

Mortality Data By Socio-Economic Group, Region and Cause of Death: What Do the Patterns Tell Us?

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Outline

- Motivation and long term goals
- Data
- England: empirical analysis
- Discussion

Note: Sessional Research Meeting, Staple Inn, 6 January 2020

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?
- Can we point to specific causes of death as responsible for *growing inequality*?
- **Leading to:** insight into mortality underpinning life insurance and pensions



Digression: The Human Cause-of-Death Database

- www.causesofdeath.org
- 16 countries
- National data only, not socio-economic subgroups
- Data \Rightarrow
 - what are the most significant causes of death?
 - analysis of trends over time
- Here: socio-economic sub-populations \Rightarrow
 - Health inequalities
 - Differential trends



- Medical advances
- Public health initiatives
- Health spending by age
- Individual risk factors:
 - **Controllable** (Cancer UK: *preventable*)
e.g. smoking, diet, exercise, alcohol, sun, drugs, hygiene, risky sex, stress, environment...
 - **Not (easily) controllable**
e.g. genetic, affluence, education, character/personality traits, ...
?? prior health events (e.g. heart attack)

Socio-economic covariates

- Potential measures of socio-economic status:
 - Deprivation: low income; poor housing; unemployed; low qualifications;
 - Education (US data; Denmark)
 - Affluence (Denmark)

- **More deprived**; low educated; low affluence
 - ⇒ more likely to: smoke; have a poor diet; exercise less; drink too much alcohol
 - ⇒ higher mortality

Cause of Death Groupings

1	Infectious diseases	2	Cancer: oesophagus, stomach
3	Cancer: bowel, gut	4	Cancer: larynx
5	Cancer: trachea	6	Cancer: lung, bronchus
7	Cancer: breast	8	Cancer: uterus, cervix
9	Cancer: ovary	10	Cancer: other female genital
11	Cancer: prostate, testicular	12	Cancer: other male genital
13	Cancer: skin, bones and certain organs	14	Cancer: lymphatic
15	Benign tumours	16	Diseases: blood
17	Diabetes	18	Mental illness (+)
19	Diseases of nervous system excl. Alzh.	20	Alzheimers
21	Blood pressure + rheumatic fever	22	Ischaemic heart diseases
23	Other heart diseases	24	Cerebrovascular diseases
25	Circulatory diseases	26	Lungs, breathing diseases
27	Digestive diseases (excl. alcohol)	28	Alcohol-related liver disease
29	Diseases: skin, bone, tissue	30	Urine, kidney and related diseases
31	Road/other accidents	32	Other causes of death
33	Suicide	34	Accidental poisonings

Colours ⇒ broad CoD groups (e.g. **cancers**)

Detail ⇒ able to separate causes with and without significant risk factors or inequality

English Cause of Death Data

- 34 CoD groups
- Age groups 20-24, 25-29, ..., 85-89
- Single years 2001-2016

- by small area *income deprivation*: 10 deciles
- by region: 9 areas

England – Deprivation – Top 10 Causes of Death

Males; Ages 70-74; Year 2016

Rank	Most Deprived	Least Deprived
1	Respiratory (*)	Skin & organ cancer
2	Ischaemic heart disease	Ischaemic heart disease
3	Lung cancer (*)	Respiratory
4	Skin & organ cancer	Lung cancer
5	Cerebrovascular	Prostate cancer
6	Oesoph., stom. cancer	Cancer: lymphatic, myeloma, etc.
7	Bowel, gut cancer	Nervous system excl. Alzh.
8	Other heart disease	Cerebrovascular
9	Digestive diseases	Oesoph., stom. cancer
10	Prostate cancer	Bowel, gut cancer

No controllable risk factors: e.g. Prostate – almost no inequality.

Significant controllable risk factors feature much more heavily amongst the most deprived.

(*) Strongest relative risk \Rightarrow even higher up table in most deprived

England – Deprivation – Top 10 Causes of Death

Females; Ages 70-74; Year 2016

Rank	Most Deprived	Least Deprived
1	Respiratory (*)	Skin & organ cancer
2	Lung cancer (*)	Lung cancer
3	Skin & organ cancer	Respiratory
4	Ischaemic heart	Ischaemic heart
5	Cerebrovascular	Breast cancer
6	Digestive diseases	Cerebrovascular
7	Other heart dis.	Cancer: lymphatic, myeloma, etc.
8	Breast cancer	Nervous system excl. Alzh.
9	Bowel, gut cancer	Bowel, gut cancer
10	Mental illnesses	Ovarian cancer

No controllable risk factors: e.g. Breast and other cancers

M/F: All significant CoD's: Group 1 mortality > Group 10 mortality

Age Standardised Mortality Rates

- Basic definition

$$ASMR = \frac{\sum_x m(x)ES(x)}{\sum_x ES(x)}$$

- $m(x)$ = population or sub-population death rate all cause, or by cause of death
- $ES(x)$ = standard population exposures
- Four variations:
 - $ASMR$: national
 - $ASMR_i(i)$, for $i = 1, \dots, 10$ deprivation deciles
 - $ASMR_R(r)$, for $r = 1, \dots, 9$ regions
 - **Age and Deprivation Standardised Mortality Rate**
 $ADSMR_R(r)$, for $r = 1, \dots, 9$ regions

More deprived regions will naturally have a higher $ASMR_R(r)$

Region By Region Deprivation Profiles

Region	Income Deprivation Decile										Row Sum
	1	2	3	4	5	6	7	8	9	10	
1	20	15	12	10	7	7	7	7	8	7	100%
2	18	11	10	9	8	8	9	9	9	9	100%
3	15	11	10	8	9	9	10	9	9	9	100%
4	8	10	10	10	10	10	12	11	11	9	100%
5	16	12	10	9	9	9	10	10	9	7	100%
6	4	6	9	10	12	11	13	11	12	11	100%
7	9	16	15	14	11	9	7	6	6	6	100%
8	3	5	7	9	10	11	12	11	14	19	100%
9	4	6	8	10	12	13	14	13	11	9	100%

E.g. Row 1: percentage of LSOAs in each of deciles 1 to 10
 Everything else being equal: North-East (1) will have heavier mortality than the South-East (8)

ASMR Variants

- Suppress gender, g , year t and cause of death, c
- $m(x)$ = national death rate at age (group) x
- $m_I(i, x)$ = income-deprivation decile i death rate,
- $m_R(r, x)$ = region r death rate,
- $m_{RI}(r, i, x)$ = death rate at age x in region r , deprivation decile i .

ASMR Variants (cont.)

Each of these has corresponding ASMRs:

$$\begin{aligned}ASMR \equiv ASMR(t) &= \frac{\sum_{x=x_0}^{x_1} m(x)ES(x)}{\sum_{x=x_0}^{x_1} ES(x)} \\ASMR_I(i) &= \frac{\sum_{x=x_0}^{x_1} m_I(i, x)ES(x)}{\sum_{x=x_0}^{x_1} ES(x)} \\ASMR_R(r) &= \frac{\sum_{x=x_0}^{x_1} m_R(r, x)ES(x)}{\sum_{x=x_0}^{x_1} ES(x)} \\ASMR_{RI}(r, i) &= \frac{\sum_{x=x_0}^{x_1} m_{RI}(r, i, x)ES(x)}{\sum_{x=x_0}^{x_1} ES(x)}\end{aligned}$$

The Age and Deprivation Standardised Mortality Rate

$$ASMR_R(r) \equiv \frac{\sum_{x=x_0}^{x_1} ES(x) \sum_{i=1}^{10} m_{RI}(r, i, x) w_{RI}(r, i, x)}{\sum_{x=x_0}^{x_1} ES(x)}$$

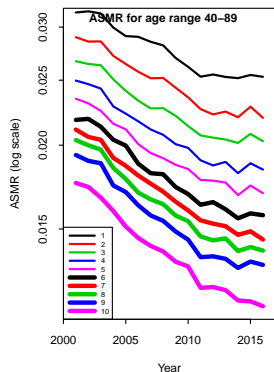
$w_{RI}(r, i, x) = E_{RI}(r, i, x) / \sum_i E_{RI}(r, i, x)$ decile i weight amongst deciles 1 to 10, region r , age x

The ADSMR replaces weights $w_{RI}(r, i, x)$ by $\tilde{w}_{RI}(r, i, x) = 0.1$. Hence

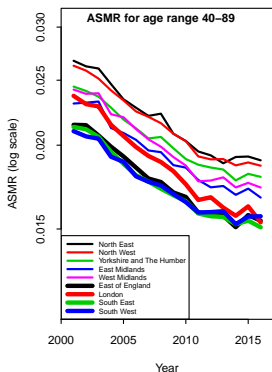
$$\begin{aligned} ADSMR(r) &= \frac{\sum_{x=x_0}^{x_1} \sum_{i=1}^{10} m_{RI}(r, i, x) \tilde{w}_{RI}(r, i, x) ES(x)}{\sum_{x=x_0}^{x_1} ES(x)} \\ &= \frac{1}{10} \sum_{i=1}^{10} ASMR_{RI}(r, i). \end{aligned}$$

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

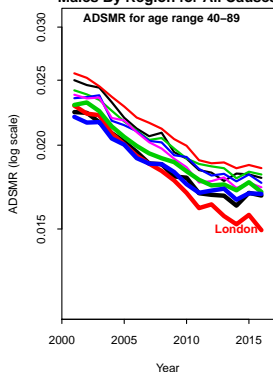
Age Standardised Mortality Rates
Males By Income for All Causes



Age Standardised Mortality Rates
Males By Region for All Causes



Age & Deprivation
Standardised Mortality Rates
Males By Region for All Causes



Income deprivation deciles: widening gap

Clear "London Effect".

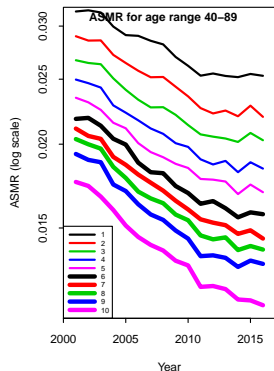
Greater improvements in healthcare??

Greater improvements in GDP??

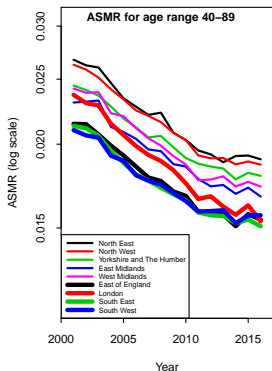
Educational attainment rising faster?? (immigration??)

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

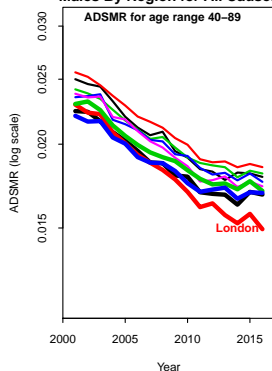
Age Standardised Mortality Rates
Males By Income for All Causes



Age Standardised Mortality Rates
Males By Region for All Causes

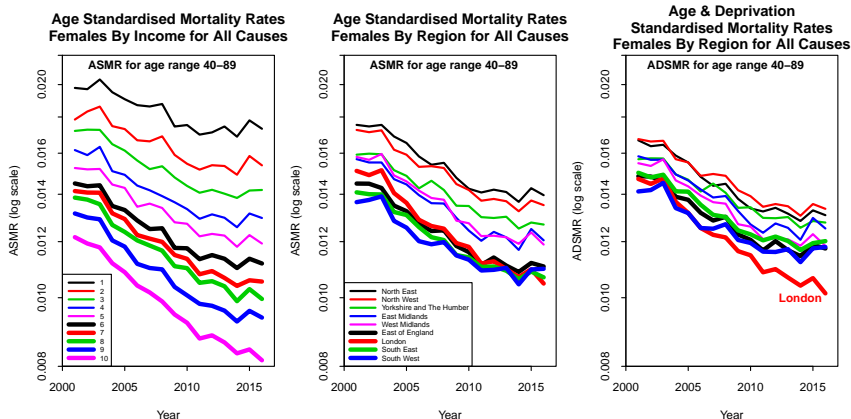


Age & Deprivation
Standardised Mortality Rates
Males By Region for All Causes



- Differing trends since 2011
- Hence (??): mortality projections
 - different short-term mortality improvement rates
 - converging to the same long-term improvement rate

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

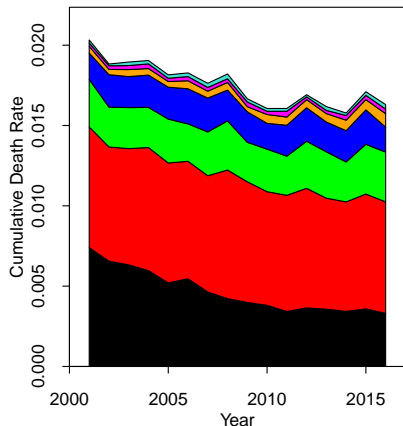


Males and females: significant regional effects remain after accounting for income deprivation

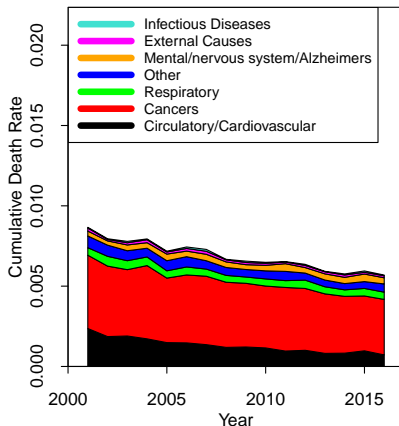
(All cause data: other non-regional covariates being investigated)

Seven CoD Groups: Females 65-69; Deciles 1 vs 10

**Decomposition of Death Rates for
Females Aged 65-69
Income Deprivation Decile 1**

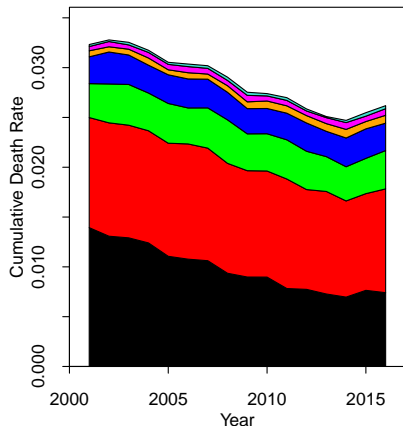


**Decomposition of Death Rates for
Females Aged 65-69
Income Deprivation Decile 10**

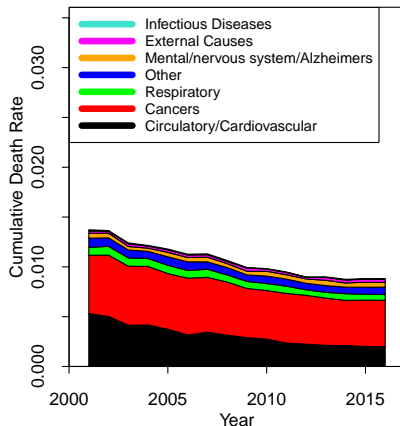


Seven CoD Groups: Males 65-69; Deciles 1 vs 10

**Decomposition of Death Rates for
Males Aged 65-69
Income Deprivation Decile 1**



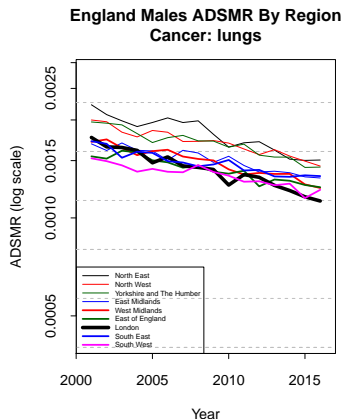
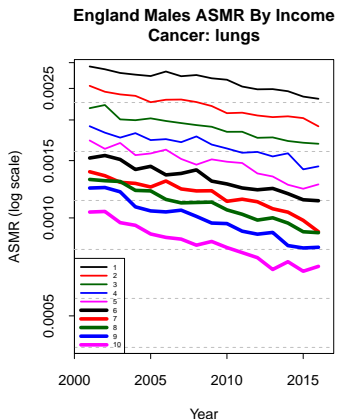
**Decomposition of Death Rates for
Males Aged 65-69
Income Deprivation Decile 10**



Higher-Level CoD Summary

- Cardiovascular: big declines; less room to contribute to future all-cause mortality improvements
- Cancers: now the biggest killer, especially for females; limited past improvements; strongest potential for future all-cause improvements
- Respiratory: biggest inequalities
- Dementias: on the rise

Lung Cancer: Males



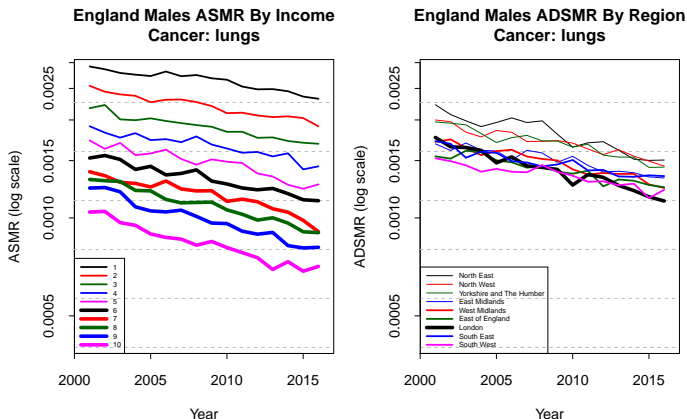
Horizontal dotted lines: $\times\sqrt{2}$ apart

Each plot: bottom to top: $\times 8$

Left: 10 income deprivation deciles, $ASMR_I(t)$

Right: 9 regions, $ADSMR(t)$

Lung Cancer: Males



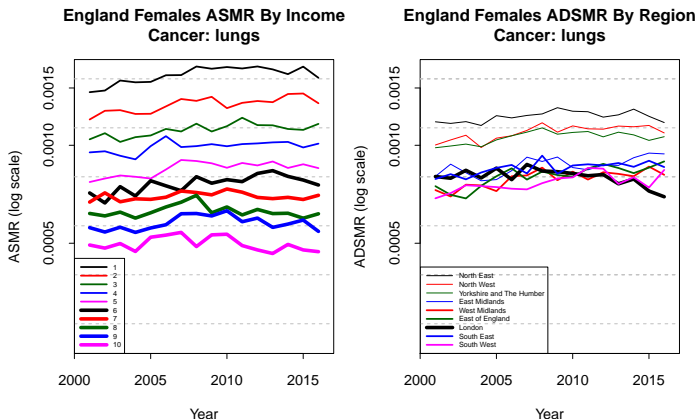
Significant variation between income deciles (\Leftarrow smoking prevalence)

Significant variation between regions (after standardisation)

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

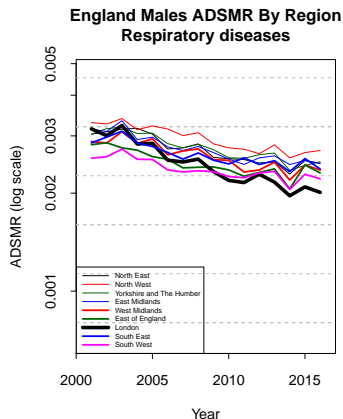
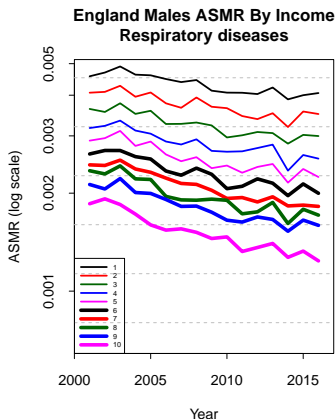
London effect; Northern regions very poor

Lung Cancer: Females



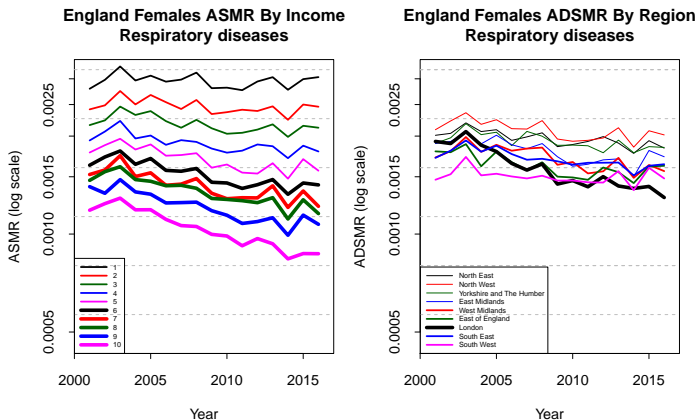
- Different pattern from males
- Slight worsening \Rightarrow ?? smoking prevalence rising
- Same northern regions do badly
- Wider regional spread
- London effect

Respiratory Diseases: Males



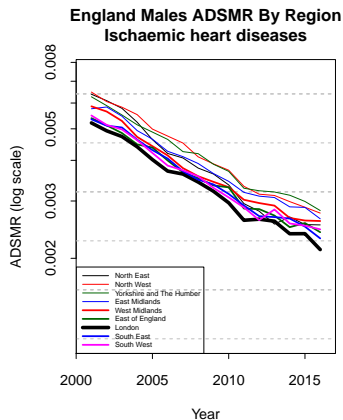
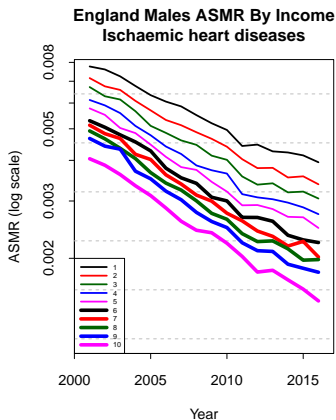
Similar pattern to lung cancer males
Chronic Obstructive Pulmonary Disease = major cause, with smoking as the major controllable risk factor

Respiratory Diseases: Females



Similar pattern to lung cancer females
Weaker improvements than males linked to smoking prevalence,
especially high deprivation

Ischaemic Heart Disease: Males



Significant inequality linked to **multiple controllable risk factors**

Success story: major improvements

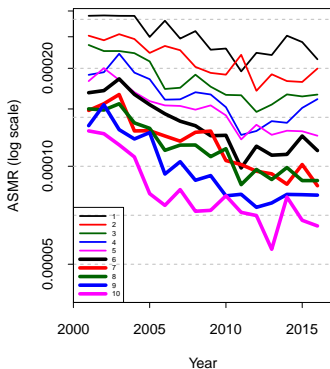
Less good: widening gap and regional inequality; **slowdown differences**

Females: similar picture

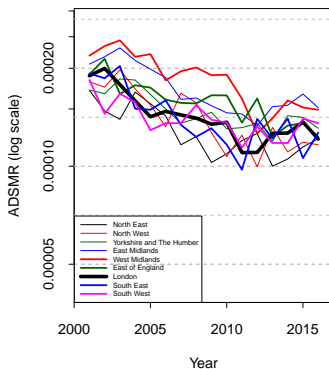


Diabetes: Females

England Females ASMR By Income Diabetes



England Females ADSMR By Region Diabetes



Widening gap and regional inequality
Males: similar picture

Impact of Controllable Risk Factors

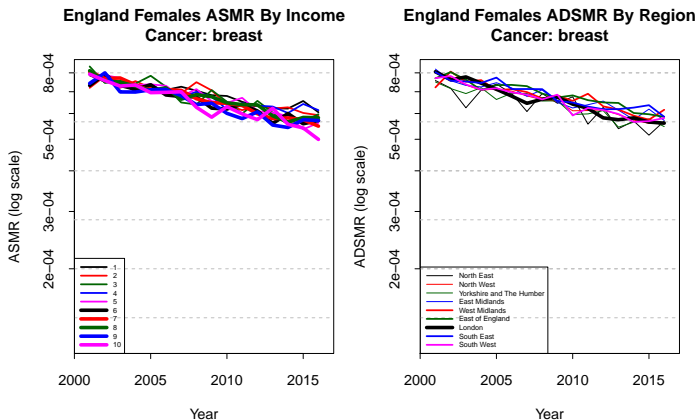
- Risk factors (controllable and not controllable) \Rightarrow Impact on cause of death rates
- Some **controllable risk factors** \Rightarrow big impact on some causes
 - e.g. smoking \longrightarrow lung cancer
 - e.g. several risk factors \longrightarrow ischaemic heart disease
 - \Rightarrow significant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

A Broad Observation

As the impact of a *controllable* risk factor on a particular CoD increases we observe:

- Greater inequality in the corresponding CoD death rates
 - by income deprivation
 - by region
 - by region **even after adjusting for differing levels of income deprivation**
- Possible sources of the region effect:
 - Other socio-economic variables?
E.g. education levels within each income deprivation decile
 - Greater deprivation on average across the region leads to generally poorer health behaviour?
 - Random variation across regions in health risk behaviours?

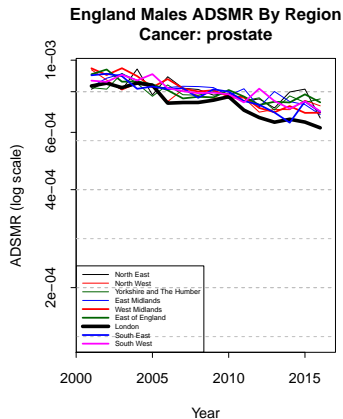
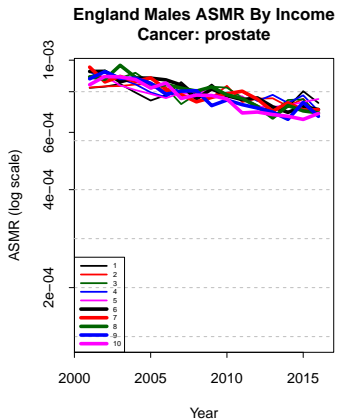
Breast Cancer: An Equality “Success Story”



Limited controllable risk factors

“Success story”: no significant income or regional inequality
(including ?? diagnosis)

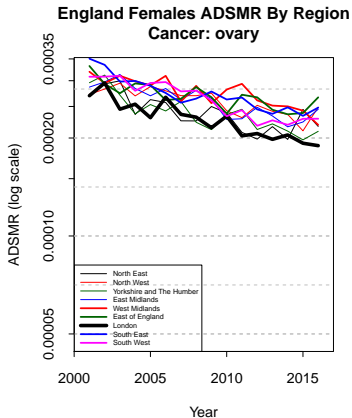
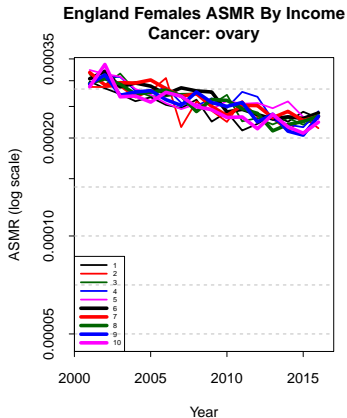
Prostate Cancer: A Small London Effect?



No significant income inequality

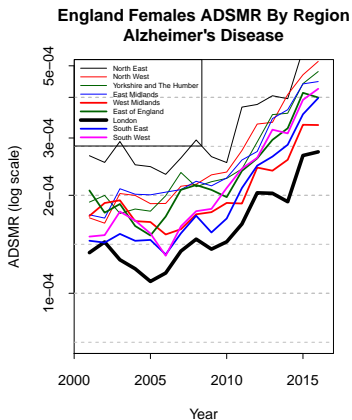
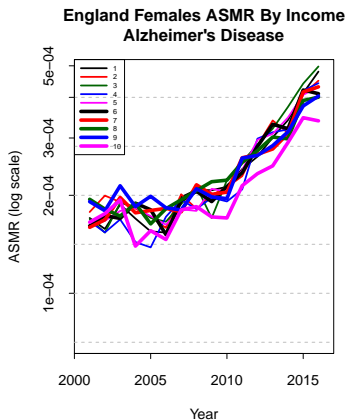
Small but significant differences between regions

Ovarian Cancer: A Regional Lottery?



Limited controllable risk factors
Limited income effect
Significant regional effect

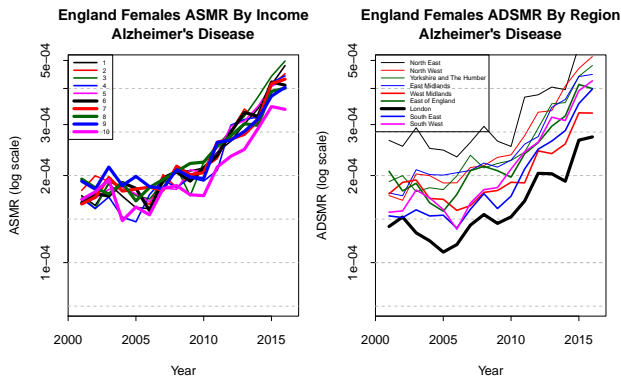
Alzheimers: Females (no clear controllable risk factors)



Modest income effect

Strong regional effect \Rightarrow ?? health migration

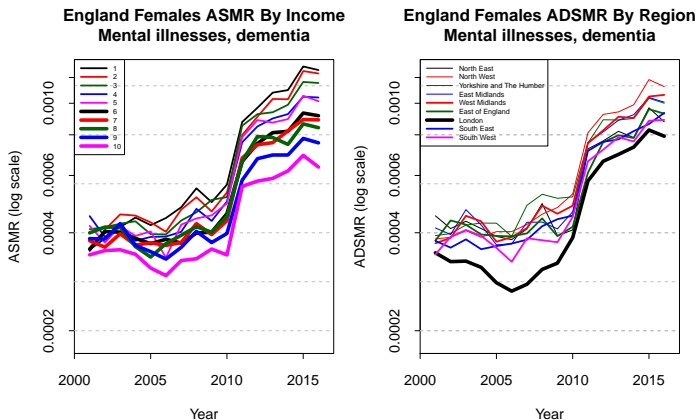
Alzheimers: Females (no clear controllable risk factors)



Deterioration ($2\times$) \Rightarrow ??^{Year}

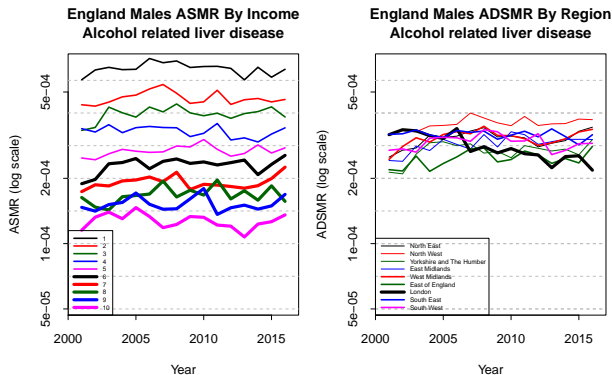
- evidence for non-independence of causes of death improvements elsewhere
 \Rightarrow ?? more frail survivors in old age
- gradual shift in *reported* cause of death

Mental illnesses + vascular dementia: females



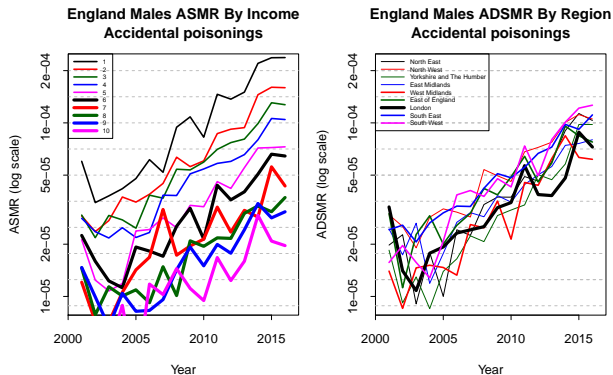
Inequality: similar risk factors to cardiovascular diseases
Deteriorating mortality
Jump in 2011: change in reporting ↔ cerebrovascular

Alcohol-related liver disease



Case and Deaton (2015): “Deaths of despair”

Accidental poisoning



Case and Deaton (2015): “Deaths of despair”

Which Causes of Death \Rightarrow Growing Inequality?

- Ischaemic heart disease
- Diabetes
- Cerebrovascular
- Circulatory
- Respiratory diseases
- Mental illnesses (females)
- Lung cancer

\Rightarrow a widening gap in the prevalence of controllable risk factors: smoking, diet, exercise, alcohol etc.

no significant causes of death with narrowing inequality gap

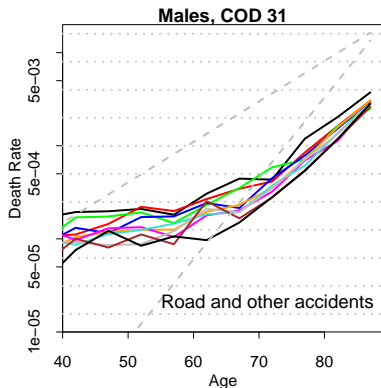
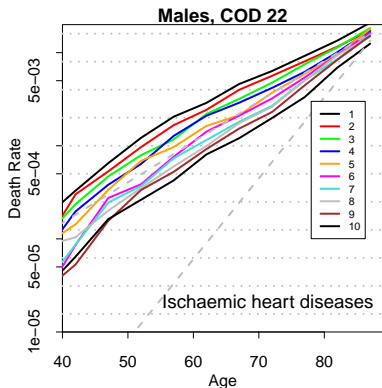
Contributors to the slowdown since 2011

Main contributors seem to be

- Heart diseases
(but less so for the least deprived)
- Dementias and Alzheimer's
- Possibly respiratory diseases
- Possibly diabetes



Death rates by age in 2016: "Group 1"



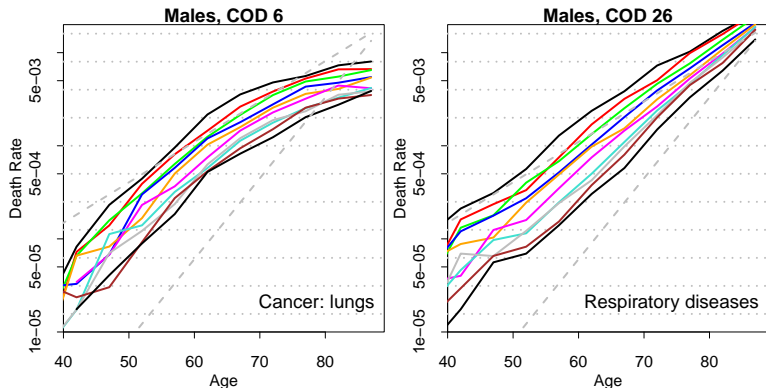
Def'n: Group 1: Gompertz type with rate ~ 0.1 (flatter grey dashed line)

\Rightarrow ??? common underlying ageing/disease mechanism

Narrowing inequality with age

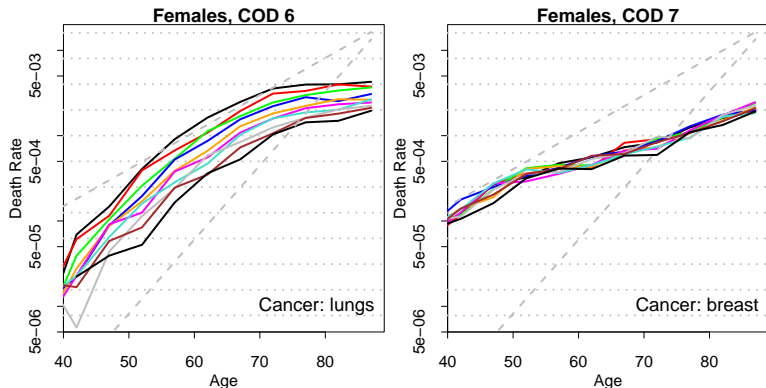
Accidents, high ages: goes hand in hand with Group 1 underlying ageing???

Death rates by age in 2016: smoking



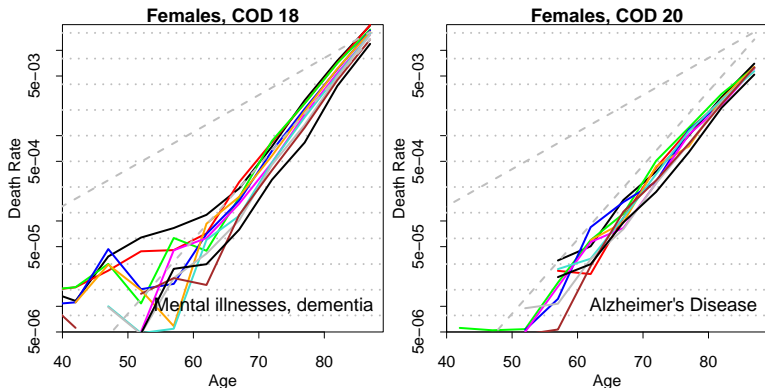
Different shapes \Rightarrow
??? changing relative risk with age
??? strong frailty effect with lung cancer

Death rates by age in 2016: Group 2



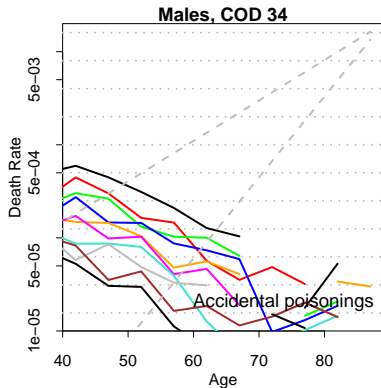
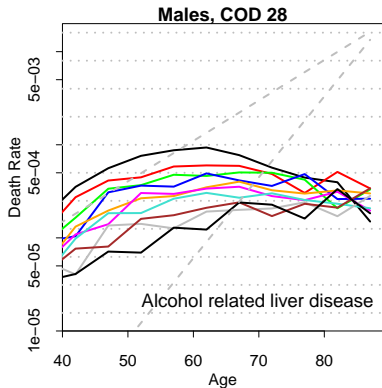
Group 2 \Rightarrow rising mortality but flatter shape than Gompertz(0.1)
Mostly cancers \Rightarrow is the disease mechanism different from Group 1???

Death rates by age in 2016: Group 3



Group 3: Gompertz with rate ~ 0.2 (steeper grey dashed line)
All Group 3: causes of death related to deterioration/disease of brain
 \Rightarrow ??? a different disease mechanism from Group 1 ageing

Death rates by age in 2016: Group 4



Group 4: flat or decreasing with age

Summary

- Causes of death with associated **controllable risk factors**
⇒ mortality inequality
- Significant levels of inequality for most of the big CoD's
- Regional differences remain even after adjusting for deprivation
- Causes of death with **no controllable risk factors**
⇒ little or no inequality
- Mortality inequalities have widened since 2001
Link to multiple controllable risk factors
- Slowdown since 2011 + ischaemic heart disease
NO slowdown in the least deprived group



Thank You!

Questions?

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W: www.macs.hw.ac.uk/~andrewc/ARCresources



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