Increase of Human Longevity: Past, Present and Future

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Topics

- Historical increase of longevity
- Age patterns of mortality
- Medical causes of death
- Social and historical causes
- Limits to the human life span?
- Future prospects
Historical Increase of Longevity
Life Expectancy at Birth, 1950-2009

Life Expectancy at Birth, France, 1816-2007

Data source: Human Mortality Database, 2009 (www.mortality.org)
Life Expectancy at Birth, France and India, 19th and 20th C.

Life Expectancy at Birth, 1950-2007
W. Europe, USA, Canada, Australia, NZ, Japan

Data source: Human Mortality Database, 2009 (www.mortality.org)
## Historical mortality levels

<table>
<thead>
<tr>
<th></th>
<th>Life expectancy at birth (in years)</th>
<th>Infant mortality rate (per 1000 live births)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prehistoric</td>
<td>20-35</td>
<td>200-300</td>
</tr>
<tr>
<td>Sweden, 1750s</td>
<td>36</td>
<td>212</td>
</tr>
<tr>
<td>India, 1880s</td>
<td>25</td>
<td>230</td>
</tr>
<tr>
<td>U.S.A., 1900</td>
<td>48</td>
<td>133</td>
</tr>
<tr>
<td>France, 1950</td>
<td>66</td>
<td>52</td>
</tr>
<tr>
<td>Japan, 2007</td>
<td>83</td>
<td>&lt;3</td>
</tr>
</tbody>
</table>

Age Patterns of Mortality
Death Rates by Age, U.S., 1900 & 1995

Data source: Social Security Administration, United States
Distribution of Deaths, U.S., 1900 & 1995

Data source: Social Security Administration, United States
Probability of Survival, U.S., 1900 & 1995

Data source: Social Security Administration, United States
Dispersion of Ages at Death vs. Life Expectancy at Birth, Sweden 1751-1995

Medical Causes of Death
Death Rates (age-adjusted), United States

Medical Causes of Decrease in Infectious Disease Mortality

• Collective efforts to control the spread of infection (sanitation, clean water, quarantine)
• Better personal hygiene (cleanliness, avoiding close contact with sick persons)
• Anti-bacterial drugs (sulfonamides, antibiotics)
Medical Causes of Decrease in Cardiovascular Disease Mortality

- Decline in cigarette smoking
- Changes in diet, especially a reduction in consumption of saturated fat and cholesterol
- Medical interventions to control high blood pressure and high cholesterol levels
- Better diagnosis and treatment of heart disease and stroke
- More and better coronary-care units and emergency services
Cancers with Infectious Causes*

* Stomach, uterus, and liver

Source: O. Gersten, M. Barbieri and J. Wilmoth (in preparation)
Cancers with Non-Infectious Causes*

* Lung, breast, colorectum, pancreas, esophagus, prostate and leukemia

Source: O. Gersten, M. Barbieri and J. Wilmoth (in preparation)
Medical Causes of Decrease in Cancer Mortality

• Better control of infection (\textit{H. pylori}, human papilloma virus, hepatitis)
• Decline in cigarette smoking
• Improved treatment (surgery, chemotherapy)
• Better screening and earlier treatment
Epidemiologic Transitions in Human History

<table>
<thead>
<tr>
<th>Type of Society</th>
<th>Major Cause of Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunting and gathering</td>
<td>External injuries</td>
</tr>
<tr>
<td>Agricultural</td>
<td>Infectious diseases</td>
</tr>
<tr>
<td>Industrial</td>
<td>Cardiovascular diseases</td>
</tr>
<tr>
<td>High-technology</td>
<td>Cancers</td>
</tr>
<tr>
<td>Future</td>
<td>Senescence (old-age frailty)</td>
</tr>
</tbody>
</table>

Social and Historical Causes
Why Mortality Falls over Time

Death

Recognition

Reaction

Reduction
Road Accident Death Rates
5 Countries 1950-1987

Income and Life Expectancy

Major Social and Historical Causes of Longevity Increase

• Increasing income (better nutrition, housing)
• Science and technology
• Application of science and technology
<table>
<thead>
<tr>
<th>Scientific Discovery</th>
<th>Impact on Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confirmation of germ theory of disease, 1880s</td>
<td>Helped spawn public health movement of late 19\textsuperscript{th} and early 20\textsuperscript{th} centuries</td>
</tr>
<tr>
<td>Discovery of anti-bacterial drugs, 1930s and 1940s</td>
<td>Led to effective therapies and improved survival of sick persons (all ages)</td>
</tr>
<tr>
<td>Development of effective therapies for cardiovascular disease and some cancers, late 1960s to the present</td>
<td>Delayed onset of disease and improved survival after diagnosis (older adults)</td>
</tr>
</tbody>
</table>
Limits to the Human Life Span?
Possible Limits

• Could there be some biological limit with respect to the maximum life span?
  – Logical difficulty of specifying an age that marks the upper limit of the human life span
  – World record life span has been increasing
  – Maximum ages at death for individual countries have been increasing
Jeanne Calment
1875-1997
Maximum Age at Death, Sweden, 1861-2007

Maximum Age at Death, Sweden, 1861-2007

Possible Limits (cont.)

- Could there be some biological limit with respect to the average life span?
  - Difficult to specify a lower bound (absolute minimum) for age-specific death rates
  - Available data do not provide strong evidence (thus far) for convergence to a limit
  - Some countries with very low mortality (like Japan) continue to make very rapid gains in longevity
Mean vs. Maximum Age at Death, Sweden

Data source: Human Mortality Database, 2009 (www.mortality.org)
Summary of Longevity Trends
Summary of major trends in human longevity in industrialized countries

<table>
<thead>
<tr>
<th></th>
<th>Before 1960</th>
<th>After 1970</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average life span</td>
<td>Increasing rapidly</td>
<td>Increasing moderately</td>
</tr>
<tr>
<td>Maximum life span</td>
<td>Increasing slowly</td>
<td>Increasing moderately</td>
</tr>
<tr>
<td>Variability of life span</td>
<td>Decreasing rapidly</td>
<td>Stable</td>
</tr>
</tbody>
</table>
## Change (per decade) in key mortality indicators, Sweden

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Average life span</td>
<td>3.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Maximum life span</td>
<td>0.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Inter-quartile range</td>
<td>-5.8</td>
<td>-0.3</td>
</tr>
</tbody>
</table>
Future Prospects
### Expected Trends in Life Expectancy at Birth

<table>
<thead>
<tr>
<th>Region</th>
<th>2009</th>
<th>2029</th>
<th>2049</th>
</tr>
</thead>
<tbody>
<tr>
<td>WORLD</td>
<td>68</td>
<td>72</td>
<td>76</td>
</tr>
<tr>
<td>More developed regions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>77</td>
<td>81</td>
<td>83</td>
</tr>
<tr>
<td>France</td>
<td>81</td>
<td>84</td>
<td>86</td>
</tr>
<tr>
<td>Japan</td>
<td>83</td>
<td>85</td>
<td>87</td>
</tr>
<tr>
<td>United States</td>
<td>79</td>
<td>82</td>
<td>83</td>
</tr>
<tr>
<td>Less developed regions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>66</td>
<td>71</td>
<td>75</td>
</tr>
<tr>
<td>China</td>
<td>73</td>
<td>77</td>
<td>80</td>
</tr>
<tr>
<td>India</td>
<td>73</td>
<td>77</td>
<td>79</td>
</tr>
<tr>
<td>Nigeria</td>
<td>64</td>
<td>70</td>
<td>74</td>
</tr>
</tbody>
</table>

Lessons of History

• Mortality decline results from a deep human desire for longer life
• Past increase was due to many causes acting simultaneously or in sequence
• No one factor caused the increase in the past; probably no one factor can stop the increase in the future
• With continuing economic growth and political stability, there are no obvious limits to future gains in human longevity
The End