Cancer: prostate, testicular	7.2	Cancer: other male genital
8	Cancer: skin, bones and certain organs	9	Cancer: lymphatic
10	Benign tumours	11	Diseases: blood
12	Diabetes	13	Mental illness
14.1	Diseases of nervous system excl. Alzh.	14.2	Alzheimers
15	Blood pressure + rheumatic fever	16	Ischaemic heart diseases
17	Other heart diseases	18	Diseases: cerebrovascular
19	Diseases: circulatory	20	Diseases: lungs, breathing
21	Diseases: digestive (excl. alcohol: 27)	22	Diseases: urine, kidney,...
23	Diseases: skin, bone, tissue	24(DU)	Senility without mental illness
25	Road/other accidents	26	Other causes
27	Alcohol $\rightarrow$ liver disease	28	Suicide
29	Accidental Poisonings		

Detail $\Rightarrow$ able to separate causes with and without significant risk factors or inequality

Data – Other Details

- US (Cristian Redondo – Session: Mortality Modelling 5)
  - Deaths subdivided into 30 CoD groups
  - Single ages 40-89 and *born between 1914 and 1970*
  - Single years 1989-2015
- Denmark (Carsten Rosenskjold)
  - 29 CoD groups
  - Age groups 31-35, 36-40, ..., 91-95
  - Five-year blocks 1985-89, 1990-94, 1995-99, 2000-2004, 2005-2009
- England
  - 34 CoD groups
  - Age groups 20-24, 25-29, ..., 85-89
  - Single years 2001-2016

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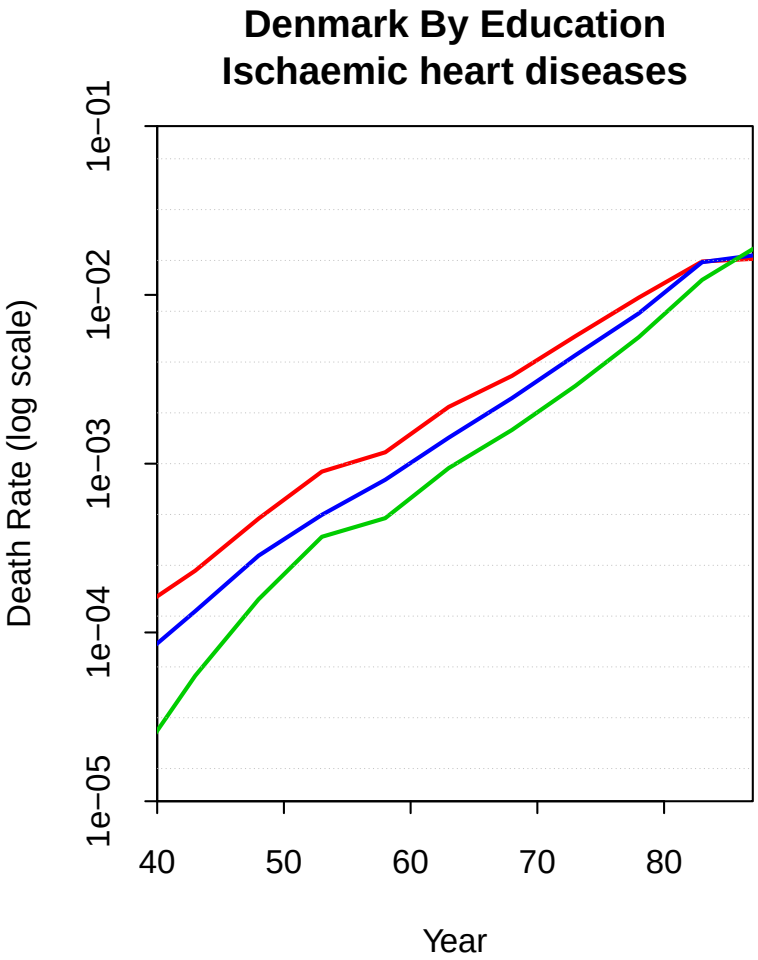
Denmark – Affluence – Top 10 CoD

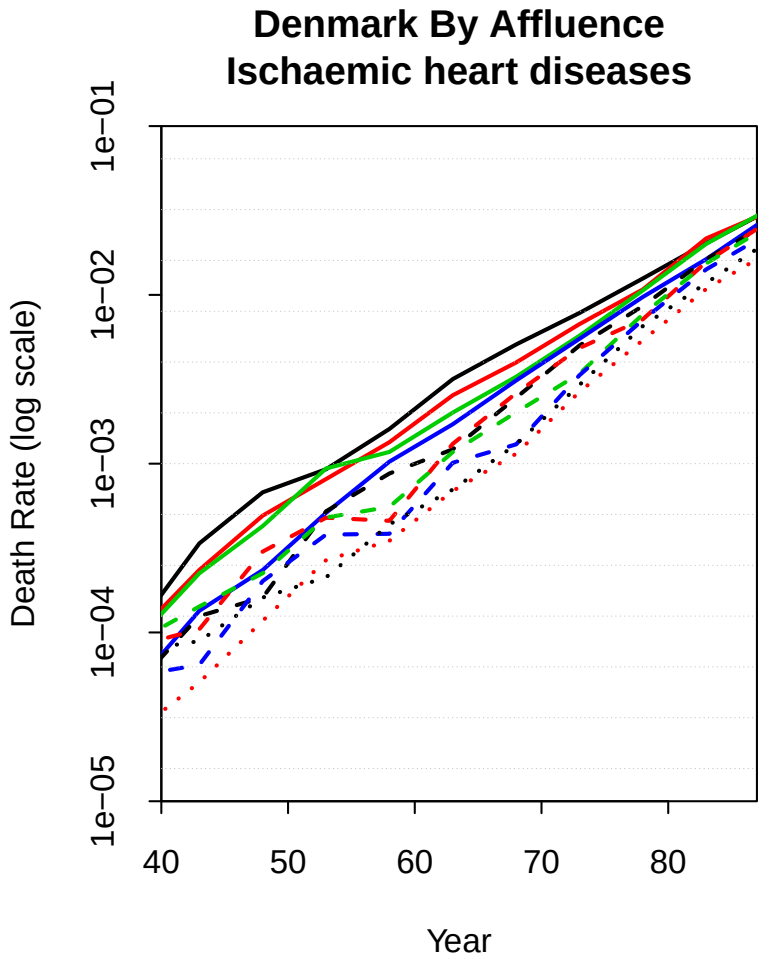
Males; Ages 71-75; Years 2005-2009

Rank	Least Affluent	Most Affluent
1	Ischaemic heart	Skin & organ cancer
2	Respiratory	Ischaemic heart
3	Lung cancer etc.	Prostate cancer
4	Skin & organ cancer	Respiratory
5	Other	Lung cancer etc.
6	Cerebrovascular	Cerebrovascular
7	Other heart	Other
8	Diabetes	Gut cancer
9	Gut cancer	Other heart
10	Prostate cancer	Alzheimers etc.

Prostate: almost no inequality.
Causes of death with significant controllable risk factors feature much more heavily amongst the least affluent.

Denmark: Cause of Death Data 2005-2009



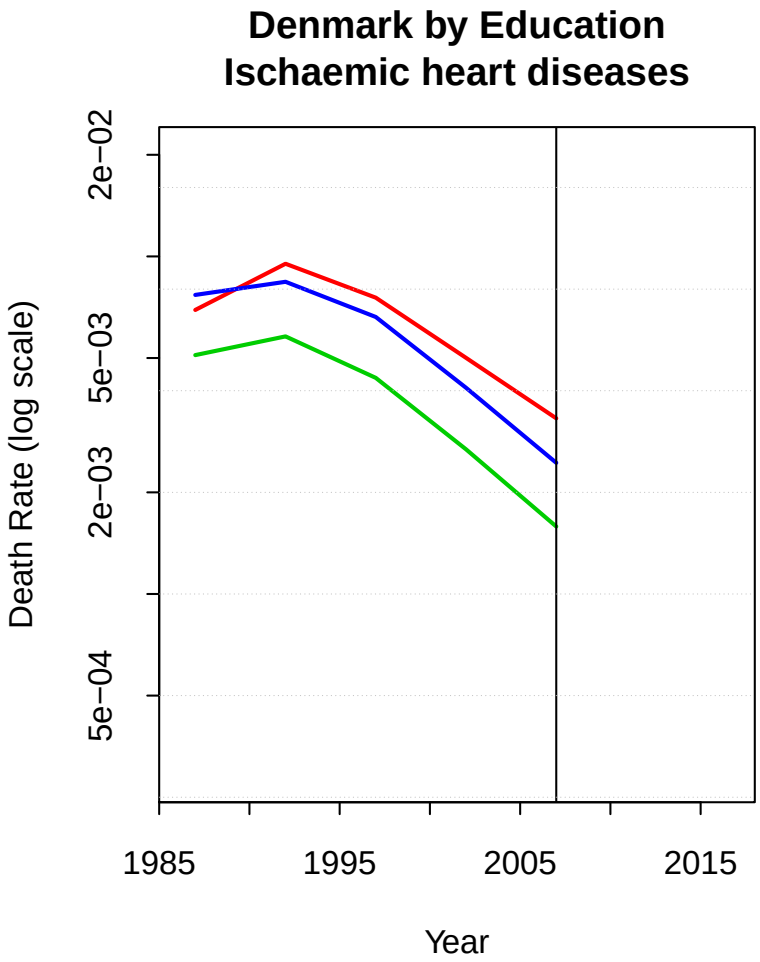


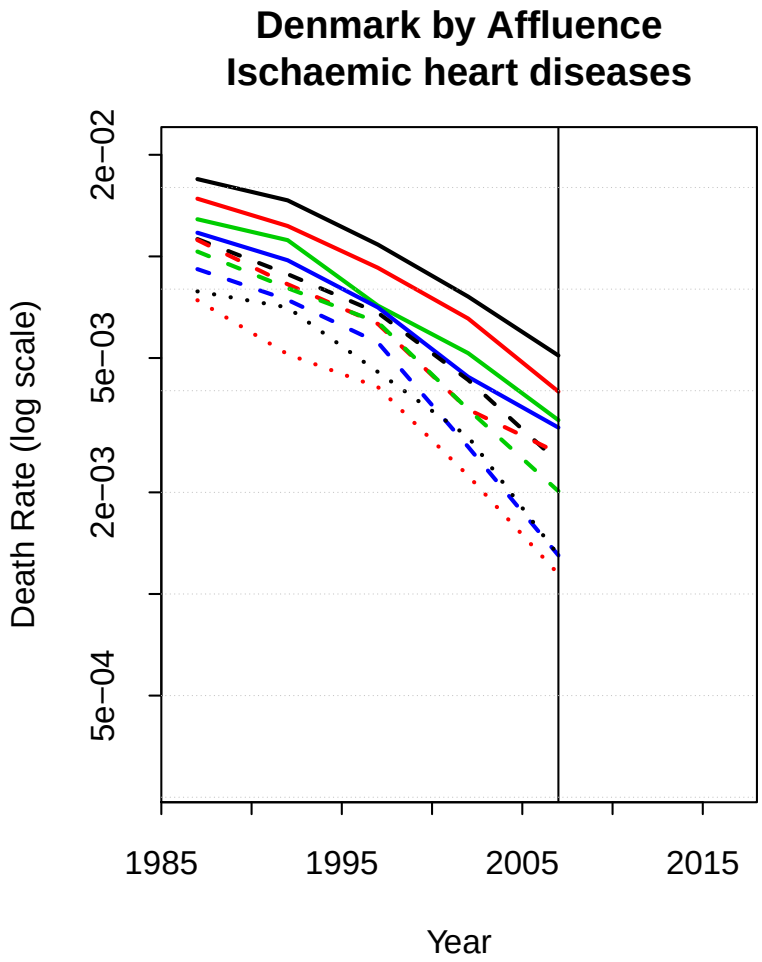
Wide gap

Affluence has a wider gap than education

Gap narrows with age

Denmark: Cause of Death Data, Age Group 66-70



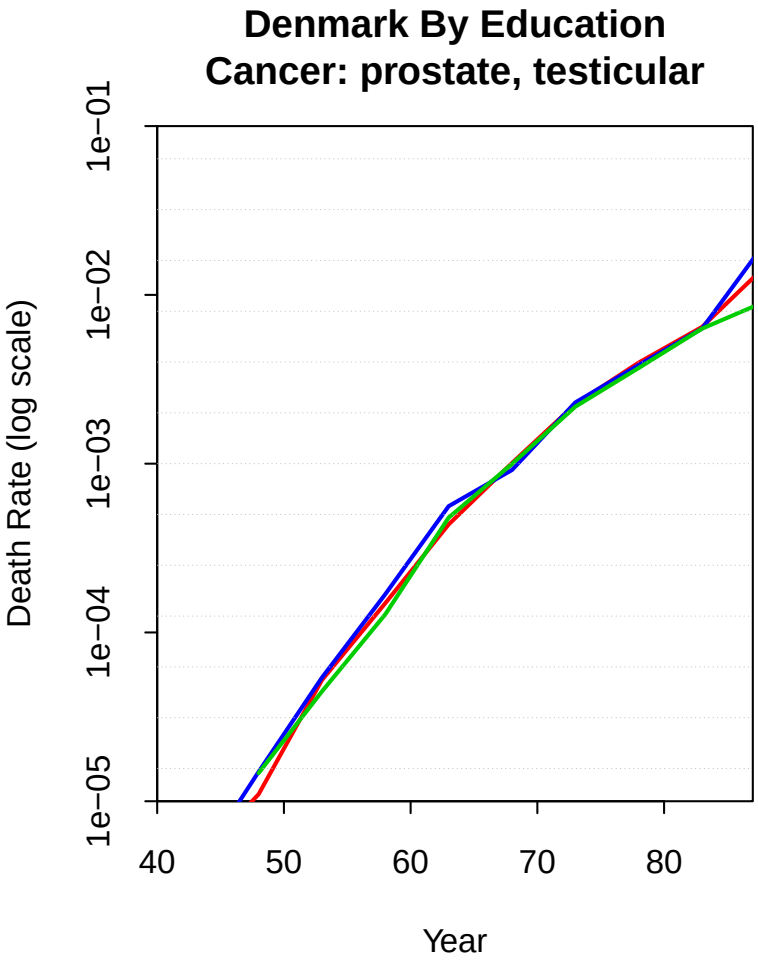


Gap widens over time

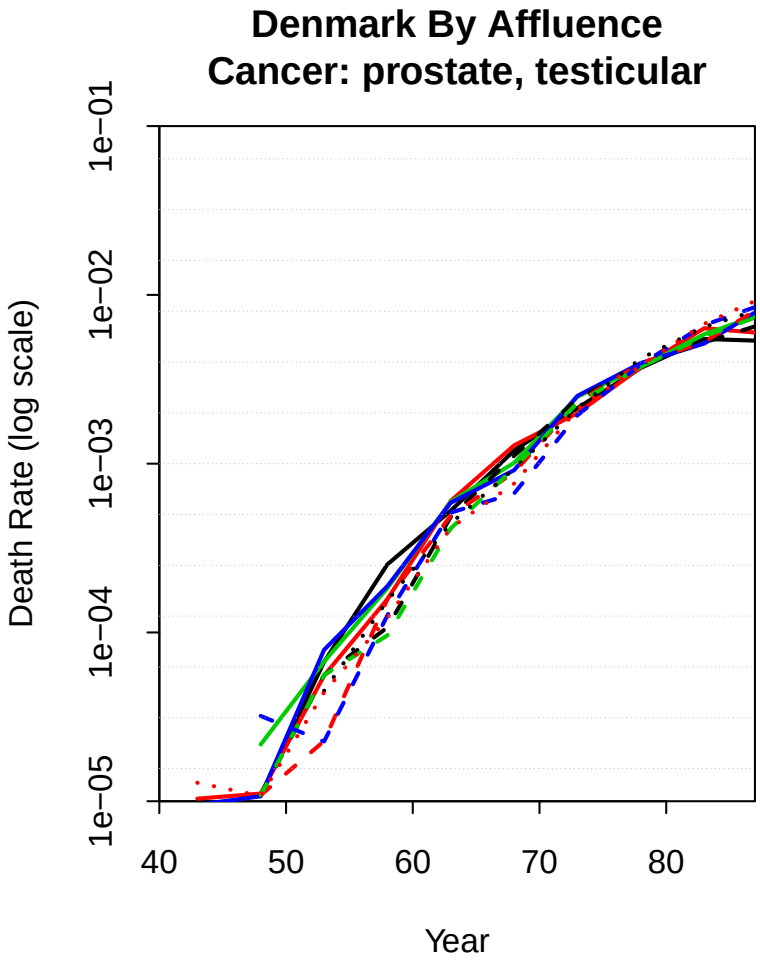
Impact of Controllable Risk Factors

- Risk factors (controllable and not controllable)
  $\Rightarrow$
  Impact on cause of death rates
- Some risk factors $\Rightarrow$ big impact on some causes
  e.g. smoking $\longrightarrow$ lung cancer
  e.g. several risk factors $\longrightarrow$ ischaemic heart disease
  $\Rightarrow$ significant inequality gaps
- Some causes of death:
  no known (significant) controllable risk factors
  e.g. prostate cancer

Denmark: Cause of Death Data 2005-2009

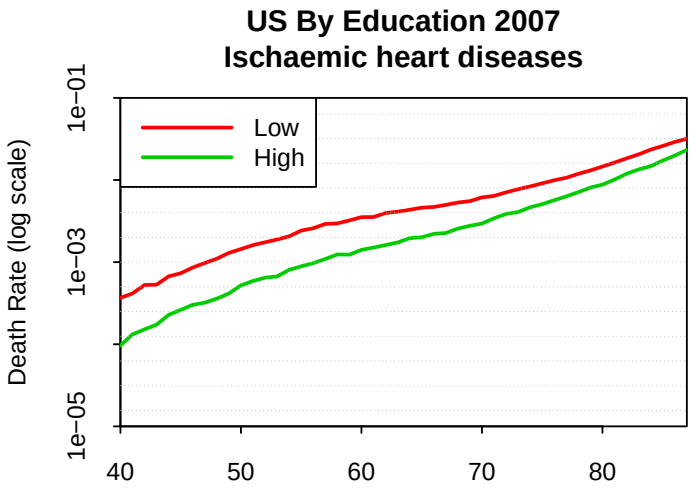


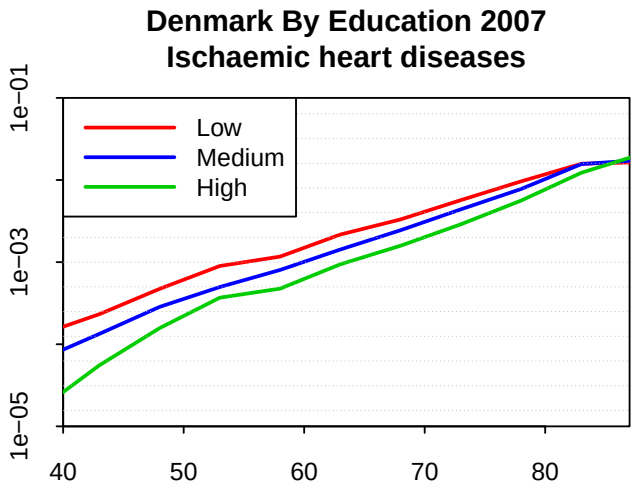
Education: no differences

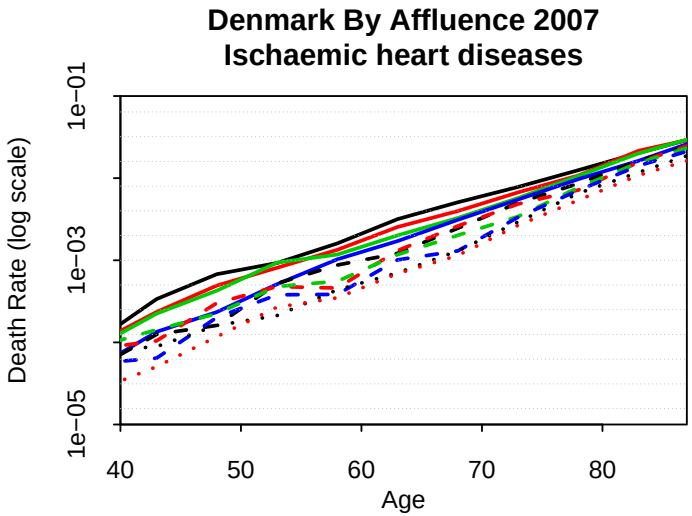


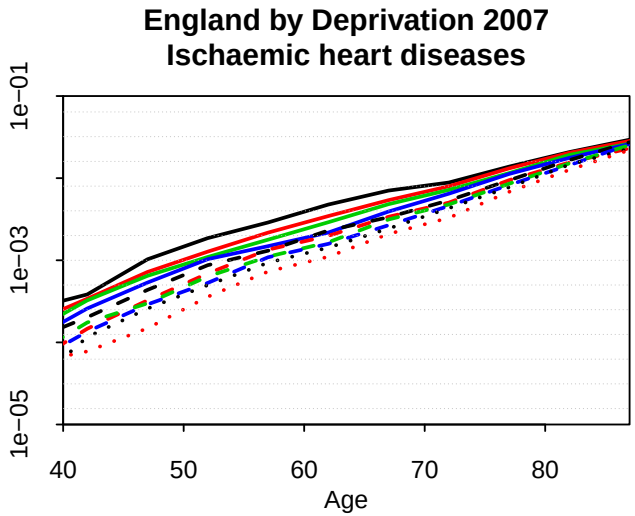
Affluence: small differences

Multi-Country: Year 2007, Males, Ischaemic Heart Disease





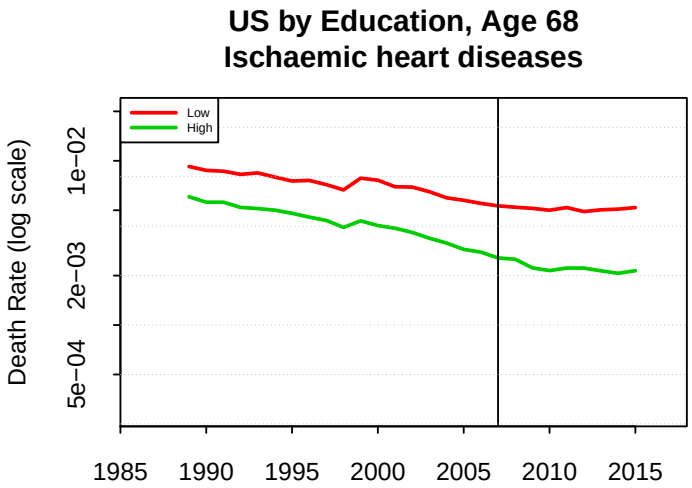


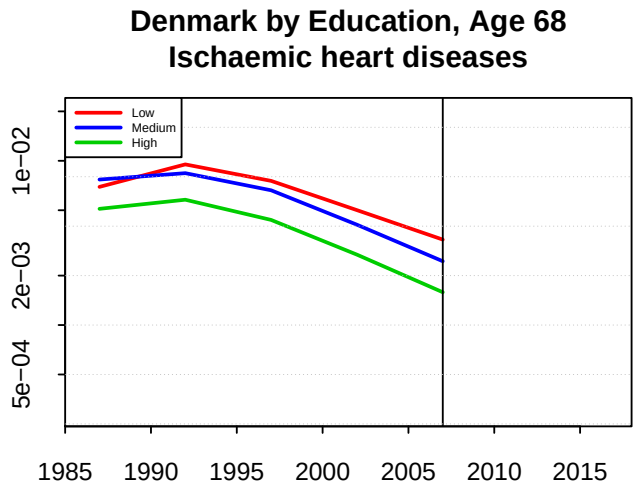


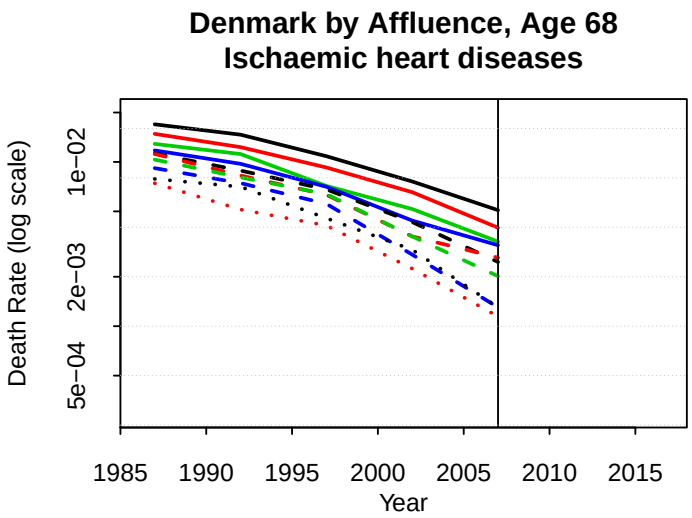
US: wider than Denmark

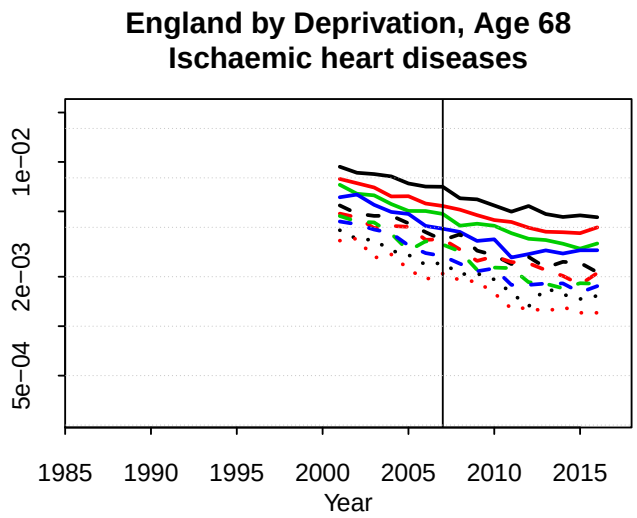
England similar to Denmark but higher

Multi-Country: Age 68, Males, Ischaemic Heart Disease



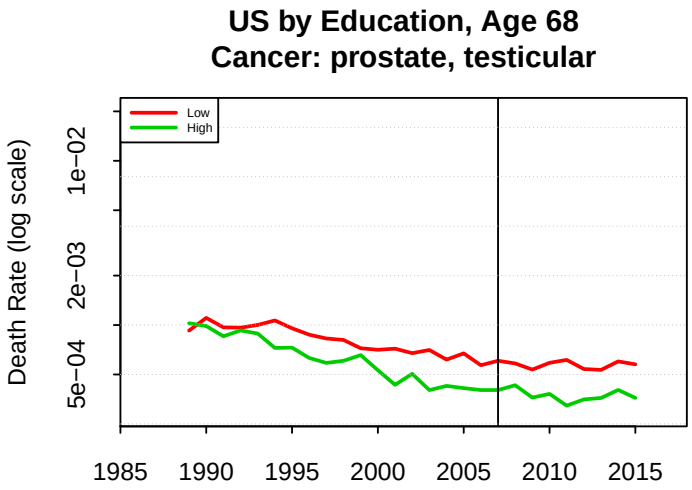


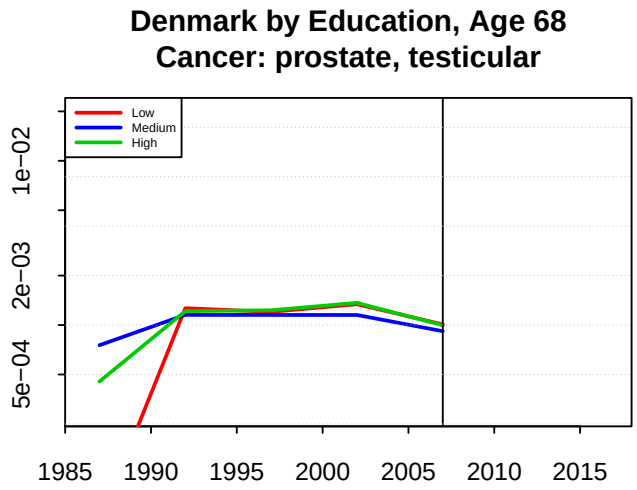


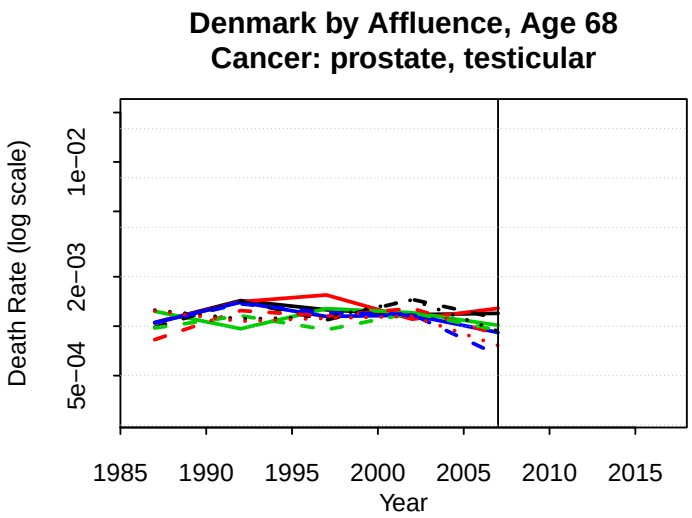


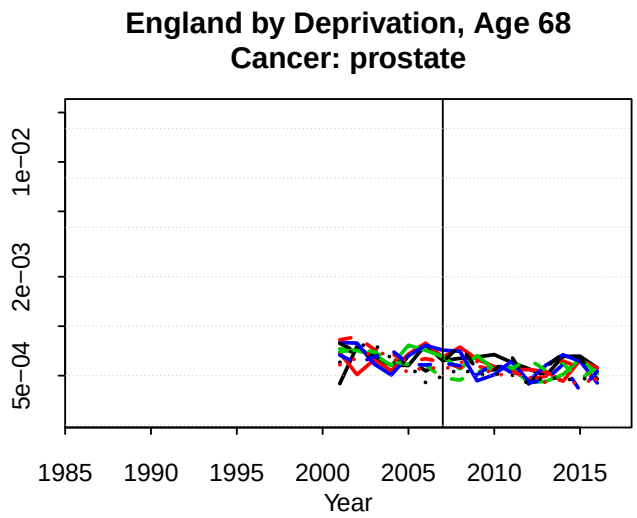
Significant improvements, but not throughout

Multi-Country: Age 68, Males, Prostate Cancer



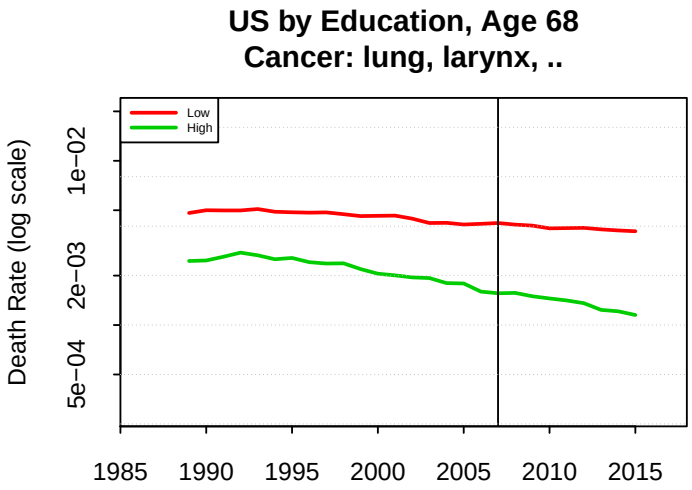


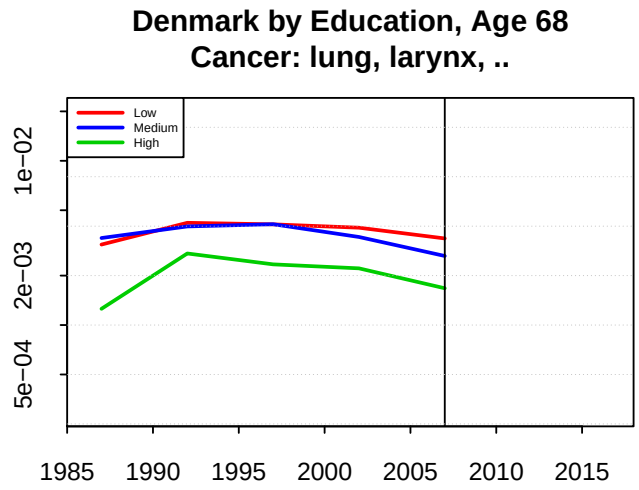


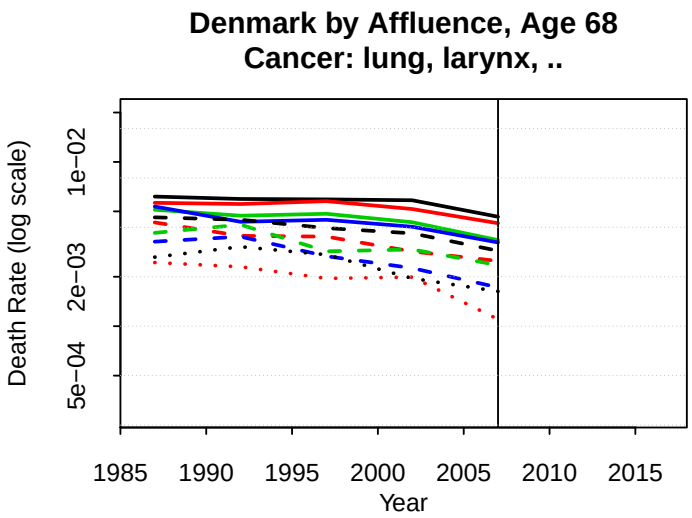


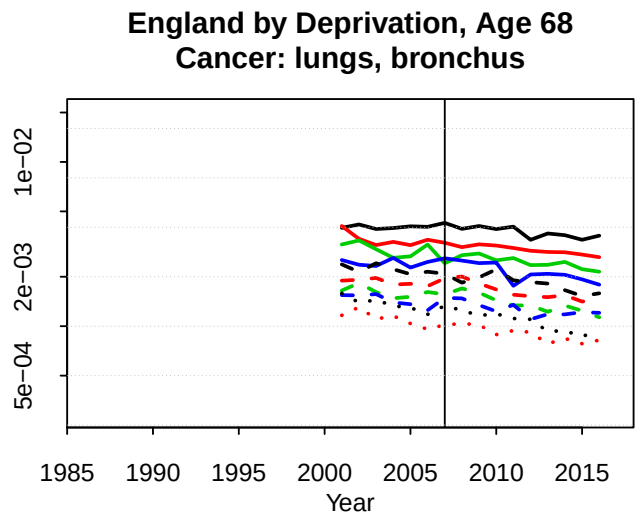
No controllable risk factors; US improvements; DK vs US genetic factors?

Multi-Country: Age 68, Males, Lung Cancer



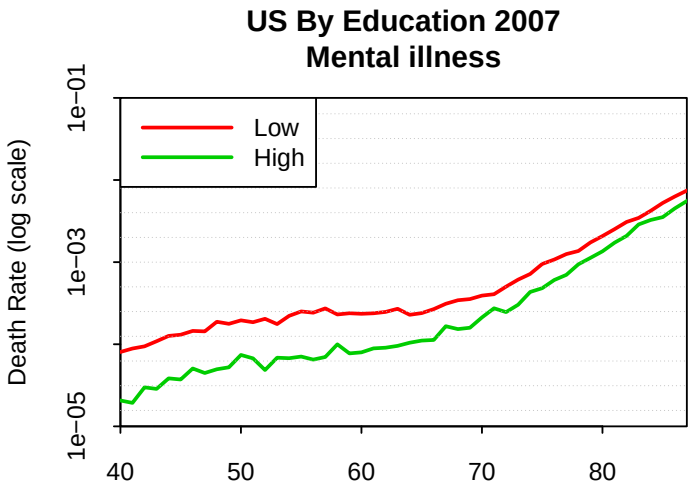


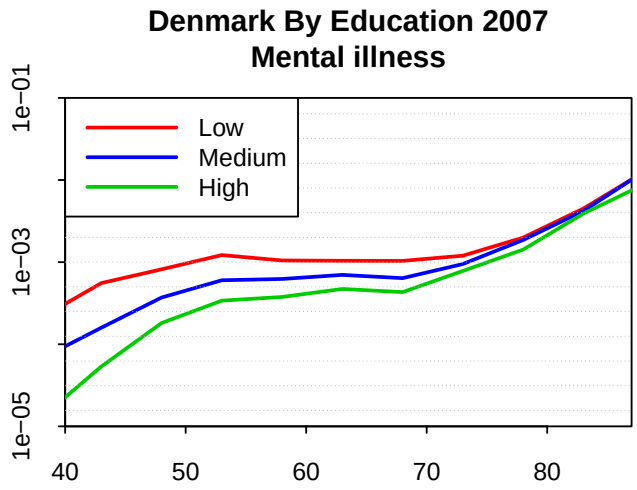


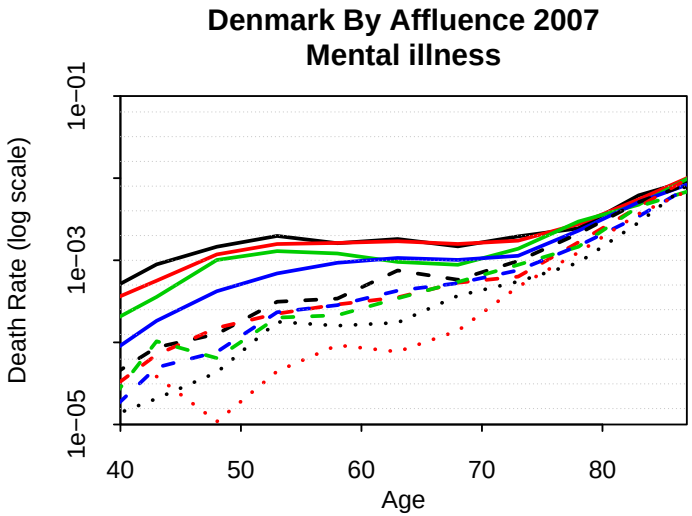


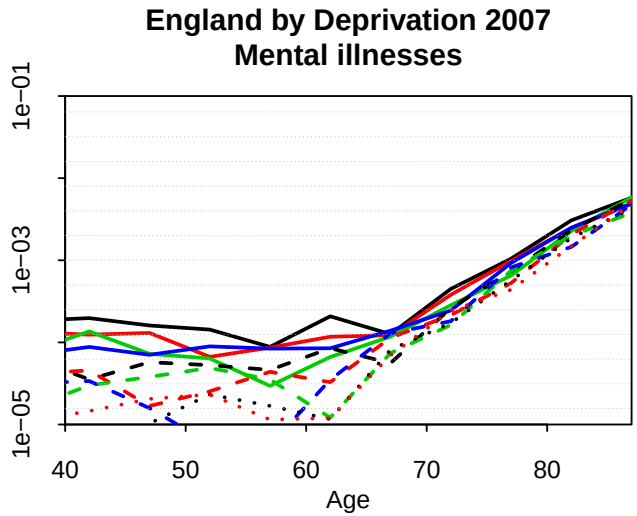
Significant inequality; improvements might be driven by smoking prevalence

Variation in Reporting Practice: e.g. Mental Illness



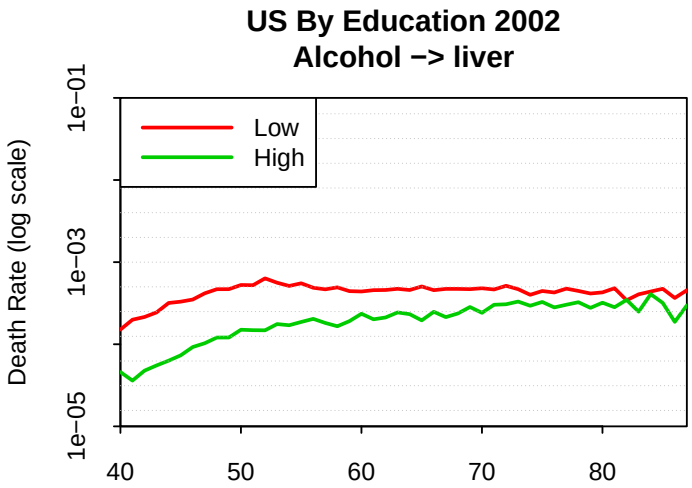


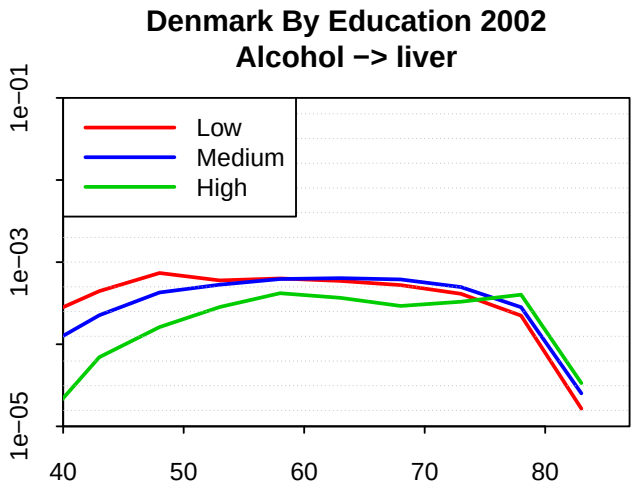


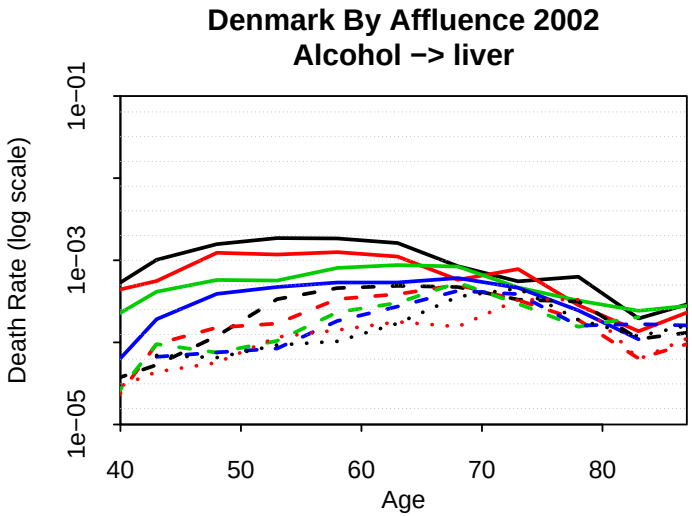


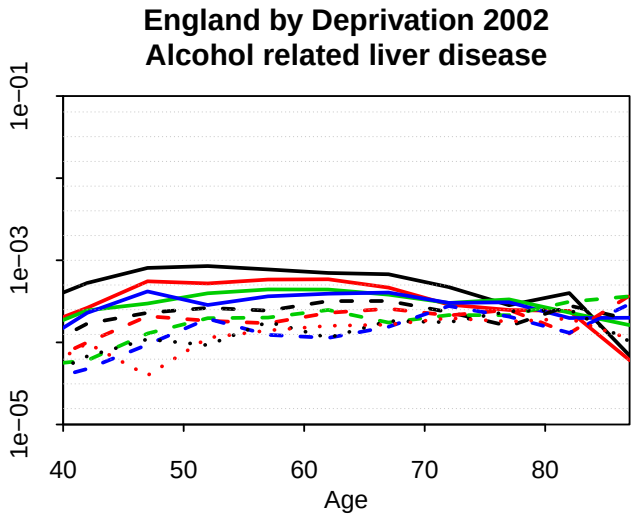
Alcohol & drug abuse; mental disorders; $\longrightarrow$ vascular dementia

Deaths of Despair: A Growing Problem? 2002/07/12



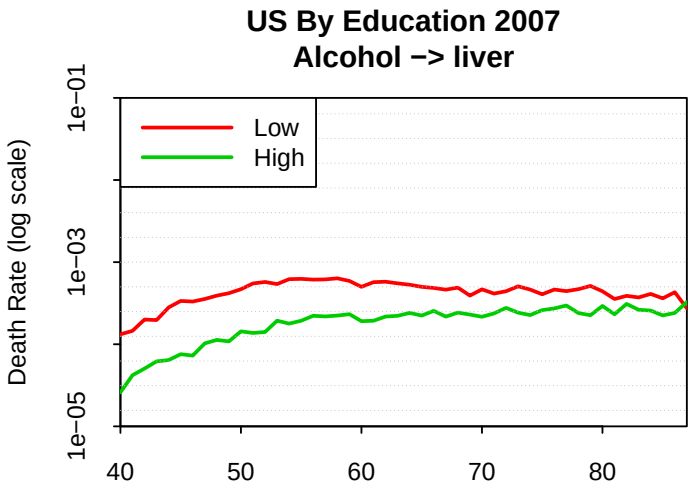


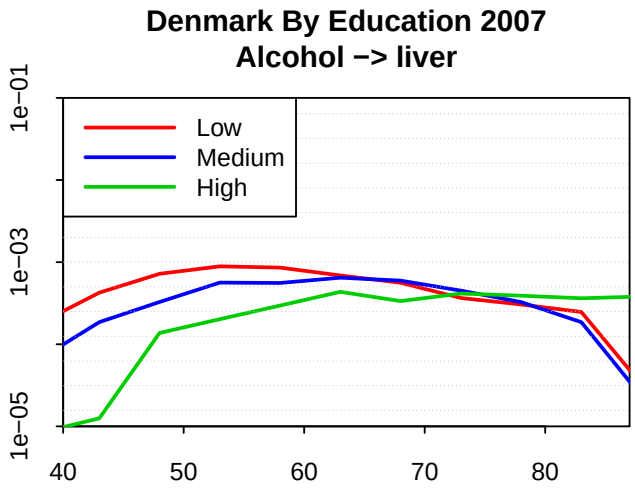


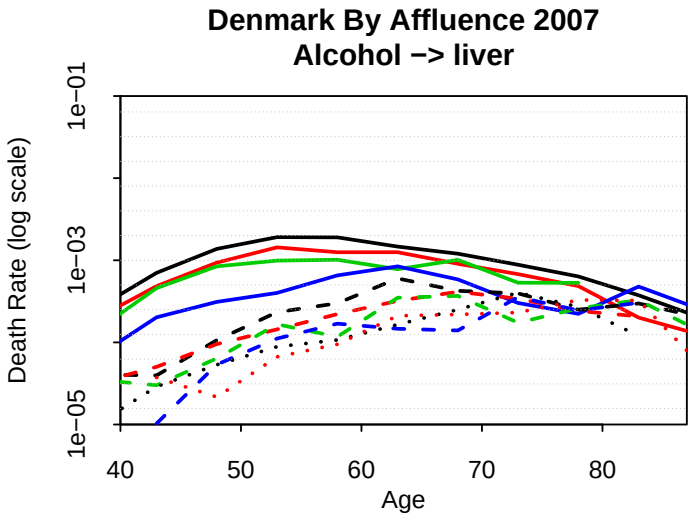


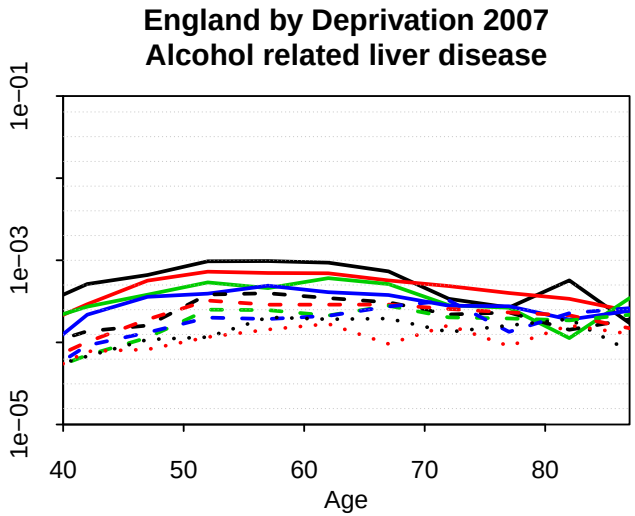
Affluence a much bigger driver

Deaths of Despair: A Growing Problem? 2002/07/12

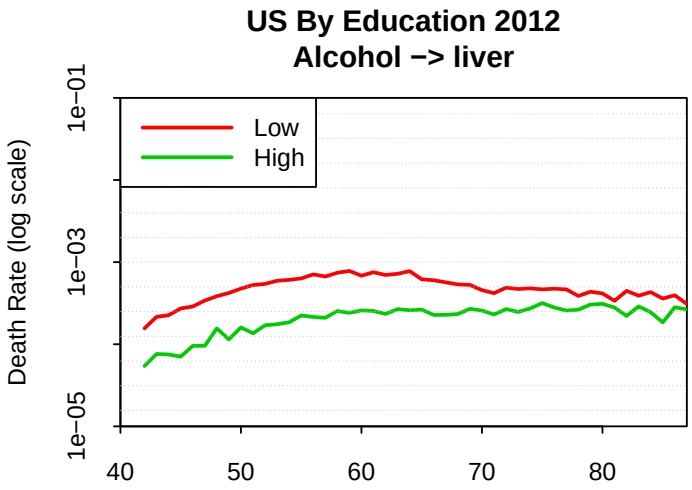


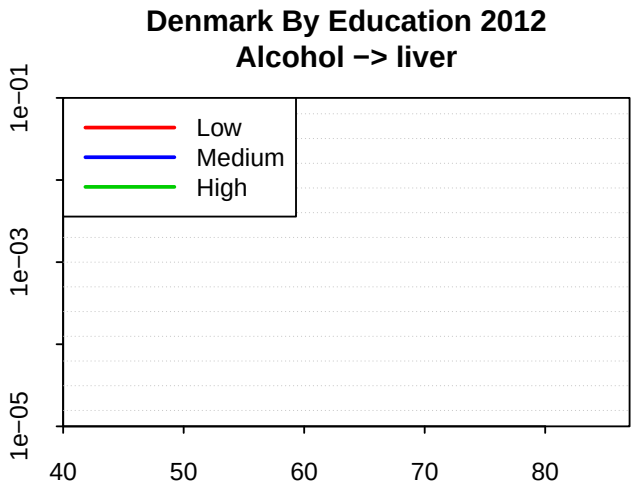


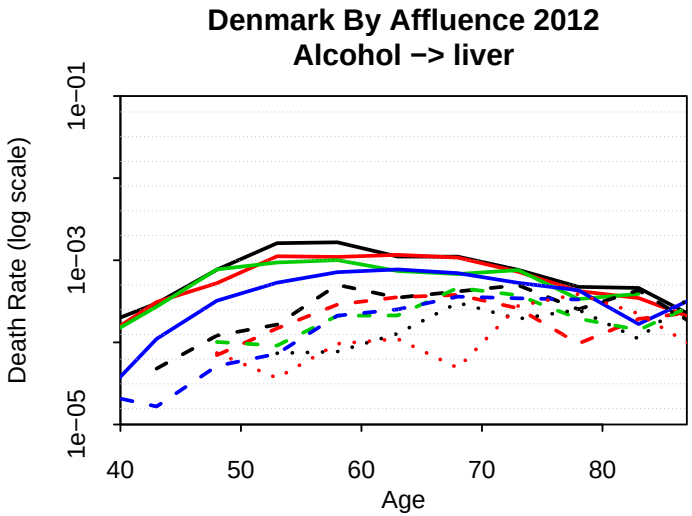


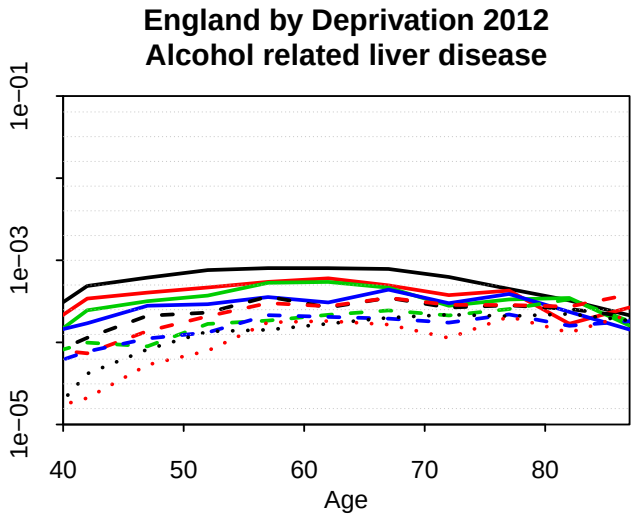


Deaths of Despair: A Growing Problem? 2002/07/12









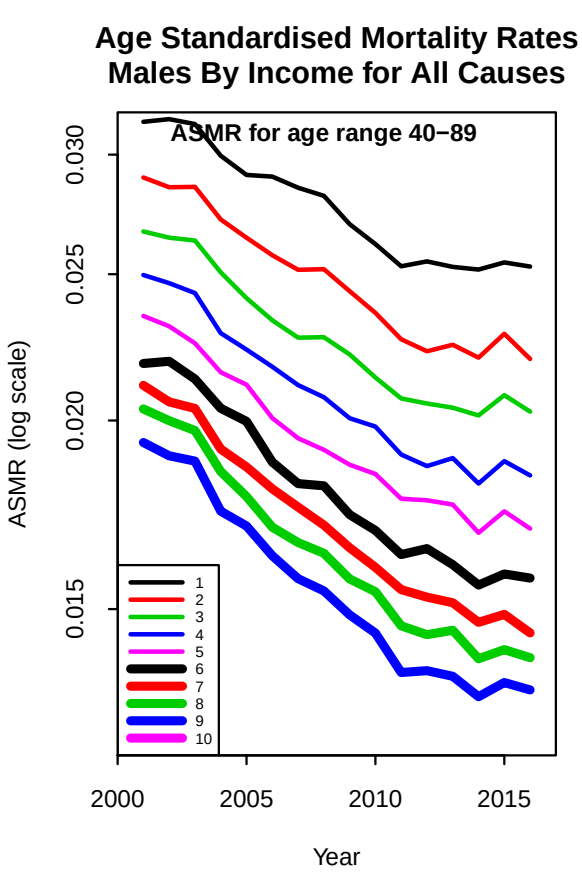
US: possible cohort effect

England: Income Deprivation versus Region

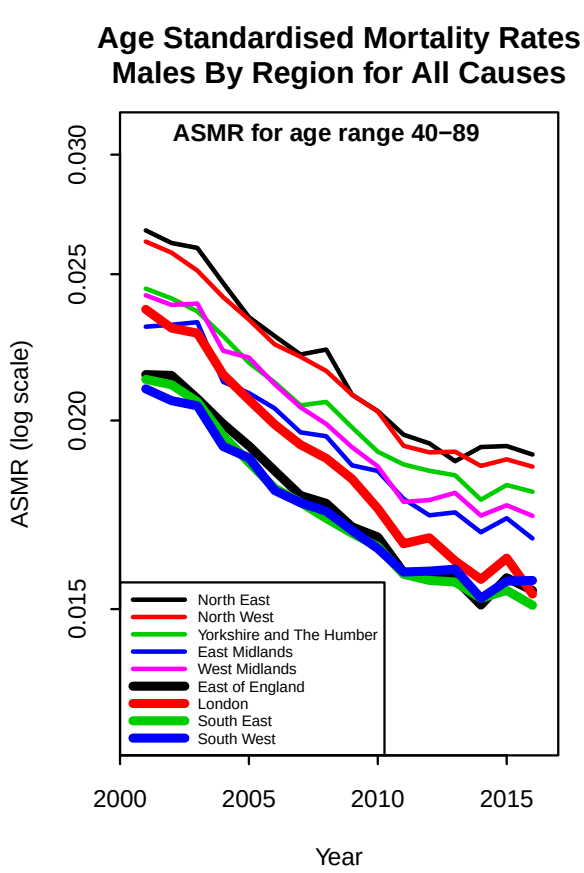
North East
North West
Yorkshire & Humber
East Midlands
West Midlands
East of England
London
South East
South West

Not in dataset:
Scotland, Wales,
Northern Ireland

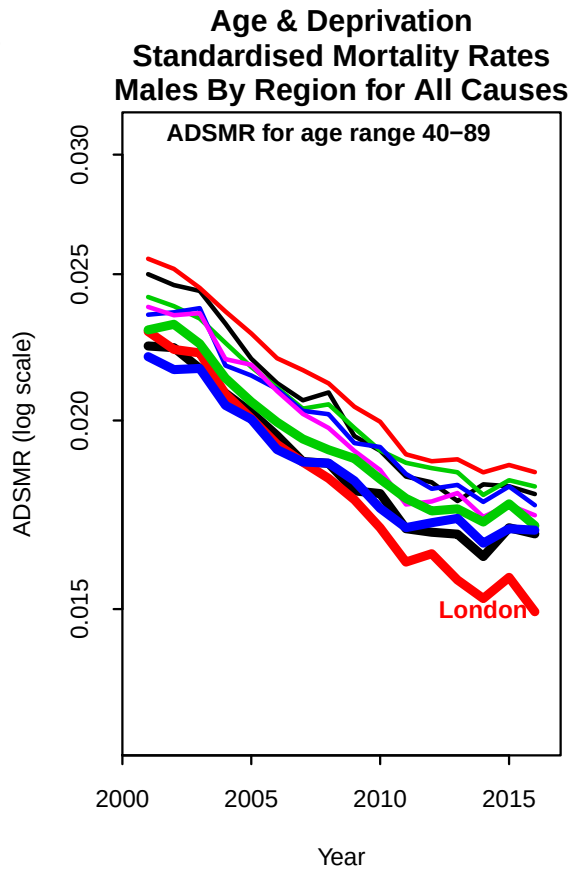
England: Males (40-89) ASMR and ADSMR Inequality



Income



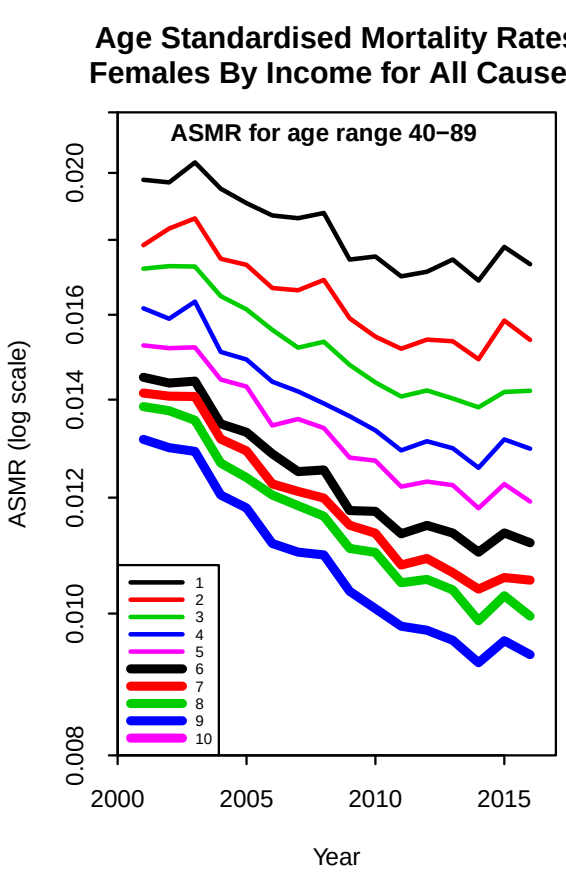
Region

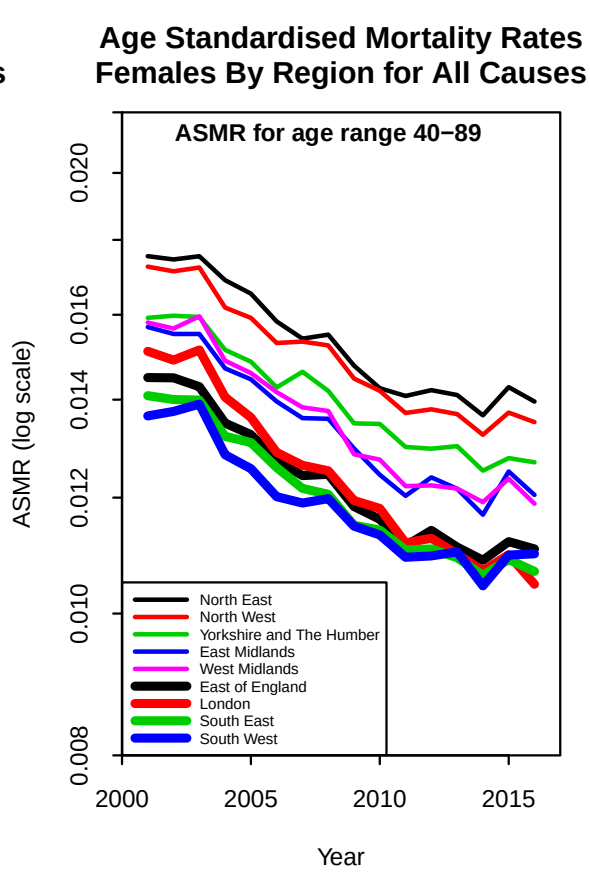


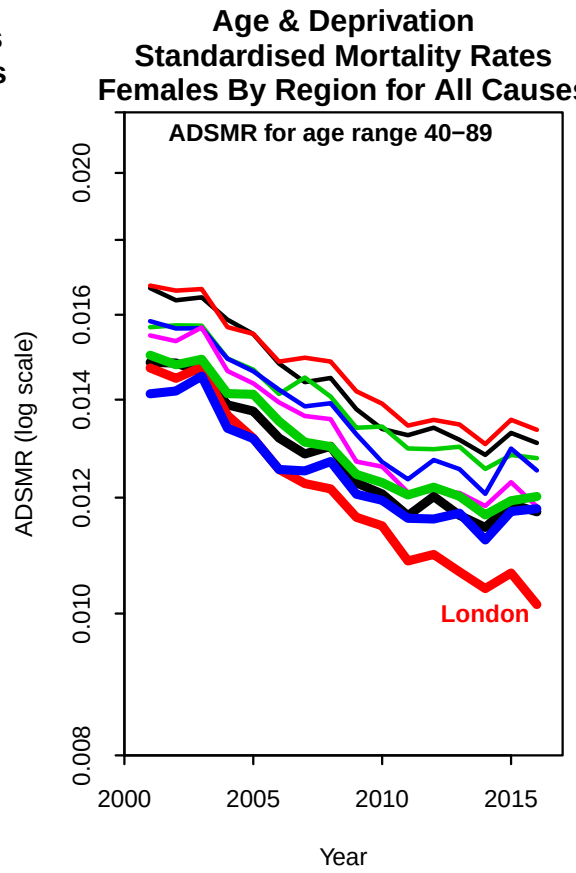
Region: standardised

ADSMR adjusts for different income deprivation mix by region

England: Females (40-89) ASMR and ADSMR Inequality





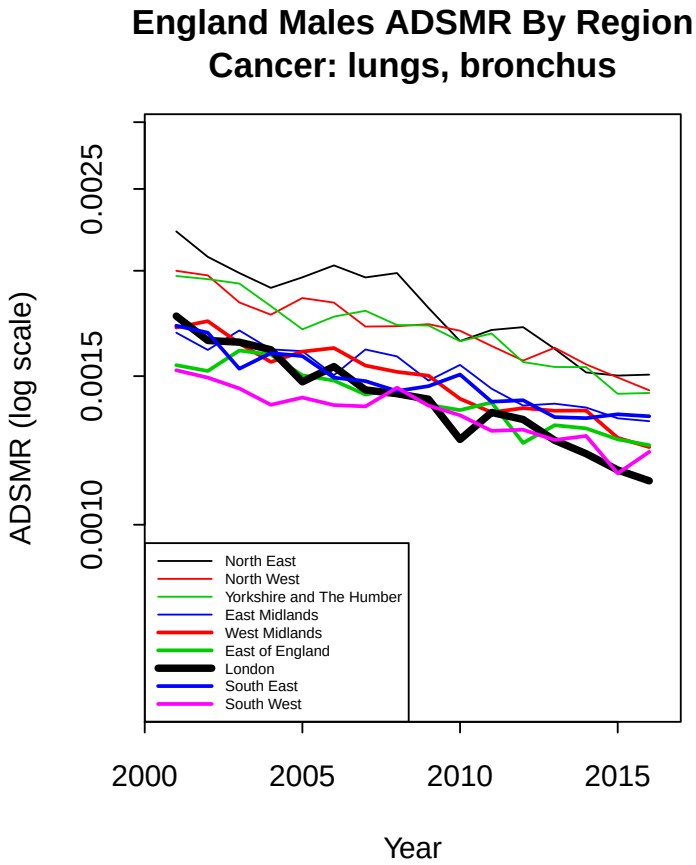


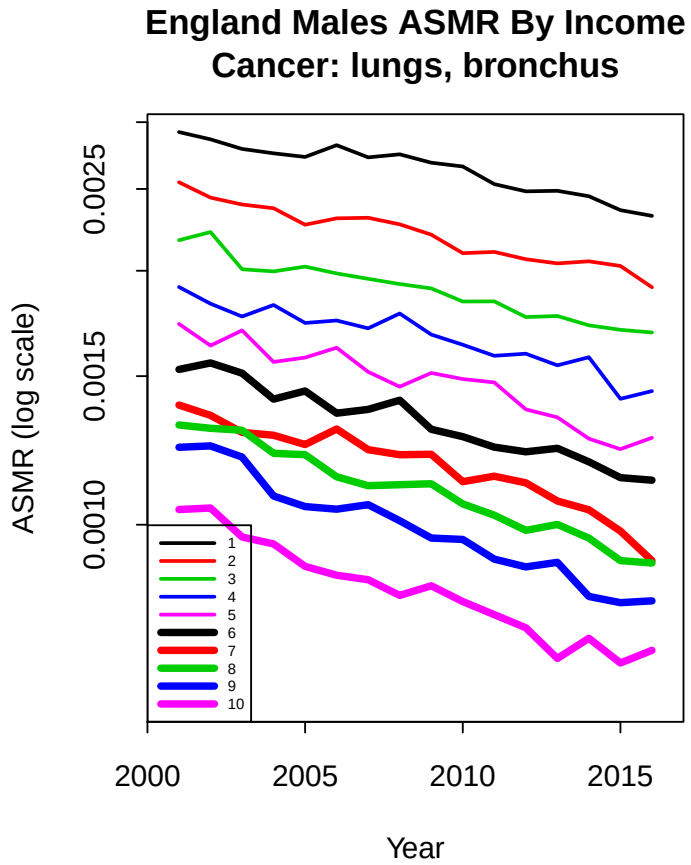
Males and Females: Clear "London Effect".

Greater improvements in healthcare??

Greater improvements in GDP??

Lung Cancer: Males





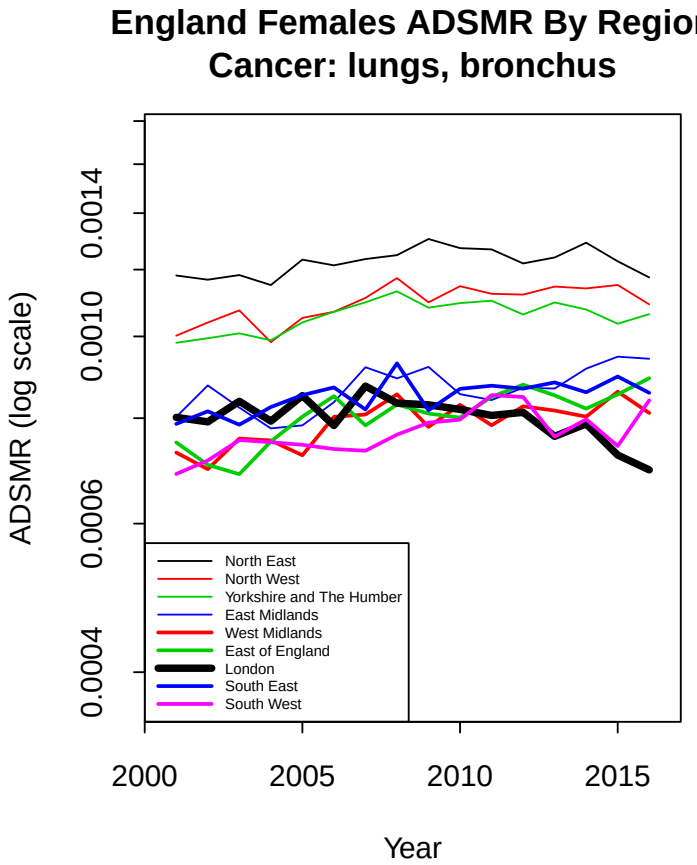
Significant variation between income deciles ($\Rightarrow$ smoking prevalence)

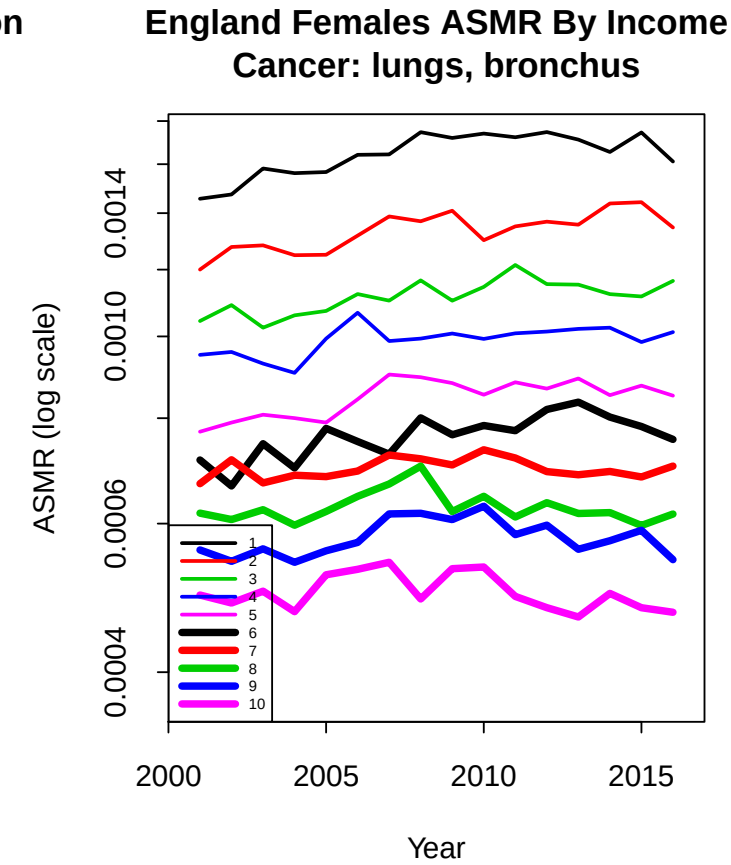
Significant variation between regions (after standardisation)

$\times 1.5$ variation by region; $\times 2.5$ by income decile

London effect; Northern regions very poor

Lung Cancer: Females





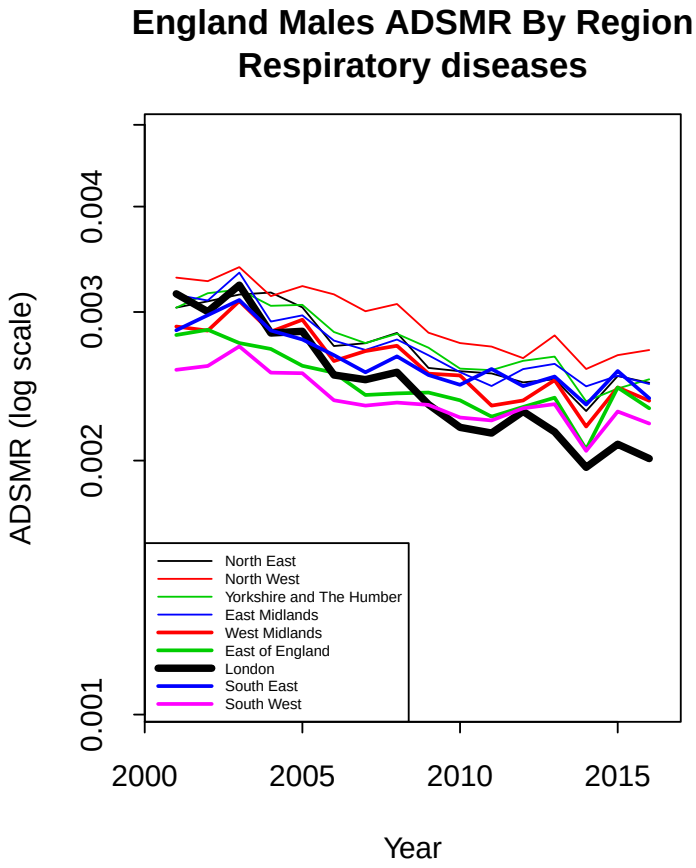
Slight worsening $\Rightarrow$ smoking prevalence rising

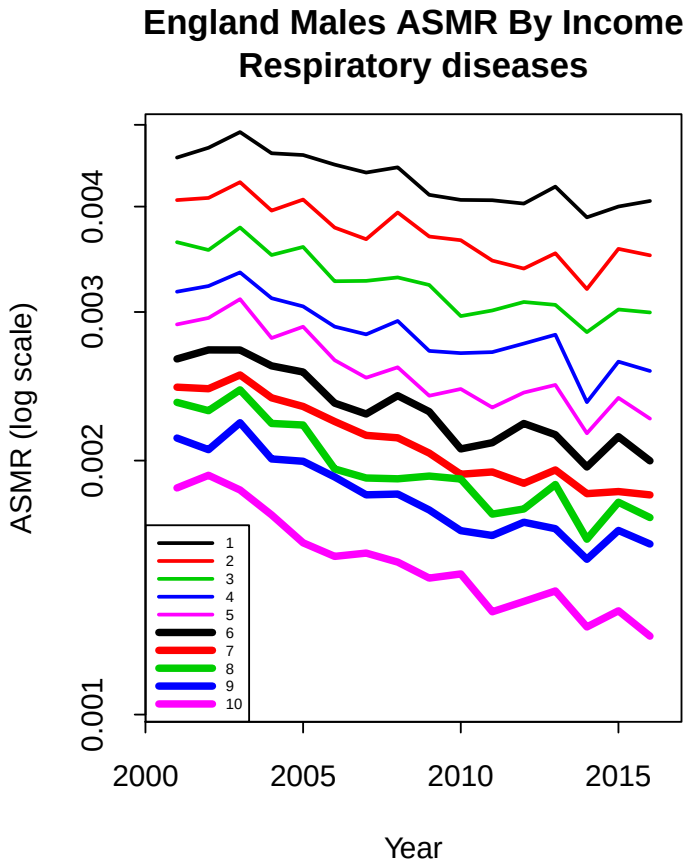
Same northern regions do badly

Wider regional spread

London effect

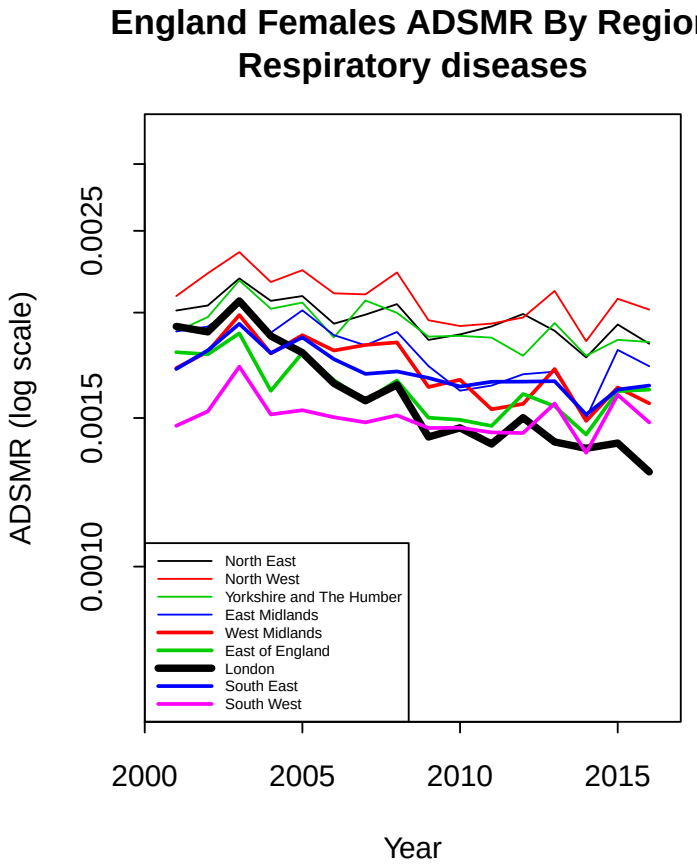
Respiratory Diseases: Males

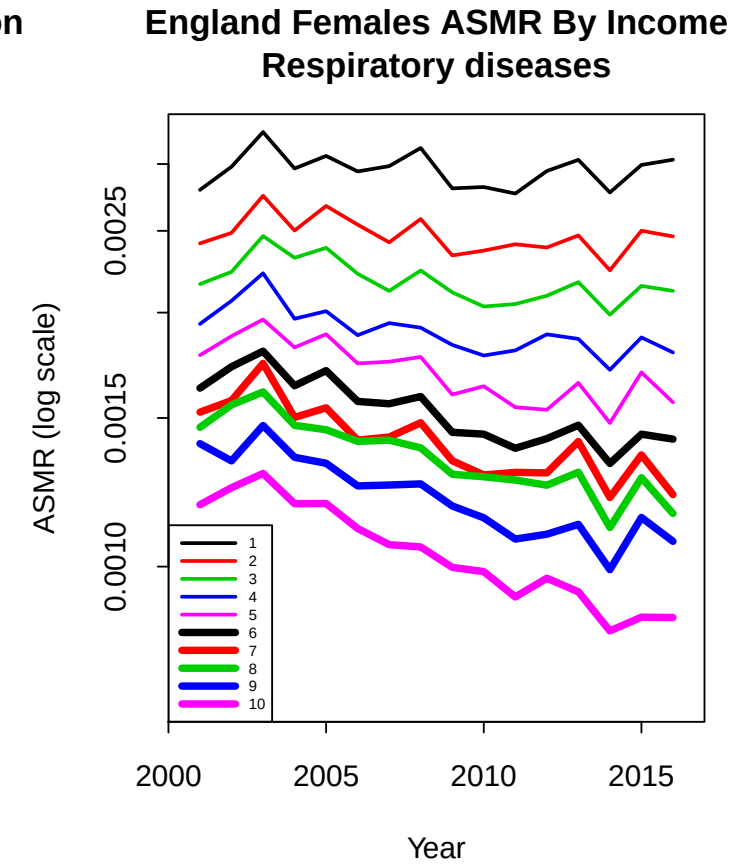




Flatter but otherwise similar pattern to lung cancer males

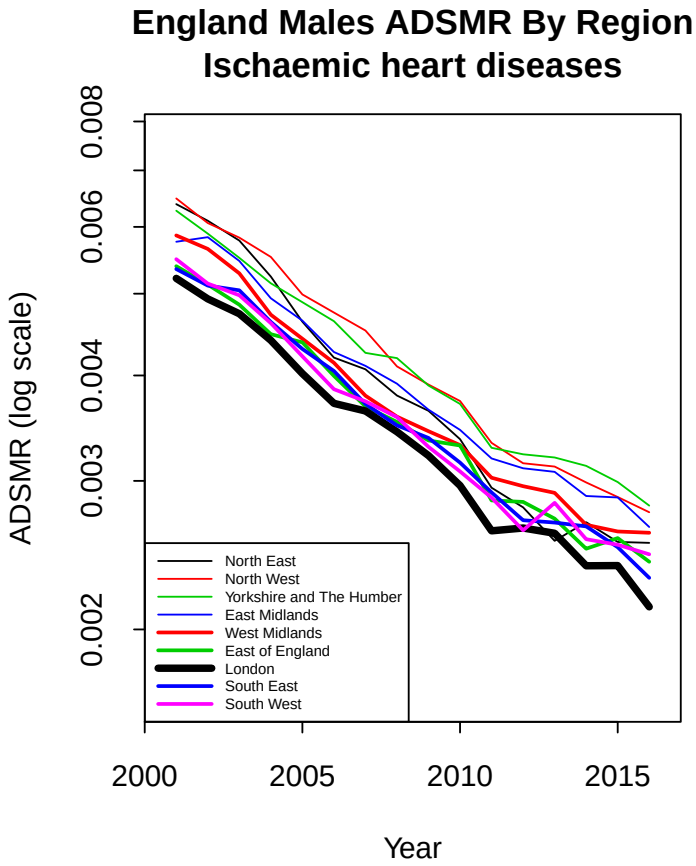
Respiratory Diseases: Females

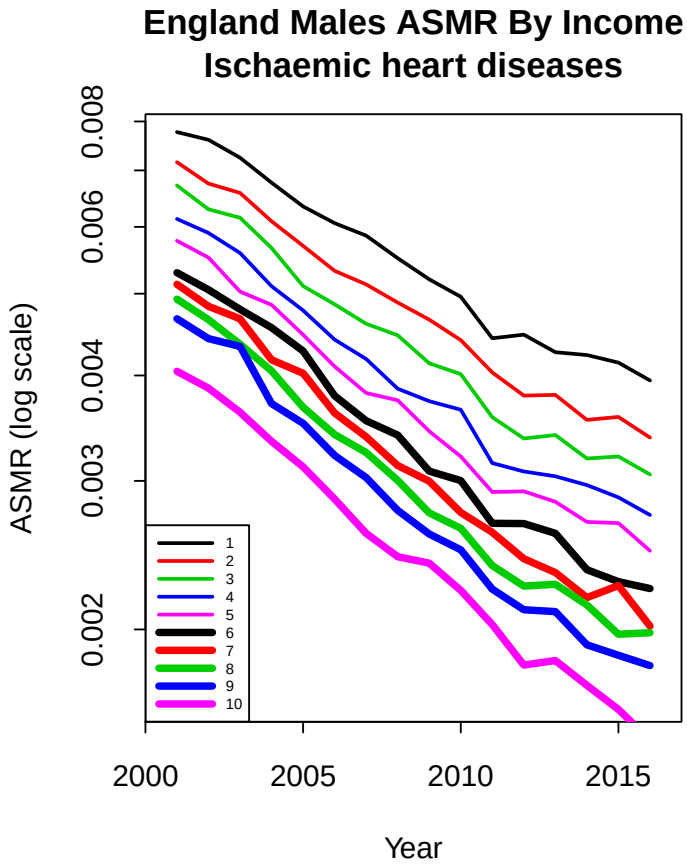




Similar pattern to lung cancer females

Ischaemic Heart Disease: Males





Success story: major improvements

Deterioration: widening gap and regional inequality

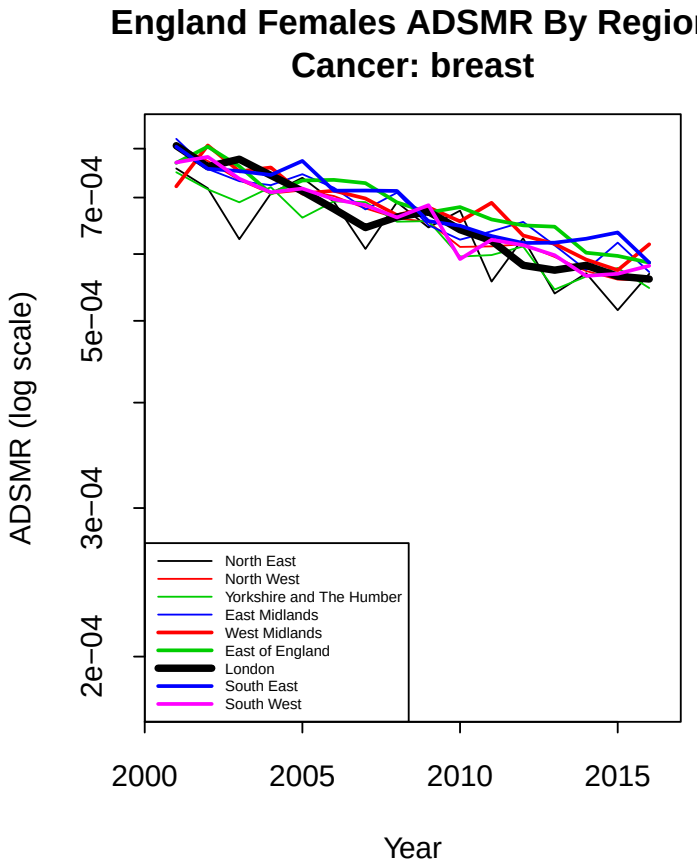
Females: similar picture

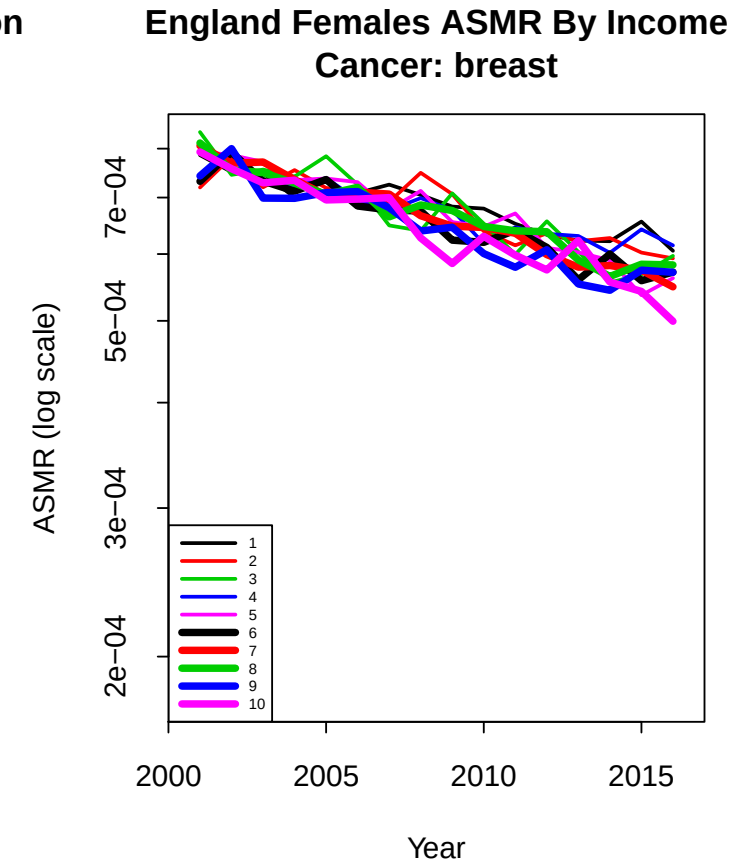
Story So Far

Causes of death with significant risk factors:

- Significant inequalities by income deprivation
- Significant *additional* inequalities by region
- Bigger income inequality "$\Rightarrow$" bigger regional inequality
- Mostly the same regions are worse

Breast Cancer: An Equality Success Story

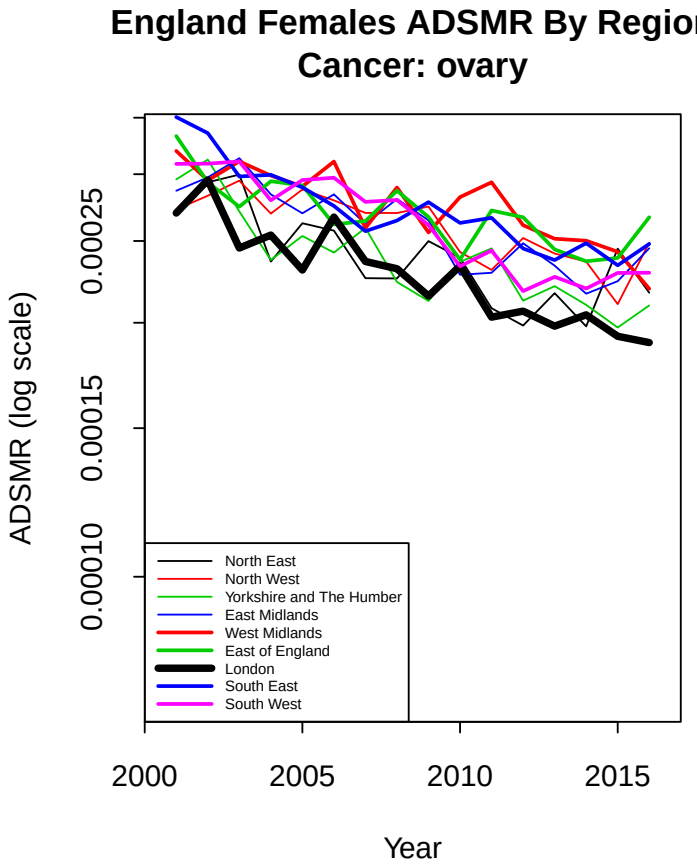


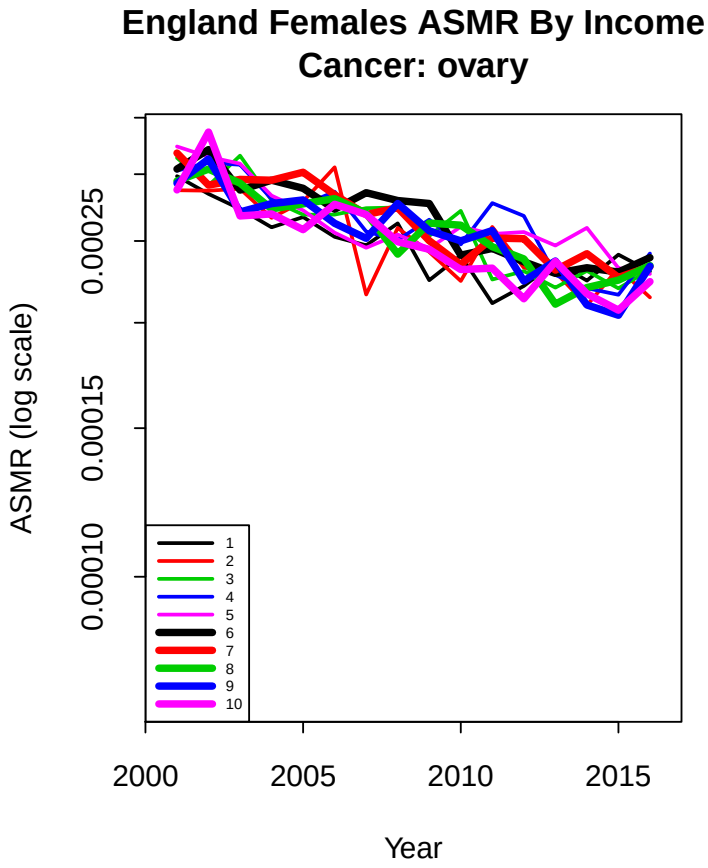


Limited controllable risk factors

Success story: no significant inequality

Ovarian Cancer: A Regional Lottery?



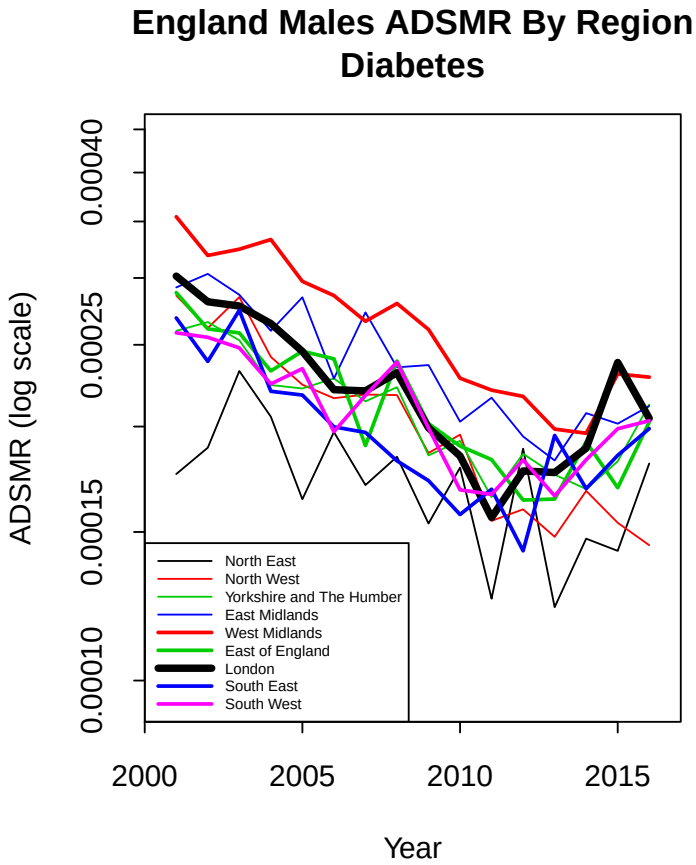


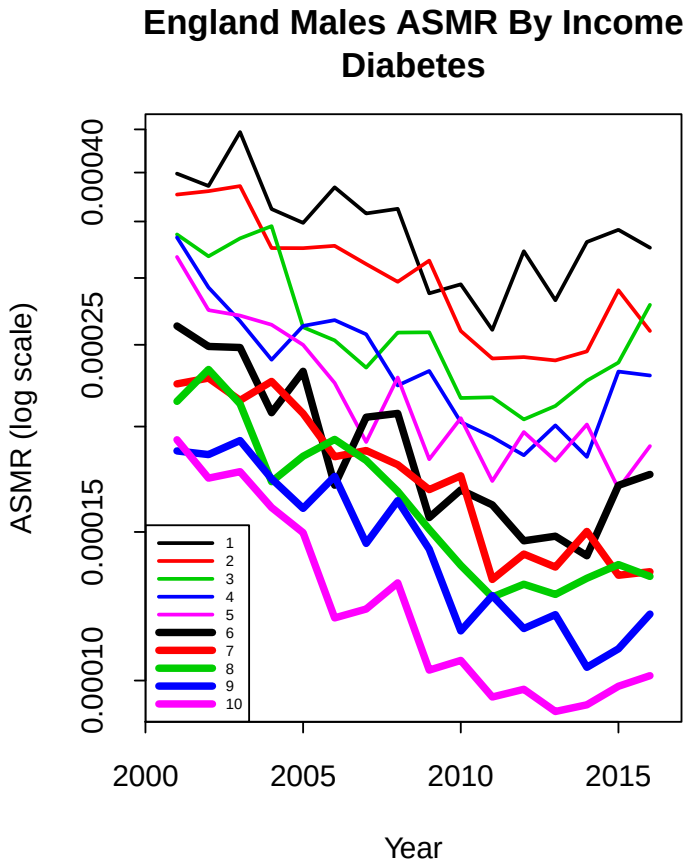
Limited controllable risk factors

Limited income effect

Significant regional effect

Diabetes: Males



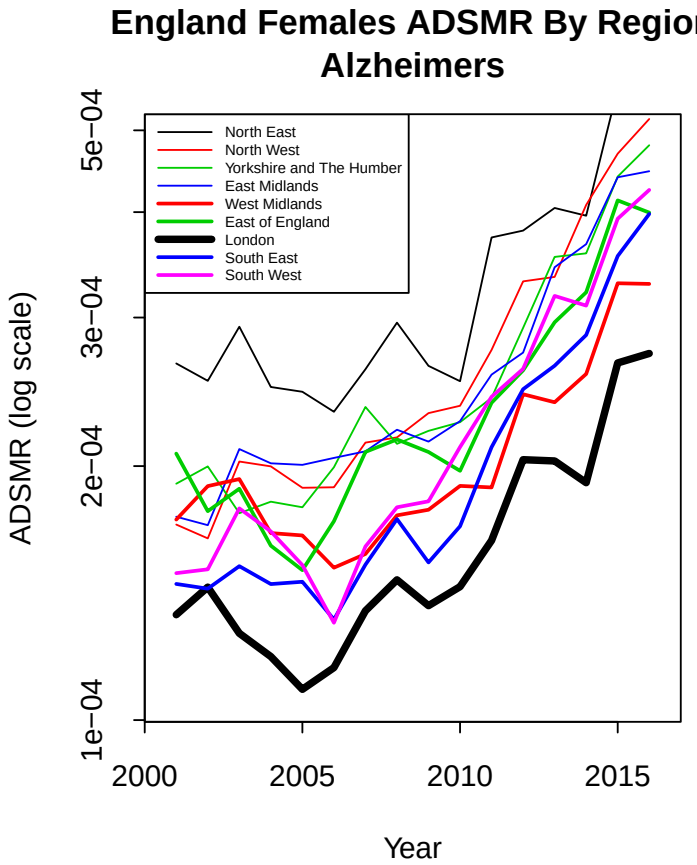


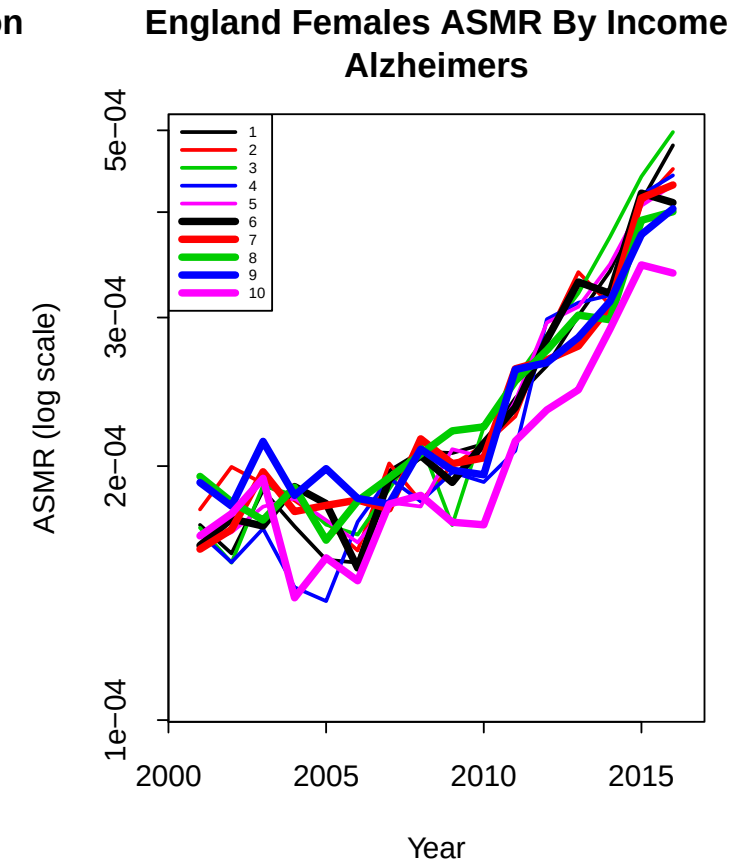
Significant inequality

Widening inequality gap by income deciles

Worsening mortality after about 2010

Alzheimers: Females (no clear risk factors)





Modest income effect; Strong regional effect $\Rightarrow$?? health migration

Deterioration ($2\times$) $\Rightarrow$??

evidence for non-independence of causes of death

improvements elsewhere $\Rightarrow$?? more frail survivors in old age

Further remarks

- US, Denmark: Need to factor in changing levels of educational attainment
- Is it possible to decompose improvements into medical advances and changes in risk "taking"?
- E.g. Can we link smoking prevalence to e.g. lung cancer mortality?
- What are the causes of the London Effect?

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Summary

- Affluence or income deprivation is better than education for all CoD if you have the data
- Impact of affluence/education/region varies with CoD
- Significant levels of inequality for most of the big CoD's
- CoD *absolute levels* vary between countries: local practice(?)
- But *degree of inequality* by CoD is consistent from country to country
- Second order differences between countries may be due to healthcare systems
- England:
  - Regional differences in addition to income effects
  - Consistent patterns by CoD connected to *controllable* risk factors

Thank You!

Questions?

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www.macs.hw.ac.uk/∼andrewc/ARCresources

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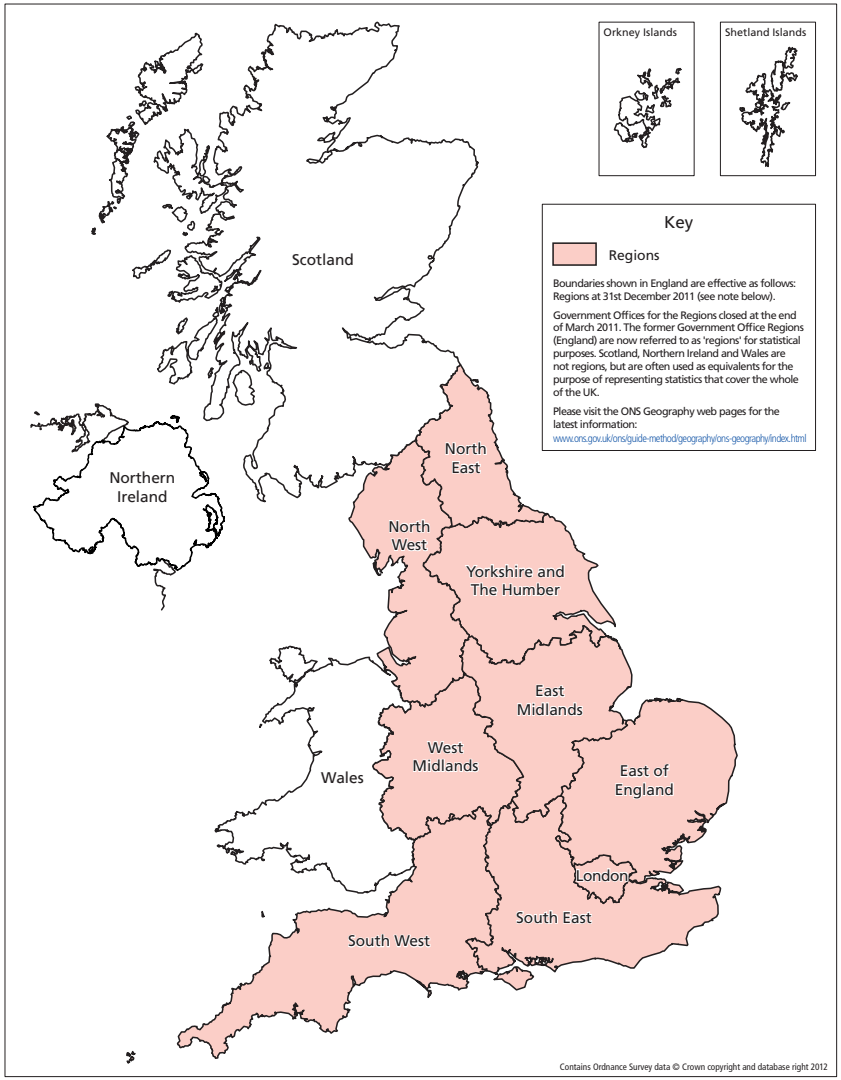
The Actuarial Research Centre (ARC) is the Institute and Faculty of Actuaries' (IFoA) network of actuarial researchers around the world. The ARC seeks to deliver cutting-edge research programmes that address some of the significant, global challenges in actuarial science, through a partnership of the actuarial profession, the academic community and practitioners.

The 'Modelling, Measurement and Management of Longevity and Morbidity Risk' research programme is being funded by the ARC, the SoA and the CIA.

`www.actuaries.org.uk/arc`

England: Income Deprivation versus Region

United Kingdom: Regions, 2011



Office for National Statistics

Produced by ONS Geography GIS & Mapping Unit

Denmark Males: Statistical Significance

- For each cause of death (29), and age group (13)
- Rank the death rates for the 10 groups $i = 1, \ldots, 10$
- For each year group, t
  $R(i,t)$ = rank of $m(i,t)$ out of $m(1,t), \ldots, m(10,t)$
  Rank 1: highest death rate
  Rank 10: lowest death rate
- Data $(i, R(i,t))$
- Test statistic, $S = \text{cor}\Big(i, R(i,t)\Big)$
- Under H_0 the ranks are a random permutation of $1, \ldots, 10$
- Under H_0, S is approximately $N(0, \sigma^2)$ where $\sigma = 0.149$.
- One-sided test: Reject H_0 if $S > \sigma\Phi^{-1}(\alpha)$
- Large $S \Rightarrow$ low affluence $\sim$ high CoD mortality

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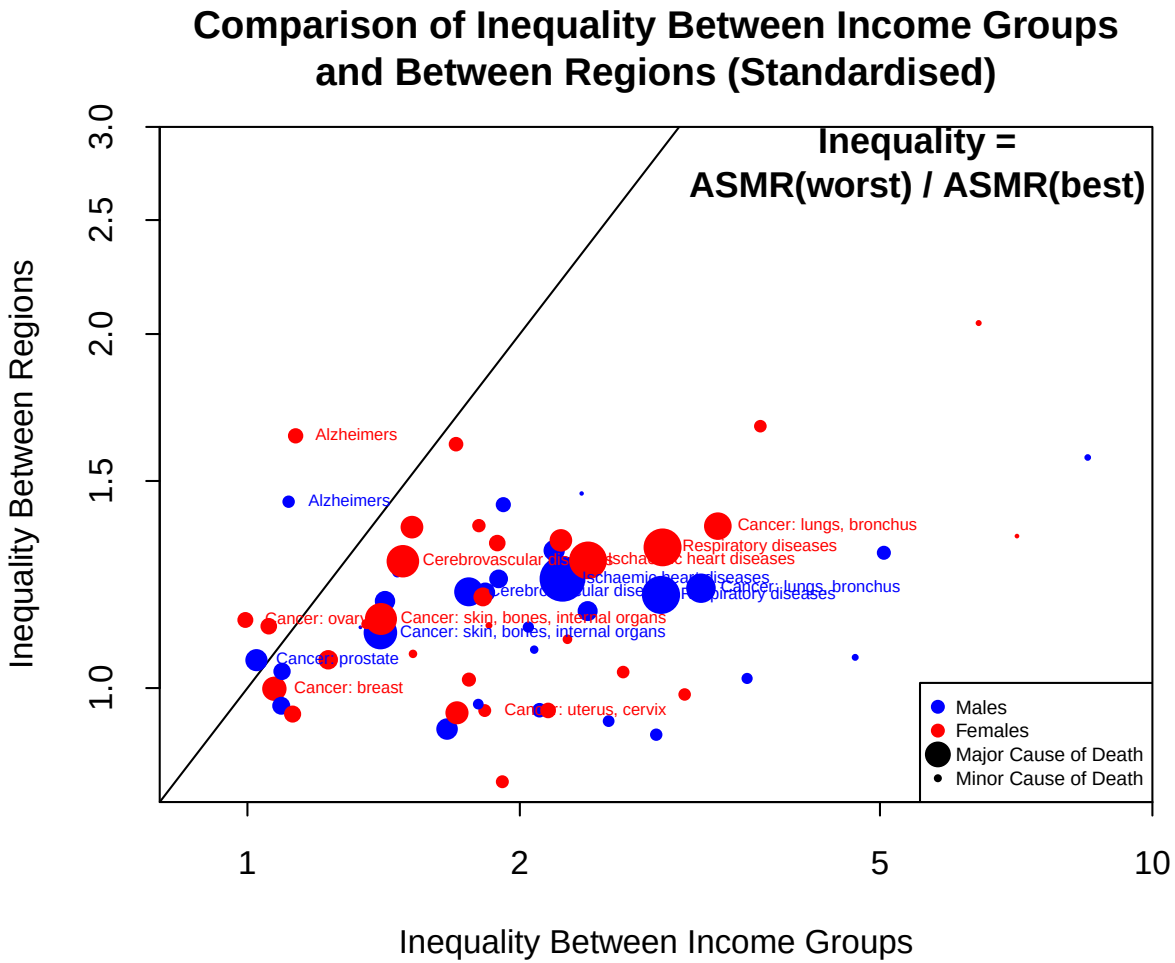
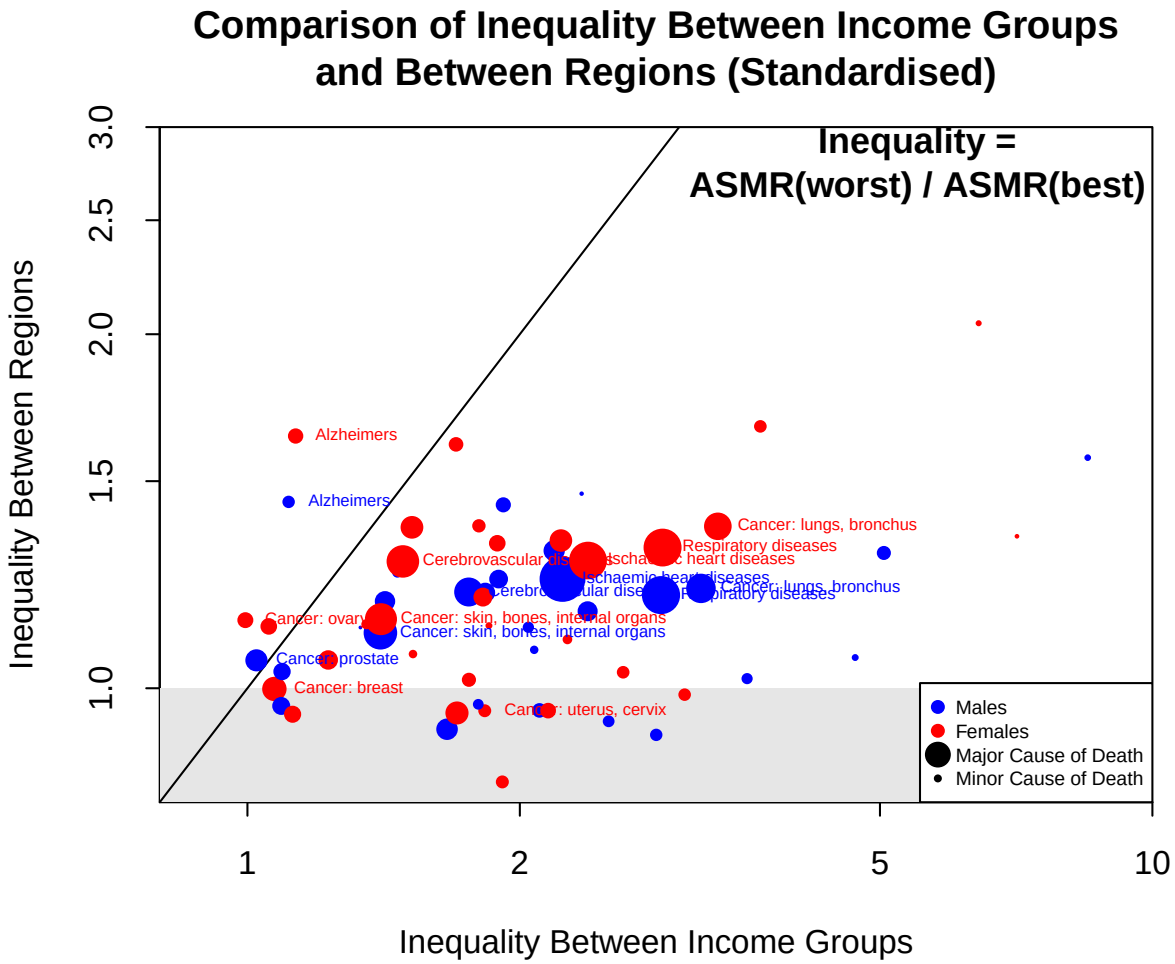
Cause of Death Inequaility: Income vs Region



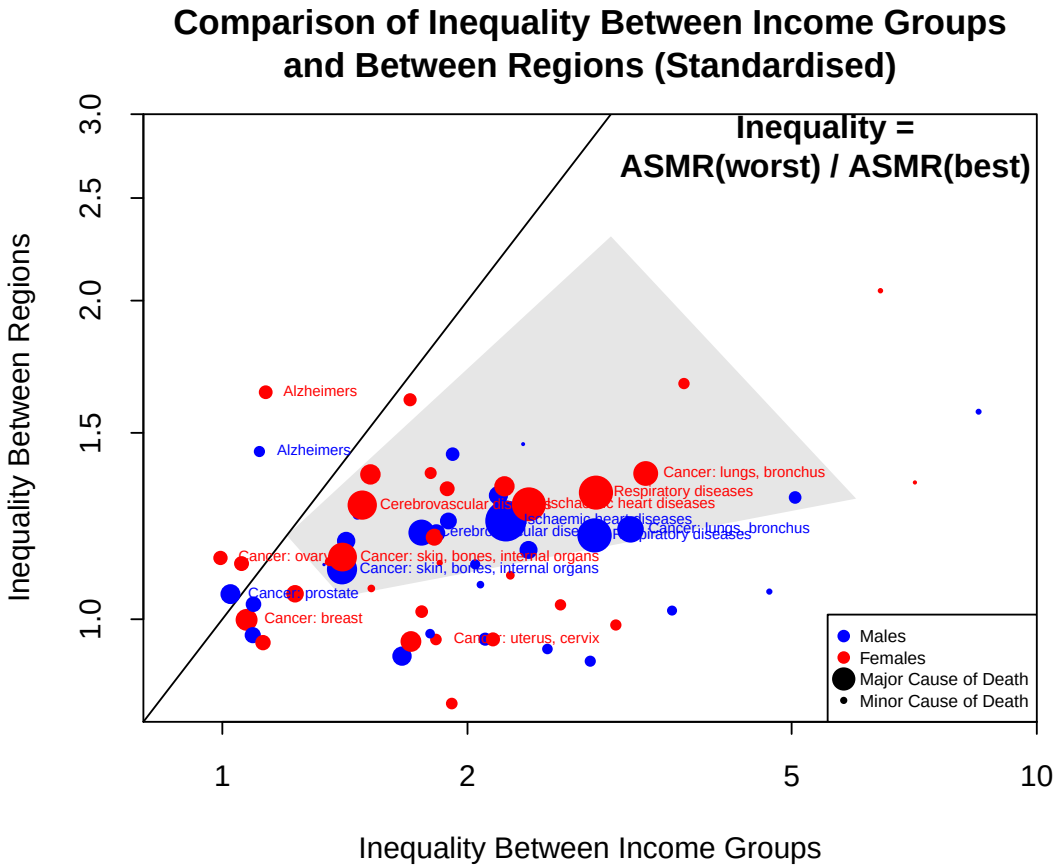
Inequality=A(D)SMR(worst)/A(D)SMR(best)
Region: best=London; worst=N.W.
Income Deprivation: best=10; worst=1

Cause of Death Inequaility: Income vs Region



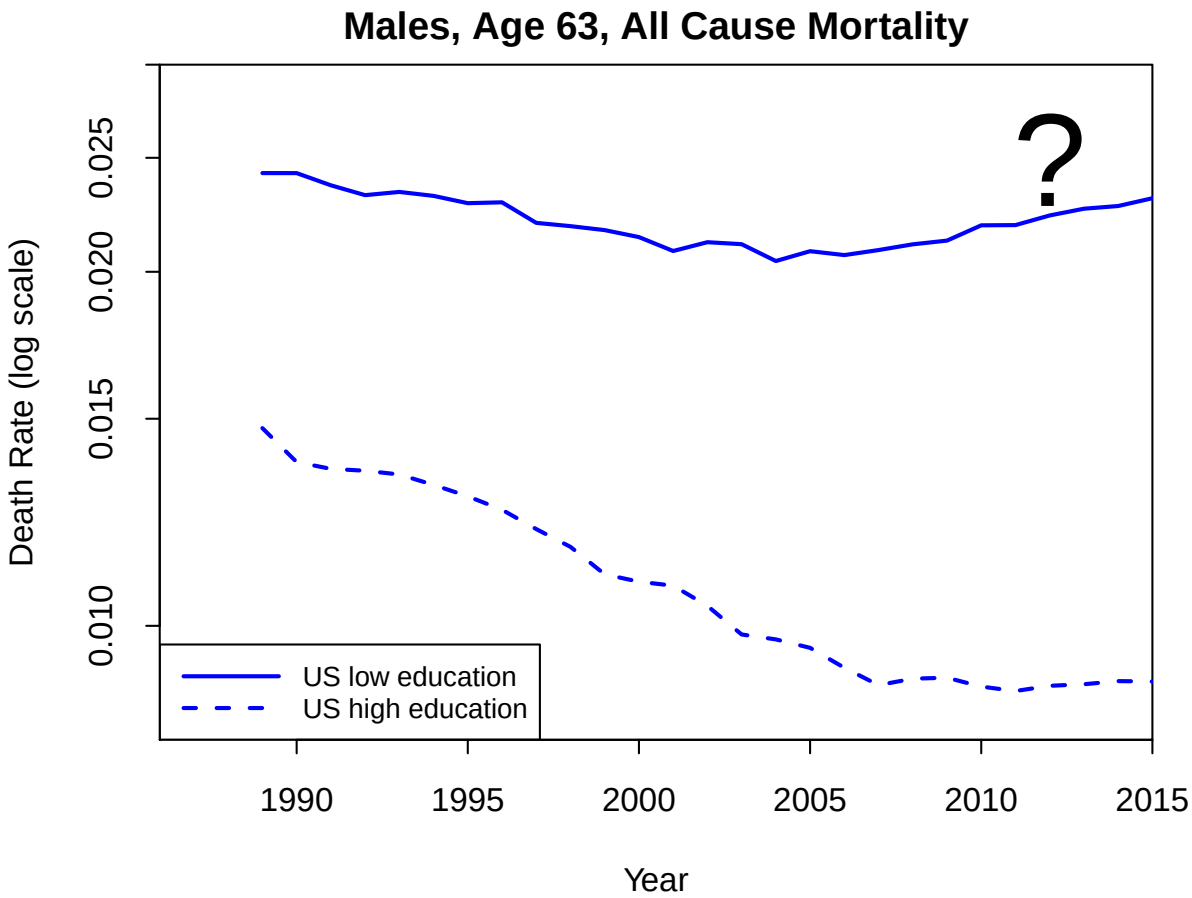
London: not always the best for individual causes of death.

Cause of Death Inequaility: Income vs Region



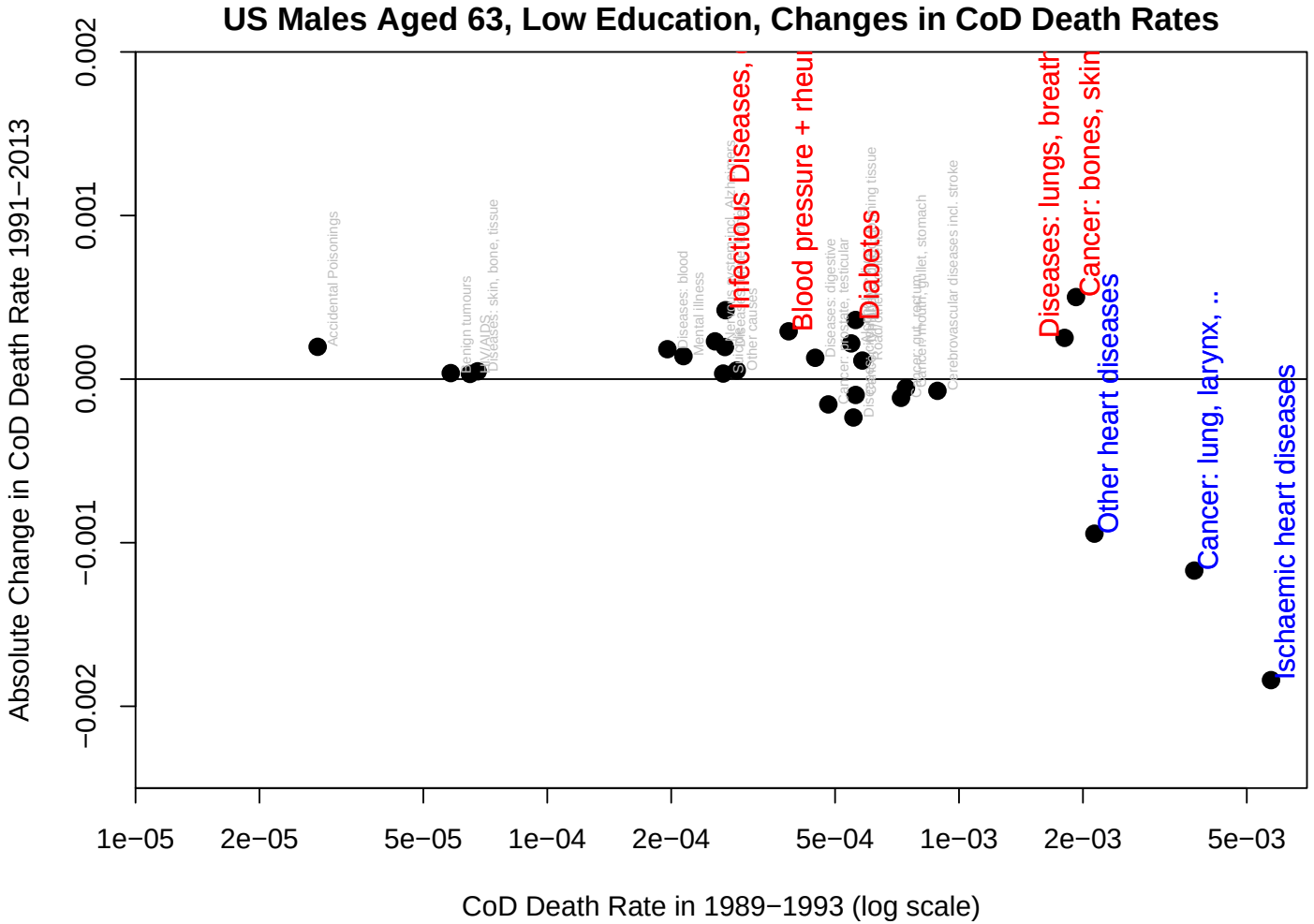
Causes of death with significant controllable risk factors:
Inequality between regions $\Rightarrow$ (??) significant variation in risk factors between regions

US Males Age 63: Stagnation



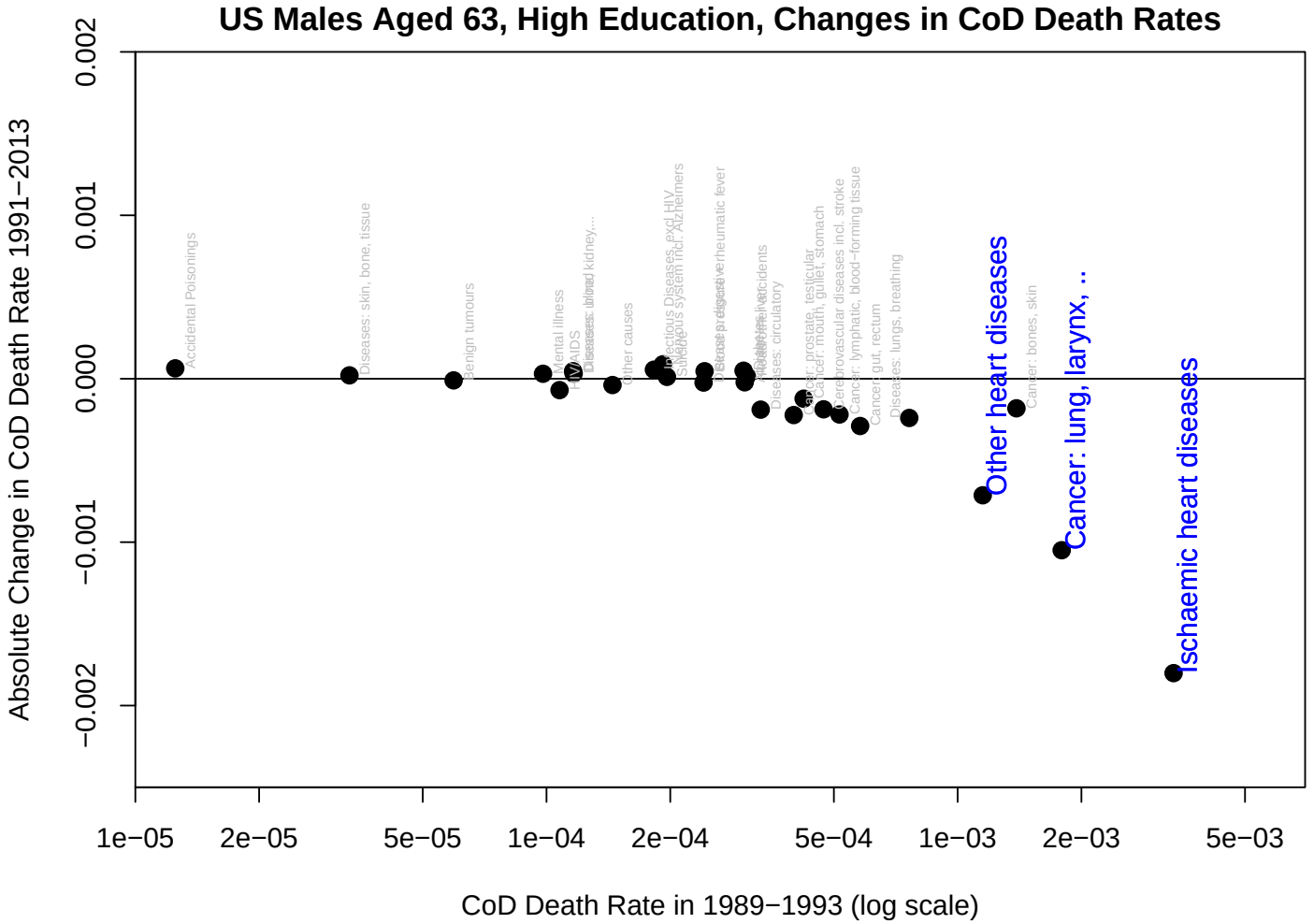
US Drivers of Change 1991-2013, Males Age 63

Low education absolute changes in mortality

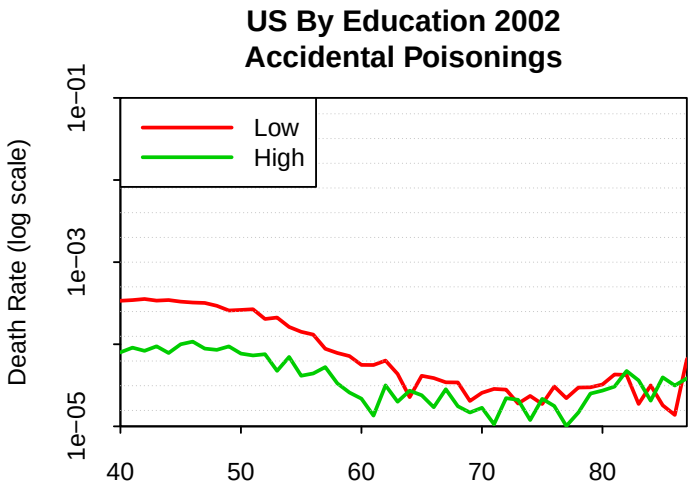


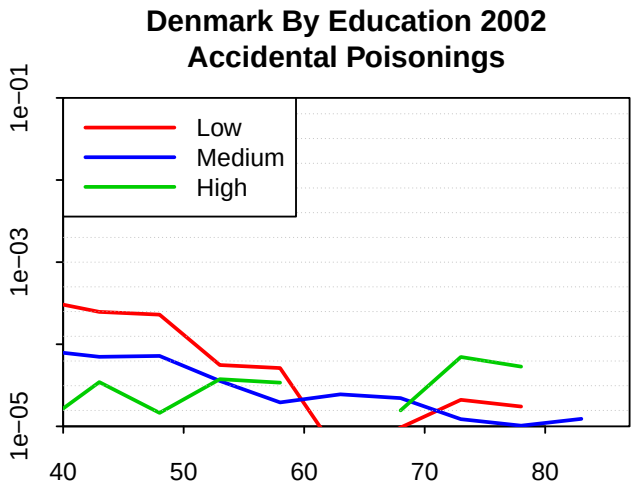
US Drivers of Change 1991-2013, Males Age 63

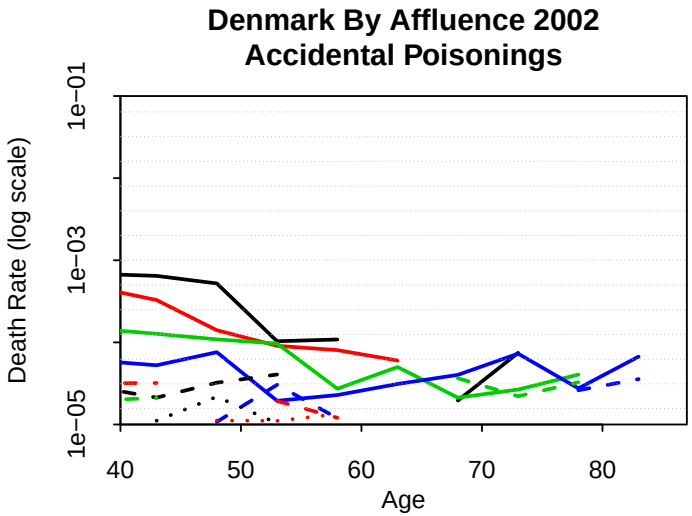
High education absolute changes in mortality

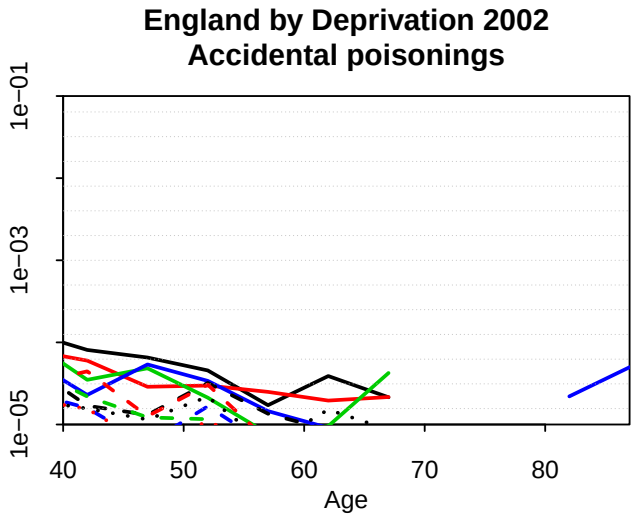


Deaths of Despair: A Growing Problem? 2002/07/12



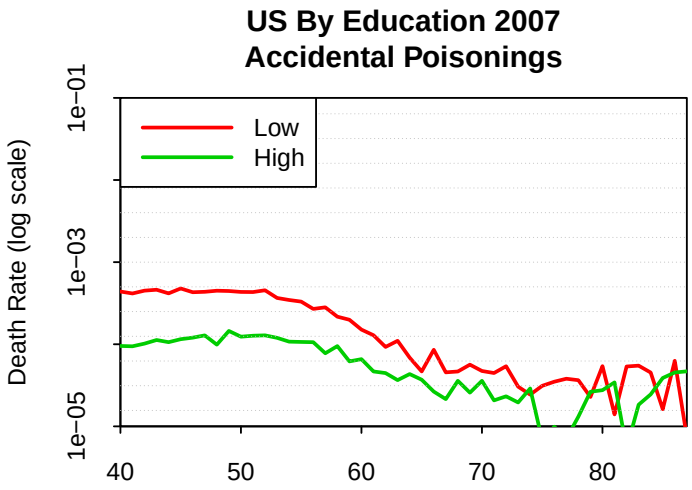


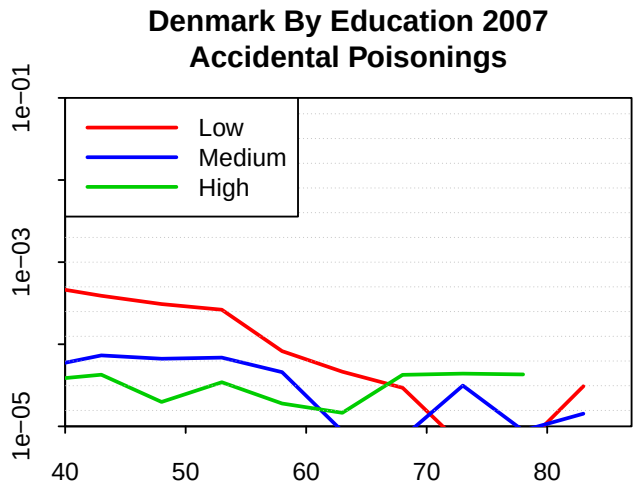


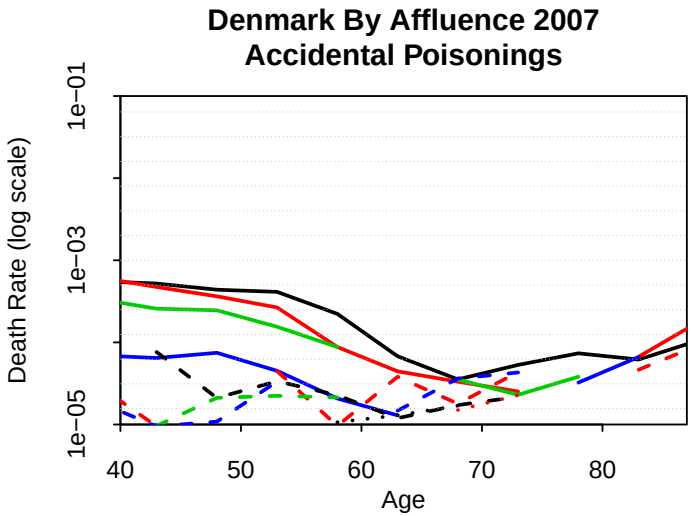


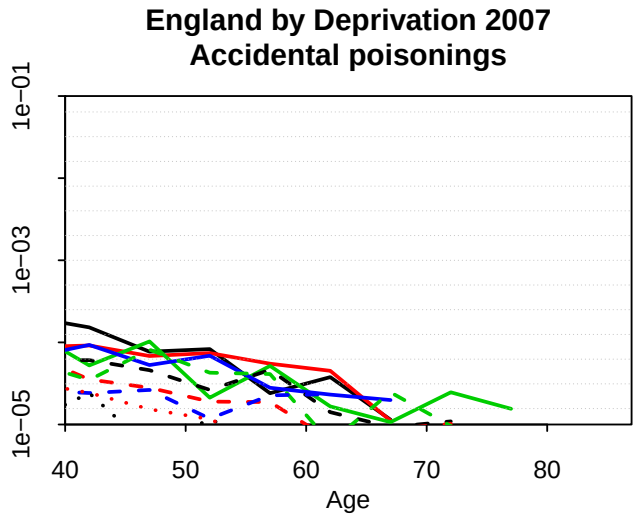
US, Denmark: significant

Deaths of Despair: A Growing Problem? 2002/07/12

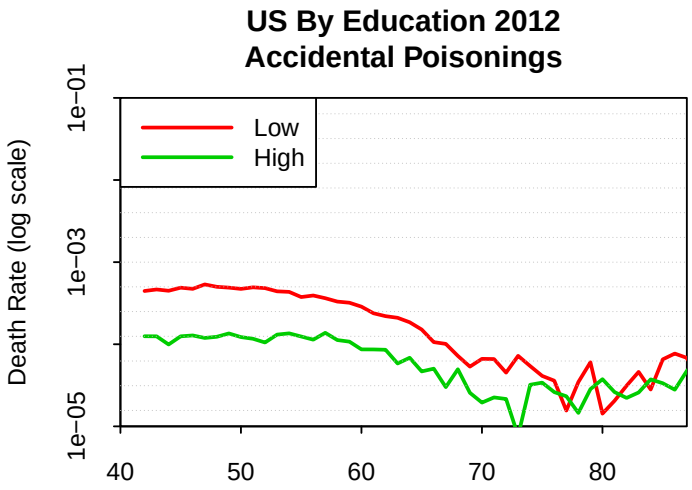


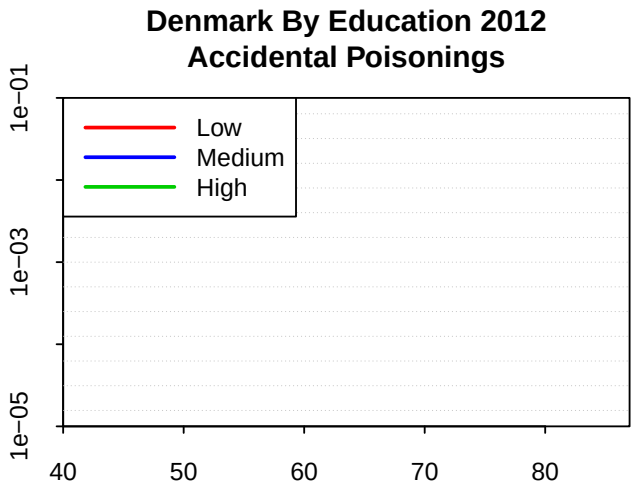


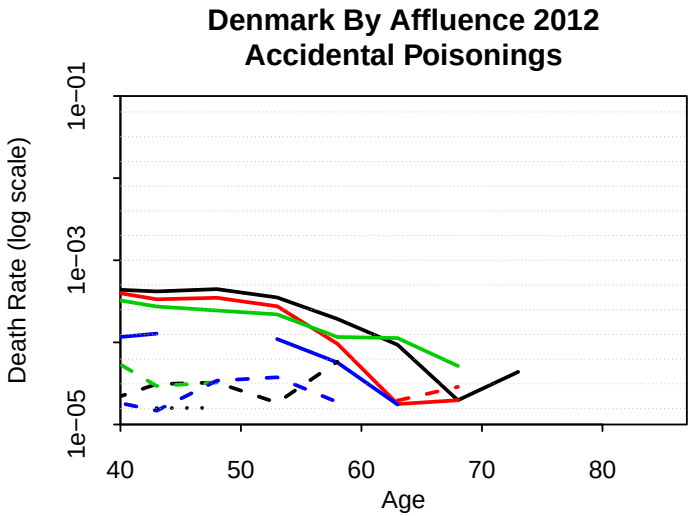


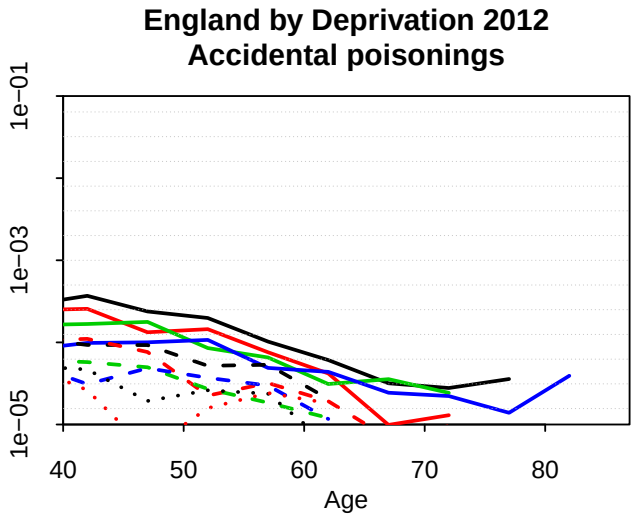


Deaths of Despair: A Growing Problem? 2002/07/12









Growth: England $>$ US $>$ DK

US: evidence of a cohort effect