

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



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

Cause of death data for:

- US (males and females)
 - by education level: low (\leq high school); high (\geq some college)
- Denmark (males only):
 - by education level: low ($<$ high sch.); medium ($=$ high sch.); high (\geq some college) (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 → liver disease	28	Suicide
29	Accidental Poisonings		

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

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

- US

- Deaths subdivided into 30 CoD groups
- Single ages 40-89 and *born between 1914 and 1970*
- Single years 1989-2015

- Denmark

- 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

England – Deprivation – Top 10 CoD

Males; Ages 70-74; Year 2016

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

England – Deprivation – Top 10 CoD

Females; Ages 70-74; Year 2016

Rank	Most Deprived	Least Deprived
1	Respiratory	Skin & organ cancer
2	Lung cancer etc.	Lung cancer etc.
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

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

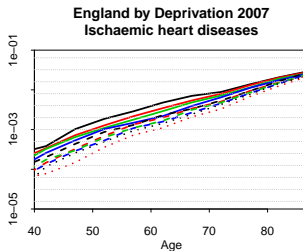
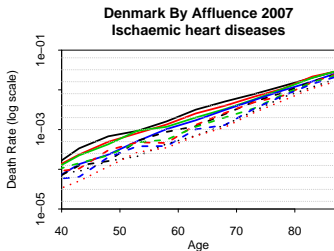
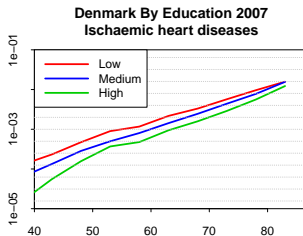
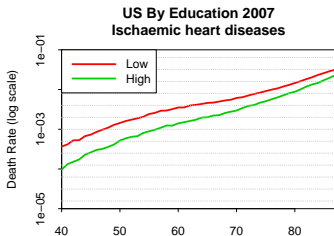
Multi-Country Comparisons

- Up to 34 causes of death
- Many very low death rates or not so interesting
- Here: a few of the more interesting cases
 - Major CoD's
 - Widening gap
 - Unexpected regional effects
 - Story to tell that might apply to other CoD's

Impact of Controllable Risk Factors

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

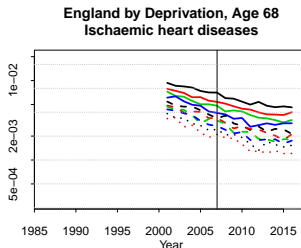
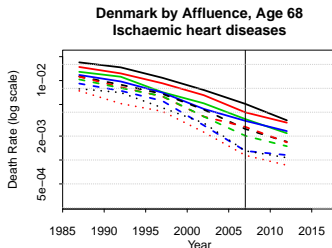
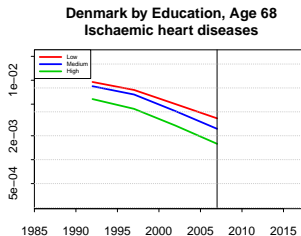
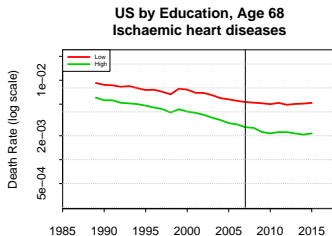
Multi-Country: Year 2007, Males, Ischaemic Heart Disease



US: slightly wider than Denmark

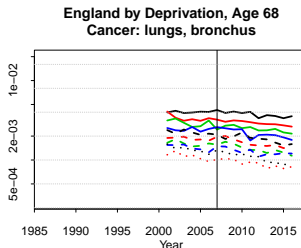
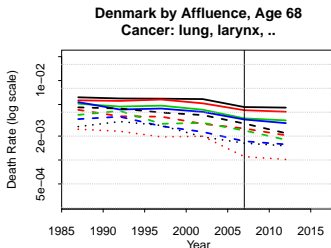
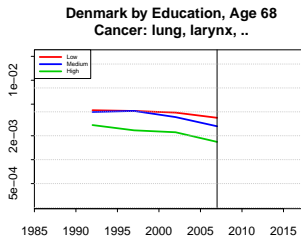
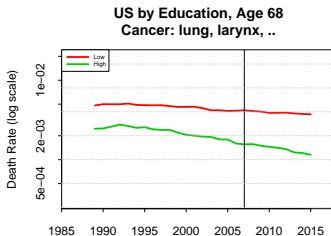
England similar to Denmark but higher

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



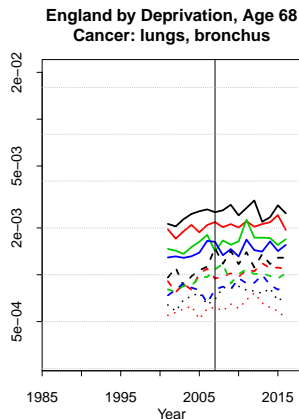
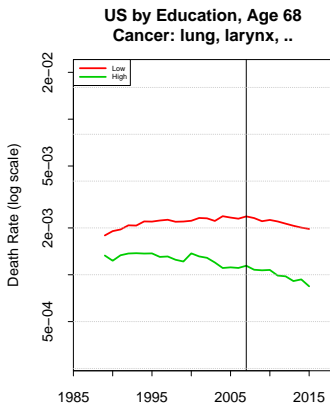
Significant improvements, but not throughout

Multi-Country: Age 68, Males, Lung Cancer



Significant inequality; improvements might be driven by smoking prevalence

Multi-Country: Age 68, Females, Lung Cancer

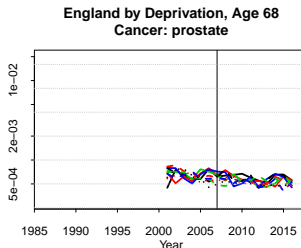
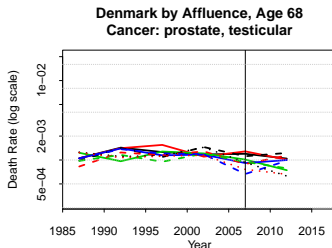
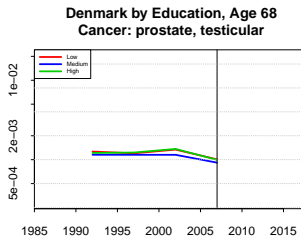
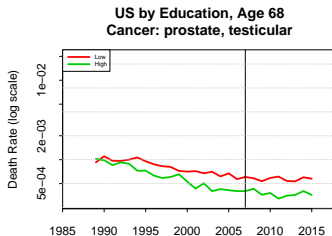


Significant inequality; deterioration mainly driven by smoking prevalence

Impact of Controllable Risk Factors

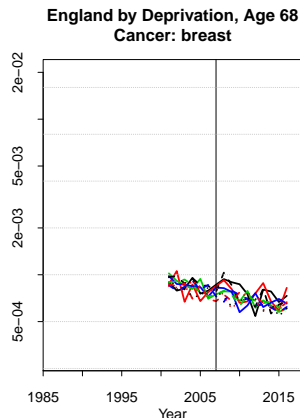
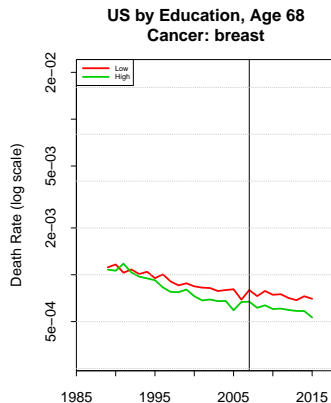
- Risk factors (controllable and not controllable)
⇒
Impact on cause of death rates
- Some risk factors ⇒ big impact on some causes
e.g. smoking → lung cancer
e.g. several risk factors → ischaemic heart disease
⇒ significant inequality gaps
- Other causes of death:
no known (significant) controllable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

Multi-Country: Age 68, Males, Prostate Cancer



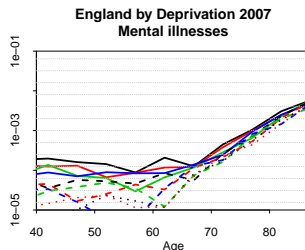
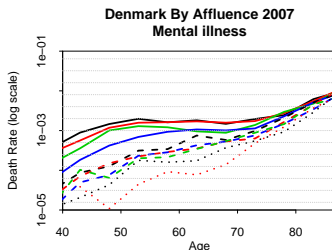
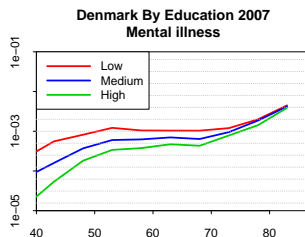
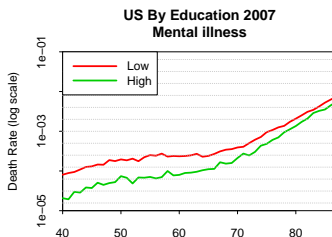
No controllable risk factors; US improvements; DK vs US genetic factors?
US some inequality vs England/Denmark: healthcare system

Multi-Country: Age 68, Females, Breast Cancer



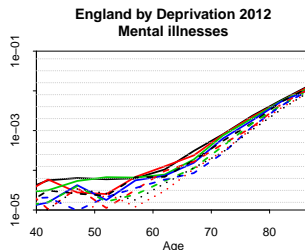
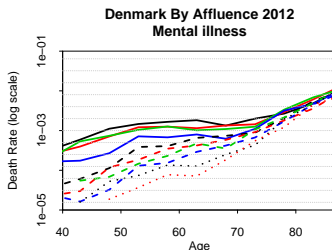
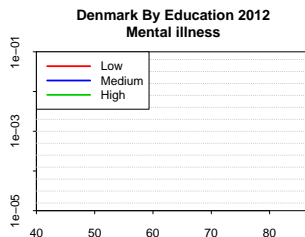
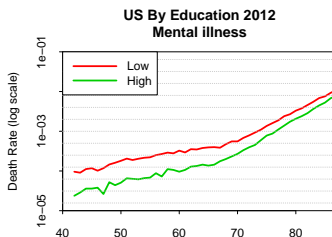
No controllable risk factors; US inequalities; England equality (?)

Variation in Reporting Practice: e.g. Mental Illness



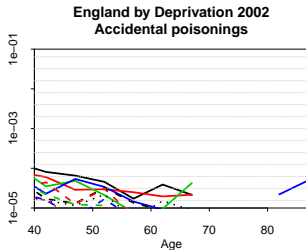
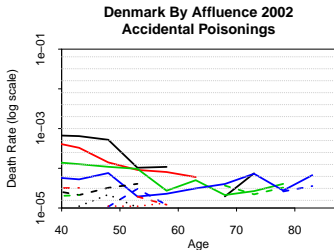
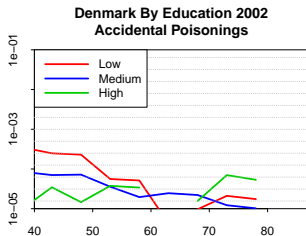
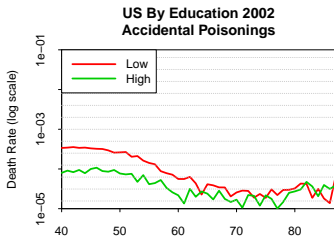
Alcohol & drug abuse; mental disorders; → vascular dementia
Multiple CoD + Reporting practice (??) ⇒ DK >> US >> Eng.

Variation in Reporting Practice: e.g. Mental Illness



Alcohol & drug abuse; mental disorders; → vascular dementia
Multiple CoD + Reporting practice (??) ⇒ DK >> US >> Eng.

Deaths of Despair: A Growing Problem? 2002-2012

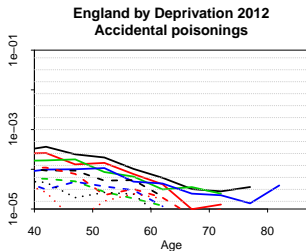
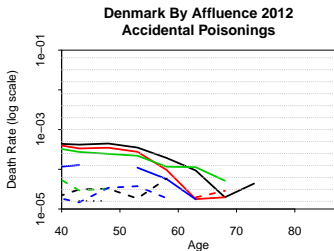
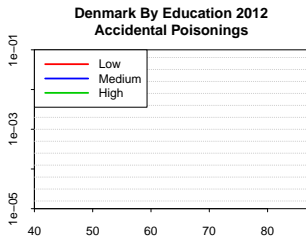
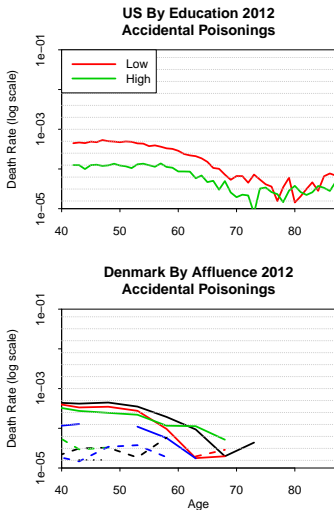


E.g. accidental drug overdoses

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

US, Denmark: significant

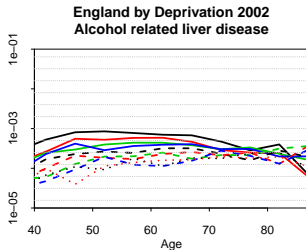
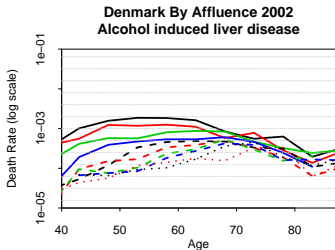
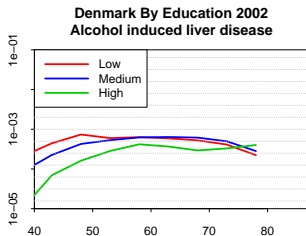
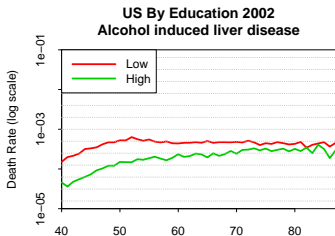
Deaths of Despair: A Growing Problem? 2002-2012



Growth: England > US > DK

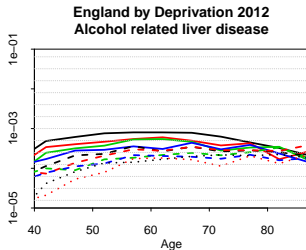
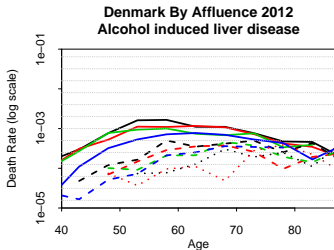
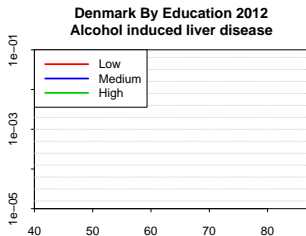
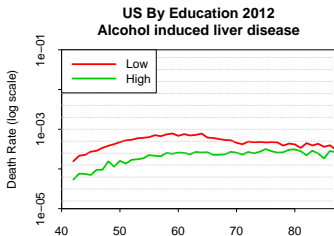
US: evidence of a cohort effect

Deaths of Despair: A Growing Problem? 2002-2012



Affluence a much bigger driver

Deaths of Despair: A Growing Problem? 2002-2012



US: possible cohort effect

2002-12: No significant growth

Denmark: education level data not currently available for this period

Compare

- Income deprivation deciles
- 9 English regions



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

Age (& Deprivation) Standardised Mortality Rate

(CoD) Death rates: $m(x)$, $m_I(i, x)$, $m_R(r, x)$, $m_{RI}(r, i, x)$

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

where $ES(x)$ = "standard" population

Variants: $ASMR_I(i) = \frac{\sum_x m_I(i, x) ES(x)}{\sum_x ES(x)}$ (income decile)

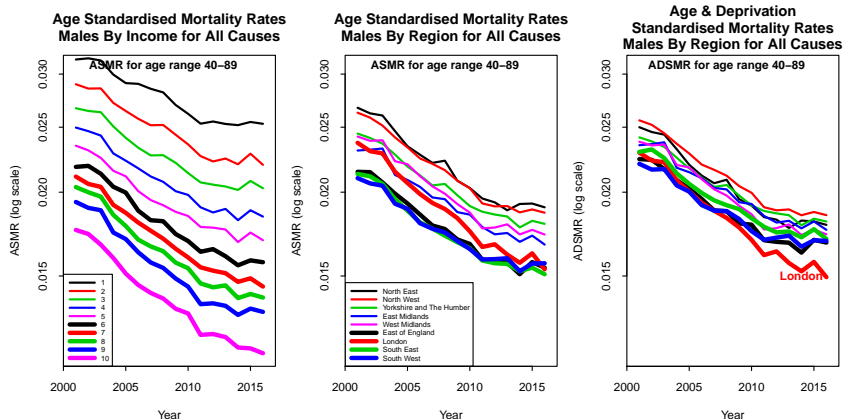
$$ASMR_R(r) = \frac{\sum_x m_R(r, x) ES(x)}{\sum_x ES(x)} \quad (\text{region})$$

$$ASMR_{RI}(r, i) = \frac{\sum_x m_{RI}(r, i, x) ES(x)}{\sum_x ES(x)} \quad (\text{region, income})$$

$$ADSMR_R(r) = \frac{1}{10} \sum_i ASMR_{RI}(r, i)$$

ADSMR adjusts for different income deprivation mix by region

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



Income deprivation deciles: widening gap

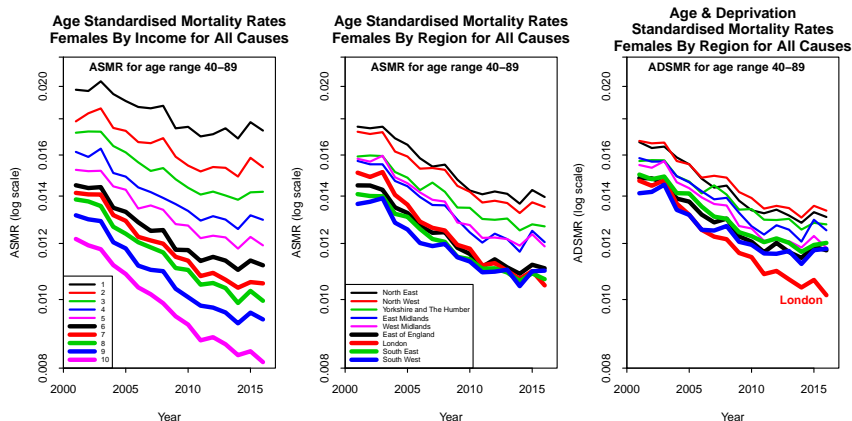
Clear "London Effect".

Greater improvements in healthcare??

Greater improvements in GDP??

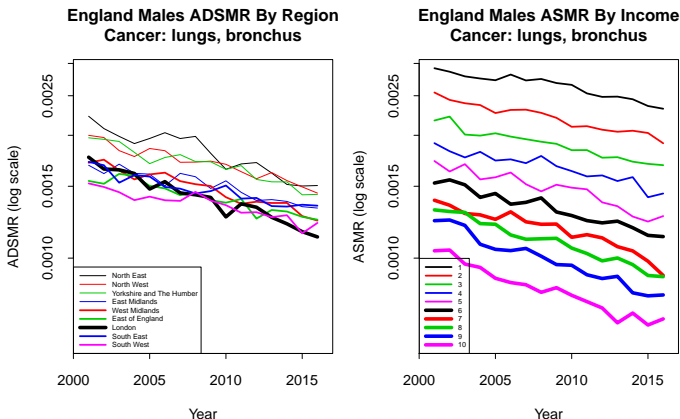
Educational attainment rising faster?? (immigration??)

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)

Lung Cancer: Males



Significant variation between income deciles (\Rightarrow smoking prevalence)

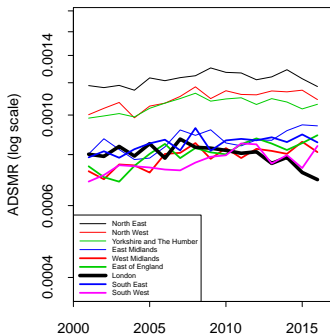
Significant variation between regions (after standardisation)

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

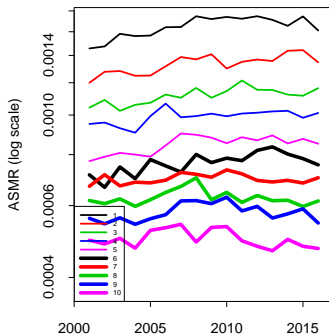
London effect; Northern regions very poor

Lung Cancer: Females

England Females ADSMR By Region
Cancer: lungs, bronchus

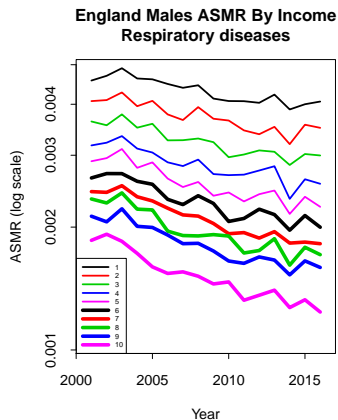
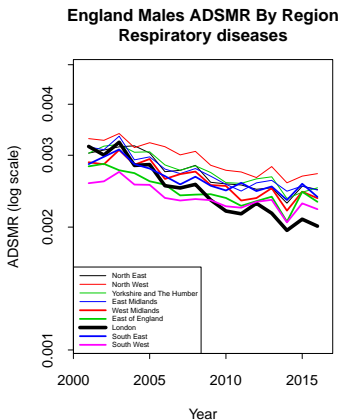


England Females ASMR By Income
Cancer: lungs, bronchus



Slight worsening \Rightarrow ?? smoking prevalence rising
Same northern regions do badly
Wider regional spread
London effect

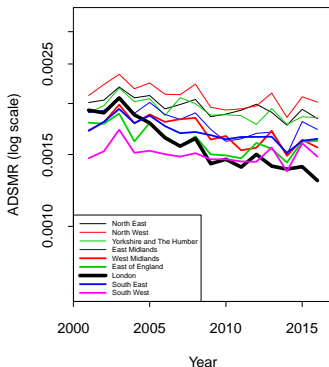
Respiratory Diseases: Males



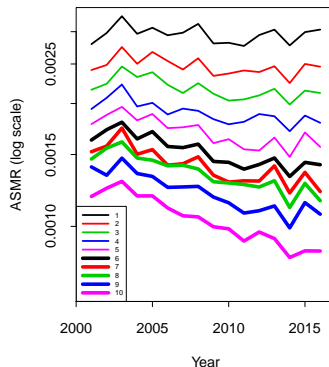
Flatter than males: similar pattern to lung cancer males

Respiratory Diseases: Females

England Females ADSMR By Region
Respiratory diseases

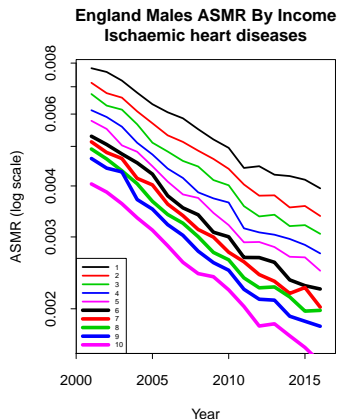
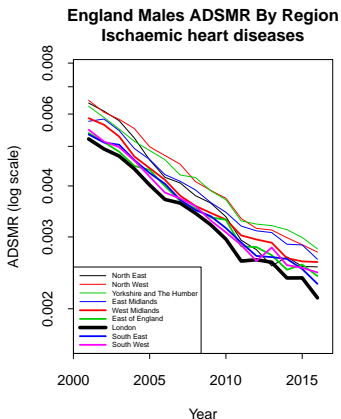


England Females ASMR By Income
Respiratory diseases



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

Ischaemic Heart Disease: Males



Success story: major improvements

Less good: widening gap and regional inequality

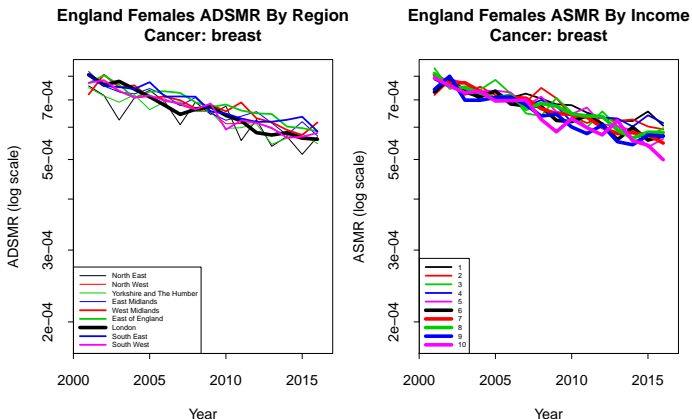
Females: similar picture

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?
 - ???

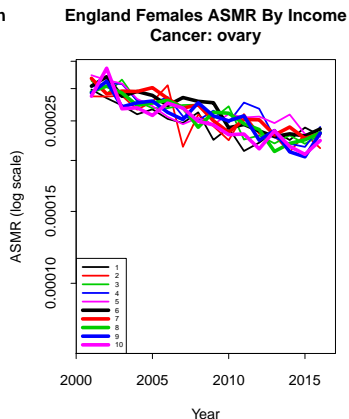
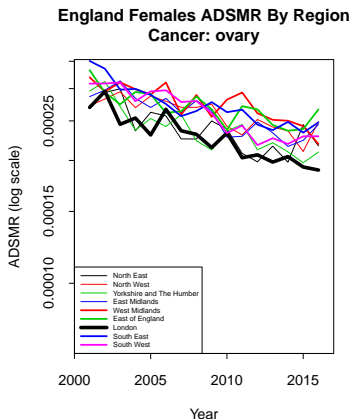
Breast Cancer: An Equality “Success Story”



Limited controllable risk factors

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

Ovarian Cancer: A Regional Lottery?

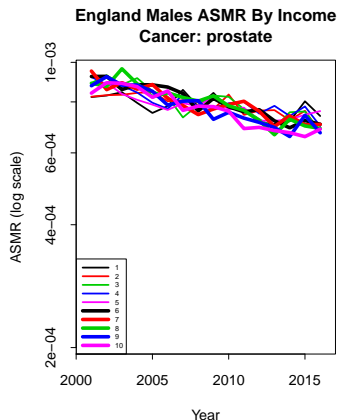
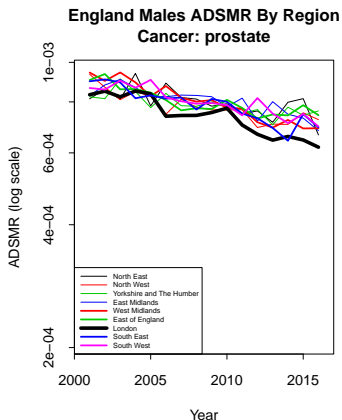


Limited controllable risk factors

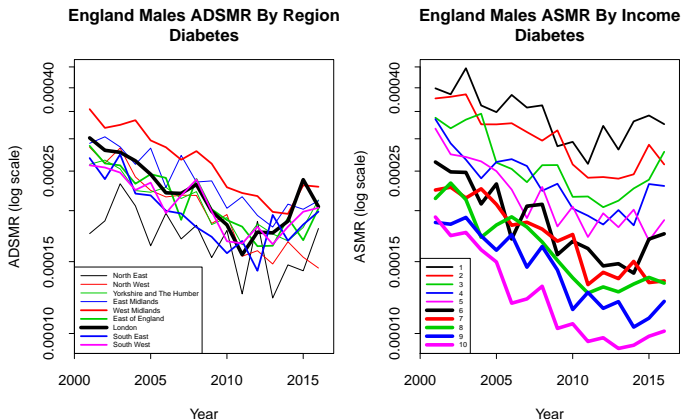
Limited income effect

Significant regional effect

Prostate Cancer: A Small London Effect?



Diabetes: Males

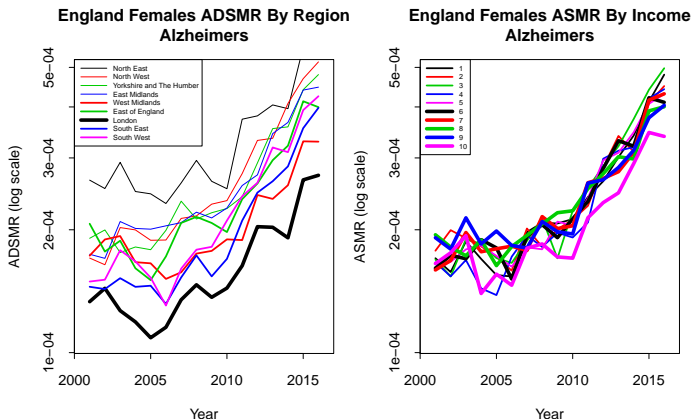


Significant inequality

Widening inequality gap by income deciles

Worsening mortality after about 2010

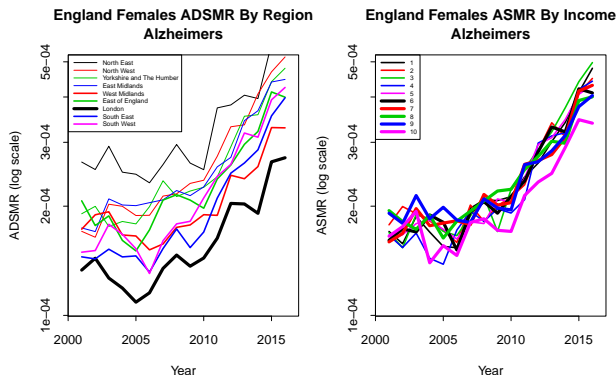
Alzheimers: Females (no clear controllable risk factors)



Modest income effect

Strong regional effect \Rightarrow ?? health migration

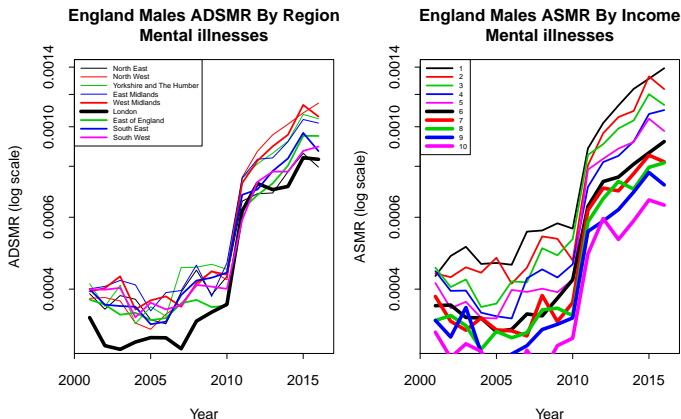
Alzheimer's: Females (no clear controllable risk factors)



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

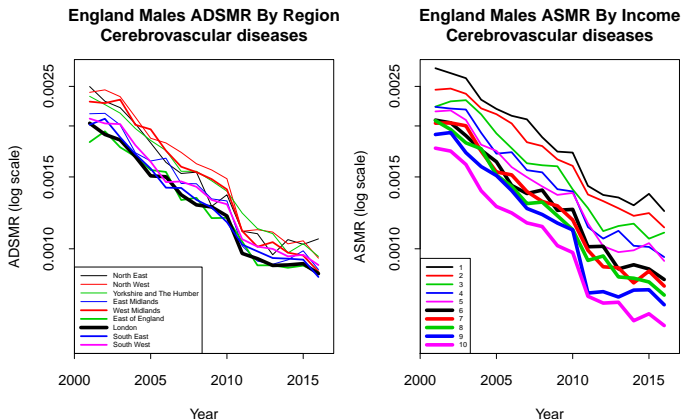
- evidence for non-independence of causes of death improvements elsewhere
 \Rightarrow ?? more frail survivors in old age
- gradual shift in reported cause of death

Shifting Classification 2010-2011: Mental Illness



Cause of shift: doubling in vascular and other dementias as CoD
(Additional source: Human Cause of Death Database (HCD))

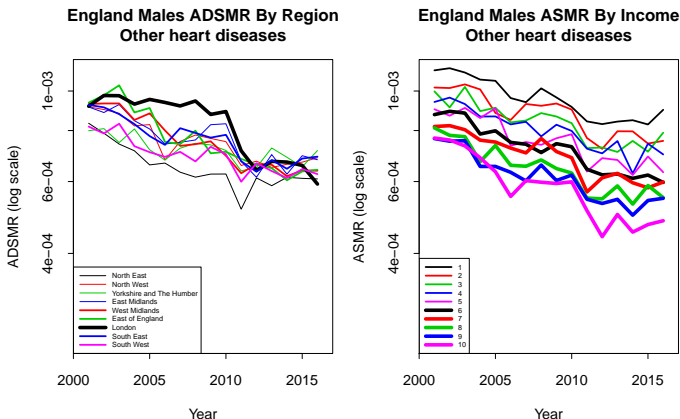
Shifting Classification 2010-2011: Cerebrovascular Diseases



E.g. stroke ↔ vascular dementia

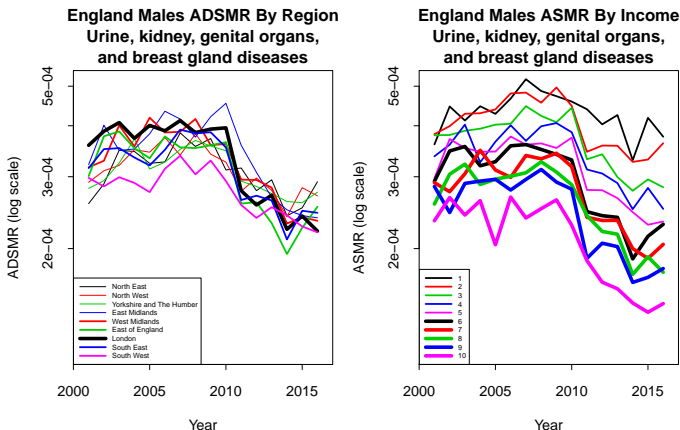
(Additional source: Human Cause of Death Database (HCD))

Shifting Classification 2010-2011: Other Heart Diseases



Pulmonary heart diseases; heart failure ↘ ↘ after 2011
(Additional source: Human Cause of Death Database (HCD))

Shifting Classification 2010-2011: Genitourinary Diseases



N39: Urinary tract infection ↘
(Additional source: Human Cause of Death Database (HCD))

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

Many Questions Remain

- 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?



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

Find Out More

- Appendix to these slides: lots more on the English data
- Work in progress: reports and papers in 2019
- Some related presentations already online
- Follow us at:

`www.macs.hw.ac.uk/~andrewc/ARCResources`

`www.actuaries.org.uk/ARC`



Thank You!

Questions?

E: A.J.G.Cairns@hw.ac.uk

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



Actuarial
Research Centre

Institute and Faculty
of Actuaries



The Actuarial Research Centre (ARC)

A gateway to global actuarial research

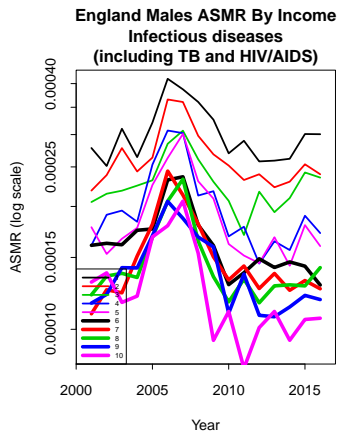
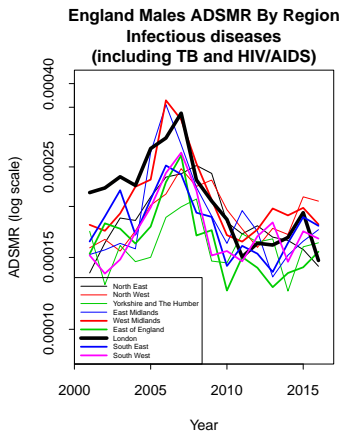
The Actuarial Research Centre (ARC) is the Institute and Faculty of Actuaries' (IFoA) network of actuarial researchers around the world. The ARC seeks to deliver cutting-edge research programmes that address some of the significant, global challenges in actuarial science, through a partnership of the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

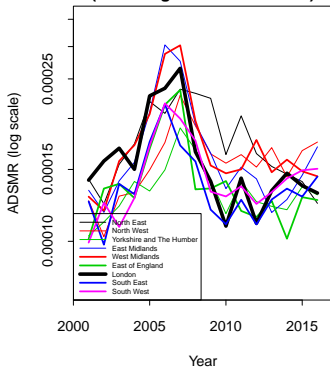
www.actuaries.org.uk/arc

England

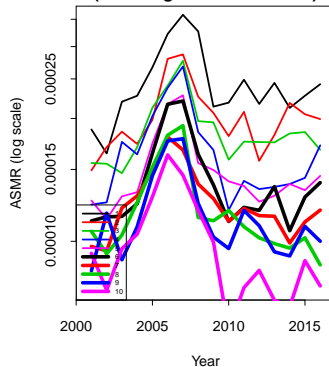
Income and Regional cause of death plots in full.



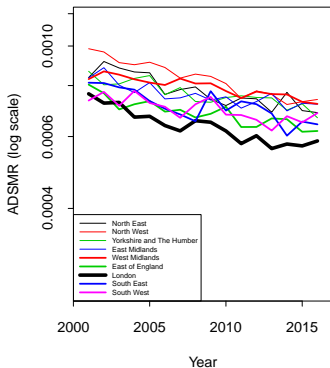
**England Females ADSMR By Region
Infectious diseases
(including TB and HIV/AIDS)**



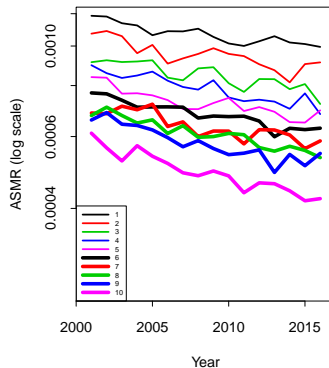
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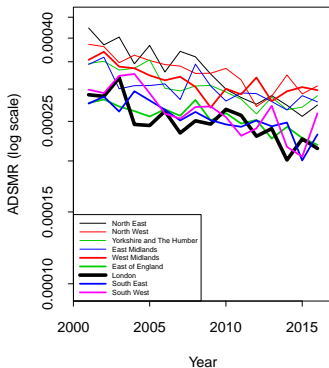
England Males ADSMR By Region
Cancer: oesophagus, stomach



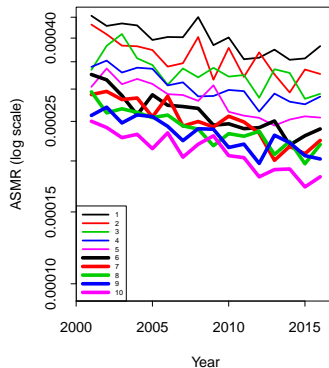
England Males ASMR By Income
Cancer: oesophagus, stomach



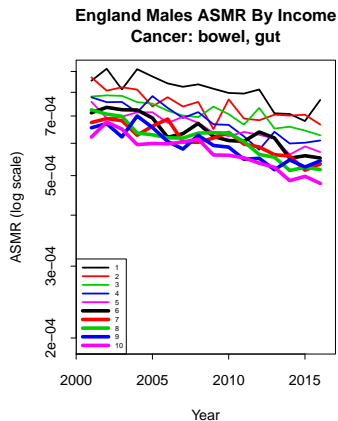
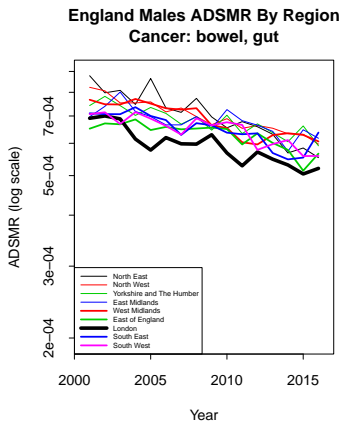
**England Females ADSMR By Region
Cancer: oesophagus, stomach**

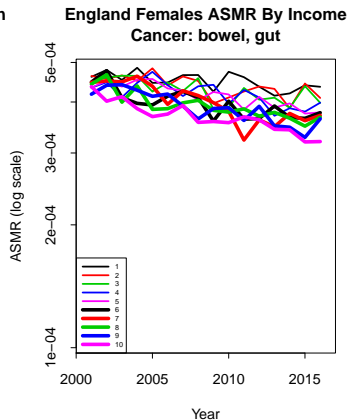
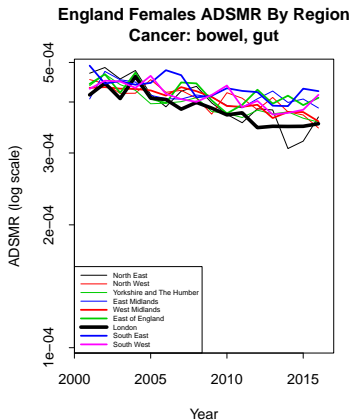


**England Females ASMR By Income
Cancer: oesophagus, stomach**



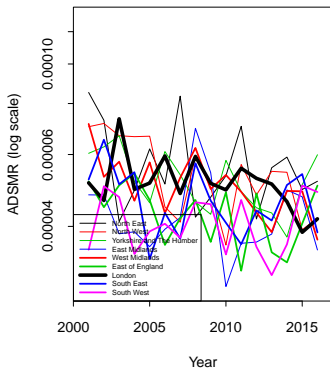
Appendix



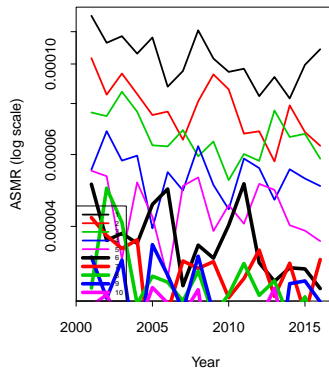


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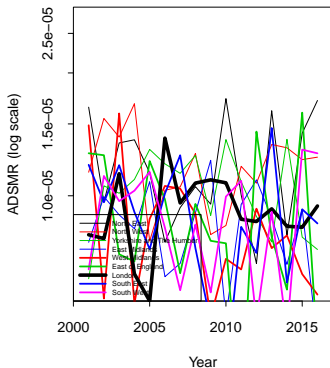
England Males ADSMR By Region
Cancer: larynx



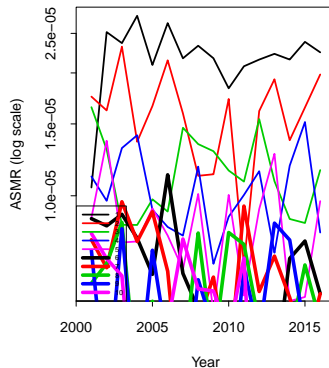
England Males ASMR By Income
Cancer: larynx



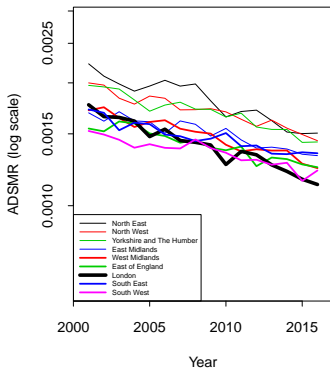
**England Females ADSMR By Region
Cancer: larynx**



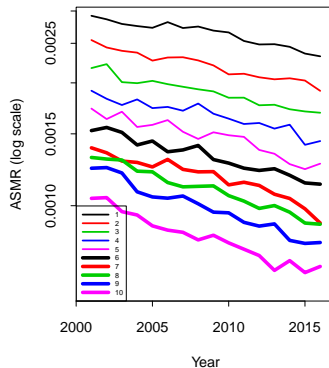
**England Females ASMR By Income
Cancer: larynx**



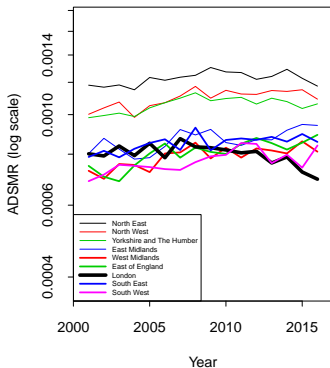
**England Males ADSMR By Region
Cancer: lungs, bronchus**



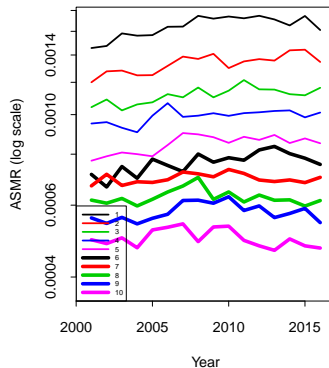
**England Males ASMR By Income
Cancer: lungs, bronchus**



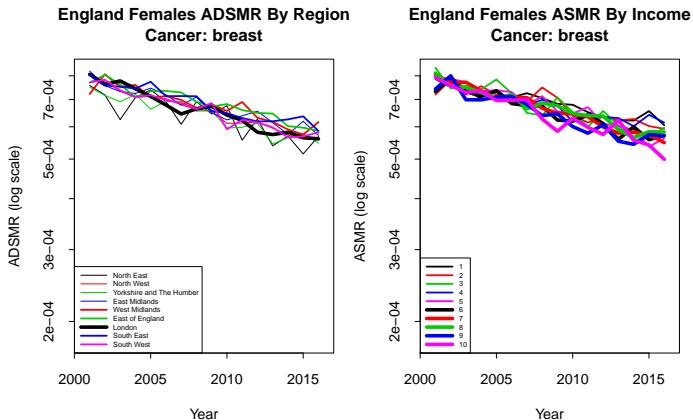
**England Females ADSMR By Region
Cancer: lungs, bronchus**

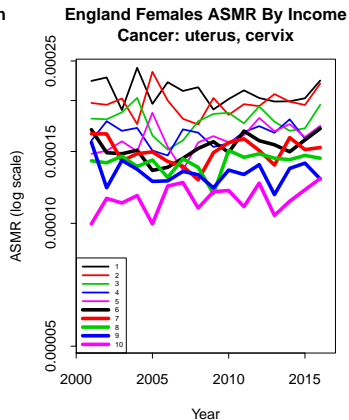
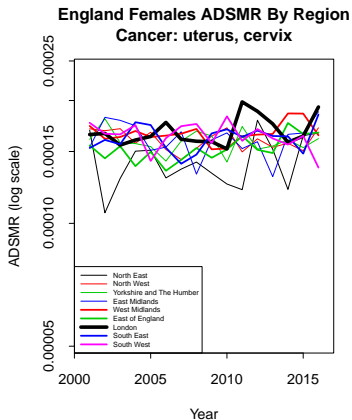


**England Females ASMR By Income
Cancer: lungs, bronchus**

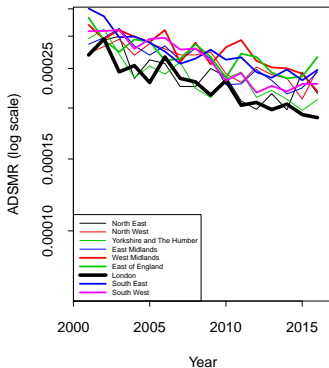


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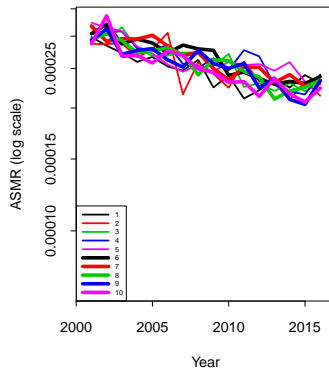




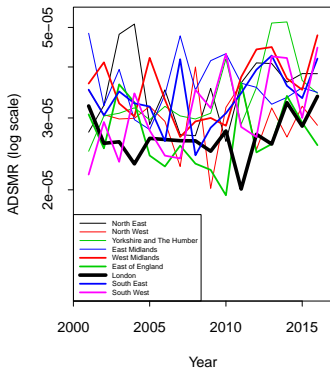
England Females ADSMR By Region
Cancer: ovary



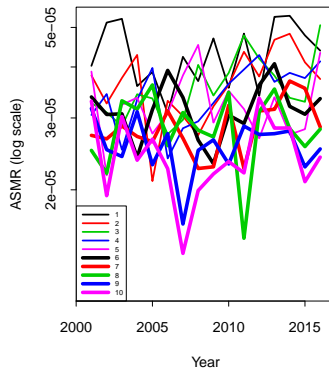
England Females ASMR By Income
Cancer: ovary



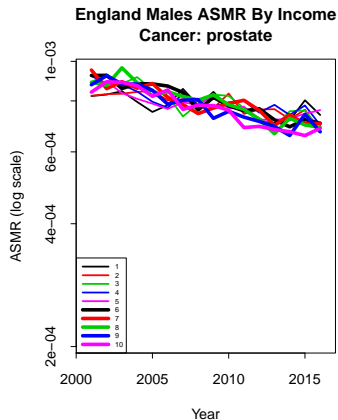
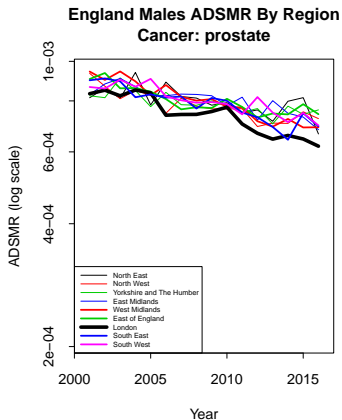
**England Females ADSMR By Region
Cancer: other female genital**



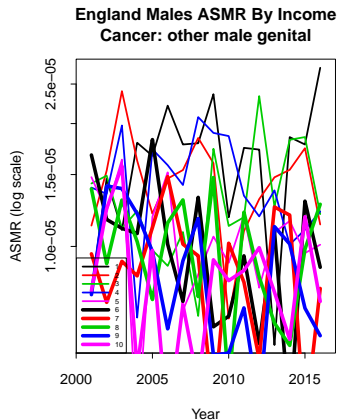
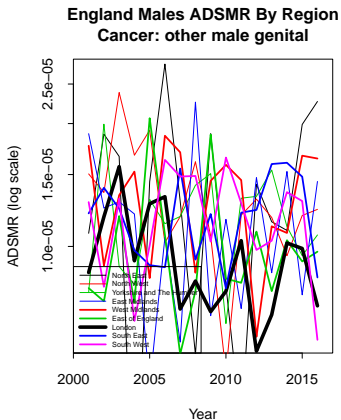
**England Females ASMR By Income
Cancer: other female genital**

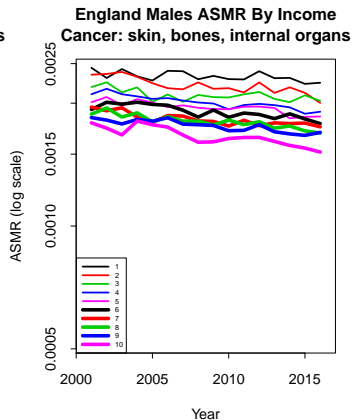
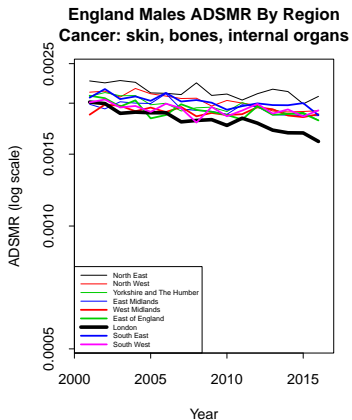


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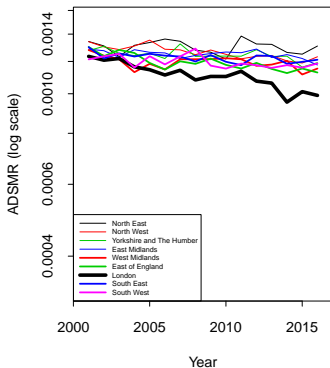


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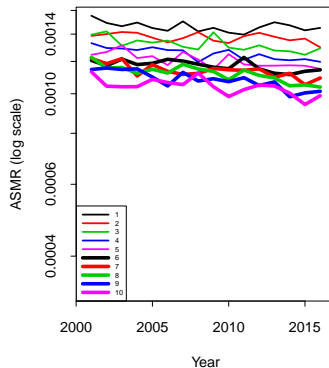




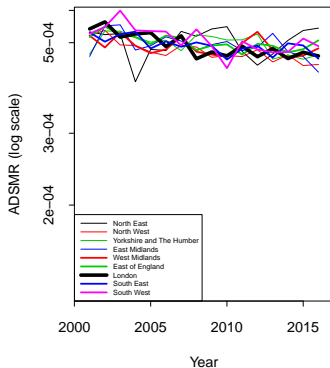
England Females ADSMR By Region
Cancer: skin, bones, internal organs



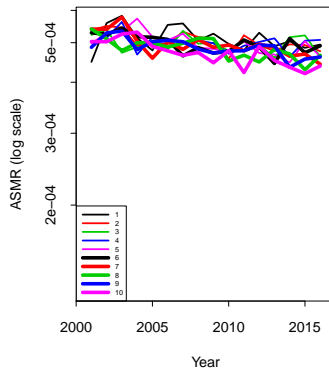
England Females ASMR By Income
Cancer: skin, bones, internal organs



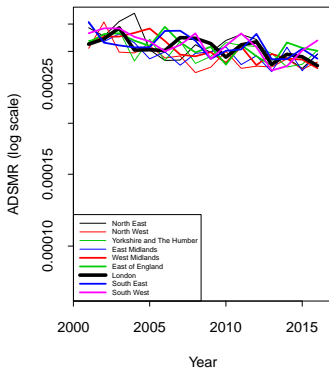
England Males ADSMR By Region
Cancer: lymphatic, myeloma, leukaemi



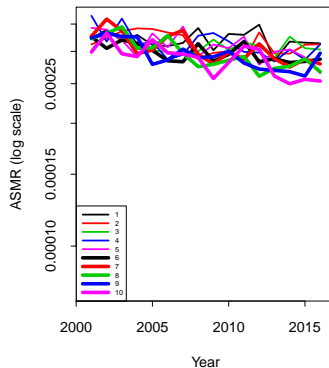
England Males ASMR By Income
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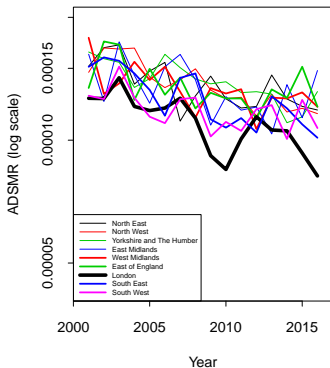
England Females ADSMR By Region
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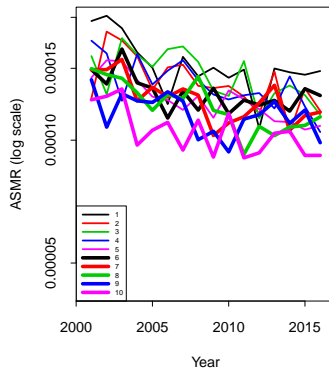
England Females ASMR By Income
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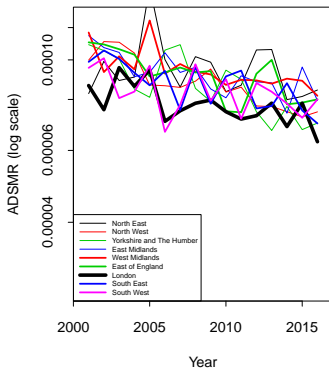
**England Males ADSMR By Region
Benign tumours**



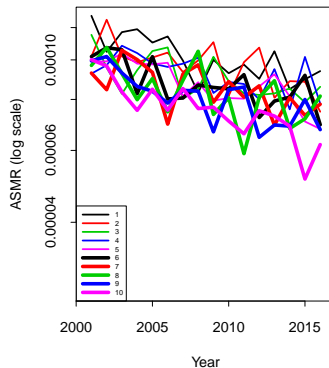
**England Males ASMR By Income
Benign tumours**



**England Females ADSMR By Region
Benign tumours**

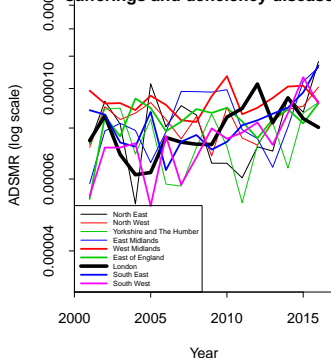


**England Females ASMR By Income
Benign tumours**

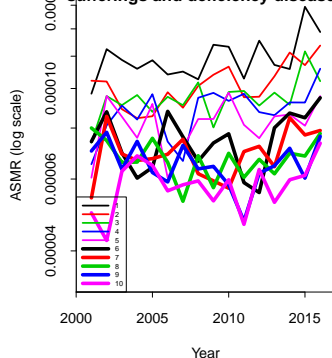


Appendix

England Males ADSMR By Region
Diseases in blood and
blood-forming organs, as well as endocri
sufferings and deficiency diseases

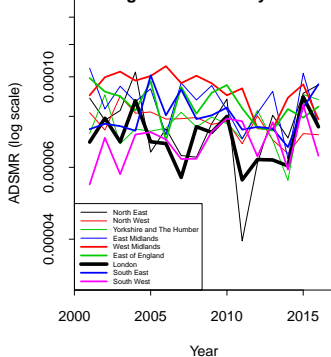


England Males ASMR By Income
Diseases in blood and
blood-forming organs, as well as endocri
sufferings and deficiency diseases

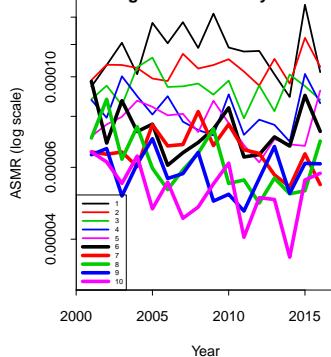


Appendix

England Females ADSMR By Region
Diseases in blood and
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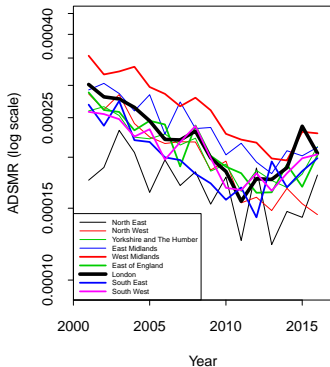


England Females ASMR By Income
Diseases in blood and
blood-forming organs, as well as endocri
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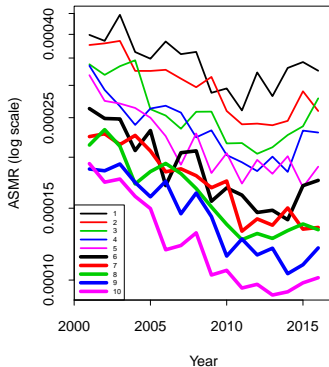


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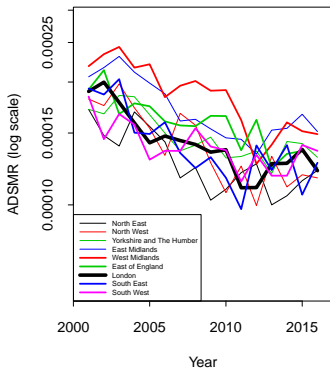
England Males ADSMR By Region
Diabetes



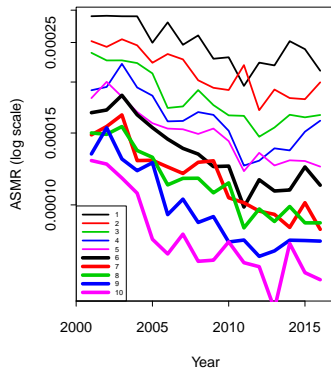
England Males ASMR By Income
Diabetes

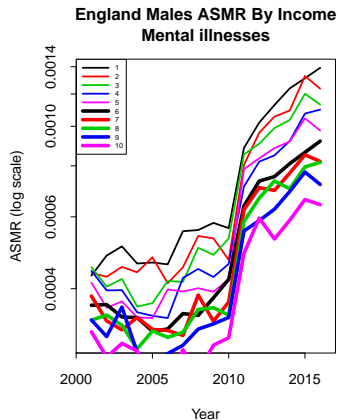
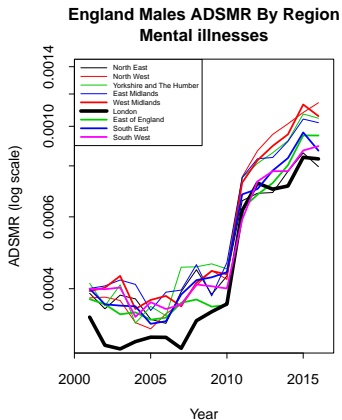


**England Females ADSMR By Region
Diabetes**

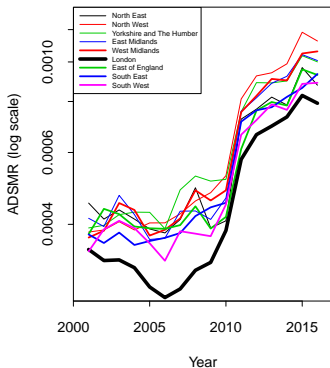


**England Females ASMR By Income
Diabetes**

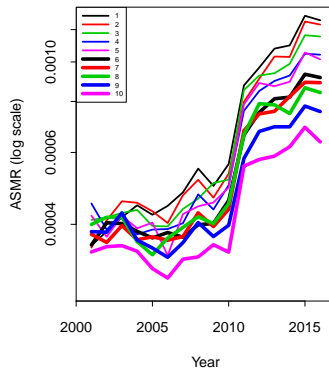




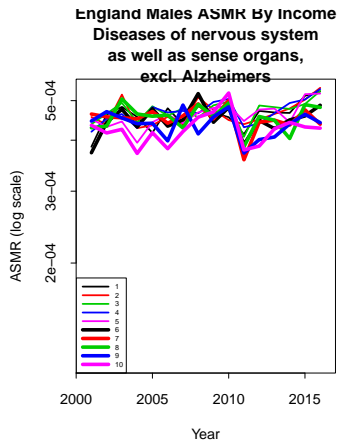
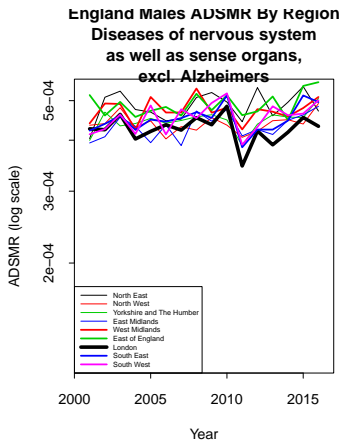
**England Females ADSMR By Region
Mental illnesses**



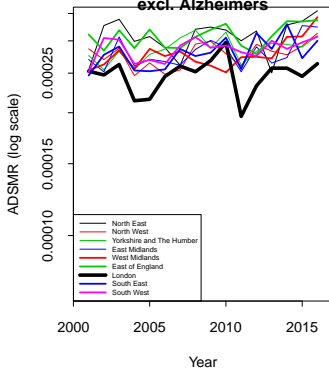
**England Females ASMR By Income
Mental illnesses**



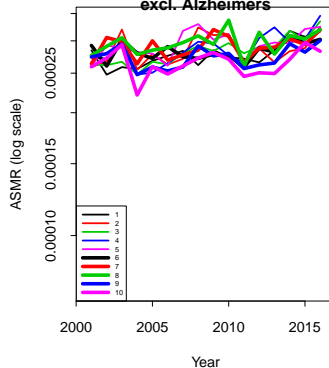
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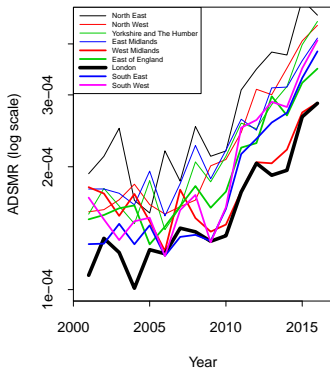
England Females ADSMR By Region
Diseases of nervous system
as well as sense organs,
excl. Alzheimers



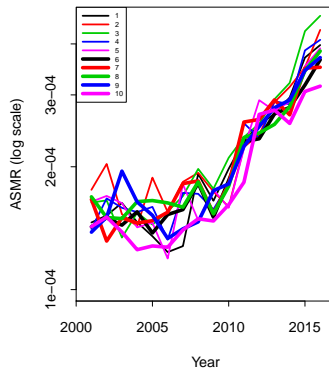
England Females ASMR By Income
Diseases of nervous system
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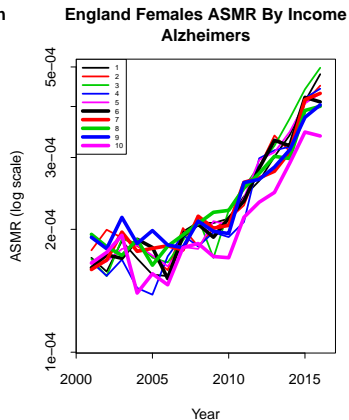
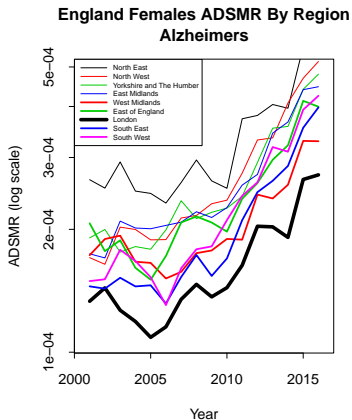


**England Males ADSMR By Region
Alzheimers**

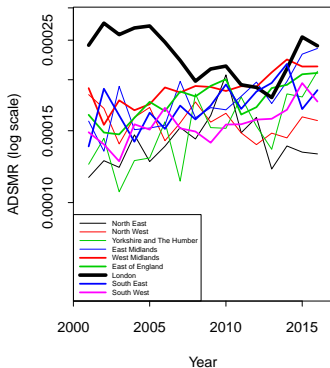


**England Males ASMR By Income
Alzheimers**

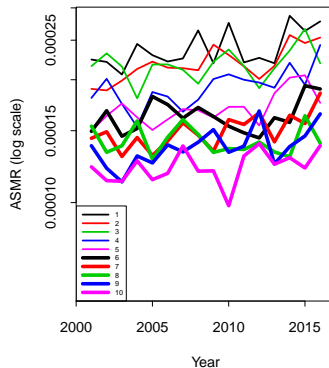




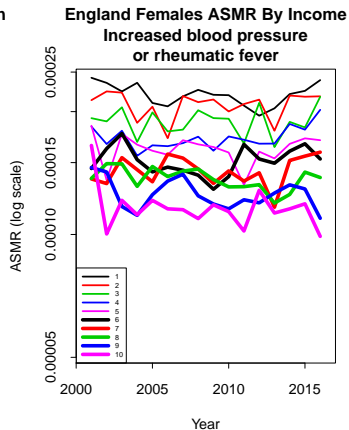
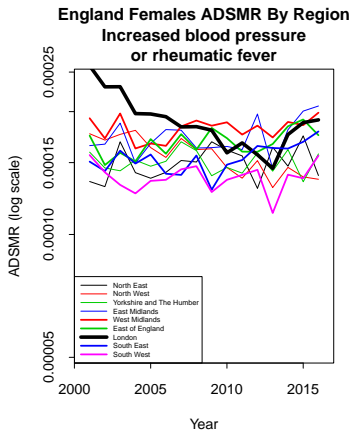
England Males ADSMR By Region
Increased blood pressure
or rheumatic fever

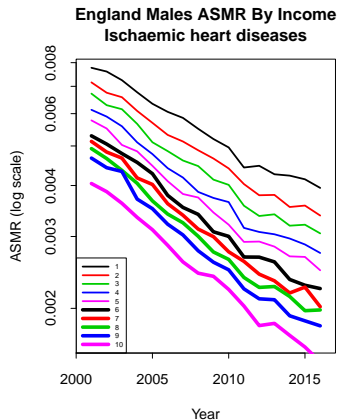
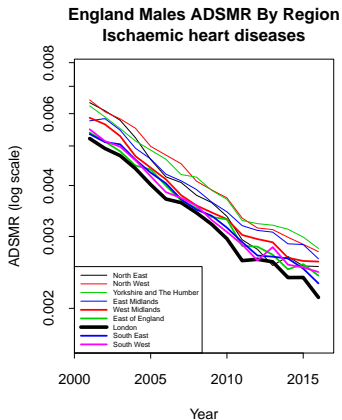


England Males ASMR By Income
Increased blood pressure
or rheumatic fever

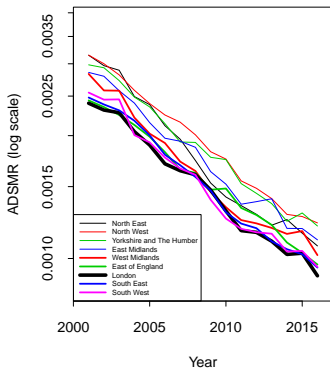


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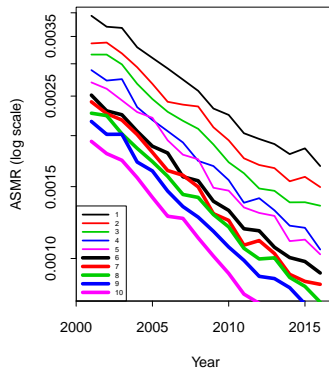


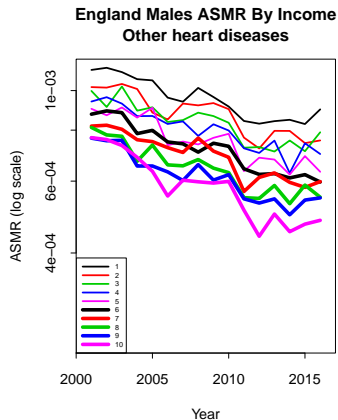
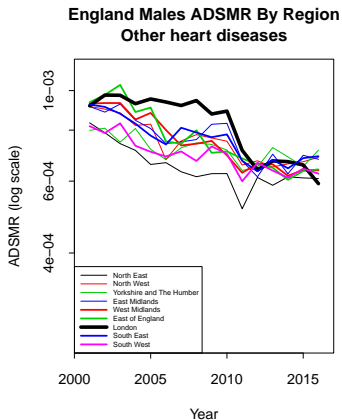


**England Females ADSMR By Region
Ischaemic heart diseases**

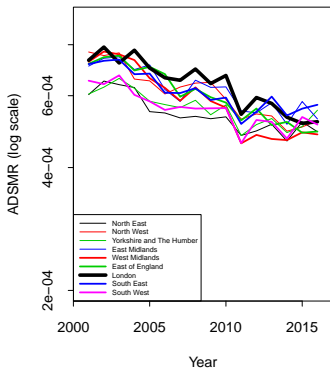


**England Females ASMR By Income
Ischaemic heart diseases**

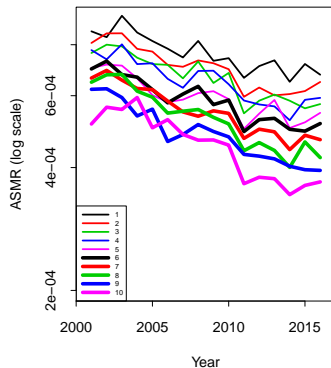


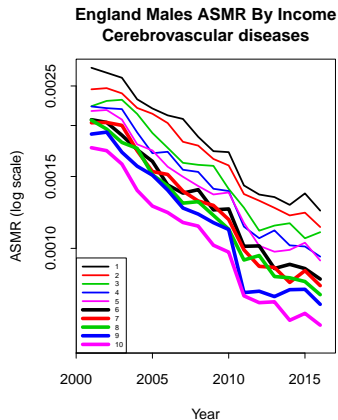
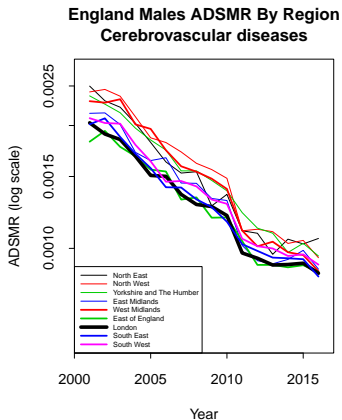


**England Females ADSMR By Region
Other heart diseases**

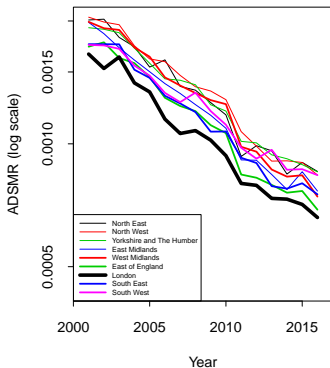


**England Females ASMR By Income
Other heart diseases**

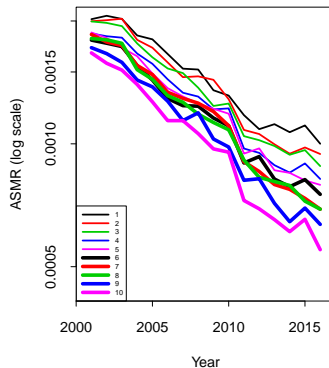




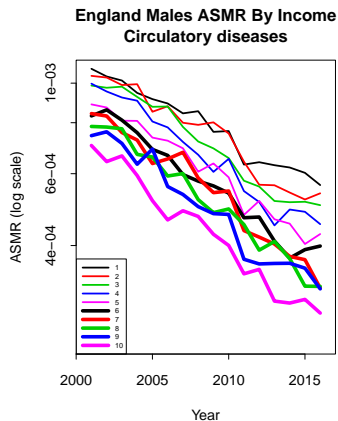
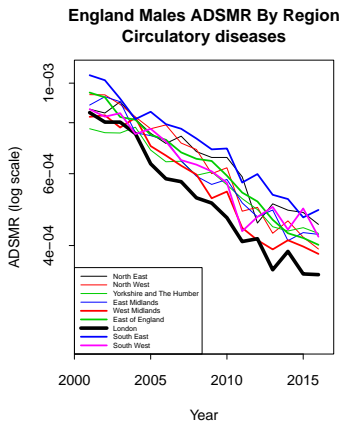
**England Females ADSMR By Region
Cerebrovascular diseases**



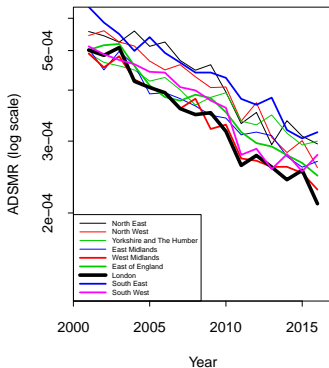
**England Females ASMR By Income
Cerebrovascular diseases**



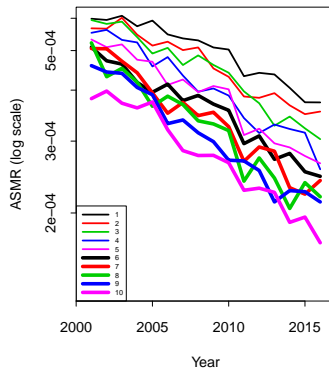
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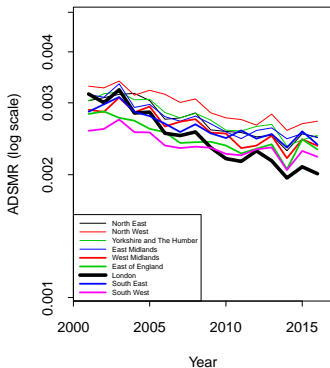
England Females ADSMR By Region
Circulatory diseases



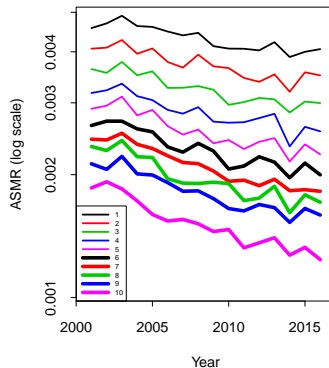
England Females ASMR By Income
Circulatory diseases



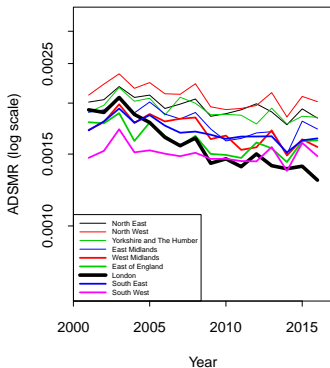
**England Males ADSMR By Region
Respiratory diseases**



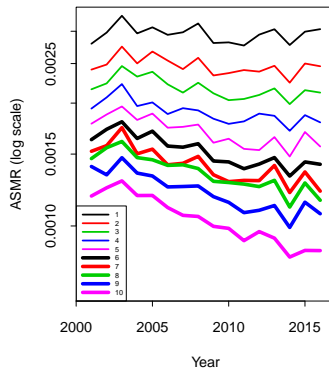
**England Males ASMR By Income
Respiratory diseases**

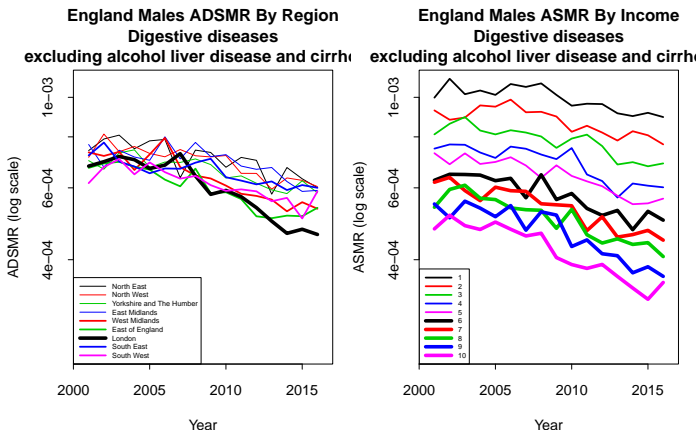


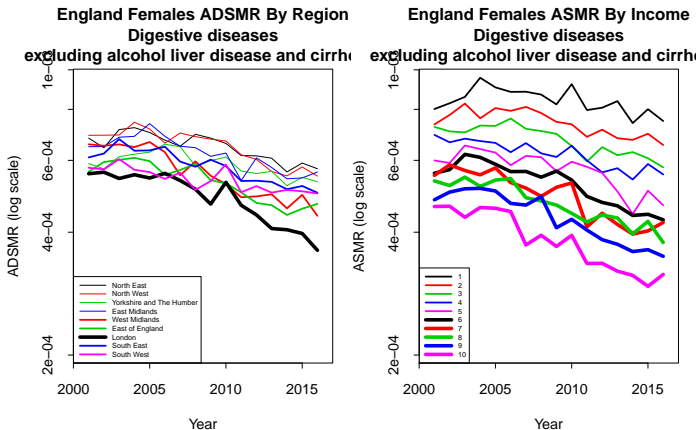
**England Females ADSMR By Region
Respiratory diseases**



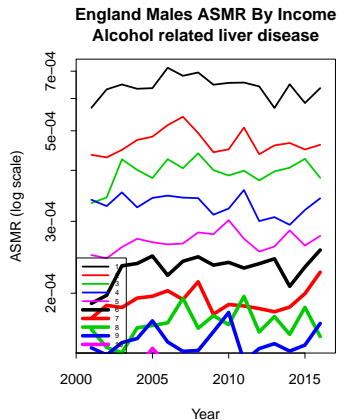
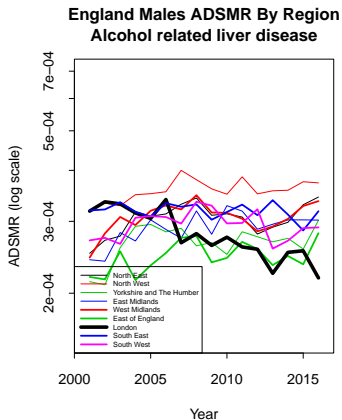
**England Females ASMR By Income
Respiratory diseases**



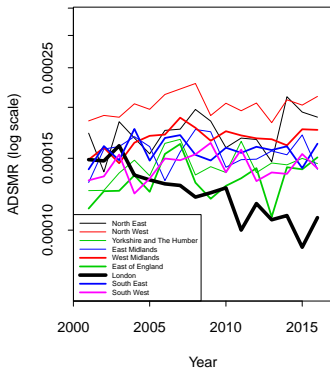




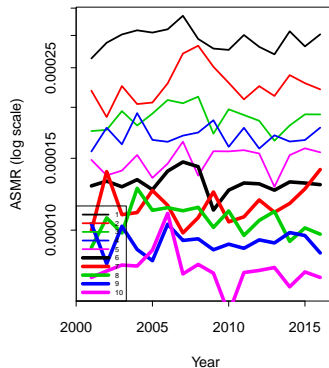
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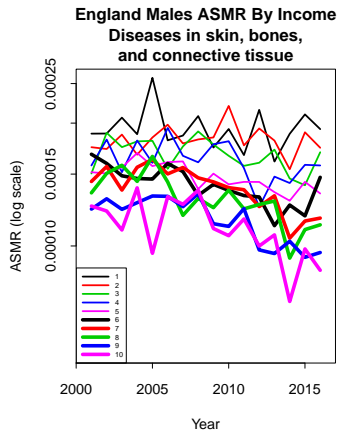
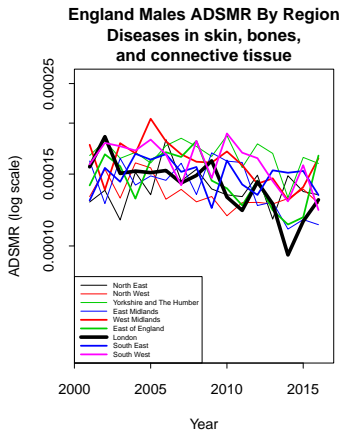
**England Females ADSMR By Region
Alcohol related liver disease**



**England Females ASMR By Income
Alcohol related liver disease**

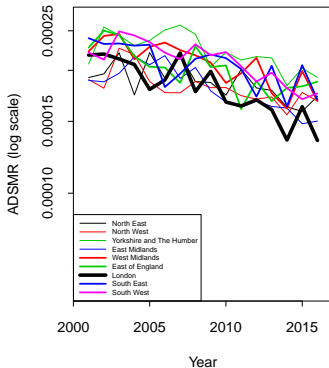


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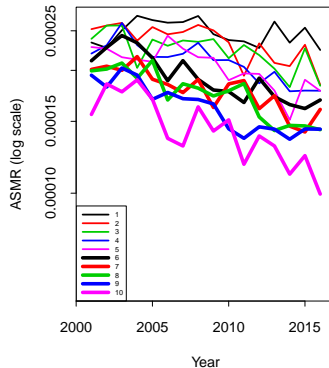


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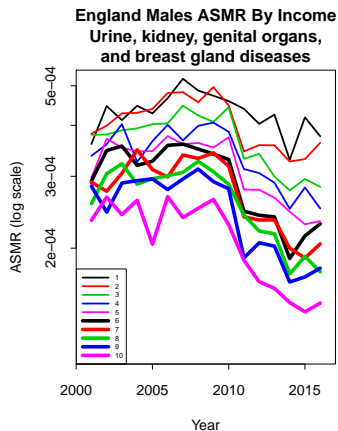
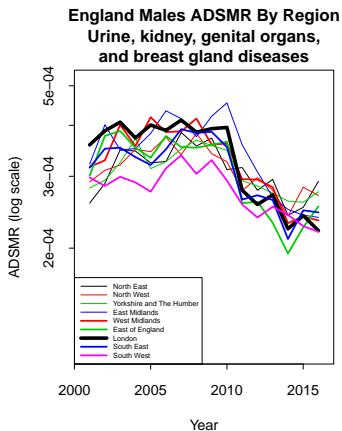
England Females ADSMR By Region
Diseases in skin, bones,
and connective tissue



England Females ASMR By Income
Diseases in skin, bones,
and connective tissue

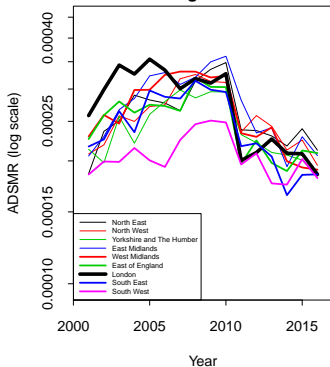


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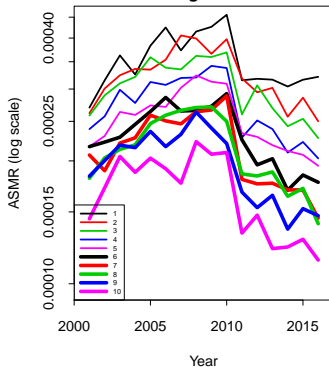


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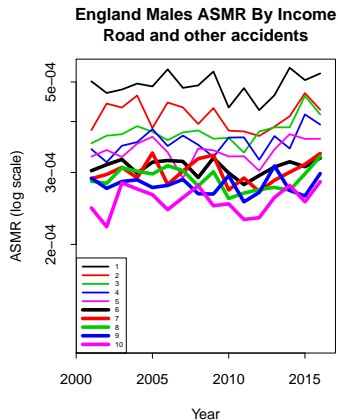
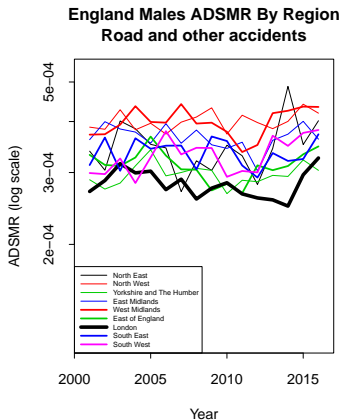
England Females ADSMR By Region
Urine, kidney, genital organs,
and breast gland diseases



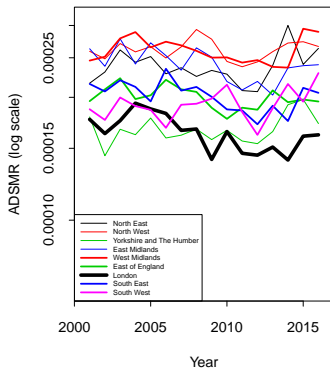
England Females ASMR By Income
Urine, kidney, genital organs,
and breast gland diseases



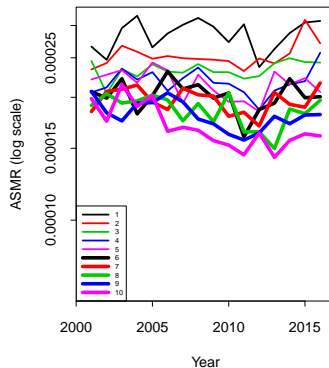
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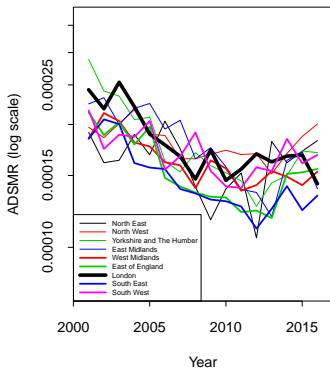
**England Females ADSMR By Region
Road and other accidents**



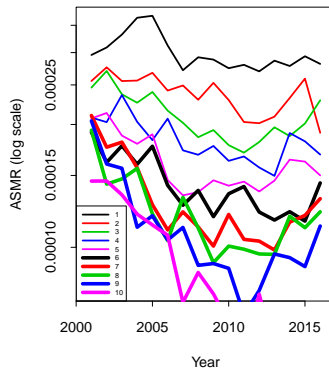
**England Females ASMR By Income
Road and other accidents**



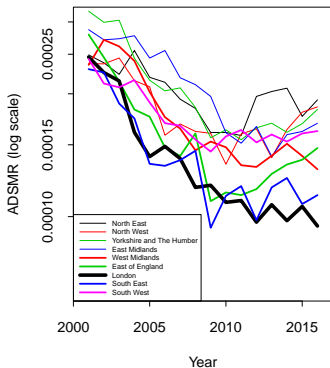
**England Males ADSMR By Region
Other causes of death**



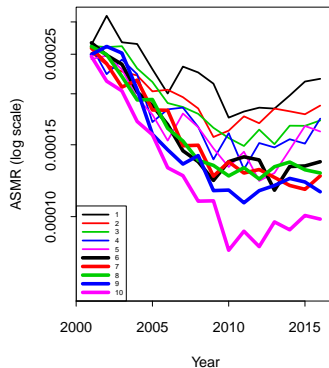
**England Males ASMR By Income
Other causes of death**



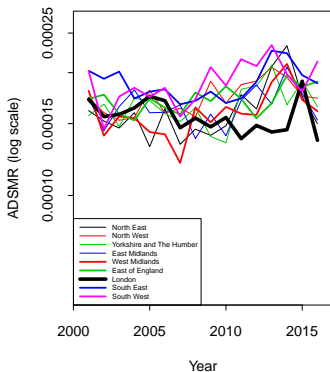
**England Females ADSMR By Region
Other causes of death**



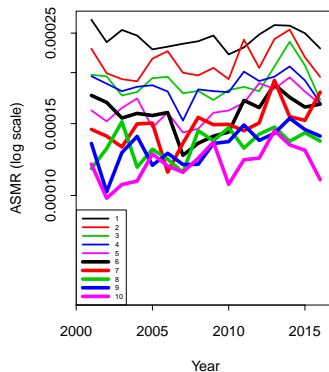
**England Females ASMR By Income
Other causes of death**



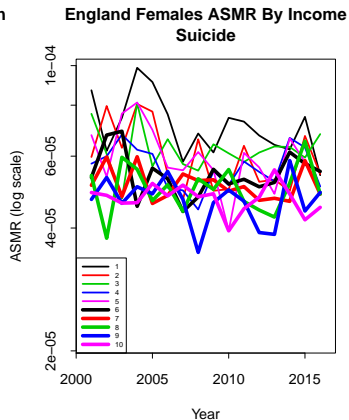
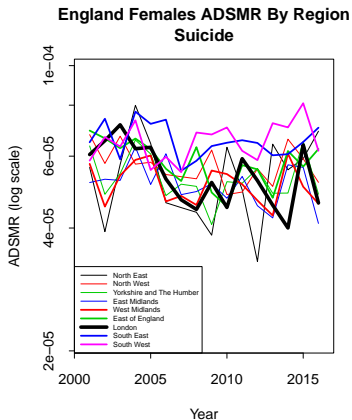
**England Males ADSMR By Region
Suicide**



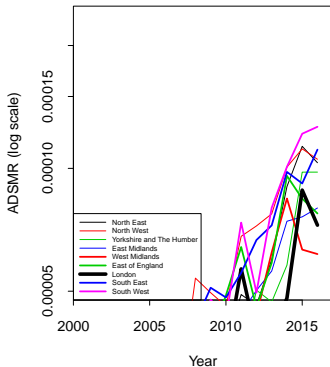
**England Males ASMR By Income
Suicide**



Appendix



**England Males ADSMR By Region
Accidental poisonings**



**England Males ASMR By Income
Accidental poisonings**

