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

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Joint work with C. Redondo, D. Blake, K. Dowd, M. Kallestrup-Lamb, C. Rosenskjold

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Outline

- Motivation and long term goals
- Data
- Comparison of US, Denmark and England
- England: deeper dive
Purpose of looking at cause of death data

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

- Medical advances
- Health spending
- Public health initiatives
- Individual risk factors:
  - Controllable
e.g. smoking, diet, exercise, alcohol, sun, drugs, hygeine, risky sex, stress, environment...
  - leading to cohort effects
  - Not (easily) controllable
e.g. genetic, affluence, education, character/personality traits, ...
Socio-economic datasets

Cause of death data for:
- US (males and females)
  - by education level: low (≤ 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

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

**Detail** ⇒ 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

- **England**
  - 34 CoD groups
  - Age groups 20-24, 25-29, ..., 85-89
  - Single years 2001-2016
### Denmark – Affluence – Top 10 CoD

**Males; Ages 71-75; Years 2005-2009**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Least Affluent</th>
<th>Most Affluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ischaemic heart</td>
<td>Skin &amp; organ cancer</td>
</tr>
<tr>
<td>2</td>
<td>Respiratory</td>
<td>Ischaemic heart</td>
</tr>
<tr>
<td>3</td>
<td>Lung cancer etc.</td>
<td>Prostate cancer</td>
</tr>
<tr>
<td>4</td>
<td>Skin &amp; organ cancer</td>
<td>Respiratory</td>
</tr>
<tr>
<td>5</td>
<td>Other</td>
<td>Lung cancer etc.</td>
</tr>
<tr>
<td>6</td>
<td>Cerebrovascular</td>
<td>Cerebrovascular</td>
</tr>
<tr>
<td>7</td>
<td>Other heart</td>
<td>Other</td>
</tr>
<tr>
<td>8</td>
<td>Diabetes</td>
<td>Gut cancer</td>
</tr>
<tr>
<td>9</td>
<td>Gut cancer</td>
<td>Other heart</td>
</tr>
<tr>
<td>10</td>
<td>Prostate cancer</td>
<td>Alzheimers etc.</td>
</tr>
</tbody>
</table>

**Prostate:** almost no inequality.

Causes of death with significant *controllable* risk factors feature much more heavily amongst the least affluent.
Denmark: Cause of Death Data 2005-2009

Wide gap
Affluence has a wider gap than education
Gap narrows with age
Gap widens over time
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
- Some causes of death: *no known (significant) controllable risk factors*
  e.g. prostate cancer
Denmark: Cause of Death Data 2005-2009

Denmark By Education
Cancer: prostate, testicular

Education: no differences

Denmark By Affluence
Cancer: prostate, testicular

Affluence: small differences

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Cause of Death Mortality
**Multi-Country: Year 2007, Males, Ischaemic Heart Disease**

- **US By Education 2007**
  - Ischaemic heart diseases
  - Low
  - High

- **Denmark By Education 2007**
  - Ischaemic heart diseases
  - Low
  - Medium
  - High

- **Denmark By Affluence 2007**
  - Ischaemic heart diseases

- **England by Deprivation 2007**
  - Ischaemic heart diseases

US: wider than Denmark

England similar to Denmark but higher
Multi-Country: Age 68, Males, Ischaemic Heart Disease

US by Education, Age 68
Ischaemic heart diseases

Denmark by Education, Age 68
Ischaemic heart diseases

Denmark by Affluence, Age 68
Ischaemic heart diseases

England by Deprivation, Age 68
Ischaemic heart diseases

Significant improvements, but not throughout

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Cause of Death Mortality
Multi-Country: Age 68, Males, Prostate Cancer

**US by Education, Age 68**
Cancer: prostate, testicular

**Denmark by Education, Age 68**
Cancer: prostate, testicular

**Denmark by Affluence, Age 68**
Cancer: prostate, testicular

**England by Deprivation, Age 68**
Cancer: prostate

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

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Cause of Death Mortality
Significant inequality; improvements might be driven by smoking prevalence.
Variation in Reporting Practice: e.g. Mental Illness

Alcohol & drug abuse; mental disorders; \(\rightarrow\) vascular dementia

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Cause of Death Mortality

US By Education 2002
Alcohol -> liver

Denmark By Education 2002
Alcohol -> liver

Denmark By Affluence 2002
Alcohol -> liver

England by Deprivation 2002
Alcohol related liver disease

Affluence a much bigger driver

US By Education 2012
Alcohol -> liver

Denmark By Education 2012
Alcohol -> liver

Denmark By Affluence 2012
Alcohol -> liver

England by Deprivation 2012
Alcohol related liver disease

US: possible cohort effect
England: Income Deprivation versus Region

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

Not in dataset:
Scotland, Wales, Northern Ireland
England: Males (40-89) ASMR and ADSMR Inequality

Age Standardised Mortality Rates
Males By Income for All Causes

ASMR for age range 40–89

Year
ASMR (log scale)

Income

Region

Region: standardised

ADSMR adjusts for different income deprivation mix by region
Males and Females: Clear “London Effect”.
Greater improvements in healthcare??
Greater improvements in GDP??
Significant variation between income deciles (⇒ smoking prevalence)
Significant variation between regions (after standardisation)
×1.5 variation by region; ×2.5 by income decile
London effect; Northern regions very poor
Lung Cancer: Females

Slight worsening ⇒ smoking prevalence rising
Same northern regions do badly
Wider regional spread
London effect
Flatter but otherwise similar pattern to lung cancer males
Respiratory Diseases: Females

Similar pattern to lung cancer females
Ischaemic Heart Disease: Males

Success story: major improvements
Deterioration: widening gap and regional inequality
Females: similar picture
Story So Far

Causes of death with significant risk factors:

- Significant inequalities by income deprivation
- Significant *additional* inequalities by region
- Bigger income inequality “⇒” bigger regional inequality
- Mostly the same regions are worse
Limited controllable risk factors
Success story: no significant inequality
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?
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.actuaries.org.uk/arc
England: Income Deprivation versus Region

United Kingdom: Regions, 2011

Key
- Regions

Boundaries shown in England are effective as follows: Regions at 31st December 2011 (see note below). The former Government Office Regions (England) are now referred to as ‘regions’ for statistical purposes. Scotland, Northern Ireland and Wales are not regions, but are often used as equivalents for the purpose of representing statistics that cover the whole of the UK.

Please visit the ONS Geography web pages for the latest information:
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, $S = \text{cor}(i, R(i, t))$
- 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
Inequality = A(D)SMR(worst) / A(D)SMR(best)
Region: best = London; worst = N.W.
Income Deprivation: best = 10; worst = 1
London: not always the best for individual causes of death.
Causes of death with significant controllable risk factors:
Inequality between regions $\Rightarrow$ (??) significant variation in risk factors between regions
US Males Age 63: Stagnation

Males, Age 63, All Cause Mortality

Death Rate (log scale)

Year

US low education
US high education

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Cause of Death Mortality
Low education absolute changes in mortality

US Males Aged 63, Low Education, Changes in CoD Death Rates

Three big gains, many small "losers"

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US Drivers of Change 1991-2013, Males Age 63

High education absolute changes in mortality

CoD Death Rate in 1989–1993 (log scale)

Absolute Change in CoD Death Rate 1991–2013

US By Education 2002
Accidental Poisonings

Denmark By Education 2002
Accidental Poisonings

US By Affluence 2002
Accidental Poisonings

England by Deprivation 2002
Accidental poisonings

US, Denmark: significant

Growth: England > US > DK

US By Education 2012
Accidental Poisonings

Denmark By Education 2012
Accidental Poisonings

Denmark By Affluence 2012
Accidental Poisonings

England by Deprivation 2012
Accidental poisonings

US: evidence of a cohort effect

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Cause of Death Mortality