Explaining socio-economic trends in coronary heart disease mortality

*England 2000-2007: the IMPACTsec model*

Madhavi Bajekal PhD

Senior Research Fellow (Honorary)
Department of Applied Health Research
University College London

*The future of human longevity: cardiovascular disease*
*Swiss Re Centre for Global Dialogue, Rüschlikon, 2013*
Outline

• Setting the context: socioeconomic differentials in all-cause mortality England in:
  • Life expectancy
  • Lifespan variability
  • Morbidity and disability
• Why CHD? (coronary heart disease)
• IMPACTsec model and results
• Next steps
Index of Multiple Deprivation 2007, England

(map at district level)

- IMD 2007 combines indicators across 7 deprivation domains into a single index score
  - Income, employment, health, education, housing and services, crime, and living environment
- Lowest-level geography IMD calculated for 32,482 Lower Super Output Areas (LSOAs) in England with c. 1,500 people each
- LSOAs ranked by ascending IMD 2007 score and grouped into population quintiles
  - Q1: Least deprived quintile
  - Q5: Most deprived quintile

Trends in LE@65: 1982-2006 Males

Area-based deprivation

Individual socioeconomic status

Gap = 3.9y

Gap = 2.6y

Gap = 2.1y

Gap = 3.1y
Lifespan dispersion measures

(Males, E&W, 2010)

- Life expectancy (79y)
- Median (81y)
- Mode (85y)
Lifespan variation Q1 v Q5: England 2001
(deaths pooled 1999-2003, smoothed moving average over 5 years of age)

Men (aged 25+)

Women (aged 25+)

Measure of dispersion

<table>
<thead>
<tr>
<th>Measure of dispersion</th>
<th>Eng</th>
<th>Q1</th>
<th>Q5</th>
<th>Q1-Q5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modal age of death</td>
<td>83</td>
<td>84</td>
<td>77</td>
<td>7</td>
</tr>
<tr>
<td>Median age of death</td>
<td>78</td>
<td>81</td>
<td>74</td>
<td>7</td>
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<tr>
<td>LE@25</td>
<td>52</td>
<td>55</td>
<td>48</td>
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</tr>
<tr>
<td>LE@65</td>
<td>16</td>
<td>17</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Stdev lifespan</td>
<td>12.7</td>
<td>11.5</td>
<td>13.8</td>
<td>-2.5</td>
</tr>
<tr>
<td>$S_{25}$</td>
<td>8.0</td>
<td>7.9</td>
<td>8.1</td>
<td>-0.3</td>
</tr>
<tr>
<td>$S_{65}$</td>
<td></td>
<td></td>
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</tbody>
</table>

Measure of dispersion

<table>
<thead>
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<th>Eng</th>
<th>Q1</th>
<th>Q5</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Modal age of death</td>
<td>85</td>
<td>88</td>
<td>84</td>
<td>4</td>
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<tr>
<td>Median age of death</td>
<td>82</td>
<td>84</td>
<td>80</td>
<td>4</td>
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<tr>
<td>LE@25</td>
<td>56</td>
<td>58</td>
<td>54</td>
<td>4</td>
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<tr>
<td>LE@65</td>
<td>19</td>
<td>21</td>
<td>18</td>
<td>3</td>
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<tr>
<td>Stdev lifespan</td>
<td>12.0</td>
<td>11.2</td>
<td>13.1</td>
<td>-1.9</td>
</tr>
<tr>
<td>$S_{25}$</td>
<td>8.3</td>
<td>8.0</td>
<td>8.7</td>
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</tr>
<tr>
<td>$S_{65}$</td>
<td></td>
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</tr>
</tbody>
</table>

7yr gap in modal age of death

4yr gap in modal age of death
Cause of death distribution by age: males


Least Deprived (Q1)

Most Deprived (Q5)
Multi-morbidity by age and deprivation deciles
Scotland, 2007

- Young and middle-aged people (25-70y) living in the most deprived areas had multiple morbidity (2+ diseases) rate as high as those 10+ years older living in most affluent areas.
Males: Life expectancy with and without disability: at birth and age 65 by deprivation quintiles England 2007-2010
(Source: adapted from ONS ‘Inequalities in DFLE, 2013’)

LE at birth

<table>
<thead>
<tr>
<th>Quintile</th>
<th>Disability-free</th>
<th>With disability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least</td>
<td>70</td>
<td>12</td>
</tr>
<tr>
<td>Q2</td>
<td>68</td>
<td>13</td>
</tr>
<tr>
<td>Q3</td>
<td>64</td>
<td>15</td>
</tr>
<tr>
<td>Q4</td>
<td>62</td>
<td>15</td>
</tr>
<tr>
<td>Most</td>
<td>55</td>
<td>19</td>
</tr>
</tbody>
</table>

LE at age 65

<table>
<thead>
<tr>
<th>Quintile</th>
<th>Disability-free</th>
<th>With disability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Q2</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Q3</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>Q4</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Most</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

Legend:
- Disability-free
- With disability
To recap..

• People in disadvantaged circumstances live shorter lives, get diseases earlier and spend more years of their (shorter) life with disability.
• Poor and rich die from the same causes, but at different rates.
• There is an inverse social gradient in health – each higher social grade has lower rates of ill-health and death.
Why model CHD?

• Fall in CHD mortality has driven rapid improvements in life expectancy over last 25 years.

• But it still remains a leading cause of death and of persistent inequalities.

• Model to explain why CHD mortality fell:
  – was it better treatments; or reductions in risk factors?
  – did the contributions of these factors differ by socioeconomic circumstances?
We live in a golden age of medical progress …

Decline in Deaths from Cardiovascular Disease in Relation to Scientific Advances

Source: Nabel & Braunwald E, NEJM 2012
Decline in Deaths from Cardiovascular Disease in Relation to Important Public Health and Primary Care: An alternative view

Age standardised CHD mortality rates by deprivation quintiles 1982-2006

Males

<table>
<thead>
<tr>
<th>Year</th>
<th>Rate per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
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<tr>
<td>1984</td>
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<td>1988</td>
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<tr>
<td>2004</td>
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<td>2006</td>
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Females

<table>
<thead>
<tr>
<th>Year</th>
<th>Rate per 100,000</th>
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</thead>
<tbody>
<tr>
<td>1982</td>
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<tr>
<td>1984</td>
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<td>2004</td>
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<td>2006</td>
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</tbody>
</table>
Average annual percentage fall in age-standardised CHD mortality rates by deprivation and sex 1982-2006

Modelled estimates of annual % change using JoinPoint
Average annual percentage change in CHD mortality by deprivation 1982-2006

**Males**

**Females**

![Graph showing average annual percentage change in CHD mortality by deprivation for males and females from 1982 to 2006.](image-url)
Explaining the fall in CHD mortality
The IMPACT model 1981-2000 (England and Wales)

Incidence CHD ↓: improved population risk factors, & detection/treatment high risk individuals

Case-fatality ↓: better treatments in acute phase, & improved secondary prevention

Risk Factors worse          +13%
Obesity (increase)           +4%
Diabetes (increase)          +5%
Physical activity (less)     +4%

Risk Factors better         -71%
Smoking                      -41%
Cholesterol                  -9%
Population BP fall           -9%
Deprivation                  -3%
Other factors                -8%

Treatment                   -42%
AMI treatments               -8%
Secondary prevention         -11%
Heart failure                -12%
CABG & PTCA                  - 4%
Angina: Aspirin etc          - 5%
Hypertension therapies       -3%

68,230 fewer CHD deaths

50%-75% due to net risk factor reduction

25%-50%: due to evidence-based therapies
**IMPACT\textsubscript{sec}** model coverage

- **Coverage:**
  - England, total population aged 25+
  - Period: 2000 (base year) to 2007 (final year) (2)
  - Estimates stratified by age & sex (7*2)
  - SEC as measured by small-area deprivation quintiles (IMD07 at LSOA level) (5)

- **Risk Factors** – 7 (smoking, diabetes, physical inactivity; systolic blood pressure (SBP), total cholesterol, fruit & veg, BMI)

- **45+ treatments in 9 patient groups** (e.g. heart attack (N/STEMI), stable angina, heart failure)
CHD mortality fall 2007 by IMD quintiles

Target Deaths Prevented or Postponed (DPP) = 38,070
Change in key risk factor levels: Males
Age standardised rates by IMD quintiles

Systolic BP (mmHg), age 55+

Diabetes, age 25+

Source: Health Survey for England
## Summary: Risk factor change by deprivation

**Adults (55+), England 2000 to 2007**

<table>
<thead>
<tr>
<th>Annual % Δ</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
</table>
| Significant decrease across all SEC groups | Smoking ↓↓  
SBP ↓↓  
Total cholesterol ↓↓ | Smoking ↓↓ (~Q4)  
SBP ↓↓  
Total cholesterol ↓↓ |
| Significant increase across all SEC groups | Obesity↑  
Diabetes↑ | Obesity↑ (~Q2)  
Diabetes↑ |
| Mixed picture by SEC | Phys activity increase: Q1-Q3  
Fruit & Veg increase: Q3 | Phys activity increase: Q1-Q4  
Fruit & Veg increase: Q3-Q4 |

Q1 = least deprived; Q5 = most deprived

Scholes, SSM 2010
Change in treatment uptake post-MI: males 55-74

Statins

ACE-Inhibitors

Source: General Practice Research Dataset
CHD deaths prevented in England
2000 to 2007

Risk Factors worse
- BMI (increase) + 2%
- Diabetes (increase) + 7%

Risk Factors better
- Smoking - 3%
- Cholesterol - 6%
- SBP fall - 29%
- Physical inactivity - 2%
- Fruit & Veg - 4%

Treatments uptake change
- AMI/NSTEACS - 1%
- 2' post MI - 9%
- 2' post-revasc - 2%
- Stable Angina - 13%
- Heart failure - 10%
- Hypertension therapies - 4%
- Hyperlipidemia Rx - 12%

Unexplained 14%

Source: Bajekal, Scholes, Love, Hawkins, O'Flaherty, Raine, Capewell. Plos Medicine, 2012
CHD deaths prevented 2007 affluent vs deprived areas

Least Deprived (Q1)

- CHD deaths prevented: DPPs 7,353
- Percentage change: -8% to 6%

Most Deprived (Q5)

- CHD deaths prevented: DPPs 6,558
- Percentage change: -8% to 16%

Distribution of deaths prevented by IMD

Key strength and limitation of English IMPACTsec model

• First ever trend analysis to examine the socio-economic dimension of treatment and risk factor contributions to falls in CHD mortality.

• Changes in risk factor levels could not explain 20% of observed CHD fall in affluent groups
  – social gradient in effect modification?
  – Imprecision/biases in survey estimates?
  – Synergistic effects?
  – Other ‘upstream’ risk factors – e.g. psychosocial?
IMPACTsec: main messages

• CHD mortality fell by 36% in just 7 years: treatments explained approximately half of this (52%) and risk factors a third (34%).

• ↑ ↑ in drug prescribing in community, AND no inequity in uptake.

• More lives saved due to bigger ↓ risk factors in deprived than affluent areas.

• But these are partly offset by faster ↑ in diabetes & BMI in deprived areas.
Implications of findings on future trends in total mortality

• CHD is the leading cause of death and so trends in CHD have a major impact on total mortality trends.
• The relative importance of smoking as a driving force for CHD mortality reductions has diminished over the latter part of the 20th century.
• However, this has not led to the (anticipated) reduction in the aggregate pace of mortality improvement in CHD or total mortality.
• Better medical management of patients has played/will continue to play an important, incremental, role in driving-up life expectancy in the early 21st century.
Next steps: linked patient records analysis

- Drilling deeper to look at socio-economic inequalities in phenotypes of CHD + Stroke.
- Survival analysis: descriptive and analytic modelling of predictors.
- Key Q: for which CVD phenotype, and at what points along the disease pathway, do inequalities widen/remain the same/shrink and by how much?
With thanks to:

• The IMPACTsec team:
  – Shaun Scholes, Prof Rosalind Raine (UCL)
  – Prof Simon Capewell, Martin O’Flaherty, Nathaniel Hawkins (Univ of Liverpool)
  – Hande Love (L&G)

• Legal & General Longevity Risk Team

• Other collaborators: Paul Norman, Andres Villegas (CASS), ONS mortality team

Contact: m.bajekal@ucl.ac.uk
Thank you. Any questions?

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England 2000-2007: the IMPACTsec model

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The future of human longevity: cardiovascular disease
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RESERVE SLIDES
Model parameters for calculating deaths prevented or postponed (DPPs)

**IMPACT is a deterministic model quantifying change between 2 time points.**

**DPPs due to TREATMENT : (improved survival with CHD)**

- \[ \text{DPPs} = \text{Eligible Patients} \times \text{treatment uptake} \times \text{relative mortality reduction} \times \text{one year case fatality} \]
- Net change \( \text{DPP} = \text{DPP final year} - \text{DPP base year} \)

**DPPs due to POPULATION RISK FACTOR CHANGE: (reduced CHD incidence)**

- \[ \text{DPPs} = \text{expected CHD deaths in 2007 (applying 2000 mortality rates)} \times \text{risk factor change between 2000 and 2007} \times B\text{-regression coefficient} \]
- \[ \text{DPPs} = \text{expected CHD deaths in 2007 (applying 2000 mortality rates)} \times (\text{PARF2000} - \text{PARF2007}) \]

3 mmHg fall in systolic BP in women aged 55-64

<table>
<thead>
<tr>
<th>CHD deaths in base yr</th>
<th>Beta coefficient</th>
<th>Reduction 1980-2000</th>
<th>Deaths prevented or postponed (DPP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( a )</td>
<td>( \beta )</td>
<td>( c )</td>
<td>( a*(1-(\exp\beta * c)) )</td>
</tr>
</tbody>
</table>

\[
26,350 \times -0.035 \times 3 = 2700 \text{ DPP}
\]

**SOURCES**
- Mortality statistics
- Oxford PSC
- HSfE
- meta-analyses
- surveys
## AMI: Thrombolysis & Aspirin, Men 55-64 years

<table>
<thead>
<tr>
<th>Patients eligible</th>
<th>Treatment uptake</th>
<th>Relative risk reduction</th>
<th>Case Fatality</th>
<th>Deaths prevented or postponed (DPP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>102,280</td>
<td>0.21</td>
<td>0.26</td>
<td>0.054</td>
<td>303</td>
</tr>
</tbody>
</table>

\[
a \times b \times c \times d = a \times b \times c \times d
\]

**Sources**
- HES statistics
- MINAP audits
- Estess & FTT
- Meta-analyses
- US/Wijeysundera
**β Coefficients** = % fall in CHD mortality per unit decrease in risk factors


<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Reduction in CHD deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholesterol lowering</td>
<td></td>
</tr>
<tr>
<td>↓ 0.1 mmol/l mean pop cholesterol</td>
<td>≈ ↓ 5%</td>
</tr>
<tr>
<td>Fruit &amp; Veg</td>
<td></td>
</tr>
<tr>
<td>↑ 1 portion/day</td>
<td></td>
</tr>
<tr>
<td>Blood pressure</td>
<td></td>
</tr>
<tr>
<td>↓ 1 mm Hg Systolic BP</td>
<td>≈ ↓ 3.5% (log -0.035)</td>
</tr>
<tr>
<td>Obesity</td>
<td></td>
</tr>
<tr>
<td>↓ 1 Kg/M² BMI</td>
<td>≈ ↓ 2.5%</td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
</tr>
<tr>
<td>↓ 1% diabetic population</td>
<td>≈ ↓ 2%</td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
</tr>
<tr>
<td>↓ 1% Smoking prevalence</td>
<td>≈ ↓ 1%</td>
</tr>
<tr>
<td>Physical Activity</td>
<td></td>
</tr>
<tr>
<td>↓ 1% inactive population</td>
<td>≈ ↓ 0.3%</td>
</tr>
</tbody>
</table>
Females: Life expectancy with and without disability: at birth and age 65, by deprivation quintiles, England 2007-2010

(ONS: Inequalities in DFLE, 2013)
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