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

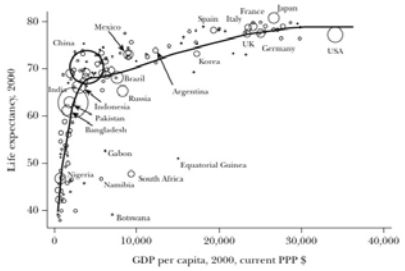
- Historical perspective in developed countries.
- Mortality in developing countries.
- Value of Mortality Decline.

Recommended Reading

- Cutler, Deaton and Lleras-Muney (2006) "The Determinant of Mortality", *Journal of Economic Perspective*.
- Fogel, Robert W. (1994). "Economic Growth, Population Theory, and Physiology: The Bearing of Long-Term Processes on the Making of Economic Policy". *American Economic Review*. June, 84:3, pp. 369-95.
- Preston, Samuel H. 1975. The Changing Relation Between Mortality and Level of Economic Development. *Population Studies*. July, 29:2, pp. 231-48.
- Murphy and Topel (2006), "The Value of Health and Longevity", *Journal of Political Economy*, 114:5, 871-904.

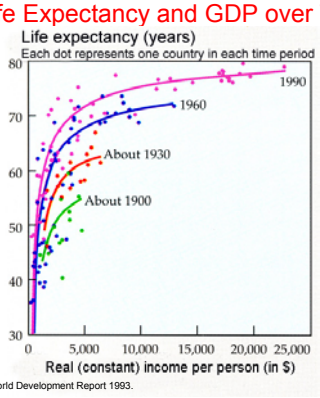
Life Expectancy versus GDP per Capita

Figure 1
The Preston Curve: Life Expectancy versus GDP Per Capita



Source: Reproduced from Deaton (2003, Figure 1).
Note: Circles are proportional to population.

Life Expectancy and GDP over Time

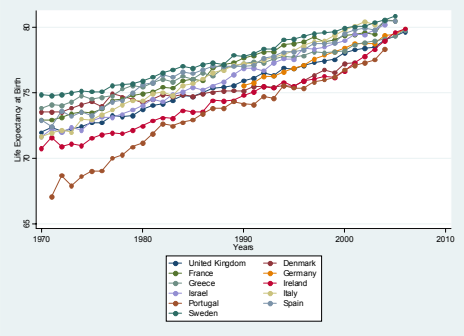


Source: World Bank, World Development Report 1993.

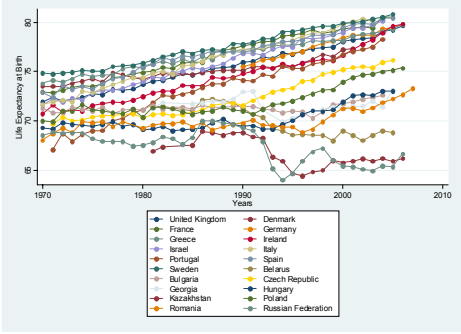
Average Life Expectancy and GDP

- 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



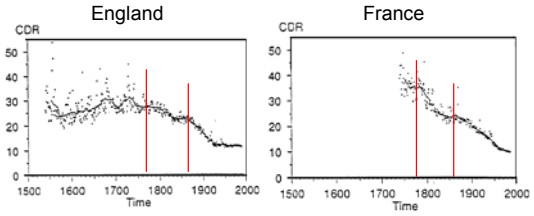
Convergence and Divergence: Standard Deviation of Measures of Health and Income

	Ln GDP	Life expectancy	Infant mortality	Child mortality	Ln IMR	Ln CMR
1960	0.98	12.0	60.9	105.7	0.72	0.83
1970	1.09	11.2	50.1	94.3	0.80	0.91
1980	1.13	10.5	48.0	80.6	0.89	1.00
1990	1.14	10.5	43.4	71.8	0.98	1.08
2000	1.18	11.7	40.1	67.0	1.11	1.18
2004	1.23	12.4	39.6	65.8	1.15	1.26

Note: All figures are standard deviations of the series noted in the heading. GDP is real chained gross domestic product per capita in constant 2000 international PPP dollars and is taken from the Penn World Table version 6.2; all other series are from the 2006 World Development Indicators. The GDP series covers 97 countries in 1960, rising to 185 in 2000, but only 79 in 2004. Child and infant mortality rates come from 151 countries in 1960 rising to 186 by 2004. In all calculations, each country is taken as a unit, and there is no weighting by population.

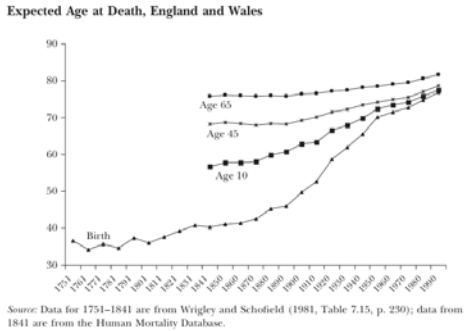
Source: Deaton (2006) "Global patterns of income and health:facts, interpretations, and policies "

Secular Trends in Mortality Rates in England and France



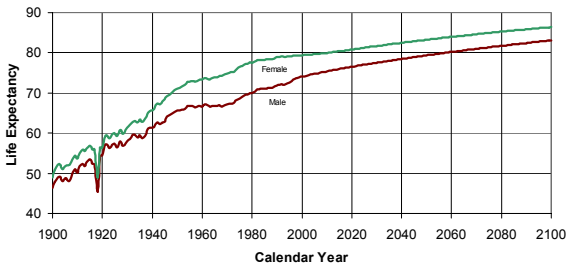
Source: Fogel (1997) "New Findings on Secular Trends in Nutrition and Mortality: some Implications for Population Theory", Handbook of Population and Family Economics.

Expected Age at Death. 1751-2000



Source: Data for 1751–1841 are from Wrigley and Schofield (1981, Table 7.15, p. 230); data from 1841 are from the Human Mortality Database.

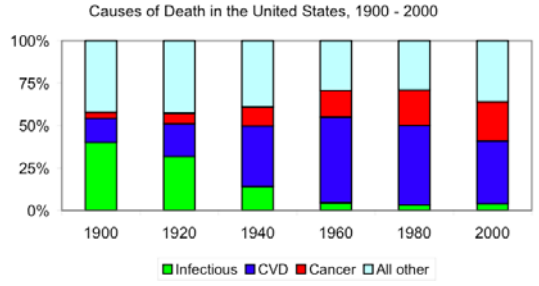
U.S. Life Expectancy at Age 0
by Sex and Calendar Year
(based on Period Tables)



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.

Causes of Death in the US, 1900-2000



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

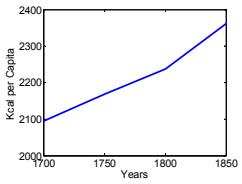
- Improved Nutrition
- Public Health
- Urbanization
- Vaccination
- Medical Treatments
- Change in Health Behaviour

Determinants: Improved Nutrition

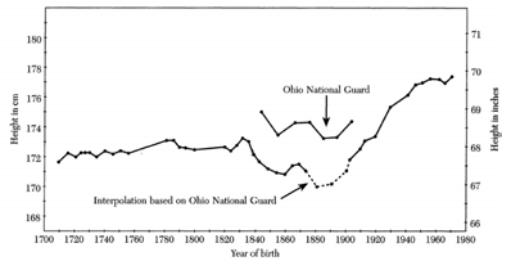
- Contribution of McKeown who challenged the role of public health and advanced nutrition as an explanation to the decline in mortality.
  - Public health measures became operative at the end of the XIX century.
  - Tuberculosis fell by 80% before there was any effective treatment.
- Increased productivity 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.

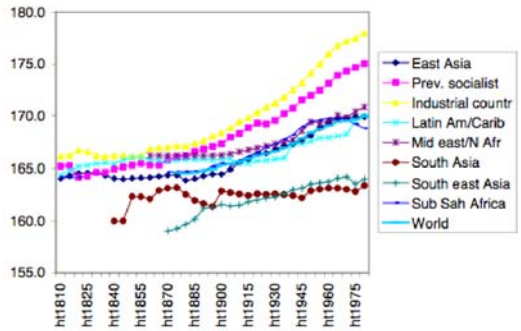


Average Height of Adult White Males, US



Source: Steckel (1995) "Stature and the Standard of Living". *JEL*

Average Height over Time Worldwide



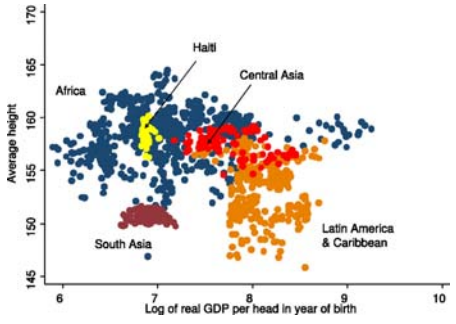
Estimated Height of Men

	(1) Date of maturity by century and quarter	(2) Great Britain	(3) Norway	(4) Sweden	(5) France	(6) Den-mark	(7) Hungary
1.	18–III	165.9	163.9	168.1	–	–	168.7
2.	18–IV	167.9	–	166.7	163.0	165.7	165.8
3.	19–I	168.0	–	166.7	164.3	165.4	163.9
4.	19–II	171.6	–	168.0	165.2	166.8	164.2
5.	19–III	169.3	168.5	165.6	165.6	165.3	–
6.	20–III	175.0	178.3	177.6	172.0	176.0	170.9

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



Source: Deaton (2007) "Height, Health and Development", PNAS.

Public Health

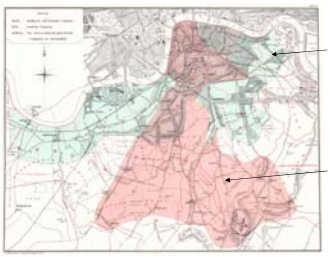
- At given GDP per capita, countries achieve nowadays much longer life expectancies.
- China in 2000 has:
  - the GDP of the USA in 1880
  - life expectancy of the USA in 1970
- Public health improvements may explain this shift.

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.

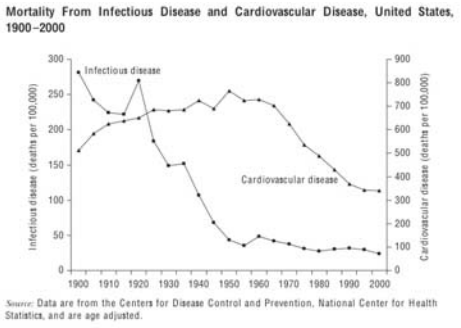
Public Health: Vaccination

- First discovered in China for smallpox.
- Since late XIX century, a number of new vaccines:
  - Rabies (1885), plague (1897), tuberculosis (1927), yellow fever (1935), polio (1955), measles (1964), hep B (1981).
- 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.

Mortality Infectious Disease and Cardiovascular Disease, US, 1900-2000



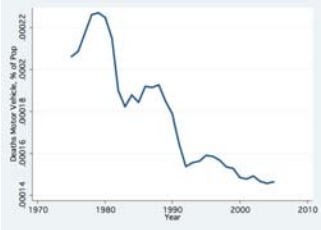
Urbanization

- 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.

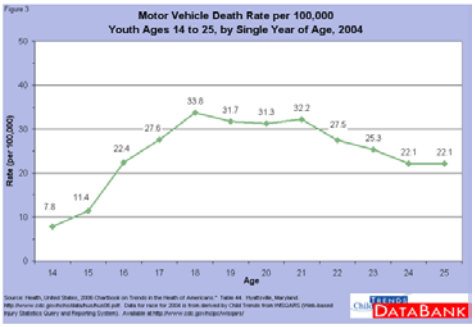
Motor Vehicle Deaths, US



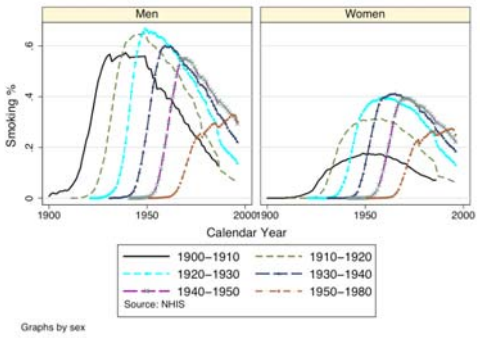
- Few deaths overall.
- Important cause of mortality for young individuals.
- Large decline over time, similar in other countries.
- Better cars, reduced speed, better hospital care.

Source: National Highway Traffic Safety Administration

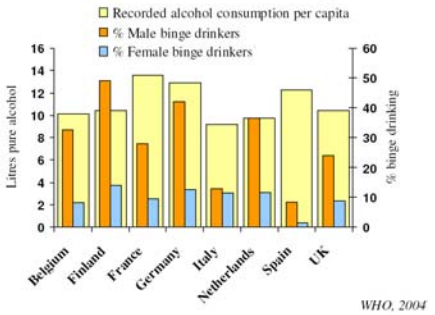
Motor Vehicle Death per 100,000 Young Individuals US, 2004,



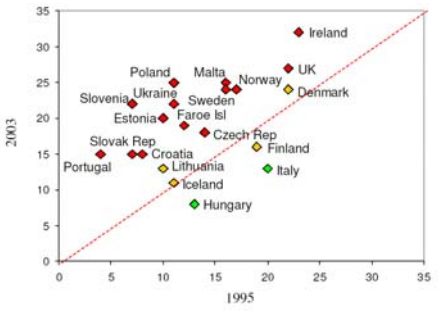
Smoking Prevalence in the US by Birth Cohorts and Gender



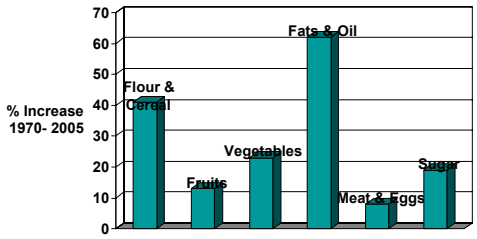
Alcohol in Europe



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

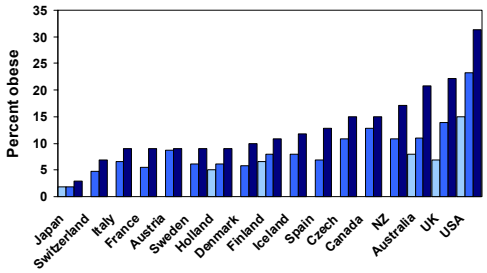


Source: USDA, Economic Information Bulletin Number 33

Health Behavior: Diet

Rising obesity in rich countries

serial surveys OECD, 1980-2002



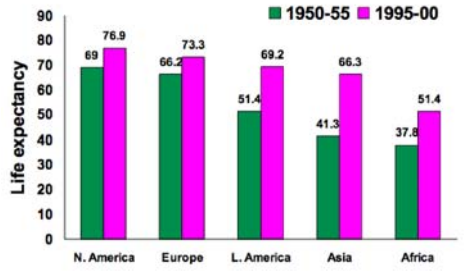
Life Expectancy in Developing Countries

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

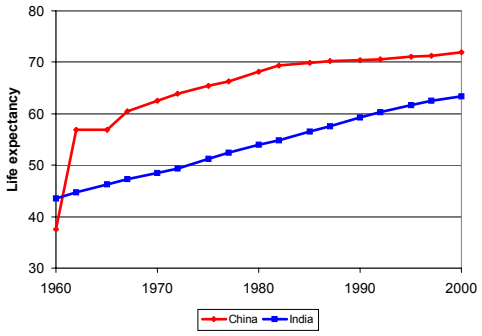
Determinants of Mortality (2002, WHO data)

	World	Poor Countries	Rich Countries
Deaths per 100,000	916	1113	846
% of total deaths by age			
Children (0-4)	18.4%	30.2%	0.9%
Elderly (60+)	50.8%	34.2%	75.7%
% of deaths from chronic diseases			
Cancer	12.4%	6.3%	26.2%
Cardiovascular diseases	29.3%	21.5%	38.1%
Number of deaths (million)			
Respiratory infections	3.96	2.90	0.34
HIV/AIDS	2.78	2.14	0.02
Perinatal deaths	2.46	1.83	0.03
Diarrheal diseases	1.80	1.54	
Tuberculosis	1.57	1.09	0.01

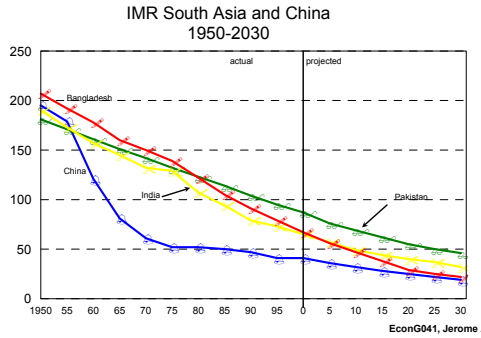
Life Expectancy Gains in Major World Regions, 1950-55 to 1995-2000



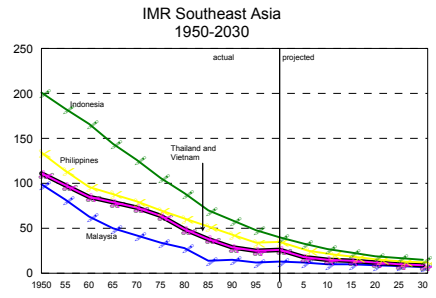
Life Expectancy in China and India



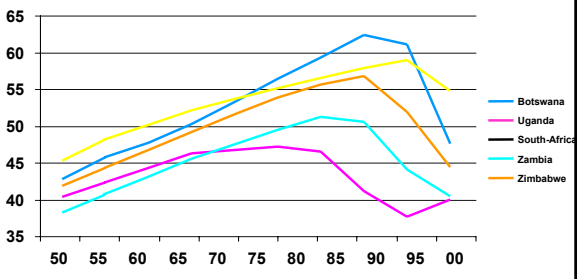
Infant Mortality in Asia (per 1000 live births)



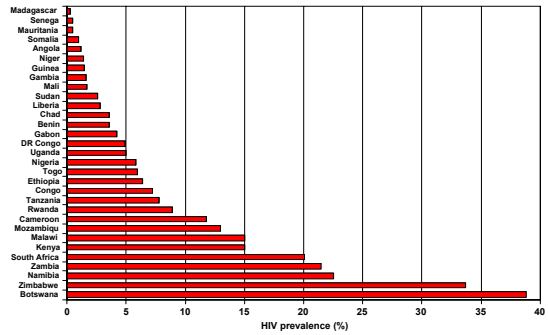
Infant Mortality in South East Asia (per 1000 live births)



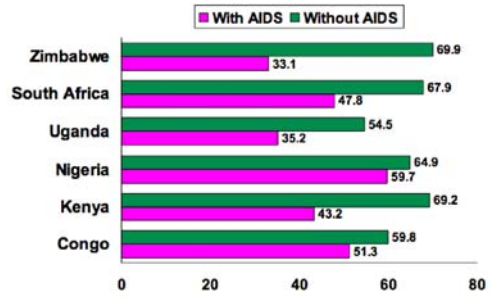
Life Expectancy in Africa



HIV Prevalence in Africa

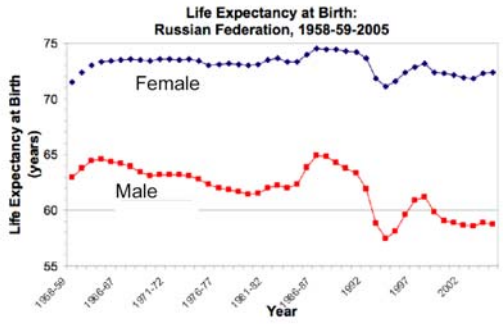


Projected Effects of AIDS on Life Expectancy in sub-Saharan Africa by Year 2010

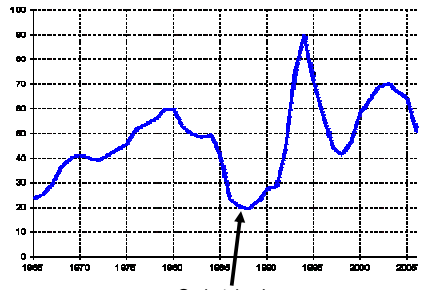


Source: US bureau of Census International Programs, 1997

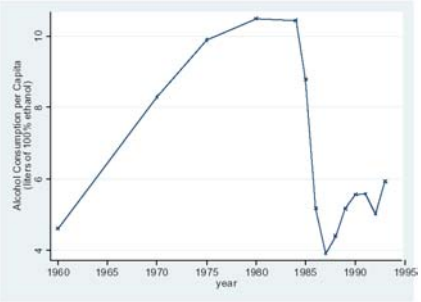
Life Expectancy in Russia



Age-standardized mortality of men (per 100,000) from accidental poisoning by alcohol



Alcohol Consumption Per Capita in Russia



Source: Balan-Cohen (2008)

Summary of Evidence

- Marked increase in life expectancy world-wide over the last 2 centuries.
- Several reasons
  - Increased prosperity and better nutrition.
  - Better understanding of infectious diseases.
  - Lately, progress in medical technology and better heatlh 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

	Women		Men	
Year	1981	2001	1981	2001
Life Expectancy	76.8	80.4	70.9	75.7
Healthy Life Expect.	66.7	68.8	64.4	67.0
% in Good or fairly Good Health	86.9%	85.6%	90.0%	88.5%

Source: statistics.gov.uk

Healthy Life Expectancy

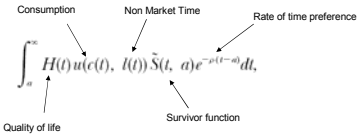
- Large gains in Life Expectancy.
- Increase in Healthy Life Expectancy as well:
  - Gender differences: Women live longer but experience proportionally more chronic ill health than men.
  - Socio-economic differences. The 10% richest have 17 more years of HLE than the poorest 10%.

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*:



$$\int_a^{\infty} H(t)\,u(c(t),\ l(t))\,\tilde{S}(t,\ a)e^{-\rho(t-a)}dt,$$

Value of Mortality Decline

- Survival function:

$$\tilde{S}(t,\ a)\ =\ \exp\left[-\int_a^t \underbrace{\lambda(\tau,\ G(\tau))}_{\text{Instantaneous mortality rate}}d\tau\right],$$

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

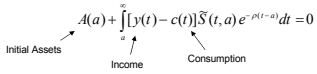
$$\tilde{S}'_{\alpha}(t,\ a)\ =\ -\tilde{S}(t,\ a)\int_a^t \lambda'_{\alpha}(\tau,\ G(\tau))d\tau\ =\ \tilde{S}(t,\ a)\Gamma_{\alpha}(t,\ a).$$

  - Larger impact when S is large.

Value of Mortality Decline

- Budget constraint:

$$A(a)+\int_a^{\infty}[y(t)-c(t)]\tilde{S}(t,a)\,e^{-\rho(t-a)}dt=0$$



- Maximisation with respect to consumption and leisure:

$$U(a)=\int_a^{\infty}\{H(t)u(c(t),l(t))e^{-\rho(t-a)}+\mu[y(t)-c(t)]e^{-\rho(t-a)}\}\tilde{S}(t,a)\,dt+\mu A(a)$$

Value of Mortality Decline

- Value of a Statistical Life: $V_\lambda(a) \equiv -\frac{\partial U(a)/\partial \lambda(a)}{\partial U(a)/\partial A(a)}$

$$V_\lambda(a) = \int_a^\infty v(t) e^{-r(t-a)} \tilde{S}(t, a) dt, \qquad v(t) = \frac{u(c(t), l(t))}{u_c'} - c(t) + y(t)$$

Value of a life-year

- 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

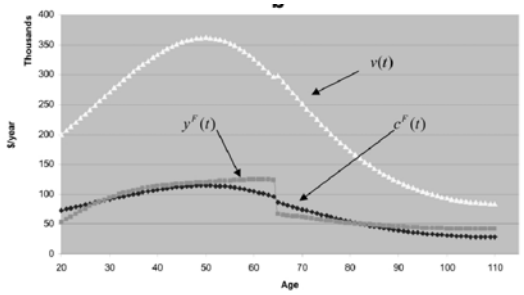
	ELASTICITY OF INTERTEMPORAL SUBSTITUTION (σ)					
z_0/z	1.2	1.1	1.0	.9	.8	.7
.05	$282	$314	$360	$426	$535	$731
.10	$229	$249	$276	$314	$373	$471
.20	$169	$180	$193	$211	$237	$278

NOTE.—The table is based on the following equation:

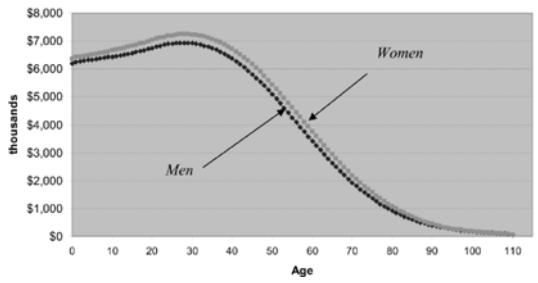
$$y^r = r^r \Phi(z) = y^r + r^r \frac{1}{\sigma - 1}\left[1 - \sigma\left(\frac{z_0}{z}\right)^{(\sigma-1)/\sigma}\right]$$

The table assumes a value of full consumption of $y^r = r^r = \$120{,}000$ for a 50-year-old man with 4,000 total available hours per year and wages of $30/hour, including benefits.

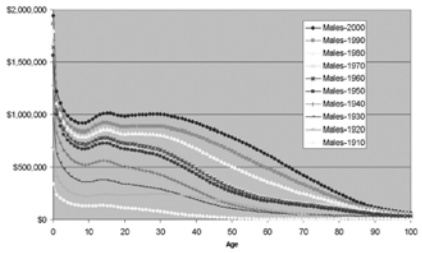
Implied Profiles for Consumption, Income and Value-of-Life-Year



Value of Remaining Life



Cumulative Values of Longevity Gains Since 1900



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

	1970–80	1980–90	1990–2000	1970–2000
Males	$26,699	$15,471	$19,153	$61,323
Females	$20,515	$9,067	$4,440	$34,022
Total	$47,214	$24,538	$23,593	$95,345

NOTE.—Aggregate gains were calculated using eq. (18) and year 2000 U.S. population by age. Population at birth includes census-predicted future birth cohorts discounted at 3.5 percent.

Life Expectancy within Nations

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