Life expectancy: how certain are we about future trends and what is driving them?

Chris Shaw
Office for National Statistics
Overview

- Latest projections
- Past accuracy
- Measures of uncertainty
  - Traditional variants
  - Stochastic forecasts
- What is driving trends?
Period life expectancy at birth, UK 1981-2081
Actual & 2006-based principal projections

<table>
<thead>
<tr>
<th>Year</th>
<th>Females</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>75</td>
<td>70</td>
</tr>
<tr>
<td>1991</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>2001</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>2011</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>2021</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>2031</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>2041</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>2051</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>2061</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>2071</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>2081</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>

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Period life expectancy at age 65, UK 1981-2081
Actual & 2006-based principal projections

- Females: Projected life expectancy to increase from 24 years in 2006 to 28 years by 2081.
- Males: Projected life expectancy to increase from 16 years in 2006 to 22 years by 2081.

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Expert Panel estimates of male period life expectancy at birth at 2030
Expert Panel estimates of female period life expectancy at birth at 2030

![Graph showing life expectancy and confidence intervals.](image)
<table>
<thead>
<tr>
<th></th>
<th>ONS 2006-based principal</th>
<th>Expert panel average</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFR</td>
<td>1.84</td>
<td>1.78</td>
</tr>
<tr>
<td>Male period life expectancy at birth</td>
<td>82.6</td>
<td>82.9</td>
</tr>
<tr>
<td>Female period life expectancy at birth</td>
<td>86.1</td>
<td>86.0</td>
</tr>
<tr>
<td>Annual net migration</td>
<td>+190,000</td>
<td>+199,000</td>
</tr>
</tbody>
</table>
UK male period life expectancy at birth
Latest ONS, Eurostat & UN assumptions

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UK female period life expectancy at birth
Latest ONS, Eurostat & UN assumptions

![Life expectancy graph]
Actual and projected male period life expectancy at birth, UK, 1966-2031
Mean absolute error: period life expectancy at birth, 1971-based to 2004-based projections
Observed mean absolute error for period life expectancy at birth for men in 14 European countries

Each unlabelled line represents one country. Data only shown where there are ten or more observations.
Older v Newer projections: Average absolute error in male period life expectancy at birth

Projection base year

- 1971 to 1985
- 1987 to 2000
- 1971 to 1981
- 1985 to 1994
- 1971 to 1979
- 1981 to 1989

- 5 years ahead
- 10 years ahead
- 15 years ahead

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## Actual and assumed overall average annual rates of mortality improvement

<table>
<thead>
<tr>
<th>England &amp; Wales</th>
<th></th>
<th></th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Past (actual)</td>
<td>Future (assumed)</td>
<td>Past (actual)</td>
</tr>
<tr>
<td>Last/next 24 years</td>
<td>2.13</td>
<td>2.12</td>
<td>1.47</td>
</tr>
<tr>
<td>Last/next 44 years</td>
<td>1.54</td>
<td>1.62</td>
<td>1.33</td>
</tr>
<tr>
<td>Last/next 74 years</td>
<td>1.23</td>
<td>1.37</td>
<td>1.27</td>
</tr>
</tbody>
</table>
Actual and projected male period life expectancy at birth, UK, 1961-2081
Actual and projected female period life expectancy at birth, UK, 1961-2081
Expert Panel estimates of male period life expectancy at birth at 2030

![Graph showing life expectancy estimates with average and 67% confidence interval](image-url)
### NPP v Expert Panel: Uncertainty at 2030

<table>
<thead>
<tr>
<th></th>
<th>ONS assumptions (High variant – low variant)</th>
<th>Expert panel average (Width of 67% confidence interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFR</td>
<td>0.40</td>
<td>0.50</td>
</tr>
<tr>
<td>Male period life expectancy at birth</td>
<td>3.7</td>
<td>4.1</td>
</tr>
<tr>
<td>Female period life expectancy at birth</td>
<td>2.4</td>
<td>3.7</td>
</tr>
<tr>
<td>Annual net migration</td>
<td>120,000</td>
<td>165,000</td>
</tr>
</tbody>
</table>
ONS Stochastic forecasting project

- **Aim**
  - To develop a model that will enable the degree of uncertainty in UK national population projections to be specified

- **Approach**
  - Express fertility, mortality and migration assumptions in terms of probability distributions
  - Generate random values from these probability distributions to produce predictive distributions for any projection result
Probability distributions

- How can we estimate future probability distributions?

- Three approaches:
  - Analysis of accuracy of past projections
  - Expert opinion
  - Time series analysis

- No ‘right’ answer – subjective judgement
## Comparative measures of uncertainty for five years ahead

<table>
<thead>
<tr>
<th></th>
<th>TFR (number of children)</th>
<th>Male e0 (years)</th>
<th>Female e0 (years)</th>
<th>Net mig (000s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experts:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.15</td>
<td>0.63</td>
<td>0.79</td>
<td>51.3</td>
</tr>
<tr>
<td>Past accuracy:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMSE</td>
<td>0.20</td>
<td>0.78</td>
<td>0.66</td>
<td>58.6</td>
</tr>
</tbody>
</table>
UK male period life expectancy at birth
Probability distribution

Year:

Life expectancy (years):
65 70 75 80 85 90 95

Estimates
Projections

95% high
67% high
Median
67% low
95% low
Estimates of period life expectancy at birth in 2049/2050, UK males
Median and 80% confidence intervals

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Estimates of period life expectancy at birth in 2049/2050, UK females
Median and 80% confidence intervals
Expert Group Questionnaire

- Given to our Expert Advisory Panel in 2007

- Developed by International Institute for Applied Systems Analysis (IIASA) in Vienna and adapted by ONS for use in UK

- Collected views on a large range of factors which might influence future fertility, mortality and migration

- Article will appear in Population Trends in December
Forces and arguments

- **Force:** Changes in bio-medical technology

- **Arguments:**
  - Increased understanding of bio-medical ageing processes will allow us to develop effective anti-ageing strategies.
  - Breakthroughs in the understanding of carcinogenic processes will lead to substantial reductions in mortality from cancers.
  - Innovative medication will make hitherto life threatening diseases containable.
  - Improvements in surgery including transplants and implants will enhance longevity.
  - Unintended adverse consequences of new bio-medical technologies will outweigh their benefit
Major forces shaping mortality

<table>
<thead>
<tr>
<th>Factor</th>
<th>% weighting</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio-medical technology</td>
<td>28</td>
<td>15</td>
<td>50</td>
</tr>
<tr>
<td>Health care systems</td>
<td>17</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Behavioural changes</td>
<td>28</td>
<td>10</td>
<td>53</td>
</tr>
<tr>
<td>New/resurgent diseases</td>
<td>9</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Environmental changes</td>
<td>8</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Population composition</td>
<td>9</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td></td>
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</table>
## Major forces shaping mortality

<table>
<thead>
<tr>
<th>Section</th>
<th>UK Panel</th>
<th>IIASA (18 world experts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio-medical technology</td>
<td>28</td>
<td>25</td>
</tr>
<tr>
<td>Health care systems</td>
<td>17</td>
<td>24</td>
</tr>
<tr>
<td>Behavioural changes</td>
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</tr>
<tr>
<td>New/resurgent diseases</td>
<td>9</td>
<td>7</td>
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<tr>
<td>Environmental changes</td>
<td>8</td>
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<td>Population composition</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
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Increased understanding of bio-medical ageing processes will allow us to develop effective anti-ageing strategies.

Validity of argument

[Diagram showing the distribution of respondents' views on the argument. The majority of respondents believe the argument is more right than wrong.]
Increased understanding of bio-medical ageing processes will allow us to develop effective anti-ageing strategies.

Importance of argument

- A large upward influence on life expectancy: 3 respondents
- A small upward influence on life expectancy: 3 respondents
- Little or no influence on life expectancy: 0 respondents
- A small downward influence on life expectancy: 0 respondents
- A large downward influence on life expectancy: 0 respondents
- Don't know: 0 respondents
Smoking prevalence will continue to decline.

Validity of argument

- Very likely to be right
- More right than wrong
- Do not know / ambivalent
- More wrong than right
- Very likely to be wrong
Smoking prevalence will continue to decline.

Importance of argument

- A large upward influence on life expectancy
- A small upward influence on life expectancy
- Little or no influence on life expectancy
- A small downward influence on life expectancy
- A large downward influence on life expectancy
- Don't know

Number of respondents

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Factors considered to be valid by the majority of the panel and considered to have the potential to impact on future levels.

Factors that could have an *upwards* impact on life expectancy:

- Greater understanding of bio-medical ageing processes leading to the development of effective anti-ageing strategies.
- Breakthroughs in the understanding of carcinogenic processes leading to reduced mortality from cancer.
- Medical advances leading to previously life-threatening diseases becoming containable.
- Progress in preventive medicine.
- Better information about health.
- A continued decrease in smoking prevalence.
- Increasing mental and social activities at old age.
- Effective and easily affordable new technologies.
Factors considered to be valid by the majority of the panel and considered to have the potential to impact on future levels.

Factors that could diminish or reverse increases in life expectancy:

- Increasing drug resistance to known infectious diseases.
- Negative impact on health of increased stress levels.
- Majority of immigration will be from countries with higher mortality than UK.
References

- 2006-based national projections, Chapter 7 (Mortality)

- Accuracy of past UK projections, Population Trends 128
- Accuracy of past European projections, Population Trends 129 (Part 2)
- Results from Expert Panel questionnaire, Population Trends 134 (to be published in December 2008)
  http://www.statistics.gov.uk/statbase/Product.asp?vlnk=6303