Methods for the Estimation of the NICE Cost Effectiveness Threshold

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2. Department of Economics and Related Studies, University of York, UK
4. Imperial College, London, UK
What do we need?

• Compare
  – Health expected to be gained
  – Health expected to be lost due to additional NHS costs

• Expected health effects of changes in NHS expenditure

• What its not
  – Consumption value of health (willingness to pay)
  – Marginal productivity of ‘ideal’ NHS

• No simple relationship with changes in
  – Budget, prices and productivity
  – Health production outside NHS
How can we estimate it?

• Implied value from past decisions based on informal judgements

• Find out what decisions are made and estimate impact on cost and health
  – Which/ whose decisions?
  – Caused by NICE guidance?
  – Effect of decisions on health and costs?
  – But we don't need to know which decisions just the health effects

• Estimate the relationship between changes in expenditure and outcomes

NICE threshold Range 2004 (2001)

Appleby et al 2007

Martin et al 2008, 2009
How can we estimate effects of expenditure on mortality?

- How are changes in expenditure allocated to PBCs? (11 PBCs)
- PBC without mortality signal (11 PBCs)

- Cost per death averted

- How does a change in PBC expenditure effect PBC mortality? (11 PBCs)

- PBC 23 GMS
How can we estimate effects of expenditure on mortality (deaths)?

- Change in PBC expenditure due to change in overall expenditure (all 23 PBCs)
  - Differences in spending on a particular PBC and total spend across PCTs
  - Account for other reasons why PBC spend might differ between PCTs
  - Isolate the effects on PBC spend of changes in overall expenditure
- Change in PBC mortality (deaths) due to change in PBC expenditure (11 PBCs)
  - Differences in PBC mortality and PBC expenditure across PCTs
  - Account for other reasons why PBC mortality might differ between PCTs
  - Isolate the effects on PBC mortality of changes in PBC expenditure
How can we estimate effects of expenditure on mortality?

- How are changes in expenditure allocated to PBCs?  
  - 11 PBCs
- PBC without mortality signal  
  - 11 PBCs
- Change in overall expenditure
- Cost per death averted
- How does a change in PBC expenditure effect PBC mortality?  
  - 11 PBCs
How can we estimate effects of expenditure on mortality?

1. Change in overall expenditure
   - How are changes in expenditure allocated to PBCs?
     - 11 PBCs

2. PBC without mortality signal
   - 11 PBCs

3. PBC 23 GMS

4. How does a change in PBC expenditure affect PBC mortality?
   - 11 PBCs

5. Cost per death averted

6. Health effects of changes in expenditure at same rate as other 11PBCs
## Estimates of the threshold (2008-09)

<table>
<thead>
<tr>
<th></th>
<th>Cost per death averted</th>
</tr>
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<tbody>
<tr>
<td>Qol associated with LYs</td>
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How can we estimate effects on life years

- How are changes in expenditure allocated to PBCs?
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- PBC without mortality signal
  - 11 PBCs

- Change in overall expenditure

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- PBC 23 GMS
How can we estimate effects on life years?

Change in overall expenditure

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Cost per death averted

- How does a change in PBC expenditure effect PBC mortality?
  - 11 PBCs

Cost per life year

- What are the LY effects of changes in PBC mortality?
  - 11 PBCs

PBC 23 GMS
What are the life year effects of changes in PBC mortality?

- Effects on all deaths within a PBC (group of ICD codes)
  - Not all deaths are reported by PCT (all ICD codes)
  - Apply % effects (observed) to deaths in all ICD codes in PBC (ONS)

- What years of life are lost due to mortality?
  - LE of the age and gender distribution in each ICD within the PBC
  - Age of death compared to LE
  - Account for all deaths below LE and above LE
    - Accounts for deaths from other causes
  - Death averted faces the mortality risk of a matched population
How can we estimate effects on life years

Change in overall expenditure

How are changes in expenditure allocated to PBCs?
11 PBCs

PBC without mortality signal
11 PBCs

How does a change in PBC expenditure effect PBC mortality?
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Cost per death averted

What are the LY effects of changes in PBC mortality?
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Cost per life year
How can we estimate effects on life years

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PBC 23 GMS
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How can we adjust life years for quality?

- How are changes in expenditure allocated to PBCs?
- Cost per death averted
- How does a change in PBC expenditure effect PBC mortality?
- What are the LY effects of changes in PBC mortality?
- Cost per life year

11 PBCs

PBC without mortality signal

PBC 23 GMS
How can we adjust life years for quality?

How are changes in expenditure allocated to PBCs? 11 PBCs

How does a change in PBC expenditure affect PBC mortality? 11 PBCs

Cost per death averted

Cost per life year

What are the LY effects of changes in PBC mortality? 11 PBCs

Adjust life year effects for quality 11 PBCs

PBC without mortality signal 11 PBCs

PBC 23 GMS
Adjusting life year effects for quality

- Life years lived at QoL norms by age and gender
  - All disease is acute or symptoms are ‘curable’
- Life years lived with QoL of disease (decrement to norms)
  - All disease is chronic (life long) and ‘incurable’
- Assumptions are relaxed using measures of burden

Quality of life for the general population by age and gender

Quality of life for males in PBC1 (infectious disease)
How can we adjust life years for quality?

- Change in overall expenditure
  - How are changes in expenditure allocated to PBCs?
    - 11 PBCs
  - PBC without mortality signal
    - 11 PBCs
  - PBC 23 GMS

-Cost per death averted
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- Cost per QALY (mortality)
  - Adjust life year effects for quality
    - 11 PBCs
How can we adjust life years for quality?

- How are changes in expenditure allocated to PBCs?
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  - Cost per QALY (mortality)
  - Health effects of changes in expenditure at same rate as other 11PBCs

- How does a change in PBC expenditure affect PBC mortality?
  - What are the LY effects of changes in PBC mortality?
  - Adjust life year effects for quality

- PBC without mortality signal
  - PBC 23 GMS

- Change in overall expenditure
## Estimates of the threshold (2008-09)

<table>
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<tr>
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<th>Cost per QALY (mortality effects only)</th>
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<tbody>
<tr>
<td><strong>Qol associated with LYs</strong></td>
<td>-</td>
<td>1</td>
<td>Norms</td>
</tr>
<tr>
<td><strong>Qol during disease</strong></td>
<td>-</td>
<td>0</td>
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</table>
How can we account for possible effects on quality of life?

- No observations of quality life by PBC at PCT level
  - Quality of life is important in 11 PBCs with mortality
  - Mortality is (almost) irrelevant in the other 11 PBCs
  - Much NHS activity is primarily to improve quality of life

- Possible responses
  - Assume that NHS expenditure has no effects on quality of life
  - Use what can be observed to impute what cannot
    - Effects on quality of life in 11 PBCs with mortality
    - QALY effects in the other 11 PBCs
  - Use all the information we have about the other 11 PBCs
How can we account for possible effects on quality of life?

- How are changes in expenditure allocated to PBCs? (11 PBCs)
- How does a change in PBC expenditure affect PBC mortality? (11 PBCs)
- % effect of a change in PBC expenditure on burden of disease (LY) (11 PBCs)

Change in overall expenditure:

- PBC without mortality signal (11 PBCs)
- PBC 23 GMS
How can we account for possible effects on quality of life?

- How are changes in expenditure allocated to PBCs?
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- PBC without mortality signal
  - 11 PBCs
- Same % effect on burden of disease (totals from the other 11 PBCs)
  - 11 PBCs
- PBC 23 GMS
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  - 11 PBCs
- PBC without mortality signal
  - 11 PBCs
- Same % effect on burden of disease (totals from the other 11PBCs)
  - 11 PBCs
- Measures of QALY burden of disease
  - Life years (ONS)
  - Quality of life (HoDAR MEPS)
  - Age, gender and duration of disease (GBD)
- Cost per QALY (life year and quality effects)
- PBC 23 GMS
- PBC 23 GMS

Cost per QALY (life year and quality effects)
## Estimates of the threshold (2008-09)

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<td>£18,317</td>
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### What are the expected health consequences of £10m?

<table>
<thead>
<tr>
<th>Category</th>
<th>Change in spend (£000)</th>
<th>Additional deaths</th>
<th>LY lost</th>
<th>Total QALY lost</th>
<th>Due to premature death</th>
<th>Quality of life effects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Totals</strong></td>
<td>£10,000</td>
<td>37</td>
<td>167</td>
<td>546</td>
<td>107</td>
<td>439</td>
</tr>
<tr>
<td>Cancer</td>
<td>£324,000</td>
<td>3</td>
<td>27</td>
<td>19</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>Circulatory</td>
<td>£550,000</td>
<td>17</td>
<td>84</td>
<td>78</td>
<td>53</td>
<td>25</td>
</tr>
<tr>
<td>Respiratory</td>
<td>£332,000</td>
<td>10</td>
<td>12</td>
<td>166</td>
<td>7</td>
<td>159</td>
</tr>
<tr>
<td>Gastro-intestinal</td>
<td>£232,000</td>
<td>2</td>
<td>18</td>
<td>32</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Infectious diseases</td>
<td>£237,000</td>
<td>1</td>
<td>4</td>
<td>11</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Endocrine</td>
<td>£137,000</td>
<td>&lt; 0.5</td>
<td>4</td>
<td>44</td>
<td>2</td>
<td>42</td>
</tr>
<tr>
<td>Neurological</td>
<td>£433,000</td>
<td>1</td>
<td>5</td>
<td>79</td>
<td>3</td>
<td>76</td>
</tr>
<tr>
<td>Genito-urinary</td>
<td>£336,000</td>
<td>2</td>
<td>2</td>
<td>8</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Trauma &amp; Injuries*</td>
<td>£558,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Maternity &amp; neonates*</td>
<td>£495,000</td>
<td>&lt; 0.05</td>
<td>&lt; 0.5</td>
<td>0</td>
<td>&lt; 0.5</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Disorders of Blood</td>
<td>£292,000</td>
<td>&lt; 0.5</td>
<td>1</td>
<td>10</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Mental Health</td>
<td>£2,532,000</td>
<td>2</td>
<td>7</td>
<td>51</td>
<td>4</td>
<td>46</td>
</tr>
<tr>
<td>Learning Disability</td>
<td>£147,000</td>
<td>&lt; 0.5</td>
<td>1</td>
<td>2</td>
<td>&lt; 0.5</td>
<td>1</td>
</tr>
<tr>
<td>Problems of Vision</td>
<td>£275,000</td>
<td>&lt; 0.05</td>
<td>&lt; 0.5</td>
<td>4</td>
<td>&lt; 0.5</td>
<td>3</td>
</tr>
<tr>
<td>Problems of Hearing</td>
<td>£124,000</td>
<td>&lt; 0.05</td>
<td>&lt; 0.5</td>
<td>6</td>
<td>&lt; 0.05</td>
<td>6</td>
</tr>
<tr>
<td>Dental problems</td>
<td>£409,000</td>
<td>&lt; 0.05</td>
<td>&lt; 0.05</td>
<td>7</td>
<td>&lt; 0.05</td>
<td>7</td>
</tr>
<tr>
<td>Skin</td>
<td>£279,000</td>
<td>&lt; 0.5</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Musculo-skeletal</td>
<td>£514,000</td>
<td>&lt; 0.5</td>
<td>2</td>
<td>25</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td>Poisoning and AE</td>
<td>£132,000</td>
<td>&lt; 0.05</td>
<td>&lt; 0.5</td>
<td>1</td>
<td>&lt; 0.5</td>
<td>1</td>
</tr>
<tr>
<td>Healthy Individuals</td>
<td>£501,000</td>
<td>&lt; 0.05</td>
<td>&lt; 0.5</td>
<td>0</td>
<td>&lt; 0.05</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Social Care Needs</td>
<td>£426,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other (GMS)</td>
<td>£735,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Is it likely to be an under or over estimate?

• Health effects over estimated (threshold underestimated)?
  – Deaths averted returns the individuals to the mortality risk of the general population (matched for age and gender)
  – Small positive correlation between expenditure and outcome elasticities
  – Apply estimates (data reported at PCT) to all PBC mortality

• Health effects under estimated (threshold overestimated)?
  – Mortality and quality of life effects restricted to one year
  – No effects of prevention (reduce incidence into the at risk population)
  – Effects of changes in GMS (and PBC22 & 16) expenditure not fully captured
  – Share of changes in expenditure favours PBCs with high cost per QALY

• Other assumptions
  – Surrogacy
    • Are % mortality effects a good surrogate for % Qol effects?
  – Extrapolation
    • Is the proportionate effect on QALY burden of changes in spend similar in the other PBCs?
Implied PBC cost per QALY

• Which PBCs matter most?
  – Share of change in spend, share of health effects and how much implied PBC cost per QALY differs from £18,317
  – 11 PBCs where proportionate effects are imputed
    • Mental health most important PBC (imputed cost per QALY £49,835)
    • Evidence suggests cost per QALY of mental health interventions lower

• Differences in the implied PBC cost per QALY
  – Misallocation of resources?
  – Social value of health effects (maternity and neonates)
  – Cannot observe quality of life effects at PCT level
    • Quality of life effects not proportional to mortality effects
    • Health effects more than proportional to QALY burden
  – Effect on outcomes in other PBCs
Implications of uncertainty in the estimate
(Single threshold value that can be compared to an ICER)
Impact of investment and disinvestment?

Variation in expenditure

- $\Delta E$

- $\frac{1}{k_1}$

- $\frac{1}{k_{1+}}$

Threshold

- $k_{1+}$

- $k_1$

- $\frac{14,083}{LY}$

- $\frac{10,604}{LY}$

- $\frac{8,441}{LY}$

Per LY
How does the threshold change with overall expenditure?

- **Increase productivity**
- **Only eliminate waste**

<table>
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<th>2008</th>
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<tr>
<td>Nominal</td>
<td>£18,624</td>
<td>£18,317</td>
</tr>
<tr>
<td>2007 NHS prices</td>
<td>£18,624</td>
<td>£17,629</td>
</tr>
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Summary of considerations

• On balance £18,317 is more likely to be an over than underestimate of the threshold
  – Upper bound of the NICE threshold is almost certainly too high
  – Lower bound may also be too high
• Uncertainty in the estimate suggests a policy threshold set as less than the mean estimate
• Threshold less than the mean estimate when imposing costs on the NHS (reducing expenditure)
• No evidence of growth in threshold with increases in real budget and prices
• Some evidence that threshold more likely to fall rather than rise as NHS comes under more financial pressure
What type of data and research could improve the estimate?

- Longer and more complex lag structure
  - Duration of effect on mortality might be feasible (capture more health effects)
  - Estimating life year effect of mortality more problematic
- Simultaneous estimation across PBCs
  - Likely to capture more health effects
- Evolving PBC data (PCT and CCG boundaries)
- Extending measures of health outcome
  - Analysis of PROMs data
  - IAPT and mental health outcomes
- Incidence and duration of disease
  - WHO GBD
  - GPRD
Additional slides

- Reserve slides if needed during discussion
Surrogacy
Quality of life effects
(each of 11 PBCs where can estimate LY effects)
% reduction in LY burden

Extrapolation
QALY effects
(other 11 PBCs)
Same % effect on burden
<table>
<thead>
<tr>
<th>PBC</th>
<th>% spend</th>
<th>% health</th>
<th>Elasticity</th>
<th>PBC cost per Qol</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Cancer</td>
<td>3.24</td>
<td>3.50</td>
<td>0.35</td>
<td>£16,997</td>
</tr>
<tr>
<td>10 Circulatory</td>
<td>5.50</td>
<td>14.32</td>
<td>1.43</td>
<td>£7,038</td>
</tr>
<tr>
<td>11 Respiratory</td>
<td>3.32</td>
<td>30.45</td>
<td>3.05</td>
<td>£1,998</td>
</tr>
<tr>
<td>13 Gastro-intestinal</td>
<td>2.32</td>
<td>5.83</td>
<td>0.58</td>
<td>£7,293</td>
</tr>
<tr>
<td>1 Infectious diseases</td>
<td>2.37</td>
<td>2.08</td>
<td>0.21</td>
<td>£20,829</td>
</tr>
<tr>
<td>4 Endocrine</td>
<td>1.37</td>
<td>8.04</td>
<td>0.80</td>
<td>£3,124</td>
</tr>
<tr>
<td>7 Neurological</td>
<td>4.33</td>
<td>14.48</td>
<td>1.45</td>
<td>£5,480</td>
</tr>
<tr>
<td>17 Genito-urinary</td>
<td>3.36</td>
<td>1.40</td>
<td>0.14</td>
<td>£43,813</td>
</tr>
<tr>
<td>16 Trauma &amp; injuries*</td>
<td>5.58</td>
<td>0</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>18+19 Maternity &amp; neonates*</td>
<td>4.95</td>
<td>0.03</td>
<td>0.00</td>
<td>£2,969,208</td>
</tr>
<tr>
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<td>2.92</td>
<td>1.89</td>
<td>0.19</td>
<td>£28,305</td>
</tr>
<tr>
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<td><strong>25.32</strong></td>
<td><strong>9.31</strong></td>
<td>0.93</td>
<td><strong>£49,835</strong></td>
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<td>1.47</td>
<td>0.34</td>
<td>0.03</td>
<td>£78,854</td>
</tr>
<tr>
<td>8 Problems of Vision</td>
<td>2.75</td>
<td>0.66</td>
<td>0.07</td>
<td>£76,850</td>
</tr>
<tr>
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<td>1.24</td>
<td>1.19</td>
<td>0.12</td>
<td>£19,070</td>
</tr>
<tr>
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<td>4.09</td>
<td>1.34</td>
<td>0.13</td>
<td>£55,916</td>
</tr>
<tr>
<td>14 Skin</td>
<td>2.79</td>
<td>0.29</td>
<td>0.03</td>
<td>£174,775</td>
</tr>
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<td>5.14</td>
<td>4.65</td>
<td>0.47</td>
<td>£20,254</td>
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<tr>
<td>20 Poisoning and AE</td>
<td>1.32</td>
<td>0.15</td>
<td>0.01</td>
<td>£163,766</td>
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<td>5.01</td>
<td>0.06</td>
<td>0.01</td>
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<td>22 Social Care Needs</td>
<td>4.26</td>
<td>0</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>23 Other</td>
<td>7.35</td>
<td>0</td>
<td>0</td>
<td>NA</td>
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</tbody>
</table>
How uncertain are the estimates?

An assessment of parameter uncertainty

Figure 5.1 Cumulative probability density function for the cost per QALY threshold

- 11 PBCs
- 23 PBCs
## Decomposing QALYs

Table C.79: Decomposing estimated QALY effects by PBC (2008)

<table>
<thead>
<tr>
<th>PBC</th>
<th>QALY change (total)</th>
<th>QALY change (death)</th>
<th>% QALY gained for premature death</th>
<th>% QALY gained for disability while alive</th>
</tr>
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<tbody>
<tr>
<td>2 Cancer</td>
<td>1,453</td>
<td>1,393</td>
<td>96%</td>
<td>4%</td>
</tr>
<tr>
<td>10 Circulatory</td>
<td>5,125</td>
<td>4,054</td>
<td>79%</td>
<td>21%</td>
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<tr>
<td>11 Respiratory</td>
<td>10,947</td>
<td>758</td>
<td>7%</td>
<td>93%</td>
</tr>
<tr>
<td>13 Gastro-intestinal</td>
<td>2,087</td>
<td>1,024</td>
<td>49%</td>
<td>51%</td>
</tr>
<tr>
<td>1 Infectious diseases</td>
<td>14</td>
<td>9</td>
<td>67%</td>
<td>33%</td>
</tr>
<tr>
<td>4 Endocrine</td>
<td>2,921</td>
<td>269</td>
<td>9%</td>
<td>91%</td>
</tr>
<tr>
<td>7 Neurological</td>
<td>441</td>
<td>43</td>
<td>10%</td>
<td>90%</td>
</tr>
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<td>13</td>
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<td>60%</td>
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<td>0</td>
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<td>NA</td>
</tr>
<tr>
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<td>22</td>
<td>7</td>
<td>30%</td>
<td>70%</td>
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<td>3 Disorders of Blood</td>
<td>689</td>
<td>35</td>
<td>5%</td>
<td>95%</td>
</tr>
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<td>91%</td>
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<td>96%</td>
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<tr>
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<td>3</td>
<td>1%</td>
<td>99%</td>
</tr>
<tr>
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<td>0</td>
<td>0%</td>
<td>100%</td>
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<td>14 Skin</td>
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<td>63%</td>
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<tr>
<td>15 Musculo skeletal</td>
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<td>84</td>
<td>5%</td>
<td>95%</td>
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<td>54</td>
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<td>84%</td>
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<tr>
<td>21 Healthy Individuals</td>
<td>23</td>
<td>4</td>
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<tr>
<td>22 Social Care Needs</td>
<td>0</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>23 Other</td>
<td>0</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>