Determinants of Mortality  
Econ G041

Why Mortality?
• Easily recorded, objective measure.
• Plenty of data worldwide.
• Extreme measure of health but a good indicator nonetheless.
• Healthy life expectancy can be used to better measure progress in health.

Alternative Measures of Health
• Morbidity
  – For instance, incidence of cardio-vascular diseases, cancers, respiratory capacity…
  – Difficult to gather, needs well trained nurses or doctors.
  – Feasible only on medium size cross-sectional surveys, or small size panel data.
• Self-reported health
• Health care use
Alternative Measures of Health

• Morbidity
• Self-reported health
  – Subjective evaluation. May vary across population, socio-economic status, gender…
  – Good correlation with mortality, even controlling for observed morbidity. Individuals may have private knowledge about their health.
  – Functioning (ability to climb stairs, to walk, run…) good measure for elder population.
• Health care use

Alternative Measures of Health

• Morbidity
• Self-reported health
• Health care use
  – Easier to record.
  – Possibility to merge data on health care use with administrative data in some countries (e.g. Scandinavia).
  – Selection problem, those who use health care may
    • care more about their health.
    • be richer, or better informed.

Plan of Lecture

• Historical perspective in developed countries.
• Mortality in developing countries.
• Value of Mortality Decline.
Recommended Reading


---

Life Expectancy versus GDP per Capita

Figure 1

The Preston Curve: Life Expectancy versus GDP Per Capita

![Graph of Life Expectancy versus GDP per Capita]

Source: Reproduced from Deaton (1993, Figure 1).
Note: Countries are grouped into geographies.

Life Expectancy and GDP over Time

![Graph of Life Expectancy and GDP over Time]

Average Life Expectancy and GDP

- Life expectancy is strongly correlated with income.
- Especially for developing countries.
- Life expectancy gaps between rich and poor countries fell between 1950 and 1980.
- In the 1990, gaps widened:
  - HIV/AIDS epidemic in Africa.
  - Transition in Russia and Eastern Europe.

Life Expectancy, Selected European Countries

Life Expectancy at Birth, More Countries
### Convergence and Divergence: Standard Deviation of Measures of Health and Income

<table>
<thead>
<tr>
<th>Year</th>
<th>Life Expectancy</th>
<th>Infant Mortality</th>
<th>Child Mortality</th>
<th>Ln GEF</th>
<th>Ln MFL</th>
<th>Ln CMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>0.98</td>
<td>12.0</td>
<td>46.9</td>
<td>100.7</td>
<td>0.72</td>
<td>0.83</td>
</tr>
<tr>
<td>1970</td>
<td>1.09</td>
<td>11.2</td>
<td>43.2</td>
<td>94.2</td>
<td>0.30</td>
<td>0.91</td>
</tr>
<tr>
<td>1980</td>
<td>1.31</td>
<td>10.5</td>
<td>40.0</td>
<td>89.6</td>
<td>0.80</td>
<td>1.00</td>
</tr>
<tr>
<td>1990</td>
<td>1.44</td>
<td>10.0</td>
<td>43.6</td>
<td>71.3</td>
<td>0.98</td>
<td>1.08</td>
</tr>
<tr>
<td>2000</td>
<td>1.90</td>
<td>11.7</td>
<td>40.1</td>
<td>67.0</td>
<td>1.11</td>
<td>1.18</td>
</tr>
</tbody>
</table>

Note: All figures are standard deviations of the series in the table. Ln GEF is real GDP per capita divided by the world average real GDP per capita. Ln CMD is the standard deviation of the ratio of the number of life expectancy in a given country to the world average life expectancy in the same year. Ln MFL is the standard deviation of the ratio of the number of infant mortality in a given country to the world average infant mortality in the same year. All series are from the 2006 World Development Indicators. The GEF series covers 97 countries in 1900, 1950, and 1990, and 111 countries in 2000. EN and FR are for France. Child and infant mortality rates were from 191 countries in 2000. All calculations, except for France, were taken at a level, and there is no weighting by population.


---

### Secular Trends in Mortality Rates in England and France

#### England

![Graph showing Secular Trends in Mortality Rates in England](image)

#### France

![Graph showing Secular Trends in Mortality Rates in France](image)


---

### Expected Age at Death, 1751-2000

![Graph showing Expected Age at Death, England and Wales](image)

Source: Black et al. (2001) and Jones, Wrigley and Schofield (1981), Table 2.1, p. 1094. Ages born 1841 and later from the Human Mortality Database.
Historical Perspective, UK

- For most of human history, life expectancy has been around 25 years.
- By 1700, in England and Netherlands, increased to 37 years.
- Mortality started to decline in the XVIII century, around 1820. Reached 41 years.
- Since then, steady increase in life expectancy reaching 77 years today, despite wars and economic crises.
Historical Perspective, UK

• Gain in life expectancy higher at birth and for children than at older ages.
• Largely due to a massive decrease in infectious diseases:
  – In 1848, represent 60% of deaths.
  – Since then, 95% reduction in this cause of death.

Determinants of the Historical Decline in Mortality

• Improved Nutrition
• Public Health
• Urbanization
• Vaccination
• Medical Treatments
• Change in Health Behaviour

Determinants: Improved Nutrition

• Contribution of McKeown who challenged the role of public health and advanced nutrition as an explanation to the decline in mortality.
  – Public health measures became operative at the end of the XIX century.
  – Tuberculosis fell by 80% before there was any effective treatment.
• Increased productivity in agriculture starting during the XVIII century.
• At the same time life expectancy increased, even before public health awareness started.
  – Better fed people resist most bacterial diseases better.
Determinants: Improved Nutrition

- Fogel (1997) shows that there is an increase in caloric intakes starting in the XVIII century.
  - Difficult to measure from production data.
- Proxying Health and Nutrition with Height:
  - Human stature is a well-established indicator for the biological standard of living.
  - It is typically correlated with health, longevity, and nutritional quality.
  - Easy to measure, commonly recorded by the army.

Average Height of Adult White Males, US


Average Height over Time Worldwide
### Improved Nutrition?

- The importance of nutrition on mortality decline is still debated.
- Some evidence of better nutrition under medieval time with the XVIII century a low point.
- During XVI-XVIII century no life expectancy advantage for the British aristocracy, despite better nutrition.

### Height and Log GDP per Capita

![Diagram showing the relationship between height and log GDP per capita.](source: Deaton (2007) "Height, Health and Development", PNAS.)
Public Health

- At given GDP per capita, countries achieve nowadays much longer life expectancies.
- China in 2000 has:
  - the GDP of the USA in 1880
  - life expectancy of the USA in 1970
- Public health improvements may explain this shift.

Public Health

- Filtering & chlorination of water supplies.
- Building sanitation systems.
- Draining swamps.
- Pasteurizing milk.
- Vaccination campaigns.
- Encouraging better health behavior
  - Washing hands
  - Ventilating rooms

Public Health

- Some early examples dating back at least to Medieval times.
- Contribution of John Snow in 1854 in London.
Public Health

• Some early examples dating back at least to Medieval times.
• Contribution of John Snow in 1854 in London.
• Started really with the understanding of the germ theory of disease in the 1880s and 1890s.
• Dramatic reduction in water and food-born diseases after that period.
  – 214 per 100000 around 1850 in the USA.
  – Virtually zero by 1970.

Public Health: Vaccination

• First discovered in China for smallpox.
• Since late XIX century, a number of new vaccines:
• Huge reduction in morbidity.
• Rather low impact on mortality, except tuberculosis.
• For instance, half million people in the US had measles before 1964, but less than 1000 deaths.
• Exclusive of tuberculosis, account for less than 3% of the decline in mortality.
• Tuberculosis accounts for about 10%, but decrease depends also on other factors.

Medical Treatments

• Antibiotics developed in the thirties and forties. Stark decline in infectious diseases.
• Since 1960, 50% reduction in cardio-vascular diseases. Accounts for 70% of the reduction in mortality between 1960-2000.
Urbanization

- Massive migration towards cities in Europe and US during XIX century.
- Spread of diseases is easier in big cities.
- Could be responsible for the lack of improvement in life expectancy during that period.

Change in Health Behavior

- Increase and then decrease in motor vehicle accidents.
- Increase and then decrease in smoking.
- Increase in heavy alcohol consumption.
- Change in diet, rise in obesity.
- Few deaths overall.
- Important cause of mortality for young individuals.
- Large decline over time, similar in other countries.
- Better cars, reduced speed, better hospital care.

Motor Vehicle Deaths, US

Motor Vehicle Death per 100,000 Young Individuals US, 2004

Smoking Prevalence in the US by Birth Cohorts and Gender
Alcohol in Europe

Binge Drinking 3+ Times in Last 30 Days
15-16 Year Olds Reporting

% Per Capita Increase in Consumption of Various Food Items, US 1970 - 2005

Source: USDA, Economic Information Bulletin Number 53
Life Expectancy in Developing Countries

- On the whole, large gains over the last decades, but
- Contrasted experiences.
- Importance of communicable diseases and health behavior.

Determinants of Mortality (2002, WHO data)

<table>
<thead>
<tr>
<th></th>
<th>World</th>
<th>Poor Countries</th>
<th>Rich Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of total deaths by age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children (0-4)</td>
<td>18.4%</td>
<td>30.2%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Elderly (60+)</td>
<td>50.8%</td>
<td>34.2%</td>
<td>75.7%</td>
</tr>
<tr>
<td>% of deaths from chronic diseases</td>
<td>12.4%</td>
<td>6.3%</td>
<td>26.2%</td>
</tr>
<tr>
<td>Cardiovascular diseases</td>
<td>29.3%</td>
<td>21.5%</td>
<td>38.1%</td>
</tr>
<tr>
<td>Number of deaths (million)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory infections</td>
<td>3.96</td>
<td>2.90</td>
<td>0.34</td>
</tr>
<tr>
<td>HIV/AIDS</td>
<td>2.78</td>
<td>2.14</td>
<td>0.02</td>
</tr>
<tr>
<td>Perinatal deaths</td>
<td>2.46</td>
<td>1.83</td>
<td>0.03</td>
</tr>
<tr>
<td>Diarrheal diseases</td>
<td>1.80</td>
<td>1.54</td>
<td></td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>1.57</td>
<td>1.09</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Life Expectancy in China and India

Infant Mortality in Asia (per 1000 live births)
Summary of Evidence

• Marked increase in life expectancy worldwide over the last 2 centuries.
• Several reasons
  – Increased prosperity and better nutrition.
  – Better understanding of infectious diseases.
  – Lately, progress in medical technology and better health awareness.
• These gains are sometimes fragile and can be reversed:
  – Importance of health behavior.

Healthy Life Expectancy

• Life expectancy is sometime seen as a crude measure of health. Does not take into account of chronic diseases and disability.
• Healthy life expectancy constructed from surveys:
  – “Over the last 12 months would you say that your health has been good, fairly good or not good?”
  – “Do you have any long-standing illness or disability?”
  – Data is combined with mortality data to estimate the number of years of healthy life.
  – However,....
**Trends in Life Expectancy and Healthy Life Expectancy, UK**

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Expectancy</td>
<td>76.8</td>
<td>80.4</td>
</tr>
<tr>
<td>Healthy Life Expect.</td>
<td>66.7</td>
<td>68.8</td>
</tr>
<tr>
<td>% in Good or fairly Good Health</td>
<td>86.9%</td>
<td>85.6%</td>
</tr>
</tbody>
</table>

Source: statistics.gov.uk

---

**Healthy Life Expectancy**

- Large gains in Life Expectancy.
- Increase in Healthy Life Expectancy as well:
  - Gender differences: Women live longer but experience proportionally more chronic ill health than men.
  - Socio-economic differences. The 10% richest have 17 more years of HLE than the poorest 10%.

---

**Value of Mortality Decline**

- Murphy and Topel (2005)
- Calibrate the value of the large mortality decline in the US.
- Write down a model of inter-temporal choice with exogenous health and life-expectancy.
- Performs counterfactual welfare simulations to evaluate the value.
Value of Mortality Decline

• Two types of health:
  – $H(t)$: quality of life,
  – $G(t)$: mortality.

• Expected utility for an individual of age $a$:

\[
\int H(t)h(t,a) + G(t)S(t,a)e^{-\rho t}dt.
\]

Survivor function
Quality of life
Rate of time preference
Non-Market Time
Consumption

Value of Mortality Decline

• Survival function:

\[
\tilde{S}(t,a) = \exp \left[-\int_{t}^{\infty} \lambda(x, G(x, a)) dx \right].
\]

– Greater type $G$ health leads to longer life.
– Impact of a change in mortality rate:

\[
\tilde{S}(t,a) = \tilde{S}(t,a) \int \lambda(x, G(x, a)) dx = \tilde{S}(t,a) \mathcal{H}(t,a).
\]

– Larger impact when $S$ is large.

Value of Mortality Decline

• Budget constraint:

\[
\begin{align*}
\dot{A}(a) + \int (c(t) - c(t)\tilde{S}(t,a)e^{-\rho t} + d) dt = 0
\end{align*}
\]

• Maximisation with respect to consumption and leisure:

\[
U(a) = \int \left( H(t)h(t,a) + G(t)S(t,a)e^{-\rho t} + \rho \tilde{S}(t,a)e^{-\rho t} \right) dt + \mu(a)
\]
Value of Mortality Decline

- Value of a Statistical Life: 
  \[ V_{s}(z) = \frac{\partial U(i)}{\partial \lambda(z)} \]
  \[ V_{s}(z) = \int_{0}^{z} v(t) \left( 1 - e^{-\Delta t \lambda(z)} \right) dt \]

- Calibrated using different sources:
  - Elasticity of substitution between consumption and leisure: consumption studies.
  - Life cycle wages and consumption.
  - Patterns of observed disability and mortality.
  - Scale of utility

---

**Value of Mortality Decline**

**Estimated Values of a Life-Year for 50 Year-Old Men**

<table>
<thead>
<tr>
<th>Elasticiy of Interpersonal Substitution (g)</th>
<th>1.2</th>
<th>1.1</th>
<th>1.0</th>
<th>0.9</th>
<th>0.8</th>
<th>0.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>$295</td>
<td>$144</td>
<td>$160</td>
<td>$625</td>
<td>$714</td>
<td>$741</td>
</tr>
<tr>
<td>50</td>
<td>$198</td>
<td>$140</td>
<td>$154</td>
<td>$675</td>
<td>$773</td>
<td>$817</td>
</tr>
</tbody>
</table>

Note: The table is based on the following equation:

\[ V_{s}(z) = \int_{0}^{z} v(t) \left( 1 - e^{-\Delta t \lambda(z)} \right) dt \]

The table assumes a value of GM consumption of \( y = 2500 \) for a 50-year-old man with 1,000 total available transits per year and ages of life less, including savings.

---

**Implied Profiles for Consumption, Income and Value-of-Life-Year**
Value of Remaining Life

Cumulative Values of Longevity Gains Since 1900

Economic Gains from Reduction in Mortality 1970-2000, (Billions of 2004 dollars)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>20.649</td>
<td>15.467</td>
<td>18.655</td>
<td>26.325</td>
</tr>
<tr>
<td>Women</td>
<td>20.355</td>
<td>19.407</td>
<td>24.169</td>
<td>34.022</td>
</tr>
<tr>
<td>Total</td>
<td>40.714</td>
<td>34.874</td>
<td>42.824</td>
<td>60.347</td>
</tr>
</tbody>
</table>

*Note: Longevity gains were calculated using U.S. male and female life tables provided in the text. Populations at birth were standardized to the 2000 U.S. standard population.
Life Expectancy within Nations

• At micro level, what are the main determinants?
  – Education.
  – Socio-economic position.
  – Health behavior.
  – Stress.