How much does it cost to save a life-year? Evidence from programme budgeting data

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Some background on links between spending and outcomes

- Cochrane, St Leger & Moore (1978)
  - OECD countries
  - All countries
- Or (2001)
  - OECD countries
- Nixon and Ullmann (2006)
  - EU countries
- Cremieux, Ouellette & Pilon (1999)
  - Canadian Provinces

- The Gravelle & Backhouse (1987) critique
English Programme Budgeting project

- Aim is “…to develop a primary source of information, which can be used by all bodies, to give a greater understanding of what we are getting for the money we invest in the National Health Service.”
- Maps all public expenditure to 23 programmes of care based on medical conditions (ICD 10).
- Information collected as part of the statutory accounts process for local health administrations (303 Primary Care Trusts).
- Intention is that it will be audited by external auditors.
- Three years’ data available (FY2003/4, FY2004/5 and FY2005/6).
The programmes of care

1: Infectious diseases
2: Cancers and tumours
3: Blood disorders
4: Endocrine, nutritional & metabolic disorders
   – Diabetes
5: Mental health problems
   – Substance abuse
   – Dementia
6: Learning disability problems
7: Neurological problems
8: Eye and vision problems
9: Hearing problems
10: Circulation problems
11: Respiratory system problems
12: Dental problems
13: Gastro-intestinal problems
14: Skin problems
15: Musculoskeletal problems
   (excludes trauma)
16: Trauma and injuries
17: Genitourinary system
18: Maternity and reproductive health
19: Neonatal conditions
20: Poisoning
21: Healthy individuals
22: Social care needs
23: Other (eg general primary care)
The broad categories of expenditure

- Pharmaceutical Prescribing
- Admitted Patient Care (inpatient & day case)
- Non-Admitted Patient Care (ambulatory hospital and community care)
- Primary care
- Other Services & Expenditure
- Education, training, research
- Administration

… assigned to programmes of care according to a variety of allocations (e.g. HRG categories for inpatient care). Allocation heavily constrained by data limitations.
Programme expenditure FY2004/05
England £ per capita

- Infectious diseases
- Cancers
- Blood disorders
- Endocrine
- Mental health
- Learning disability
- Neurological system
- Eye and vision
- Hearing
- Circulation
- Respiratory
- Dental
- Gastro-intestinal
- Skin
- Musculo-skeletal
- Trauma
- Genito-urinary
- Maternity
- Neonate conditions
Minimum & Maximum £ per head, FY2004/05
Correlation of selected socio-economic indicators with programme expenditure
England FY2004/05 n=303

<table>
<thead>
<tr>
<th>Socio-economic indicator</th>
<th>Cancers</th>
<th>Mental health</th>
<th>Circulatory disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of working age with long-term illness</td>
<td>0.233</td>
<td>0.382</td>
<td>0.558</td>
</tr>
<tr>
<td>Proportion of pop providing some unpaid care</td>
<td>0.234</td>
<td>-0.139</td>
<td>0.558</td>
</tr>
<tr>
<td>Proportion of aged 16-74 no qualifications</td>
<td>0.212</td>
<td>0.170</td>
<td>0.487</td>
</tr>
<tr>
<td>Proportion of households not owner occupied</td>
<td>-0.121</td>
<td>0.663</td>
<td>0.079</td>
</tr>
<tr>
<td>Proportion of households that are one parent</td>
<td>0.033</td>
<td>0.528</td>
<td>0.251</td>
</tr>
<tr>
<td>Proportion of aged 16-74 permanently sick</td>
<td>0.229</td>
<td>0.389</td>
<td>0.561</td>
</tr>
<tr>
<td>Proportion of aged 16-74 long-term unemployed</td>
<td>0.160</td>
<td>0.538</td>
<td>0.316</td>
</tr>
<tr>
<td>Proportion not in management/professions</td>
<td>-0.263</td>
<td>0.165</td>
<td>0.565</td>
</tr>
<tr>
<td>Proportion exempt from prescription charges</td>
<td>0.114</td>
<td>0.610</td>
<td>0.241</td>
</tr>
<tr>
<td>Proportion not in white ethnic group</td>
<td>-0.170</td>
<td>0.362</td>
<td>-0.218</td>
</tr>
</tbody>
</table>
Spending and mortality: all amenable causes FY04/05, with and without needs adjustment
Spending and mortality: cancer FY04/05

Exp per capita, cancer, adjusted for MFF & need

SMR <75 all cancers
Spending and mortality: circulatory diseases
FY04/05
Mortality: cancer and circulatory diseases
FY04/05

SMR <75 all cancers
SMR <75 all circulation

Graph showing a scatter plot with SMR values on the x-axis and SMR <75 all circulation on the y-axis. The data points are distributed across the graph, with a notable concentration in the lower right quadrant.
The health production function for programme i

\[ H_i \]

\[ X_i \]
Algebraic representation

• Health production function
  \[ H_i = f_i(N_i, X_i, E_i) \]

• Societal welfare
  \[ W = W(H_1, H_2, ..., H_k) \]

• Budget constraint
  \[ X_1 + X_2 + ... + X_k = Y \]

\( N_i \) needs;
\( X_i \) expenditure;
\( E_i \) environment
Trade off between two programmes

Programme 1

The budget line

Programme 2

(H1*,H2*)

(X1*,X2*)
Equations to be estimated

- Health production function
  \[ H_i = f_i(N_i, X_i, E_i) \]

- Expenditure choice
  \[ X_i^* = X_i(N_1, N_2, \ldots N_k, E_1, E_2, \ldots E_k, Y) \]
Estimation issues

• System of equations: potential simultaneity
• Simple OLS regression will estimate ‘reduced form’ link between outcomes and spending – jumble of influences
• Need to use instrumental variables to estimate structural outcome and expenditure equations
• Have tested two stage and three stage least squares
• 2SLS reported here: models well specified
• Detailed issues:
  – Logarithmic functional form
  – Three observations discarded (outliers/missing data)
  – Expenditure adjusted for price variations
  – FY 2004/05 only
Cancer programme equations

• OLS

  Cancer SMR = 4.966** – 0.038 X + 0.684** N
  (R² = 0.60)

• Structural equations

  Cancer SMR = 6.919** – 0.491** X + 0.916** N
  (R² = 0.113)

  Cancer EXP = 0.751 + 0.588** N + 0.874** Y – 0.576** O
  (R² = 0.295)
Circulatory disease equations

• OLS

\[
\text{Circ SMR} = 6.492^{**} - 0.402 \times^{**} + 1.595^{**} N \\
(R^2 = 0.682)
\]

• Structural equations

\[
\text{Circ SMR} = 11.226^{**} - 1.387^{**} X + 2.450^{**} N \\
(R^2 = 0.280)
\]

\[
\text{Circ EXP} = 4.490 + 1.069^{**} N + 0.764^{**} Y - 1.052^{**} O + 0.369^{**} \%\text{White} \\
(R^2 = 0.528)
\]
Calculating implicit value of a life year saved

• Equations re-estimated using standardized ‘years of life lost’

• Cancer:
  – a 1% increase in expenditure per head (£0.751) is associated with a 0.378% reduction in life years lost (0.020866 days) and implies that one life year costs £13,137
    • 95% confidence interval £(9,118 - 23,490).

• Circulatory disease:
  – a 1% increase in expenditure per head (£1.22) is associated with a 1.427% reduction in life years lost (0.055806 days) and implies that one life year costs £7,979
    • 95% confidence interval £(6,549 – 10,208).
Converting to a QALY

- Utility scores are available for ICD10 codes based on EQ-5D (HODaR).
- Sample of 15,113 subjects accounting for more than 37,000 ICD10 observations (some multiple diagnoses).
- Averaging utility scores across the ICD10 codes
  - cancer programme of care 0.689.
  - circulatory diseases is programme of care 0.669.
- Implies cost per QALY estimates of
  - cancer programme of care £19,020.
  - circulatory diseases is programme of care £11,960.
- Very rough estimates.

Acknowledgement: Dr Craig Currie, Director and Senior Lecturer in Health Outcomes Research, HODaR, Cardiff Medicentre, University Hospital of Wales.
Major limitations

• Limited outcomes data (mortality rates for small number of programmes) – but major enhancements in data sources are planned
• Cross sectional data set (single year)
• Mortality experience the result of years of endeavour - data for one (or at most three) years
• Some health system expenditure difficult to assign to programmes
• Accounting practice variable – a learning experience. Accounts not yet fully audited.
• Primary Care Trusts ‘reorganized’ again – break in the time series.
Future work

- Use of panel data
- Examination of more outcomes data
- Extension to more programmes of care
- Integration of morbidity measures as better indicators of need
- Integrated modelling of all programmes of care
Results from 2005/06

- Satisfactory models (but no YLL estimates) in other programmes of care
- Additional needs data (e.g. QOF) rarely useful
- Problems modelling neonatal/maternal programme of care.

- £13,931 for cancer (£13,137 in 2004/05)
- £8,426 for circulation problems (£7,979 in 2004/05)
- £7,397 for respiratory problems
- £18,999 for gastro-intestinal problems
- £26,453 for diabetes
Provisional conclusions

- Expenditure has a strong positive effect on outcomes in the two programmes investigated.
- Some evidence that effect is stronger in circulatory disease than in cancer.
- Evidence of strong substitution effect between expenditure on programmes of care.
- Strong evidence of either lower levels of need or ‘unmet’ need amongst non-white population in circulatory disease.
- Proper econometric modelling essential if nature of relationship is to be estimated correctly.
- More data and analysis needed to assure robustness of results, and to compare across more programmes.