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

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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

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

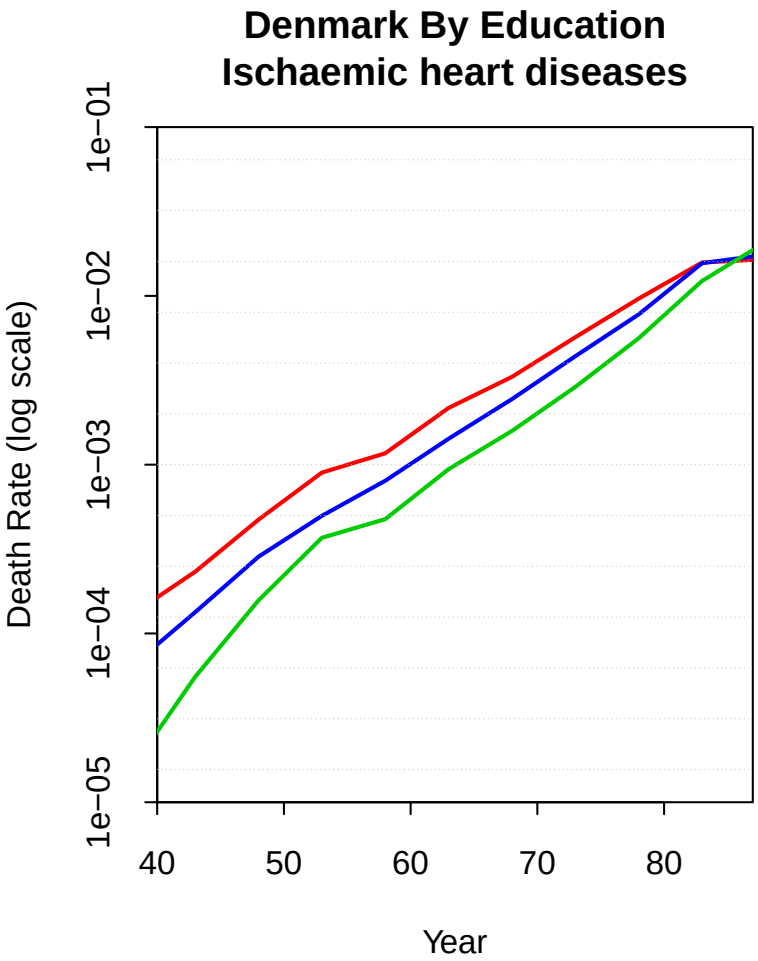
Males; Ages 71-75; Years 2005-2009

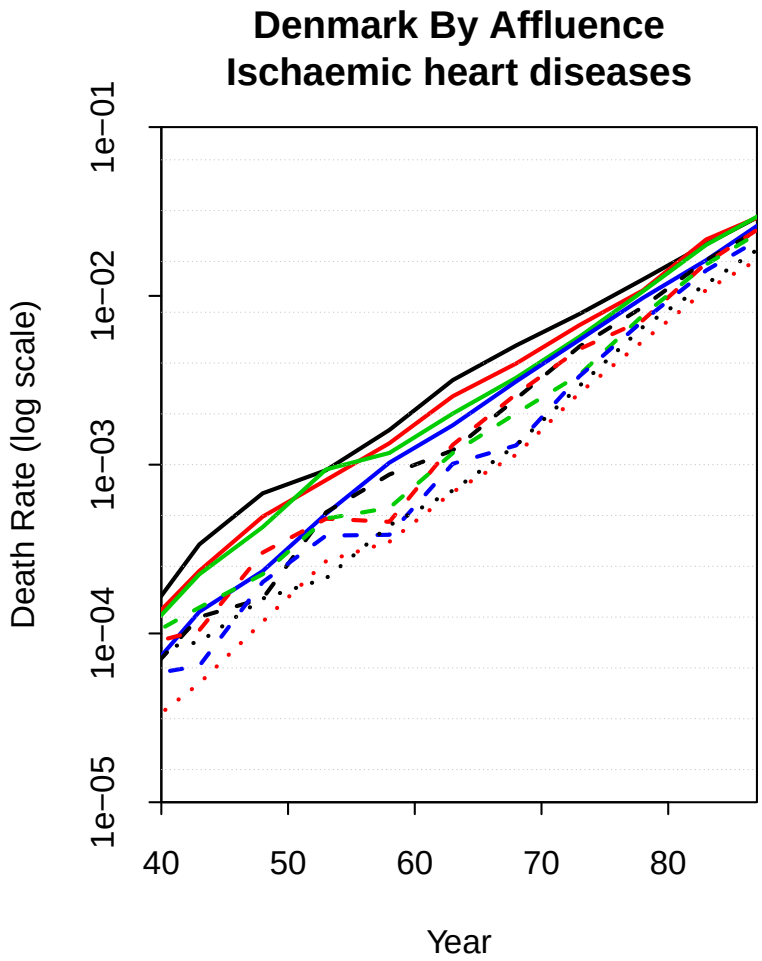
Rank	Least Affluent	Most Affluent
1	Ischaemic heart	Skin & organ cancer
2	Respiratory	Ischaemic heart
3	Lung cancer etc.	Prostate cancer
4	Skin & organ cancer	Respiratory
5	Other	Lung cancer etc.
6	Cerebrovascular	Cerebrovascular
7	Other heart	Other
8	Diabetes	Gut cancer
9	Gut cancer	Other heart
10	Prostate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



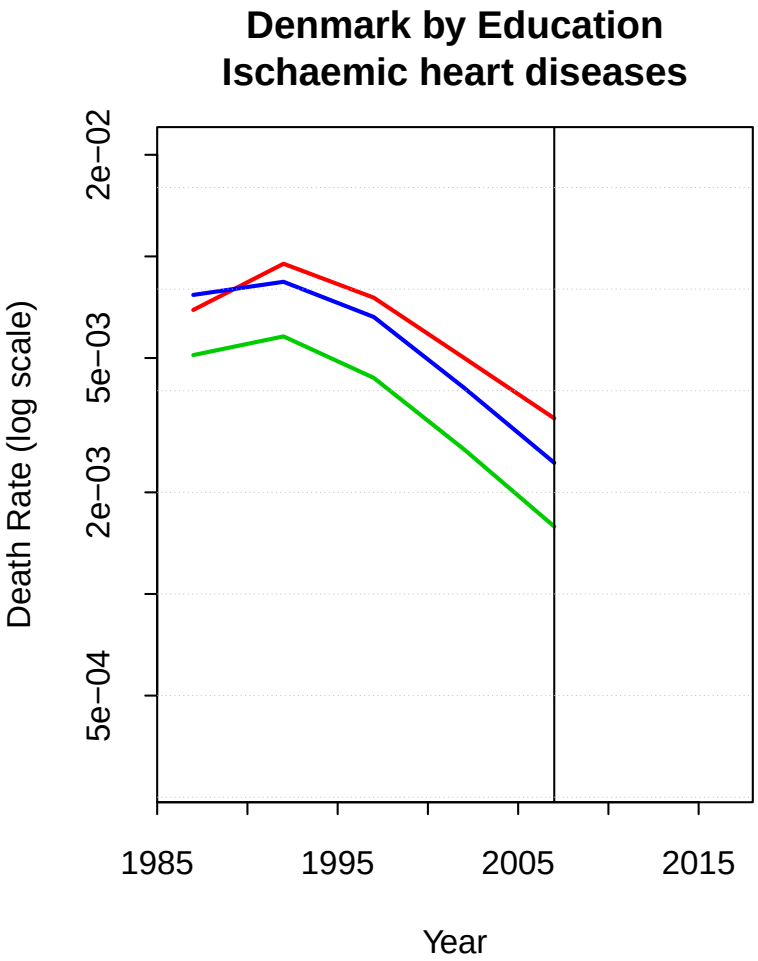


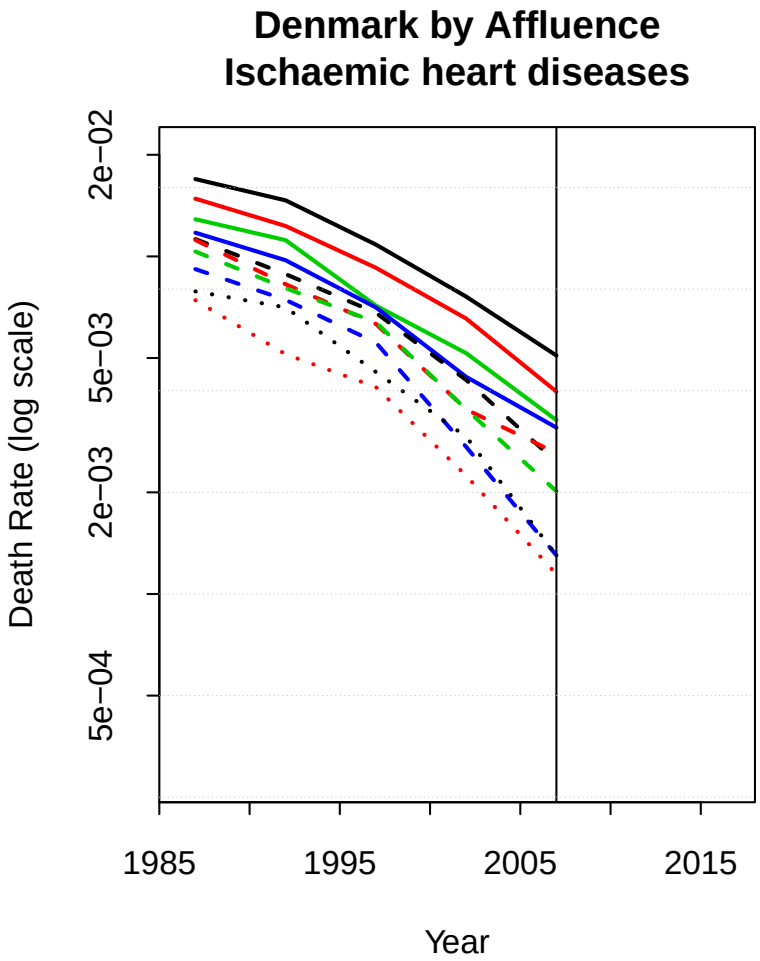
Wide gap

Affluence: wider gap

Gap narrows with age

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



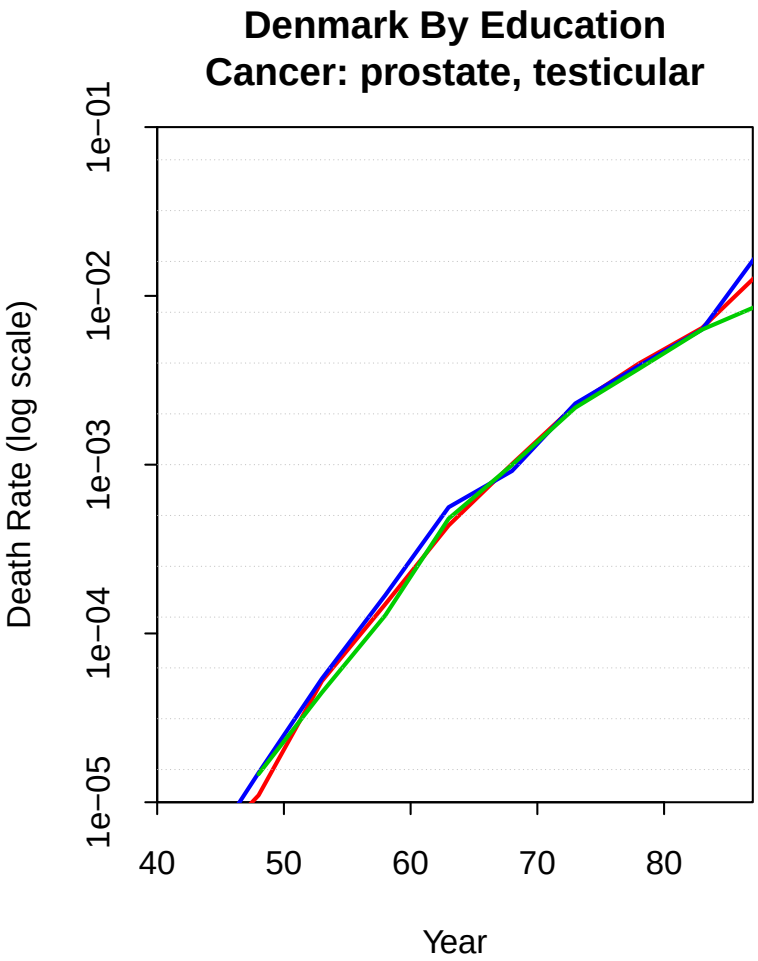


Gap widens over time

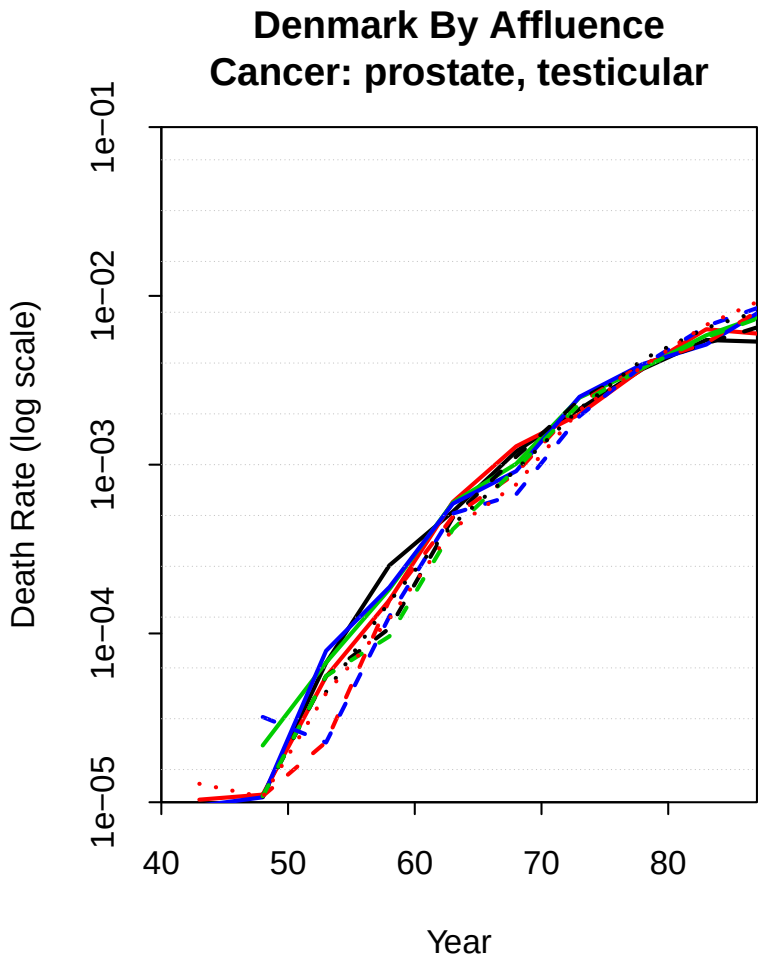
Impact of Controllable Risk Factors

- 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
- Other causes of death:
  no known (significant) controllable risk factors
  e.g. prostate cancer

Denmark: Cause of Death Data 2005-2009

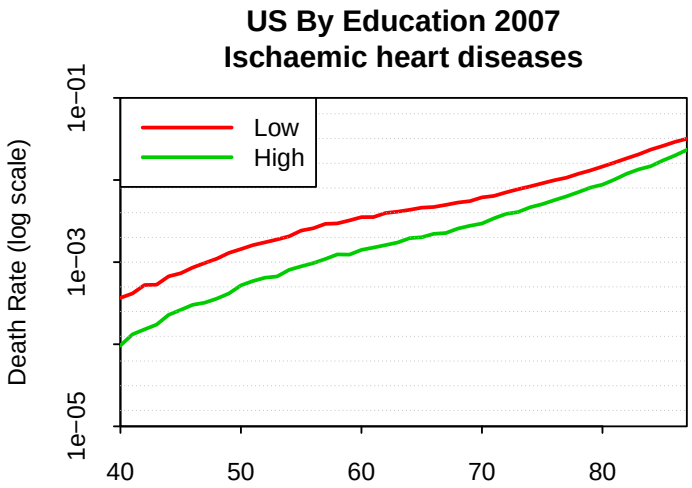


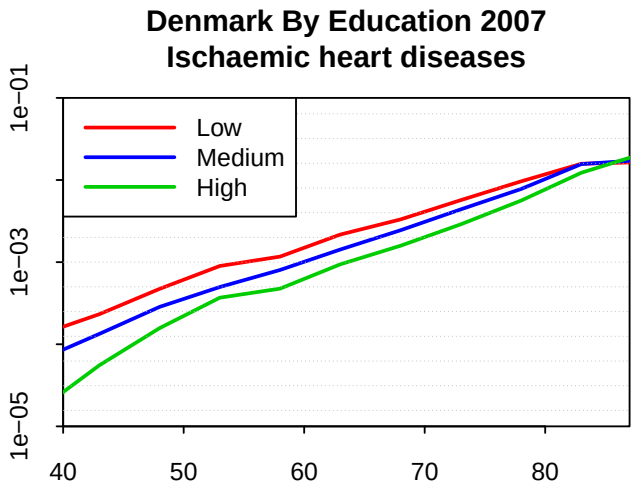
Education: no differences

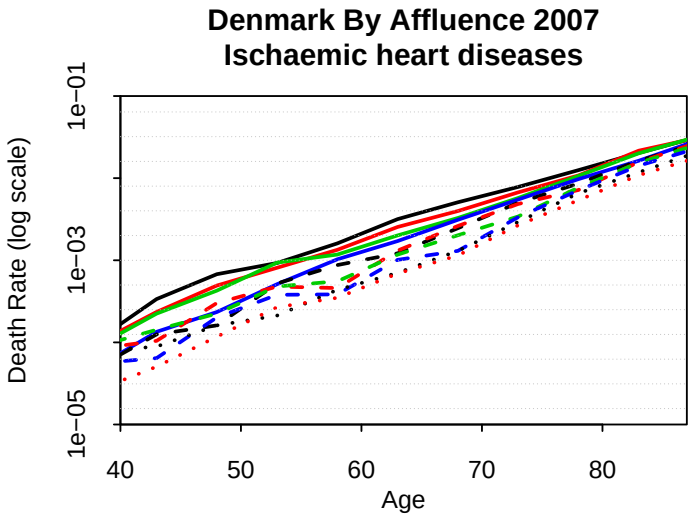


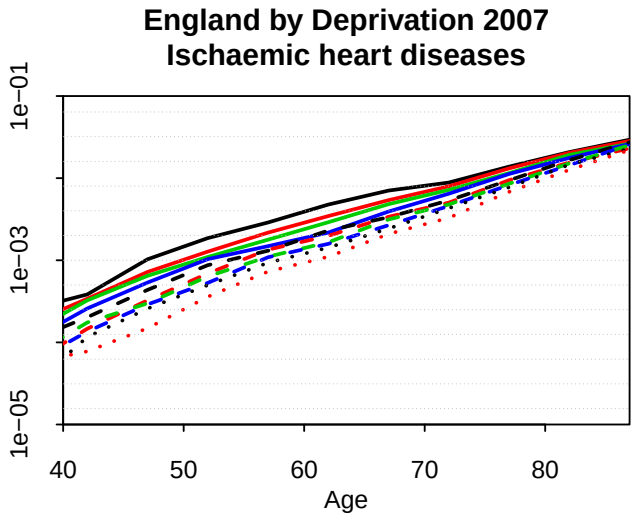
Affluence: small differences

Multi-Country: Year 2007, Ischaemic Heart Disease





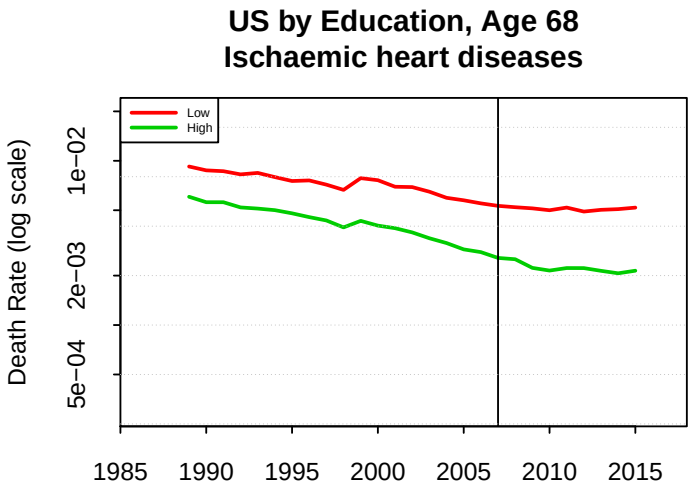


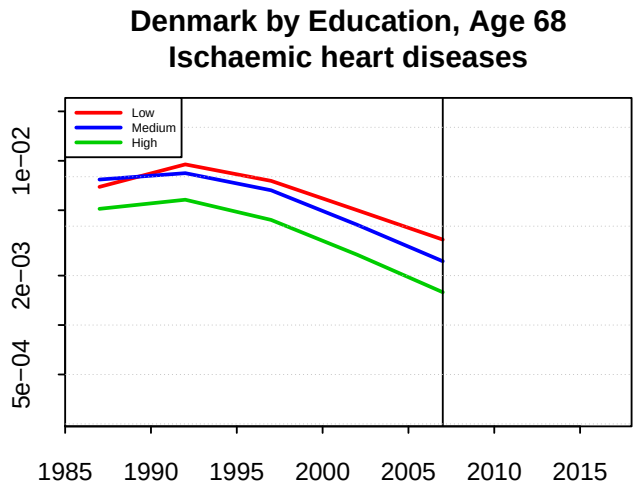


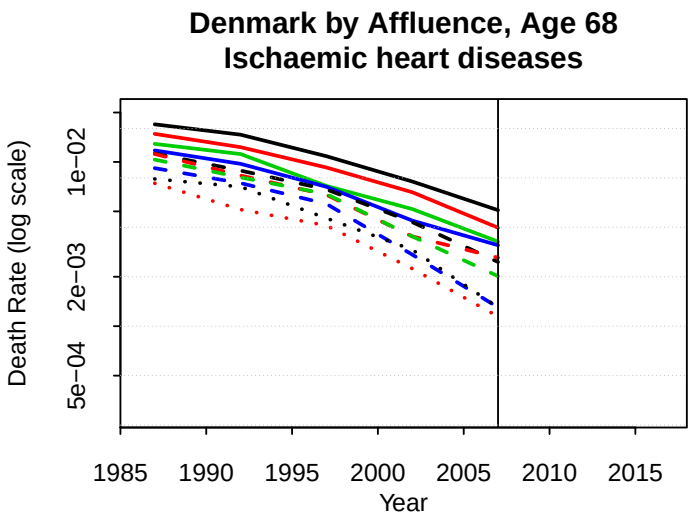
US: wider than Denmark

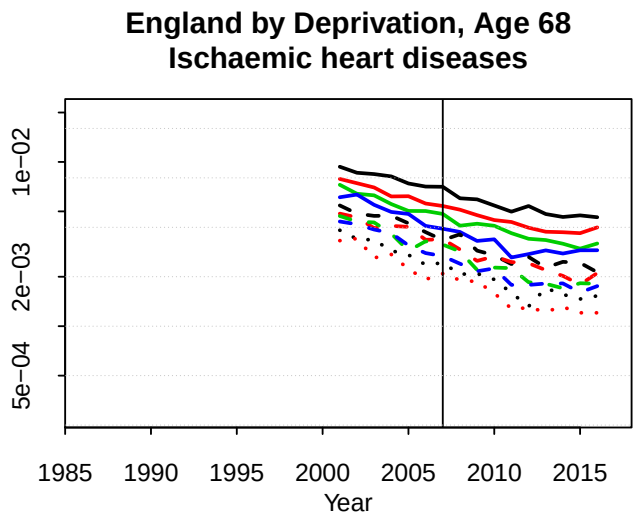
England similar to Denmark but higher

Multi-Country: Age 68, Ischaemic Heart Disease



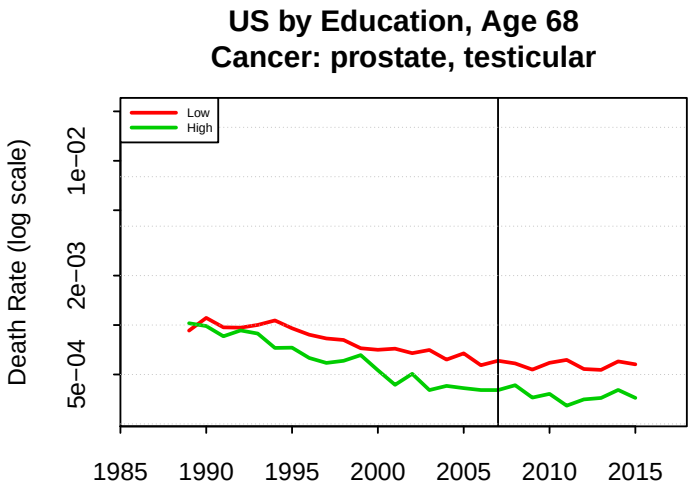


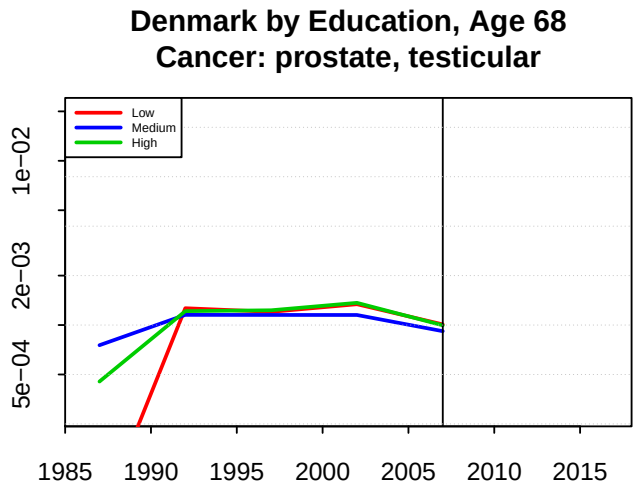


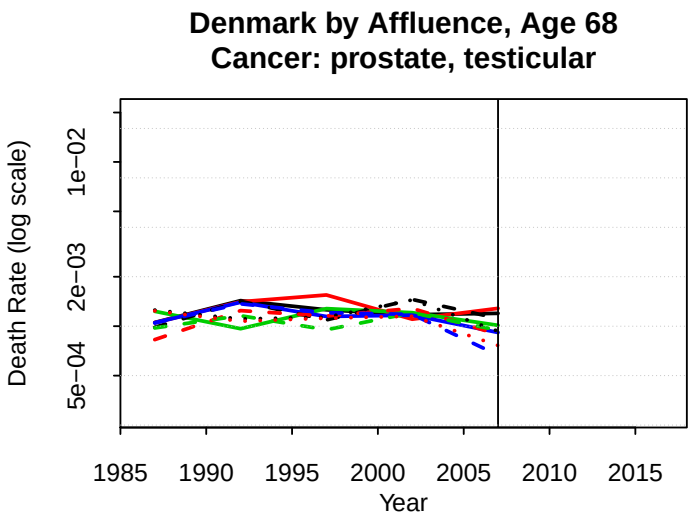


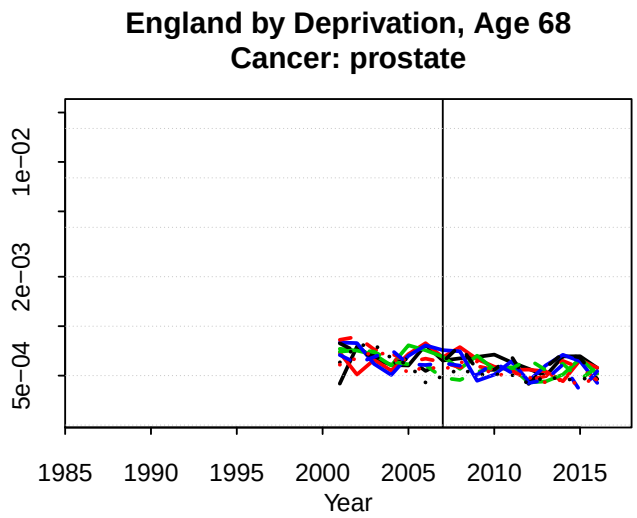
Significant improvements, but not throughout

Multi-Country: Age 68, Prostate Cancer



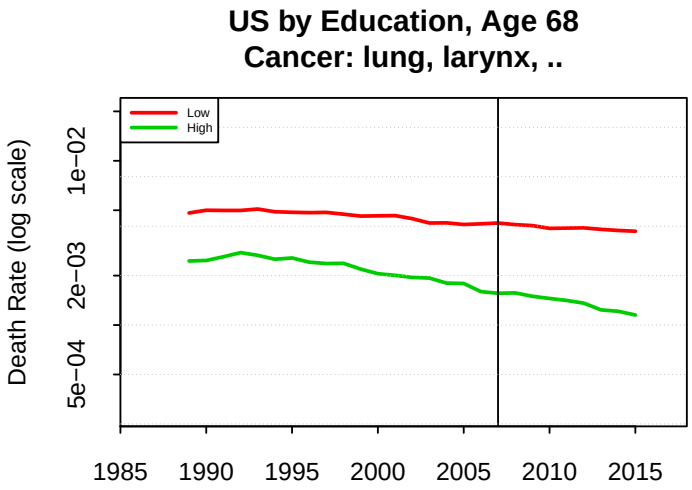


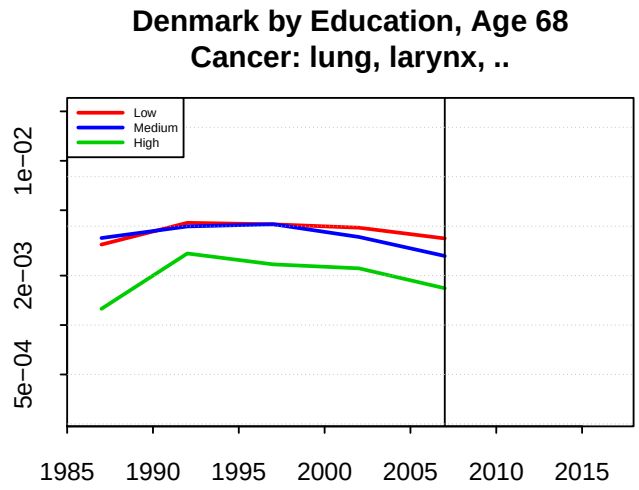


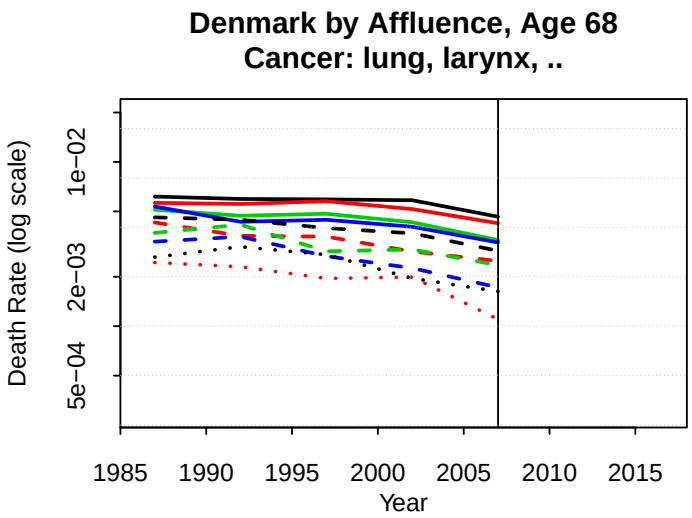


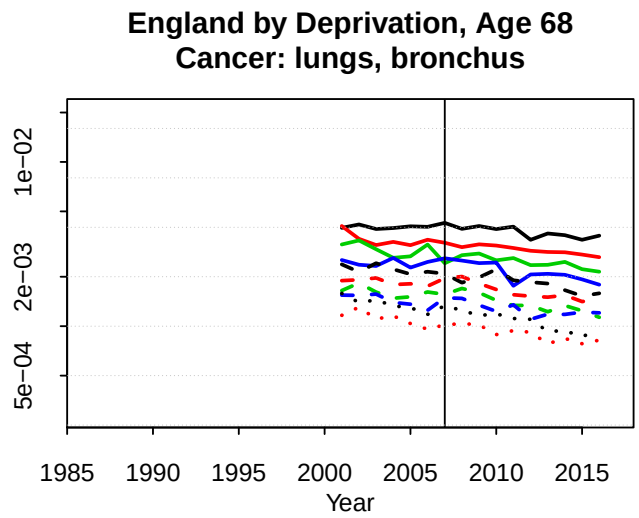
No controllable risk factors; US improvements; DK vs US genetic factors?

Multi-Country: Age 68, Lung Cancer



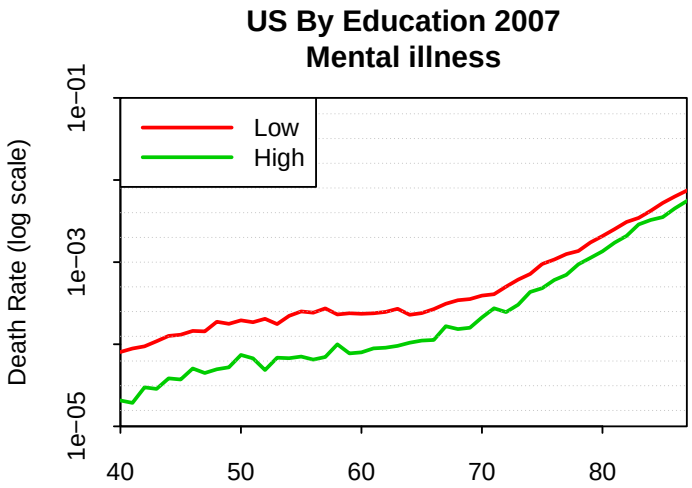


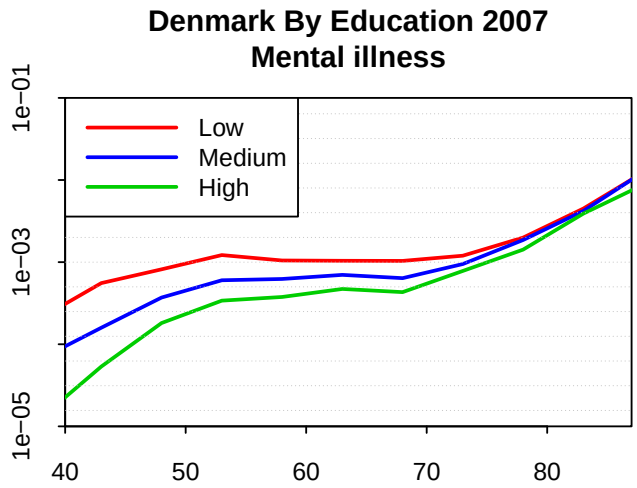


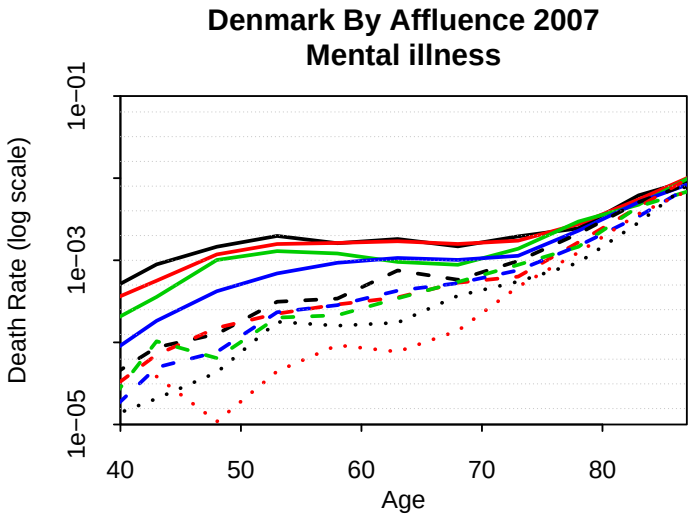


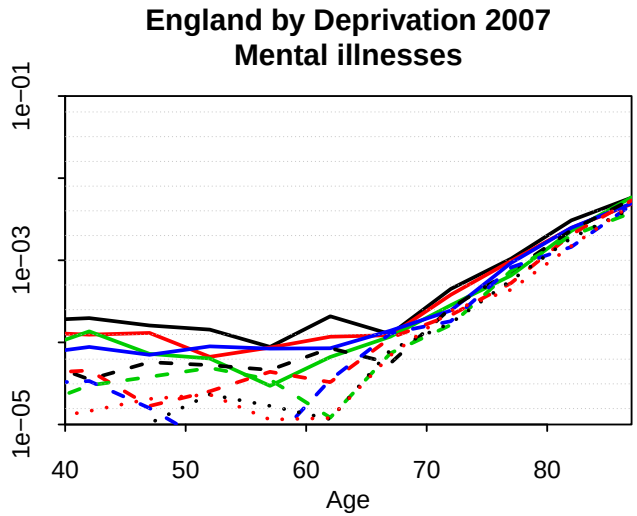
Significant inequality; improvements might be driven by smoking prevalence

Variation in Reporting Practice: e.g. Mental Illness



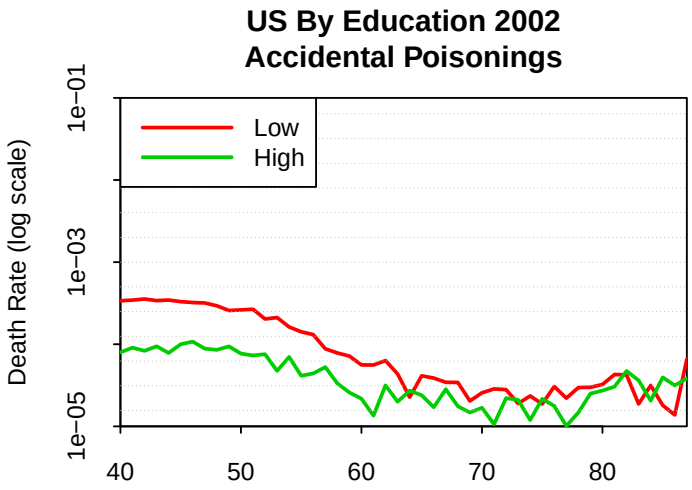


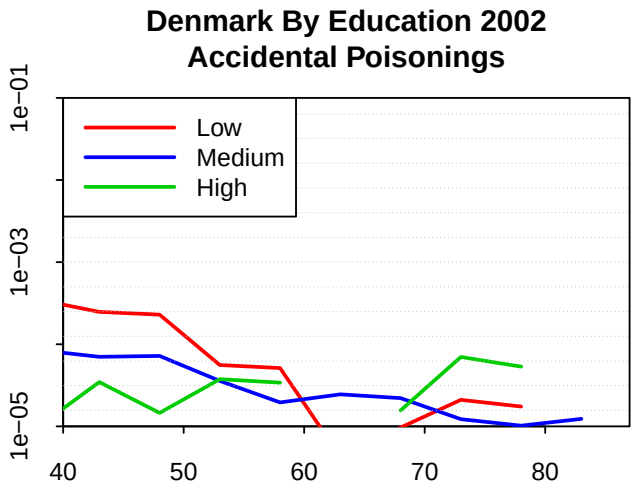


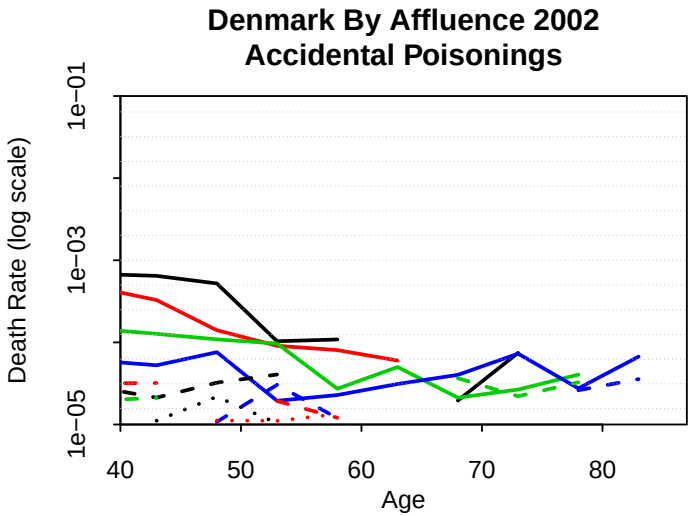


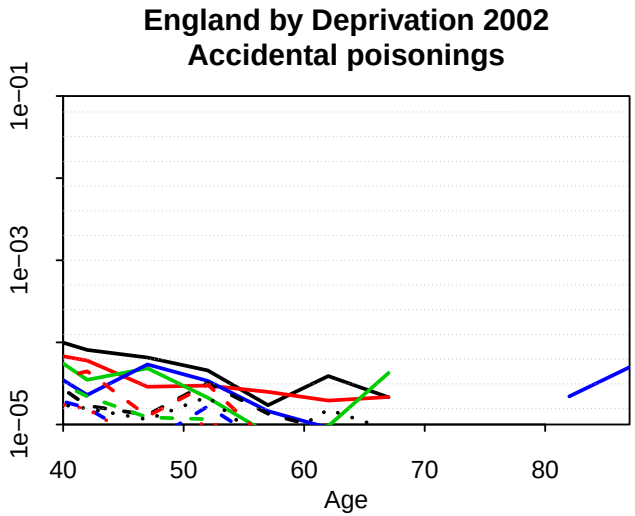
Alcohol & drug abuse; mental disorders; $\longrightarrow$ vascular dementia

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









US, Denmark: significant

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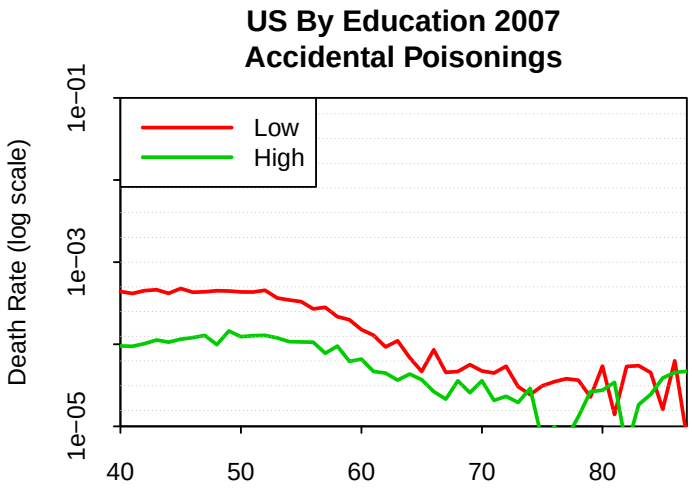
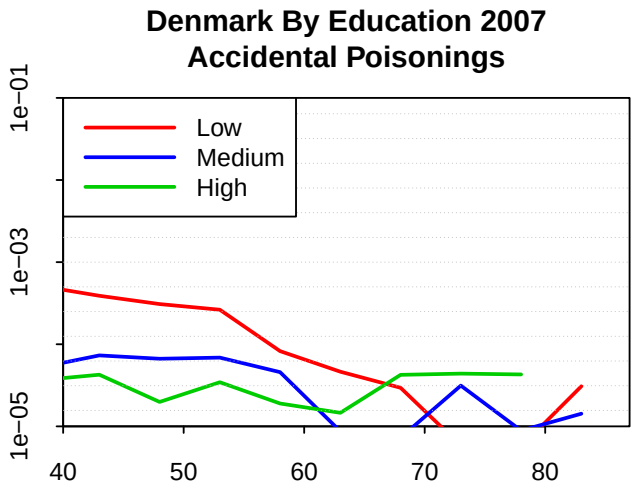
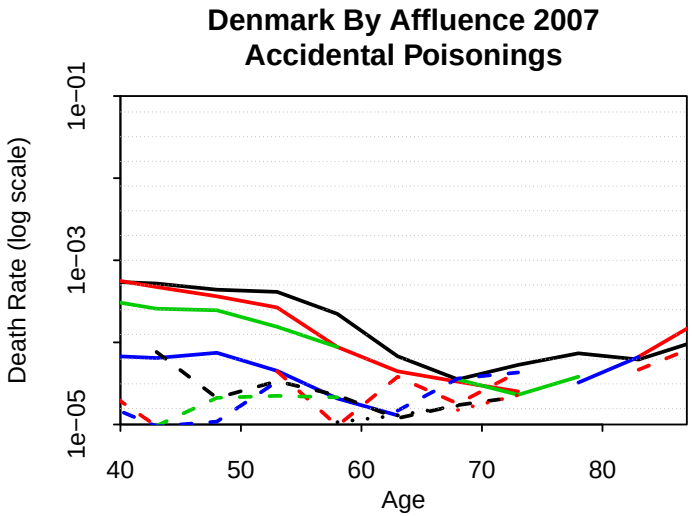
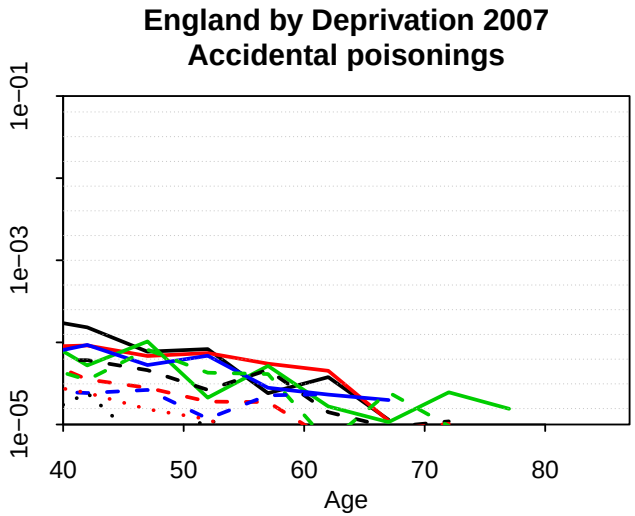
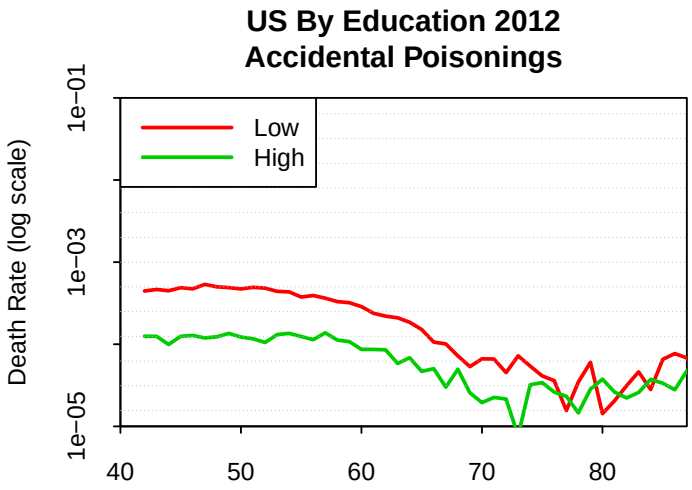


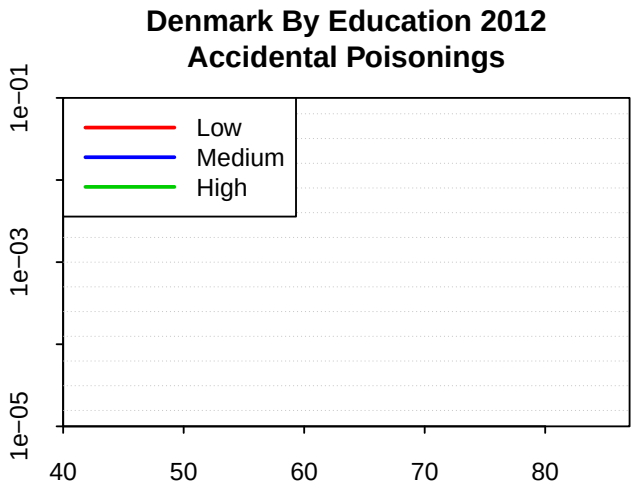


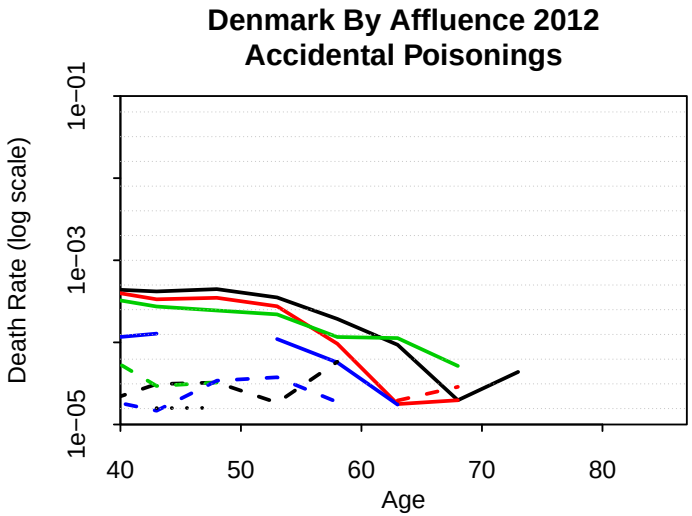


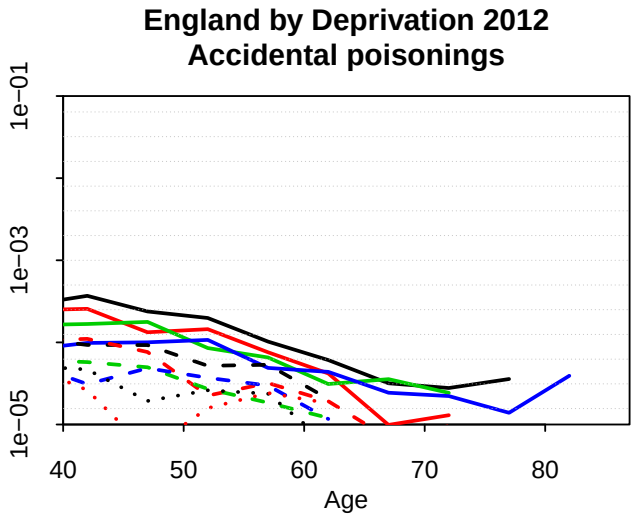


Deaths of Despair: A Growing Problem? 2002/07/12





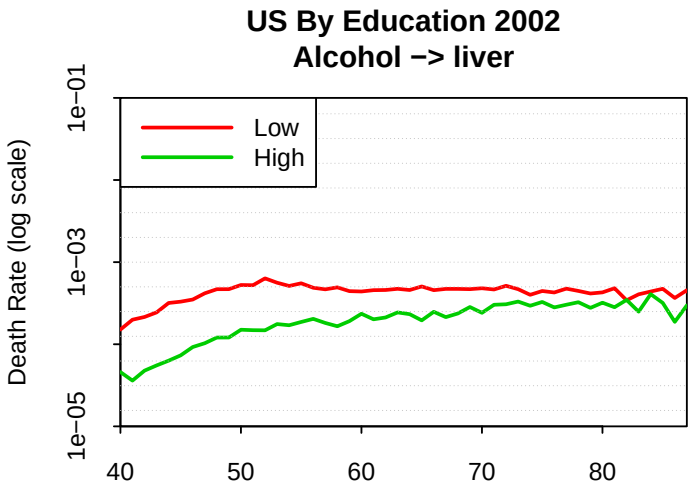


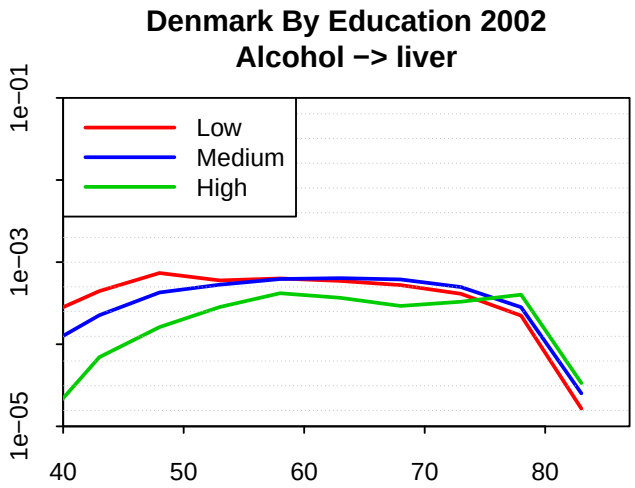


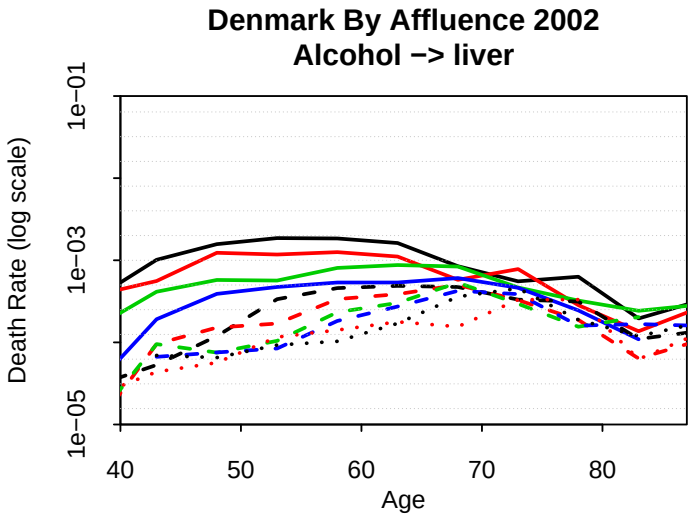
Growth: England $>$ US $>$ DK

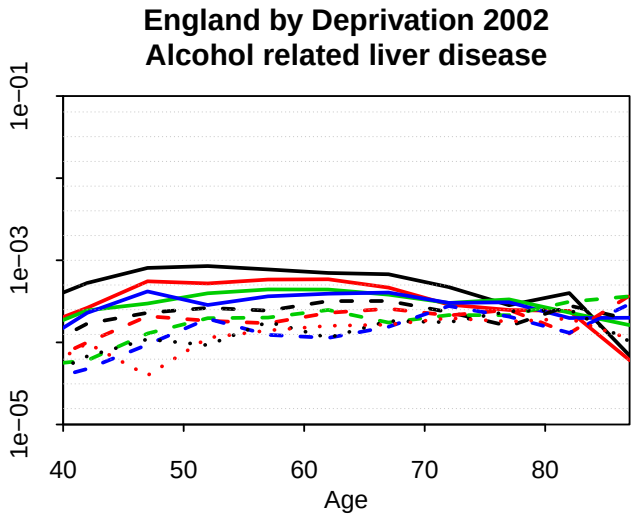
US: evidence of a cohort effect

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









Affluence a much bigger driver

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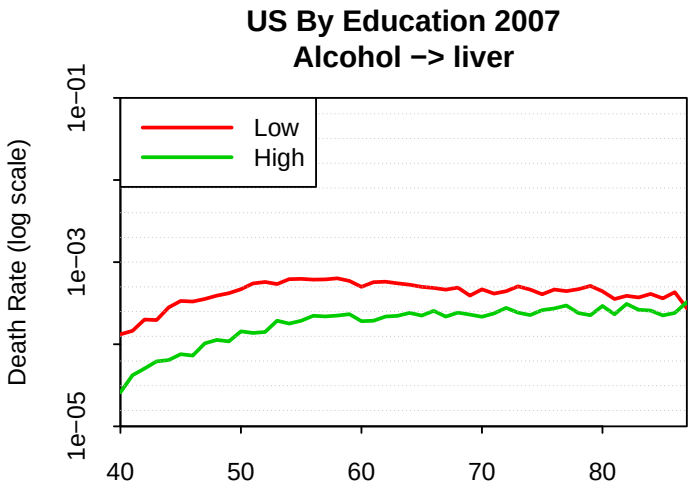
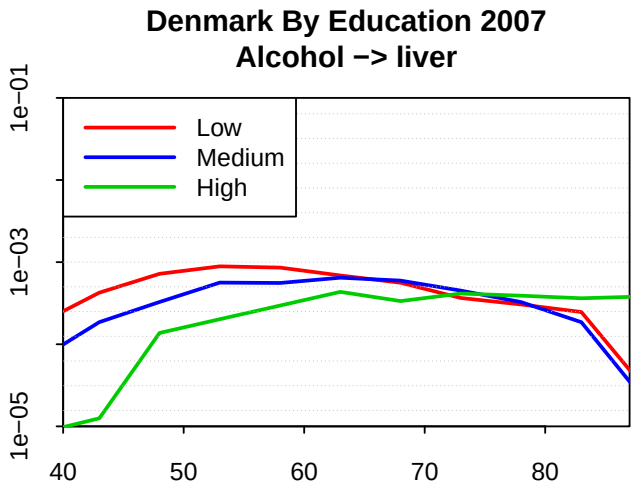
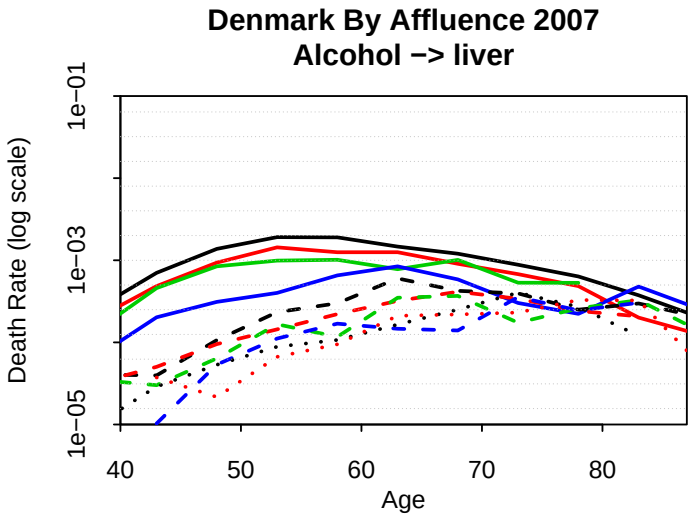
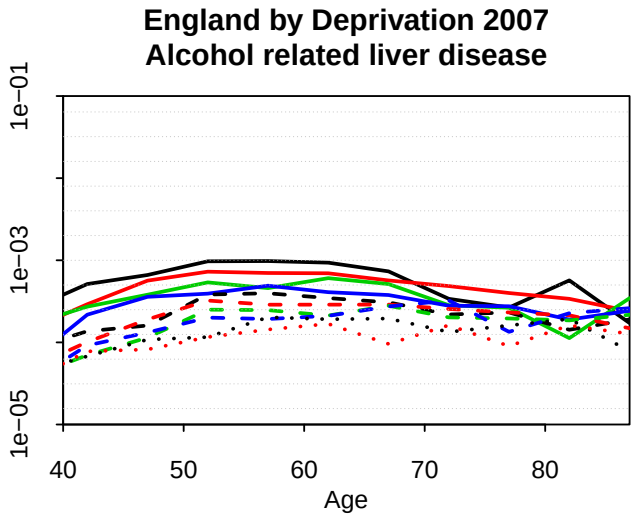
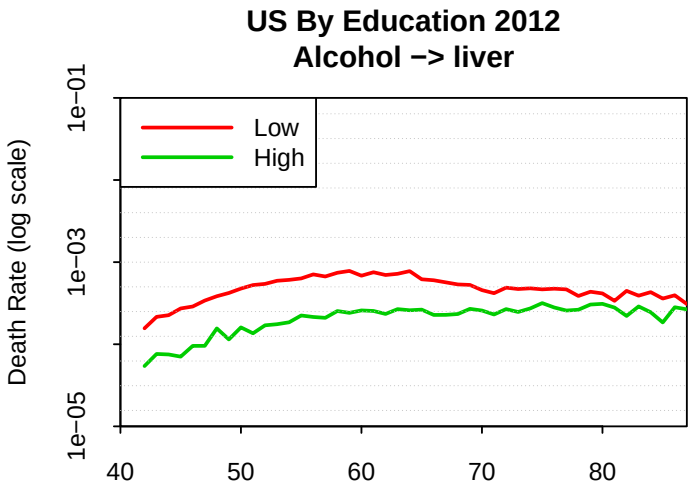


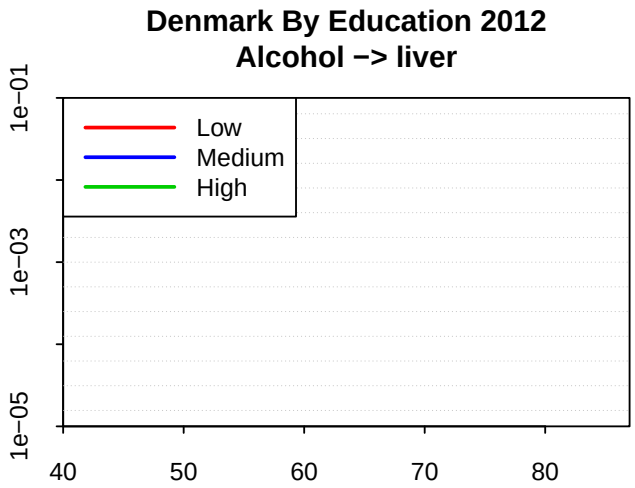


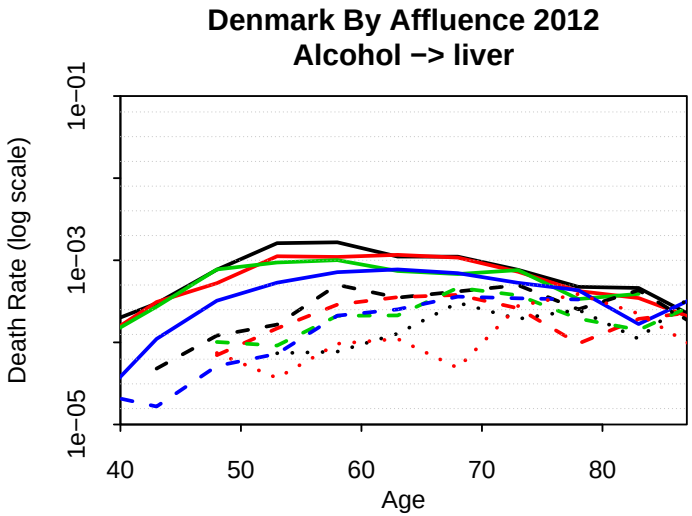


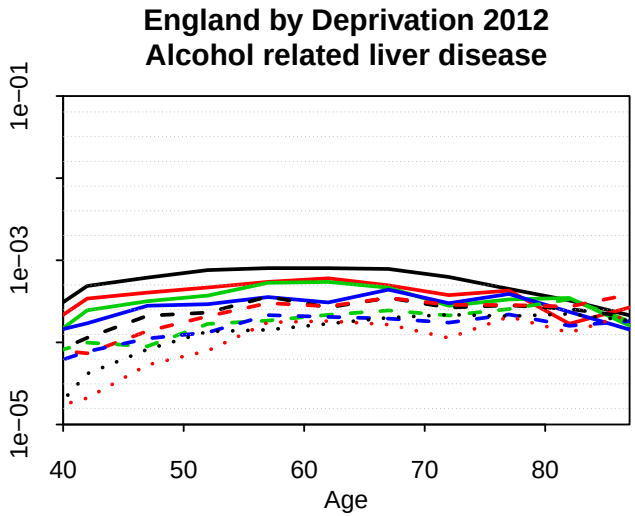


Deaths of Despair: A Growing Problem? 2002/07/12



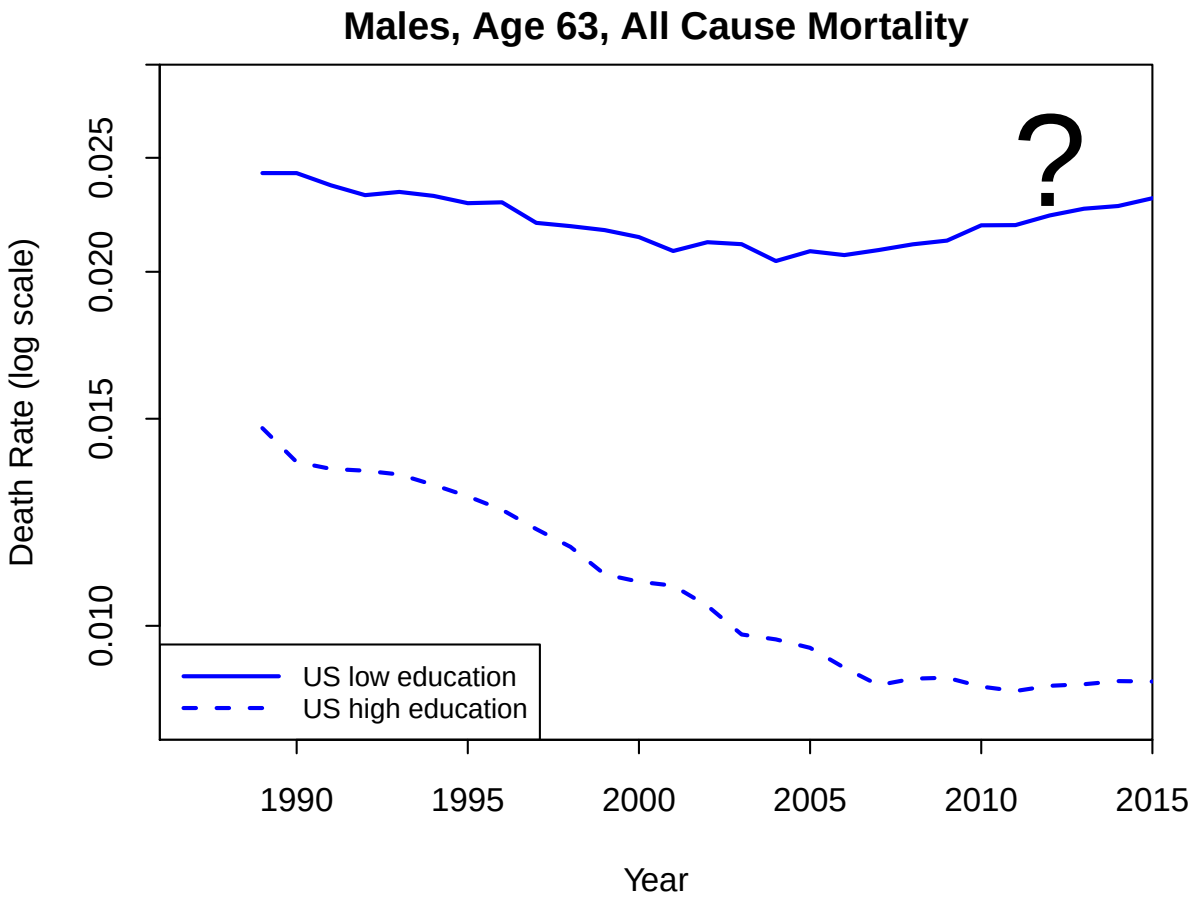






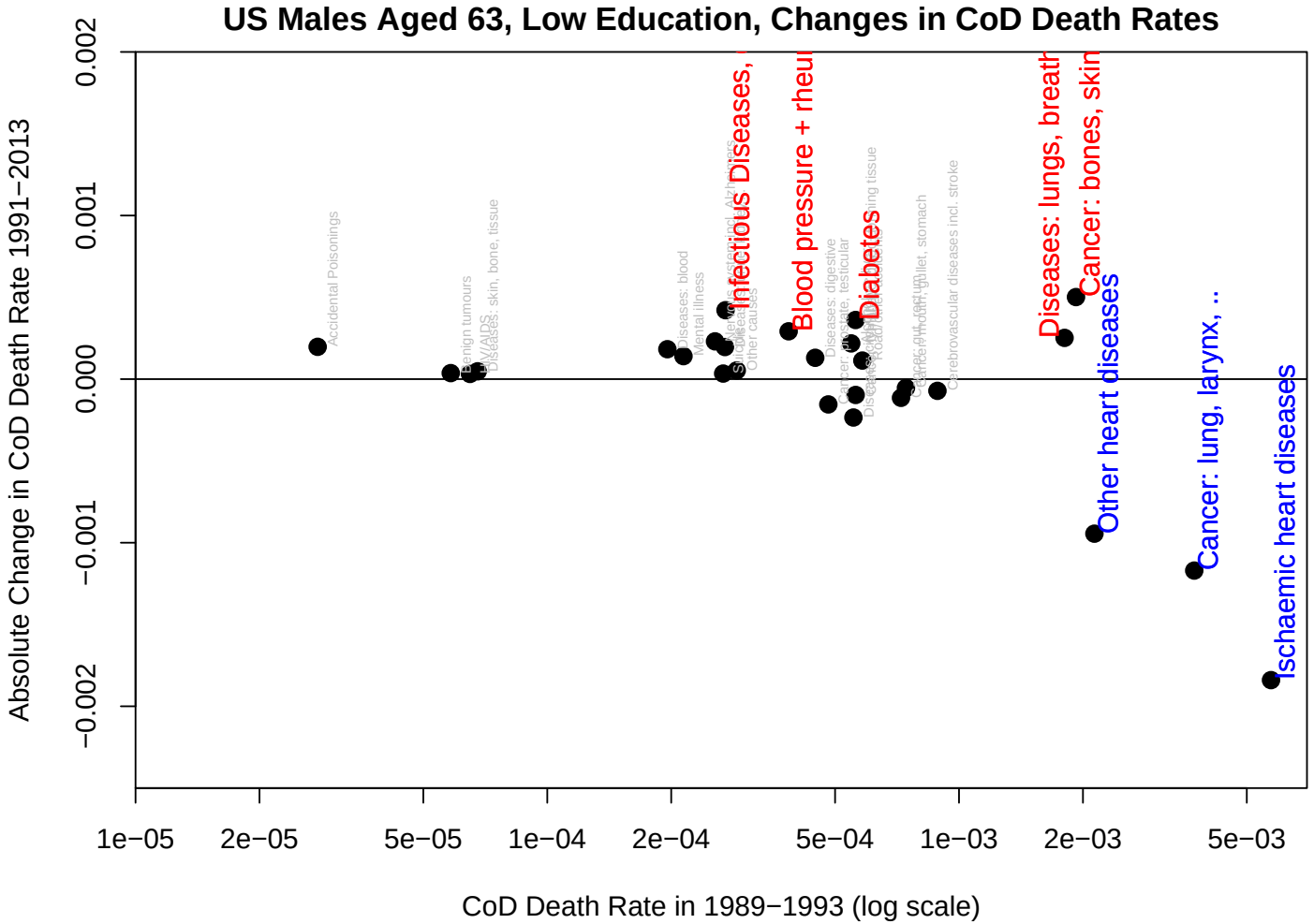
US: possible cohort effect

US Males Age 63: Stagnation



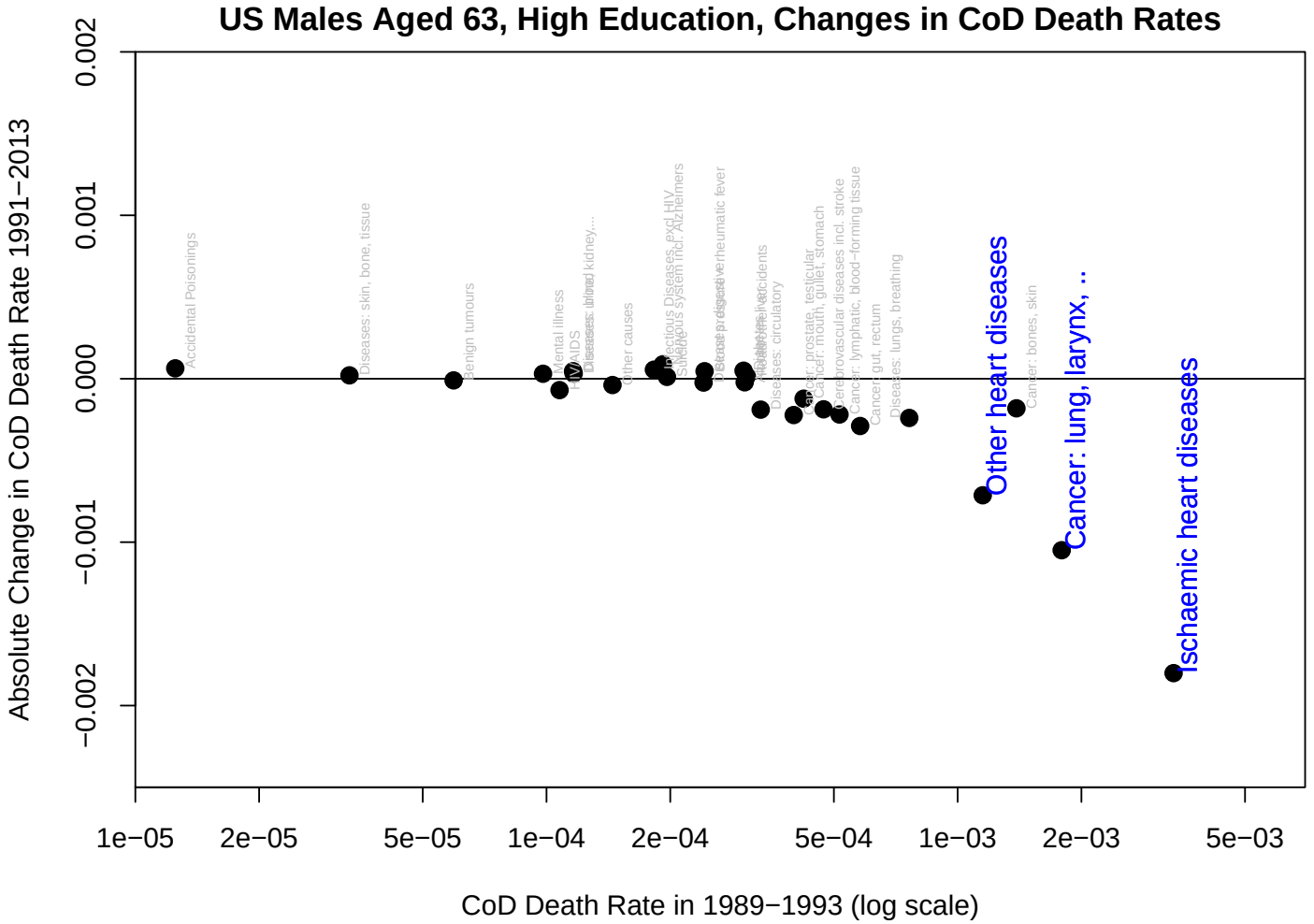
US Drivers of Change 1991-2013, Males Age 63

Low education absolute changes in mortality



US Drivers of Change 1991-2013, Males Age 63

High education absolute changes in mortality

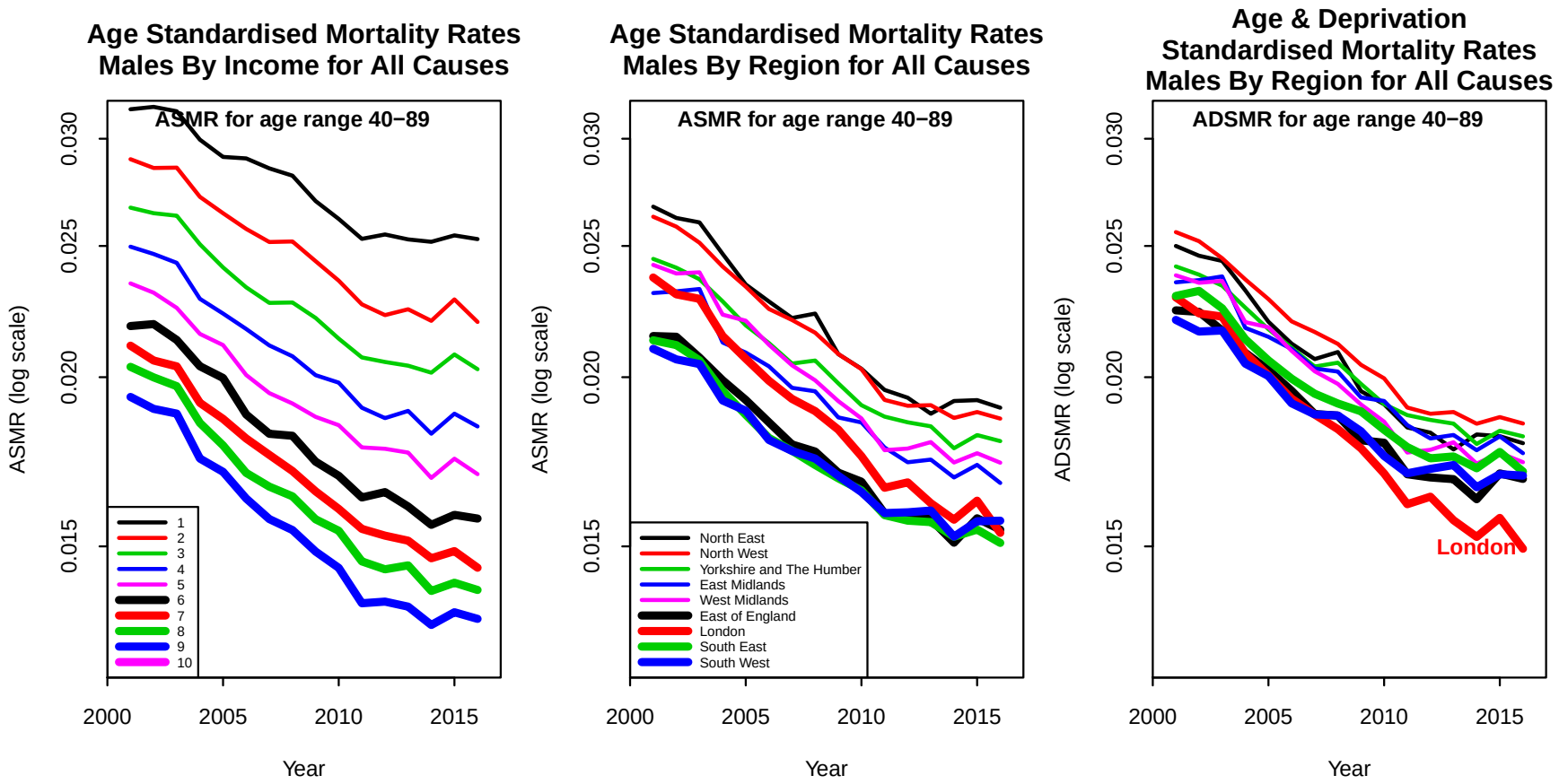


England: Income Deprivation versus Region

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



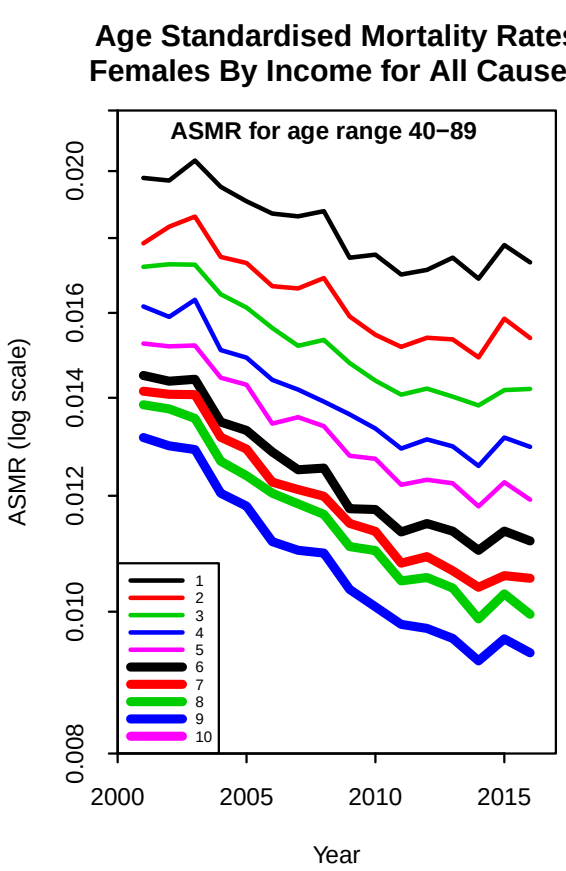
ADSMR adjusts for different income deprivation mix by region

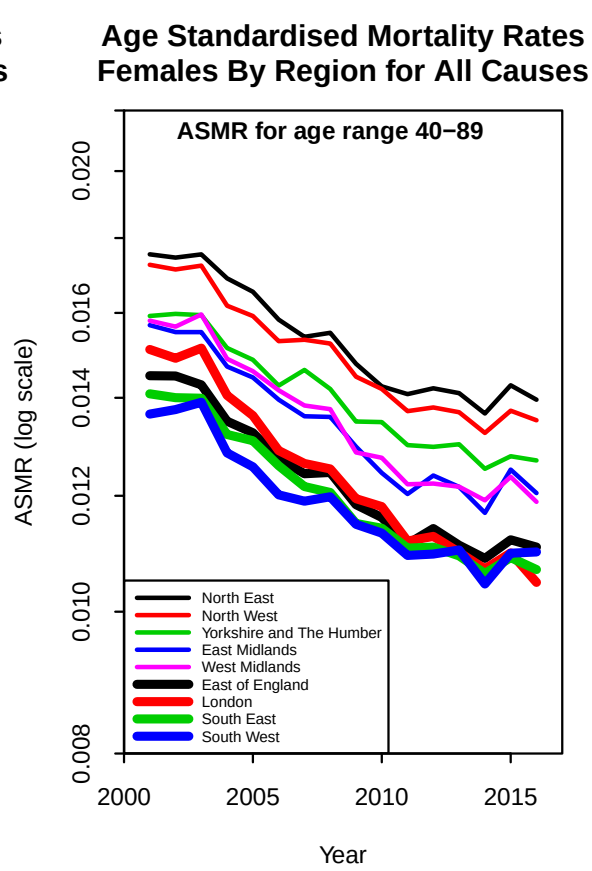
Clear "London Effect".

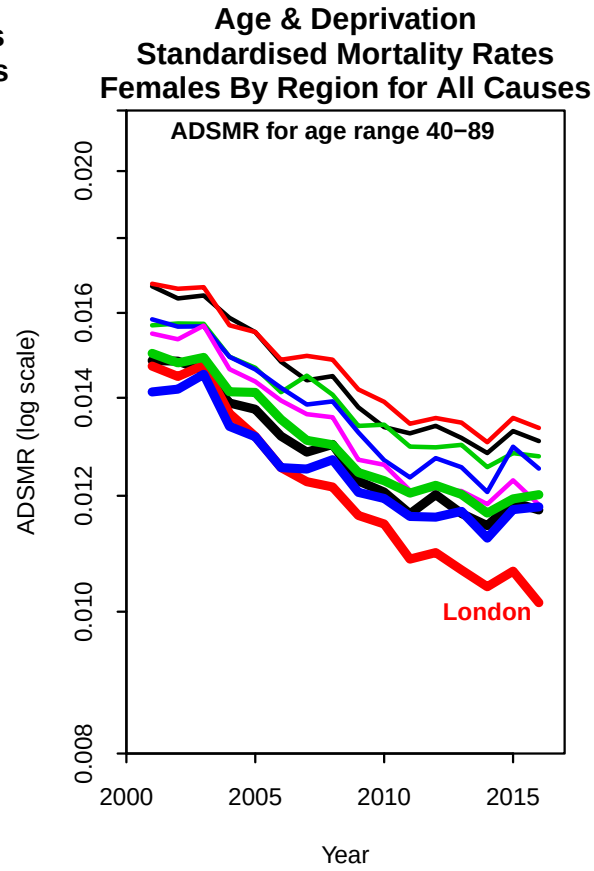
Greater improvements in healthcare??

Greater improvements in GDP??

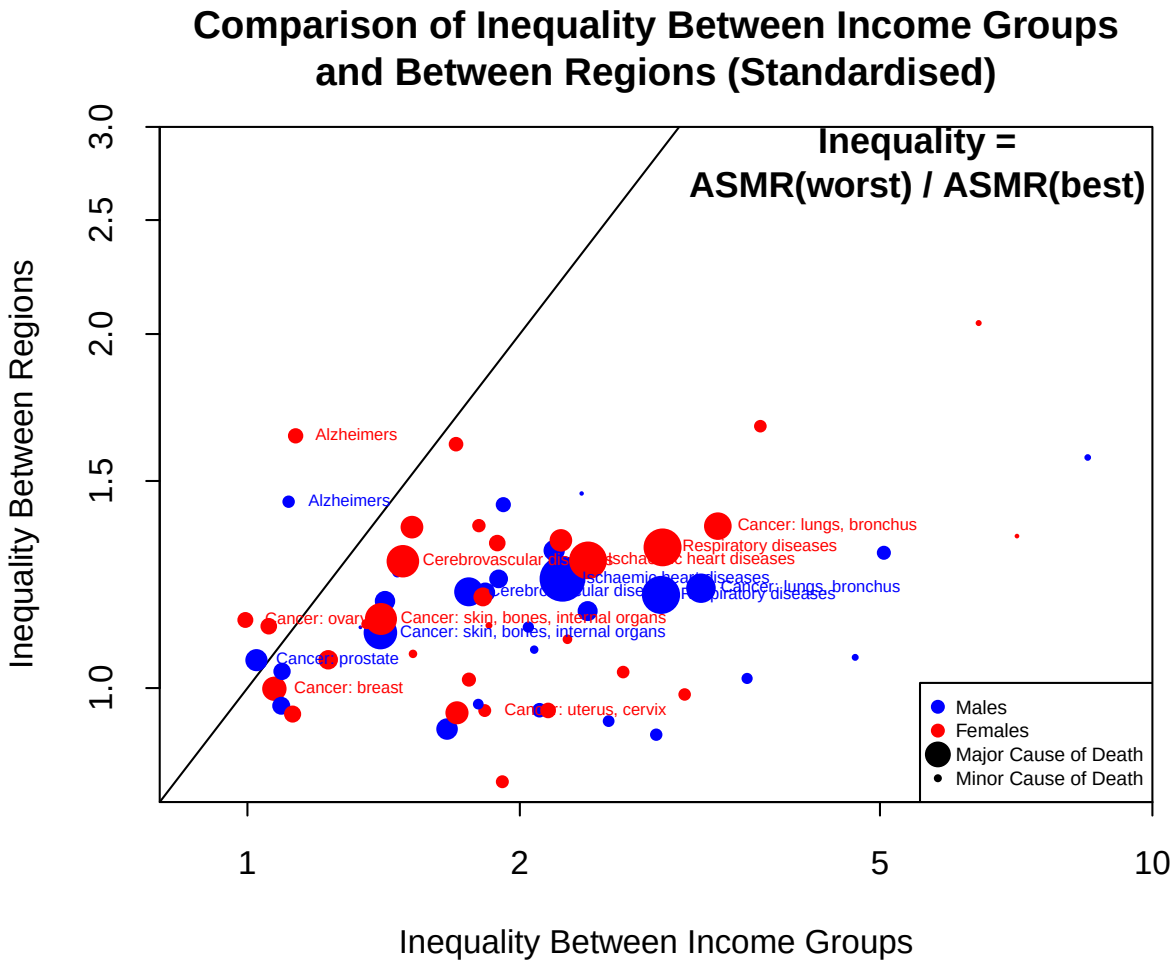
England: Females (40-89) ASMR and ADSMR Inequality





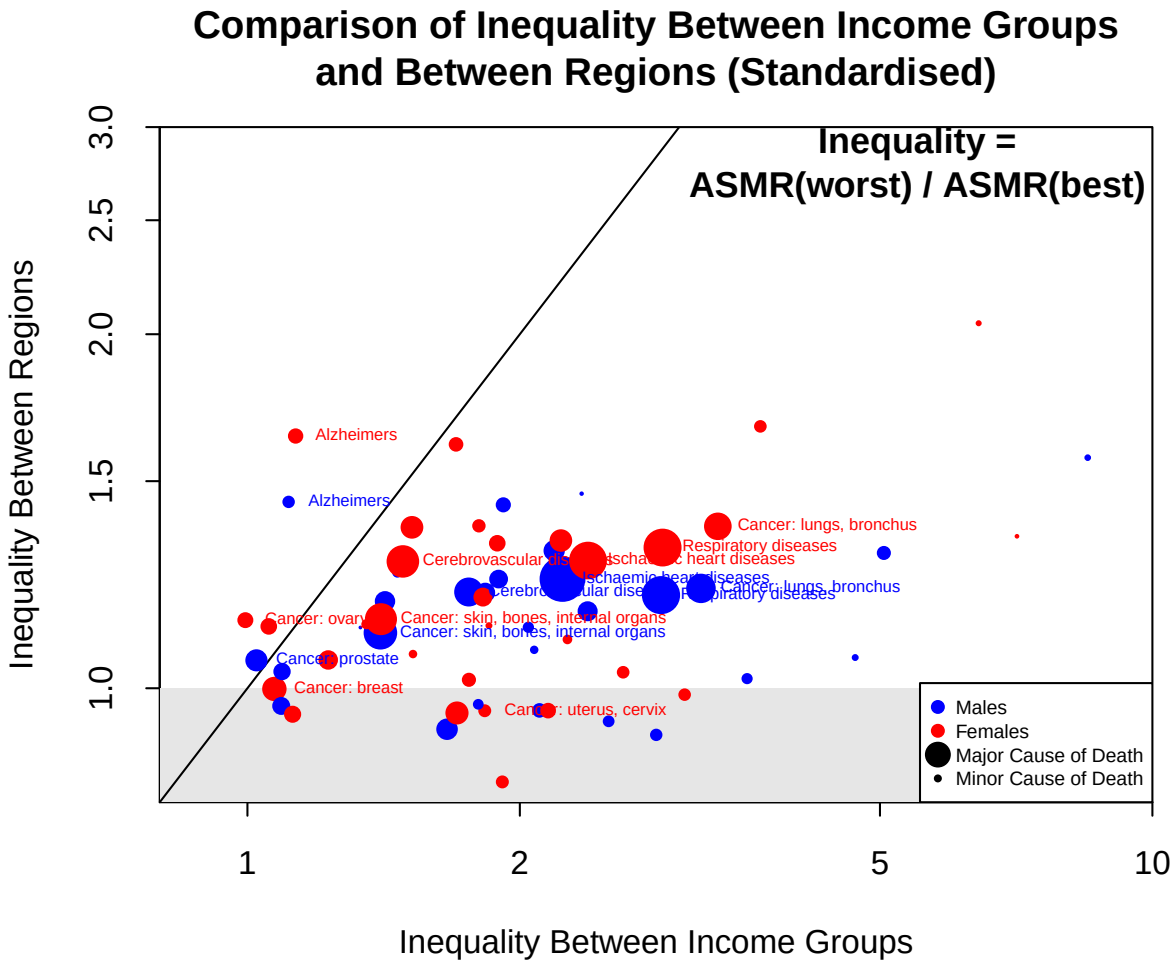


Cause of Death Inequaility: Income vs Region



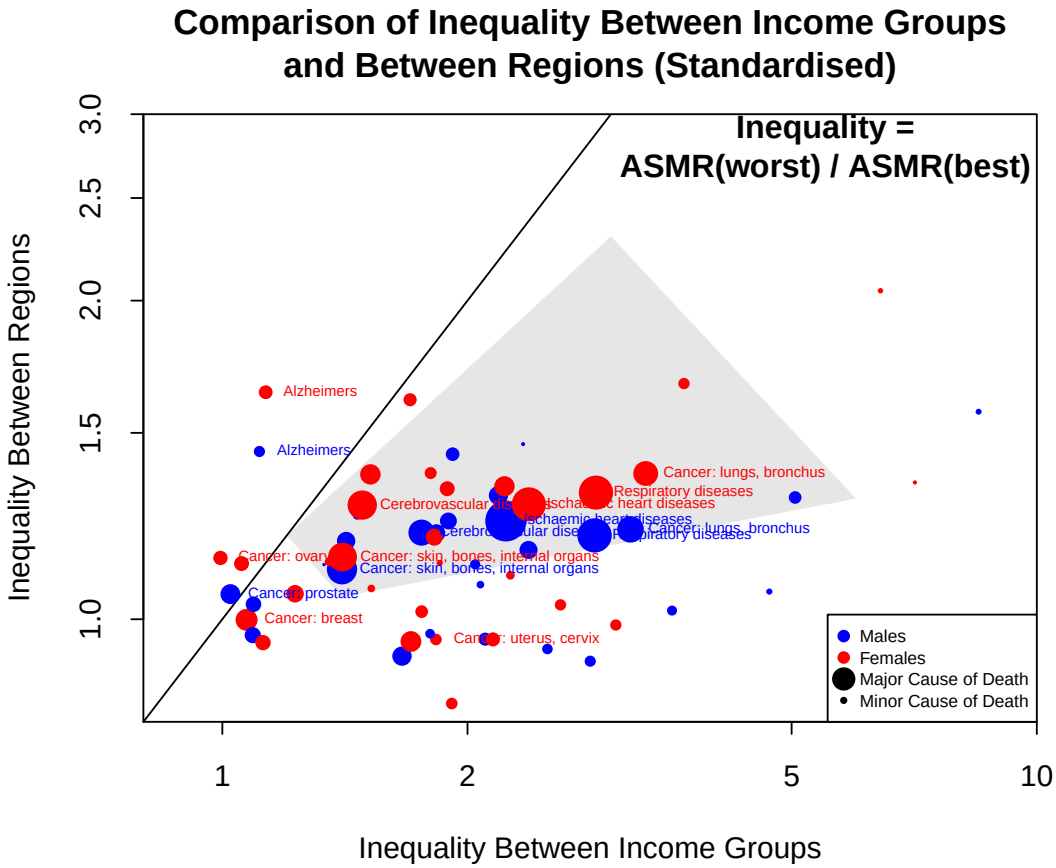
Inequality=A(D)SMR(worst)/A(D)SMR(best)
Region: best=London; worst=N.W.
Income Deprivation: best=10; worst=1

Cause of Death Inequaility: Income vs Region



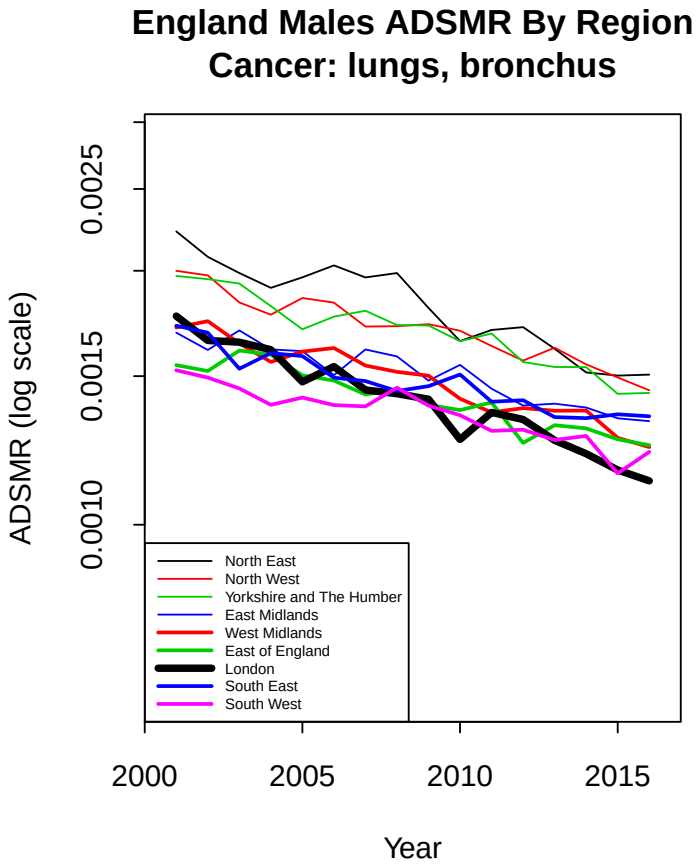
London: not always the best for individual causes of death.

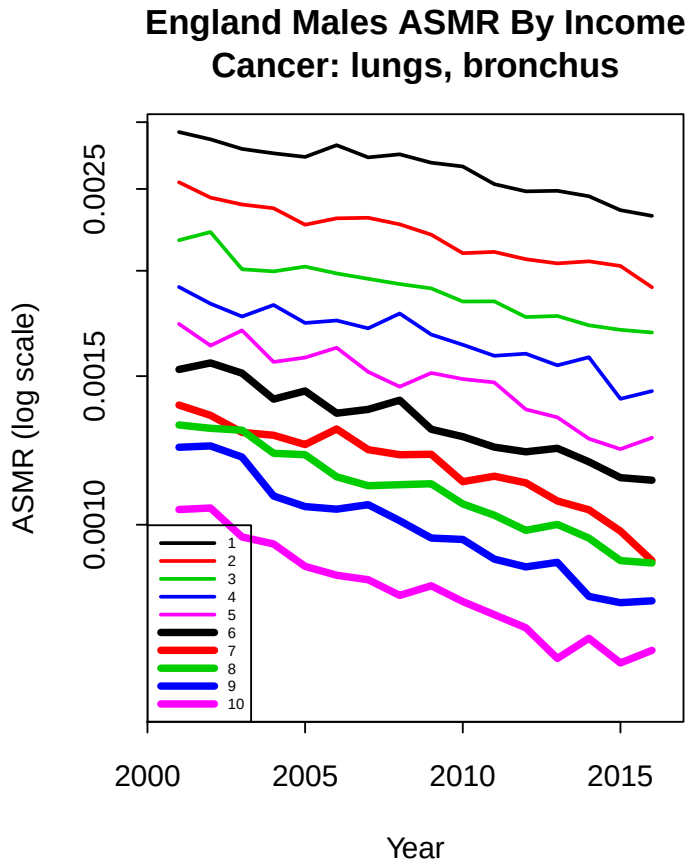
Cause of Death Inequaility: Income vs Region



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

Lung Cancer: Males





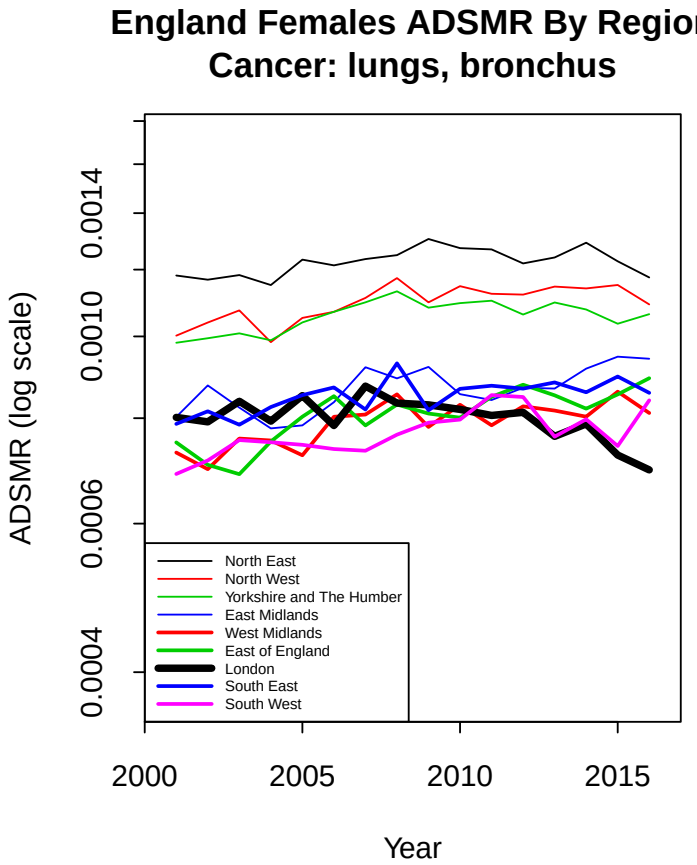
Significant variation between income deciles ($\Rightarrow$ smoking prevalence)

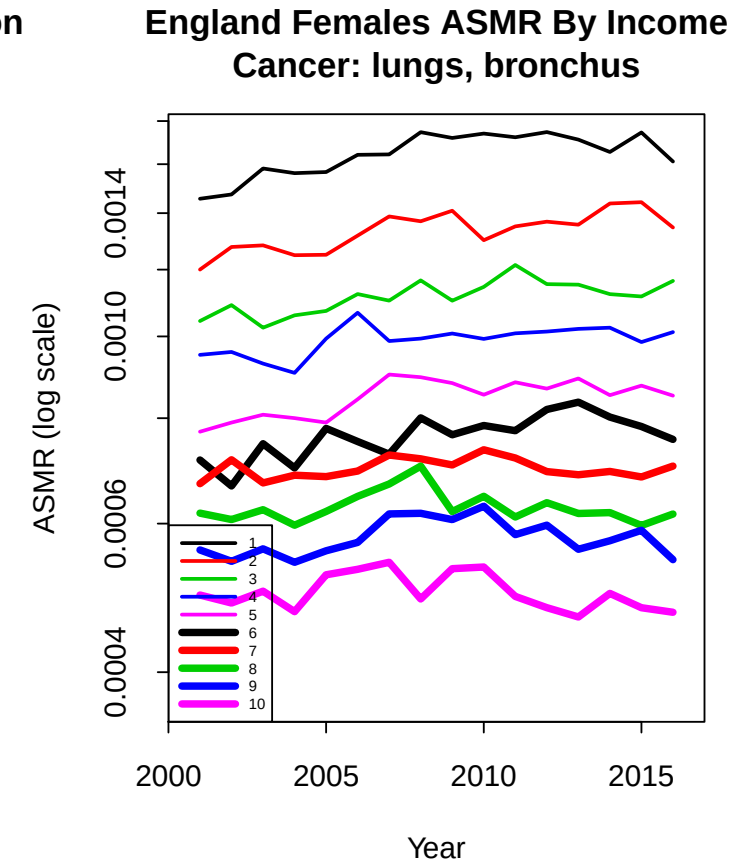
Significant variation between regions (after standardisation)

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

London effect; Northern regions very poor

Lung Cancer: Females





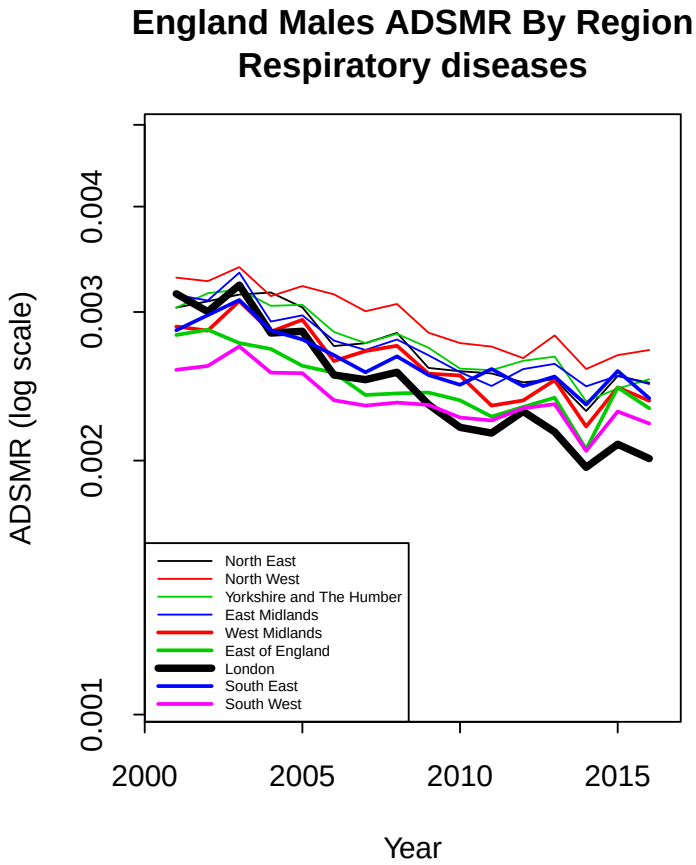
Slight worsening $\Rightarrow$ smoking prevalence rising

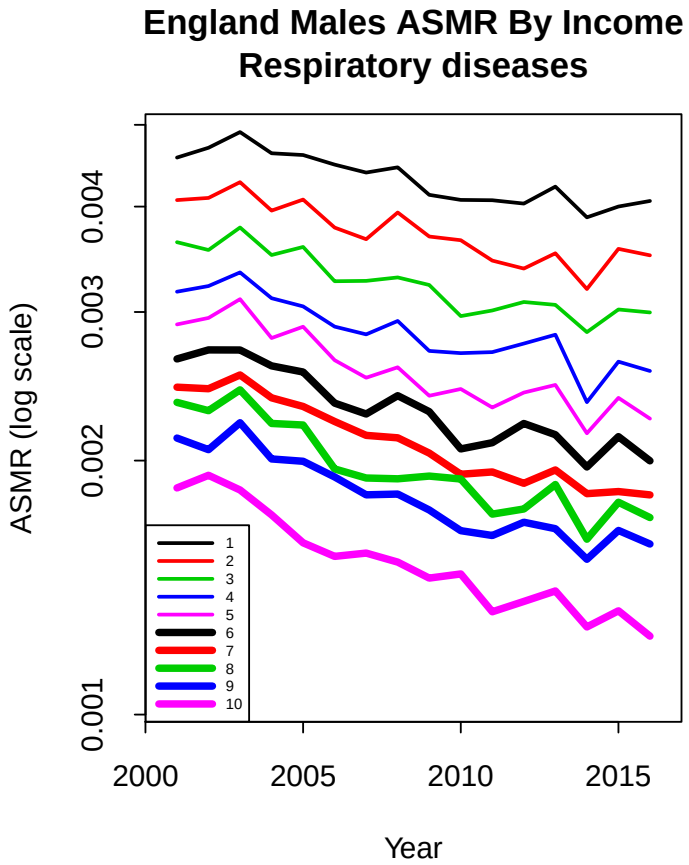
Same northern regions do badly

Wider regional spread

London effect

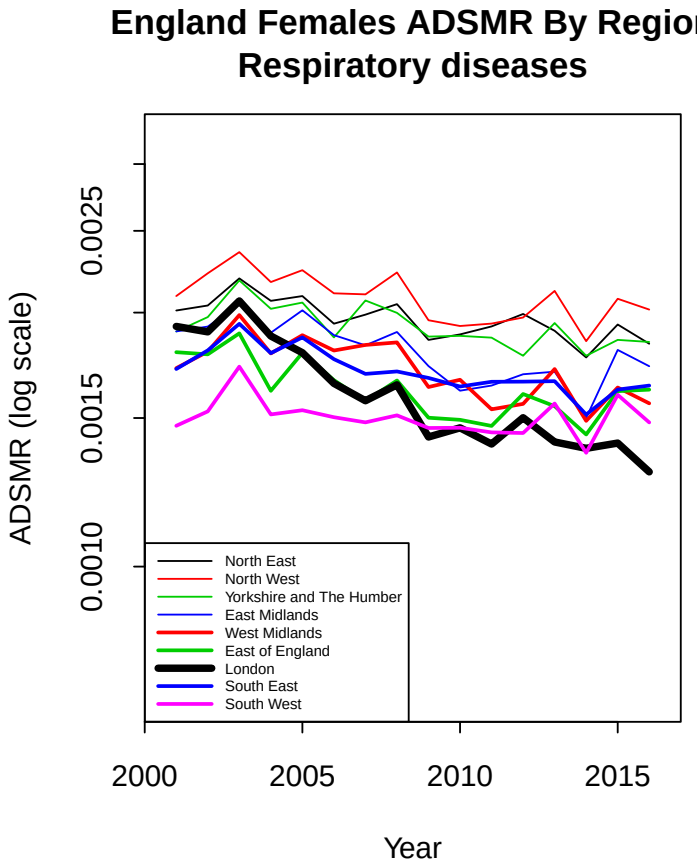
Respiratory Diseases: Males

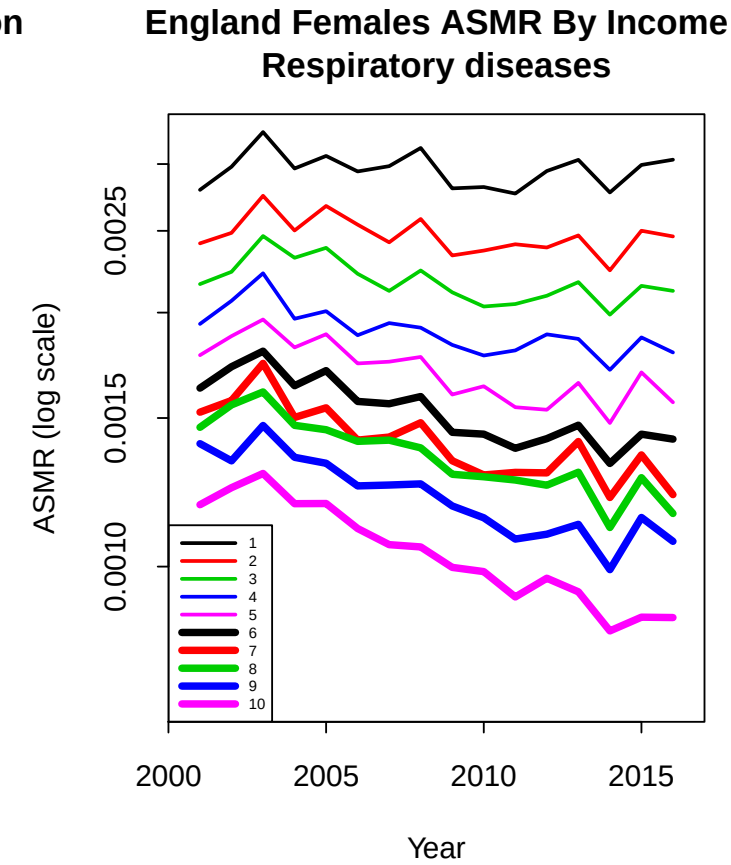




Flatter than males: similar pattern to lung cancer males

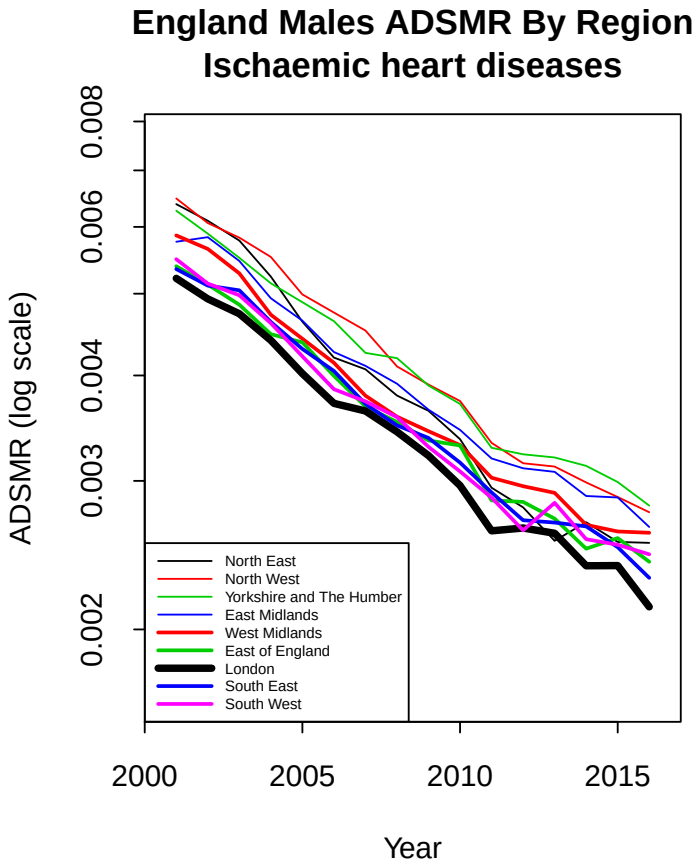
Respiratory Diseases: Females

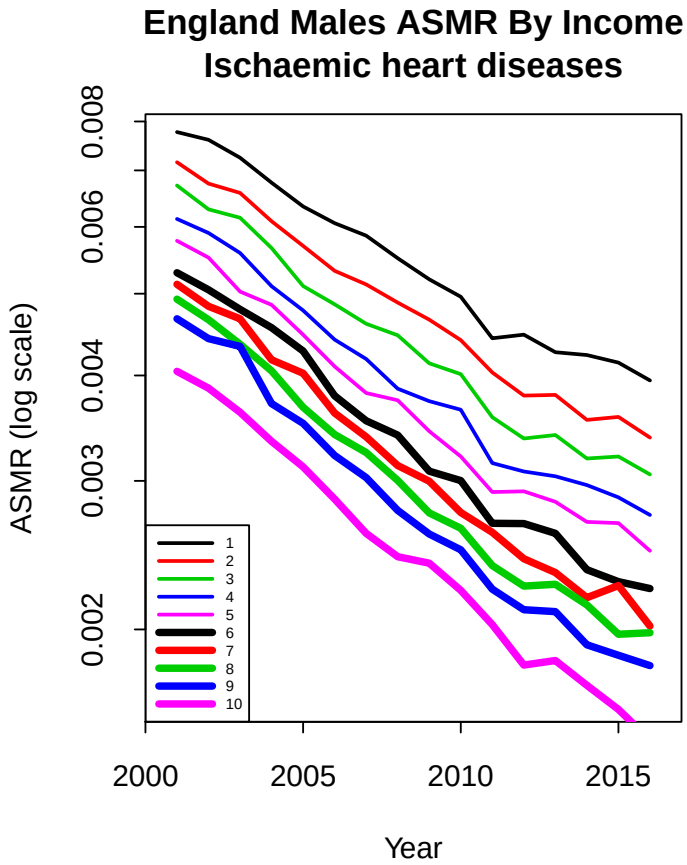




Similar pattern to lung cancer females

Ischaemic Heart Disease: Males



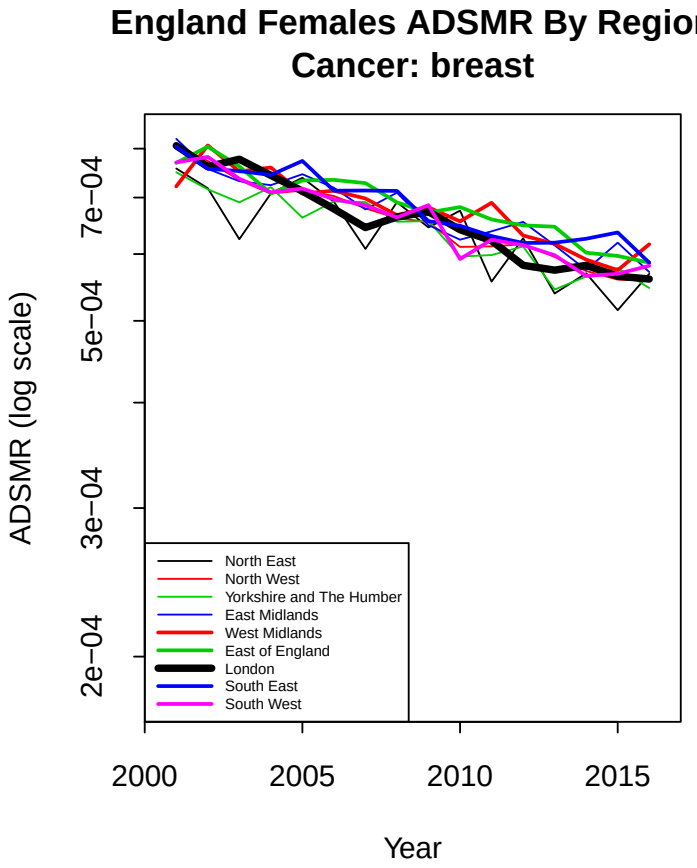


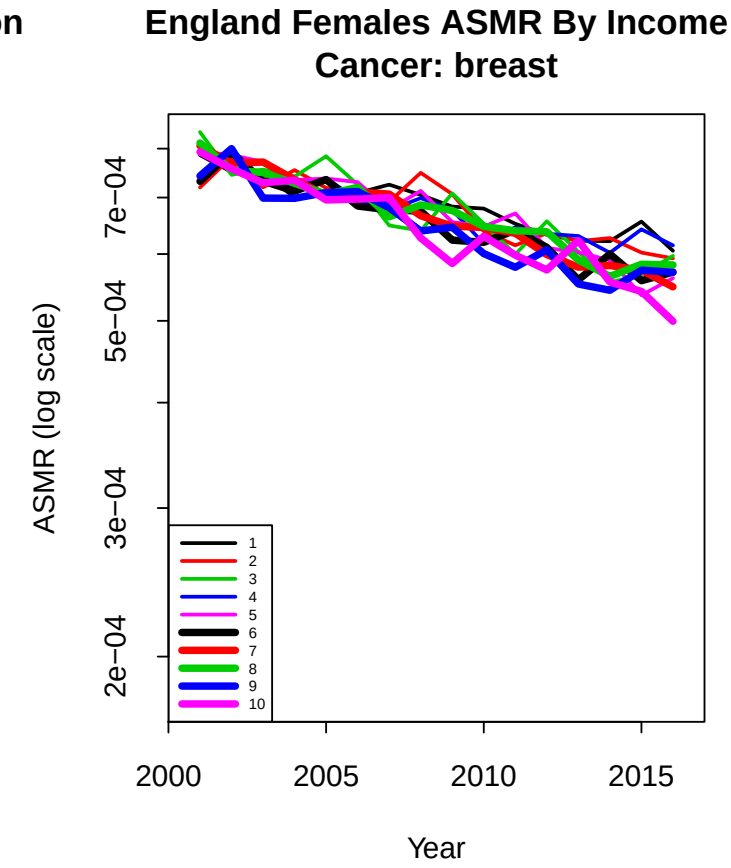
Success story: major improvements

Deterioration: widening gap and regional inequality

Females: similar picture

Breast Cancer: An Equality Success Story

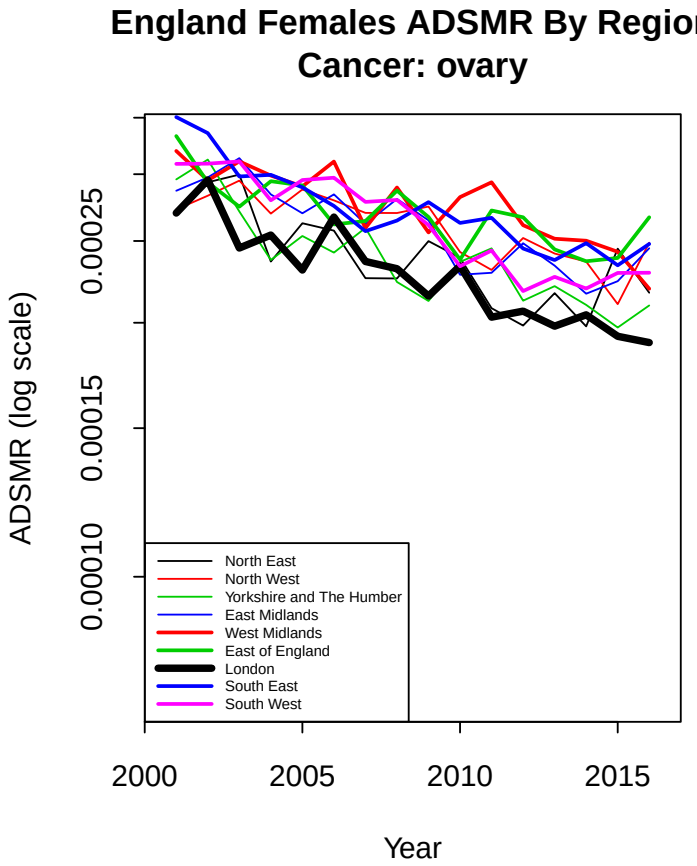


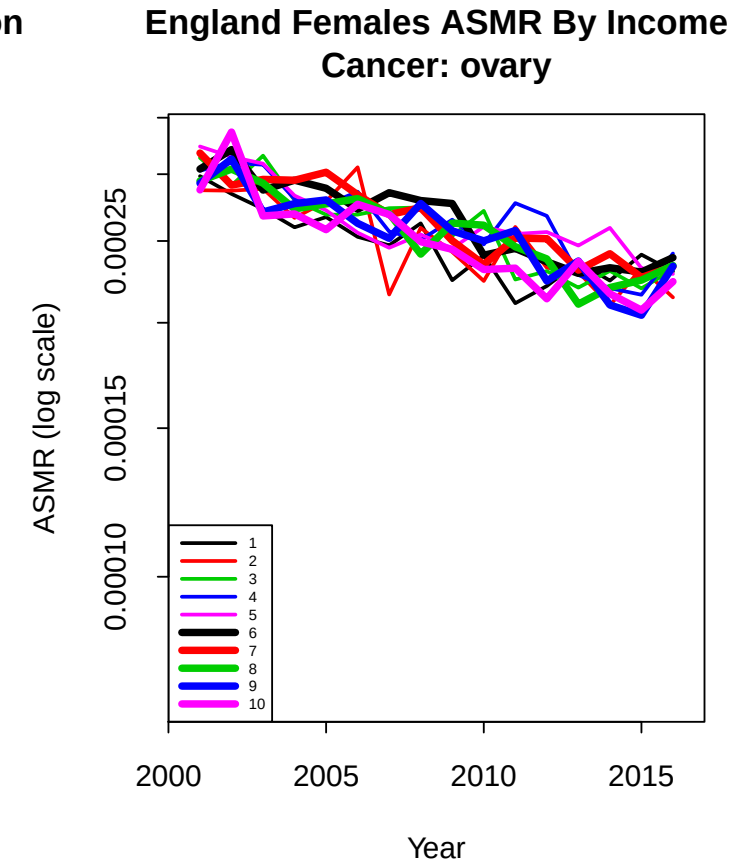


Limited controllable risk factors

Success story: no significant inequality

Ovarian Cancer: A Regional Lottery?



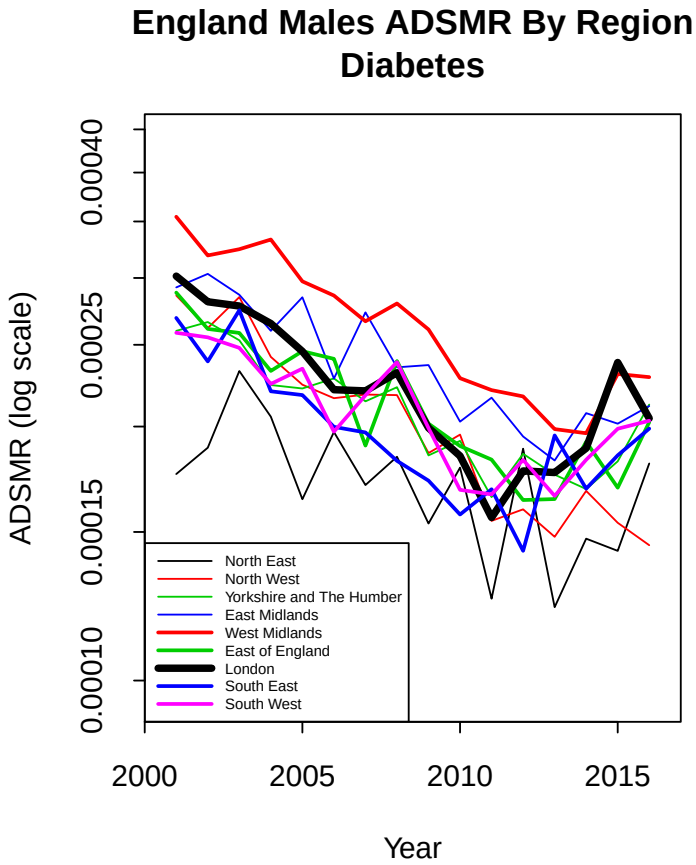


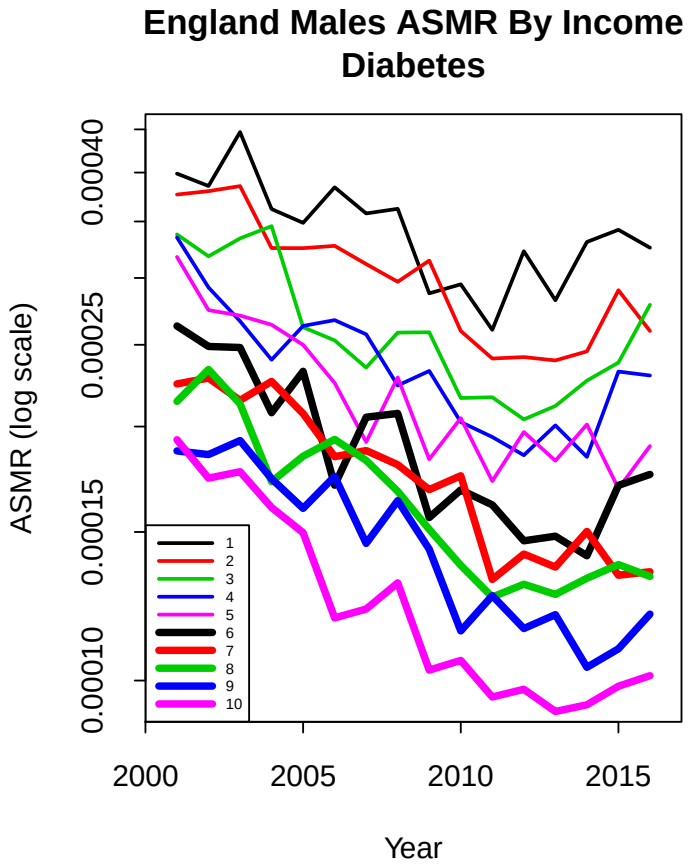
Limited controllable risk factors

Limited income effect

Significant regional effect

Diabetes: Males



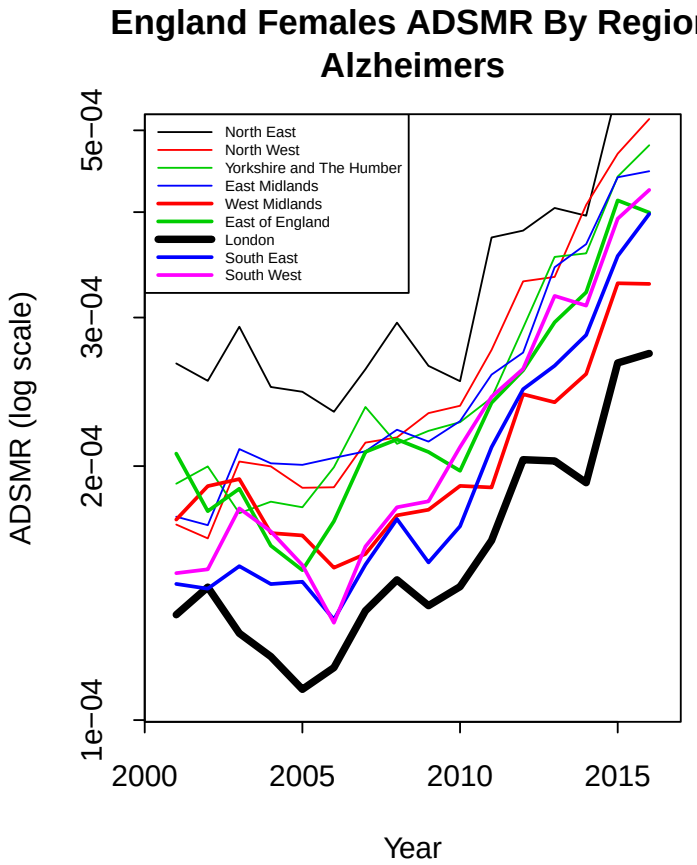


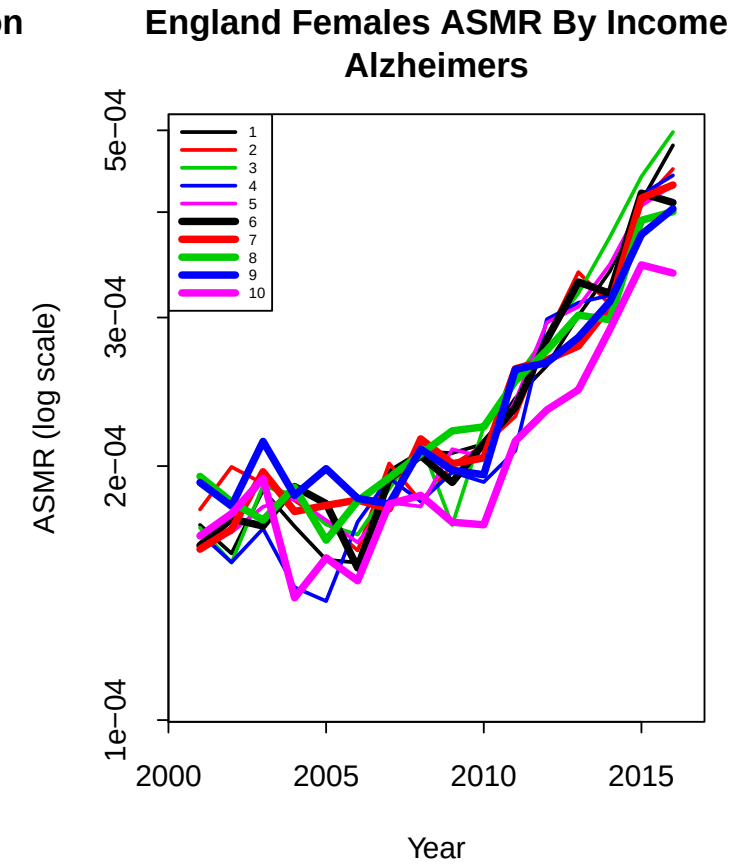
Significant inequality

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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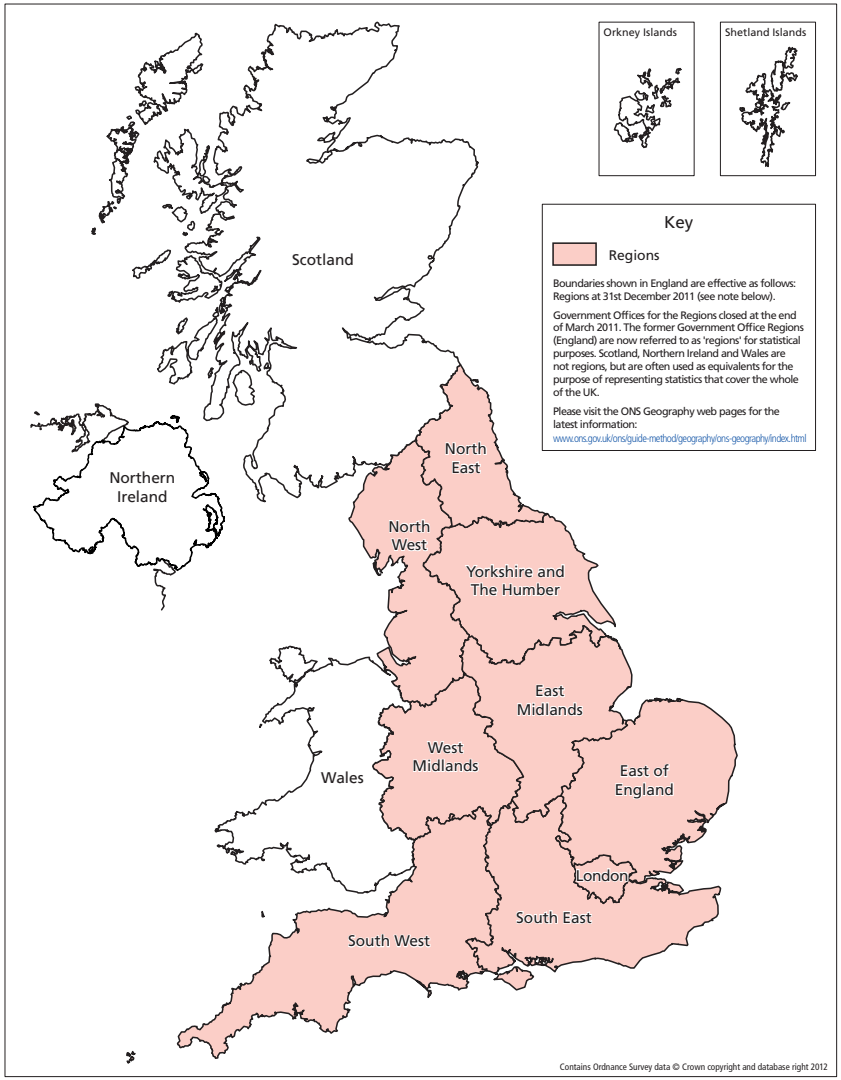
`www.actuaries.org.uk/arc`

England: Income Deprivation versus Region

United Kingdom: Regions, 2011



Denmark: Cause of Death Data 2005-2009

- Many causes of death have known risk factors or drivers

  e.g. smoking, diet, healthy lifestyle etc.

  $\Rightarrow$ clear socio-economic differences
- Biggest differences at ages < 60
- Affluence $\Rightarrow$ stronger predictor than education (sometimes very much stronger)
- Other diseases do not have strong differences:

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Denmark Males: Statistical Significance

Which CoD's are significantly affected by socio-economic status?

- H_0: Affluence groups all have the same CoD death rate $m_i(c,t,x) = m_j(c,t,x) \quad \forall i \neq j$ versus
- H_1: Affluence groups do not all have the same CoD death rates

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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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