Modern correlates of health

ECON 40656
Health Economics
Fall 2007

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Table 1
The worldwide structure of mortality in 2002

	Treatments/ Prevention	World	Low Income Countries	High Income Countries
Deaths per 100,000		916	1,113	846
Percent of total deaths by age				
Children (0-4)		18.4%	30.2%	0.9%
Elderly (60+)		50.8	34.2	75.7
Percentage of deaths from chronic diseases				
Cancer	Partially preventable and treatable	12.4	6.3	26.2
Cardiovascular disease	Partially preventable and treatable	29.3	21.5	38.1
Numbers of deaths, millions				
Respiratory infections*	Antibiotics	3.96	2.90	0.34
HIV/AIDS	HAART	2.78	2.14	0.02
Perinatal deaths*	Pre- and post-natal care	2.46	1.83	0.03
Diarrheal diseases*	Oral rehydration therapy	1.80	1.54	---
Tuberculosis	Preventable with public health; usually treatable	1.57	1.09	0.01
Malaria*	Partially preventable; treatable	1.27	1.24	---
DPT/Polio/Measles*	Vaccinations	1.12	1.07	---

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Fig. 1: All cause mortality[a]

a - Death rates shown are adjusted to standard population of U.S. in 1940

Fig. 2: Life Expectancy at Birth

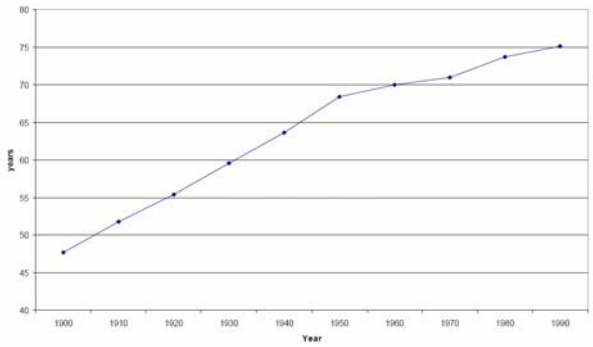

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Fig. 4: All Cause Mortality by Age

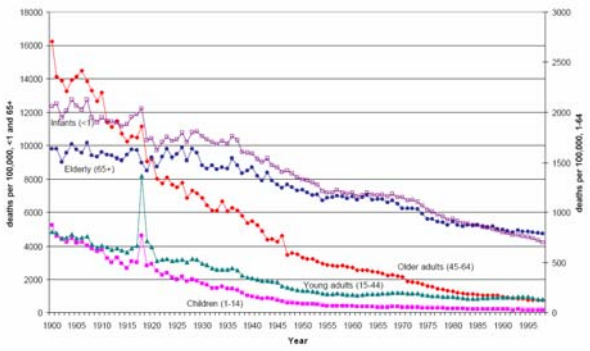

Table 1: Contributions to Life Expectancy at Birth

Change in Life Expectancy at Birth	1900-40	1940-60	1960-90
Total change	15.9	6.4	5.1
Change attributable to:			
Infant mortality (<1)	4.7	1.4	1.2
Child mortality (1-14)	4.4	0.7	0.3
Young adult mortality (15-44)	3.6	1.6	0.3
Older adult mortality (45-64)	1.0	1.1	1.4
Elderly mortality (65+)	0.4	1.2	1.8
Covariance terms	1.8	0.4	0.1

Note: The text describes the decomposition.

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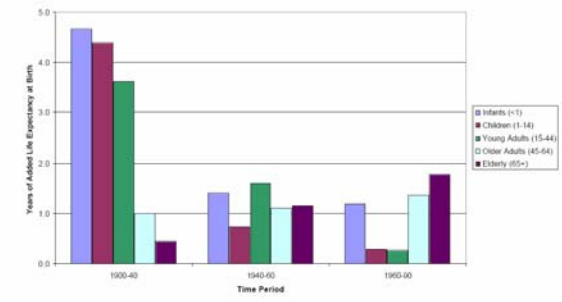
Fig 3: Sources of Life Expectancy Improvement by Age



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Vital Statistics, 2002

- **280 million people**
- **4 millions births**
- **2.4 million deaths**

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Leading Causes of Death, 2002

- Heart disease 696,947
- Cancer 557,271
- Stroke 167,677
- Chronic lower resp. diseases 124,742
- Accidents 106,742
- Diabetes 73,249
- Influenza/Pneumonia 65,681
- Alzheimer's 58,866
- Nephritis 40,974
- Septicema 33,865

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Distribution of Deaths by Age

Age	Fraction of deaths
<1	1.1%
1-14	0.5%
15-24	1.4%
25-34	1.7%
35-44	3.7%
45-54	7.1%
55-64	10.4%
65-74	17.3%
75-84	28.9%
85+	27.9%

74.1% of deaths are to people aged 65+

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Leading causes of death, 2002

Top 3	15-24 years of age	45-54 years of age	65+ years of age
1	Unintentional Injury	Cancer	Heart Disease
2	Homicide	Heart Disease	Cancer
3	Suicide	Unintentional Injury	Stroke

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Actual Causes of Death

Cause of death	# (% of deaths) 1990	# (% of deaths) 2000
Tobacco	400,000 (19%)	435,000 (18%)
Diet/inactivity	300,000 (15%)	400,000 (17%)
Alcohol	100,000 (5%)	85,000 (5%)
Micorbial agents	90,000 (4%)	75,000 (4%)
Toxic agents	60,000 (3%)	66,000 (3%)
Motor Vehicles	25,000 (1%)	43,000 (2%)
Firearms	35,000 (2%)	29,000 (1%)
Sexual Behavior	30,000 (1%)	20,000 (<1%)
Illegal drugs	20,000 (<1%)	17,000 (<1%)
Total	1,060,000 (50%)	1,060,000 (48%)

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What causes big changes in life expectancy?

- Most deaths are to the elderly
- But, when an infant dies, you add a small number to the numerator in a life expectancy calculation
- Big changes will be generated by
  - Changes in the infant mortality rate
  - Changes in mortality for the elderly which are a large fraction of deaths

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Numeric Example

- Population with 100 people
- 10% die at age 1
  - ~ the 1900 infant mortality rate)
- If they survive, they live to age 75
- Life expectancy = (.1)(1) + (.9)(75) = 67.6

- Suppose infant mortality rates drops to 1%
  - ~ the 1980 Infant mortality rate
- Life expectancy = (0.01)(1) + (.99)(75) = 74.3

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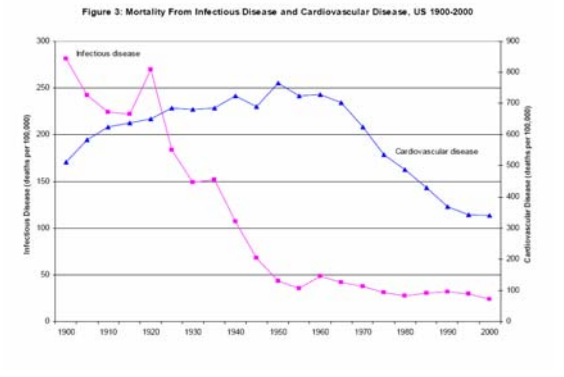

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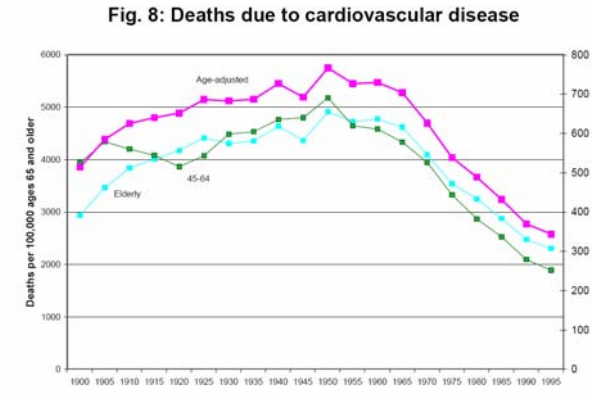

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Improvements in heart attack treatment

- In 1950s, standard treatment was bed rest
  - Medical textbook in the 1950s, "..bed rest for at least 6 weeks should be planned…"
  - Today we know bed rest is counter productive
- Now, right after heart attack
  - Patient is administered blood thinners (aspirin, heparin)
  - Beta blockers to make heart work more efficiently
  - Thrombolytics to dissolve clots

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- Variety of surgical procedures to deal with blockages
  - Cardiac catheterization (detects extent of blockage)
  - CABG (coronary artery bypass surgery)
  - Angioplasty (balloon inserted into blocked artery and expanded to reduce clot)
  - Stents can be inserted to maintain bloodflow

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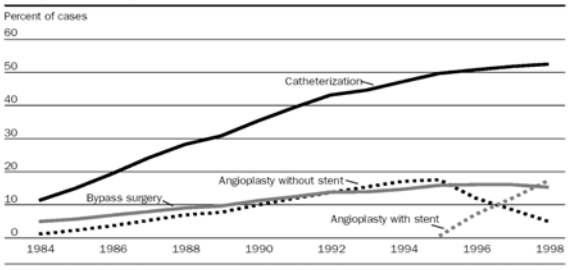
EXHIBIT 2
Changes In The Surgical Treatment Of Heart Attacks, 1984–1998



SOURCE: Authors' analysis of Medicare claims records for all elderly patients with a heart attack.
NOTES: Procedure use is within ninety days of the initial admission for the heart attack. See references in text for more detail.

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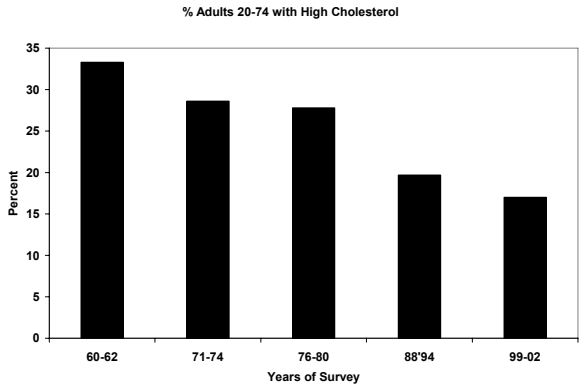

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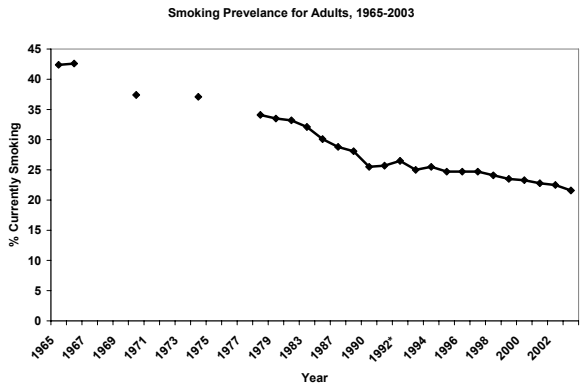

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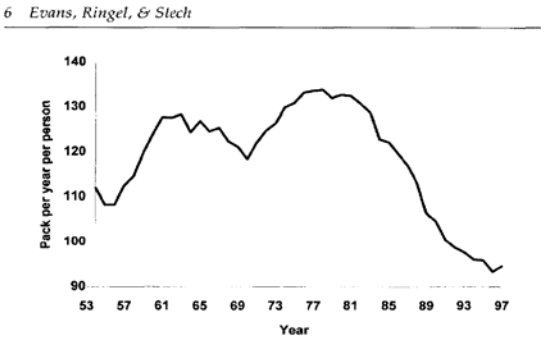

FIGURE 1. *Per Capita Cigarette Consumption*

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Example: AIDS Drugs

- **Through 2003**
  - **929,000 people diagnosed with AIDS**
  - **Over half have died**
- **AIDS caused by HIV**
  - **about 1 million people HIV+**
  - **Infection that weakens resistance to infection by reducing CD4 counts**
- **Before mid 1990s,**
  - **30% of AIDS patients died each year**

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- **Treatment prior to mid 90s**
  - **Treat opportunistic infections caused by weakened immune system**
  - **4 drugs that were designed to reduce spread of virus in host (e.g. AZT)**
  - **Not particularly effective**
- **Mid 1990s**
  - **Major advances in pharmaceutical treatments**
  - **Epivir (nucleoside reverse transcription inhibitor)**
  - **Protease inhibitors**

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- **New drugs**
  - Prevent virus from replicating in patients
  - Work very well
    - Increase CD4 counts
    - Suppress viral load to zero for many patients
- **Immediate results**
  - Drugs released in Nov 1995 – June 1996
  - Mortality rates fell 70% in a three-year period

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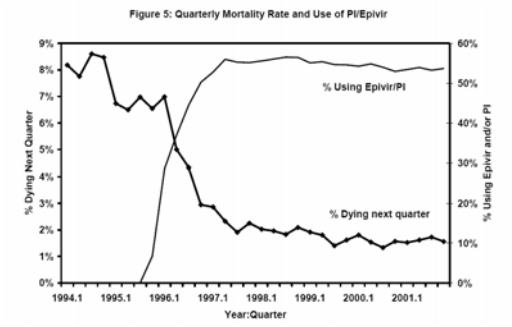

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Describing determinants of mortality in a cross section

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% that Died in Next 5 Years, Adults, 40-64 Years of Age, NLMS

- **By sex**
  - Males 6.9%
  - Females 3.6%
- **By race**
  - Black 7.1%
  - White 4.9%
- **By ethnicity**
  - Non-hispanic 5.2%
  - Hispanic 4.2%
- **By marital status**
  - Not married 7.0%
  - Married 4.6%
- **By education**
  - < HS 6.9%
  - HS 4.4%
  - College 3.6%
- **By Income**
  - < $25K 6.0%
  - $25-$50K 3.4%
  - >$50K 2.7%

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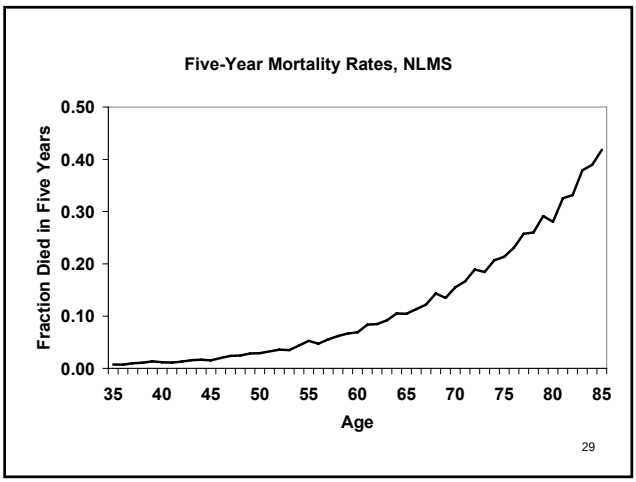

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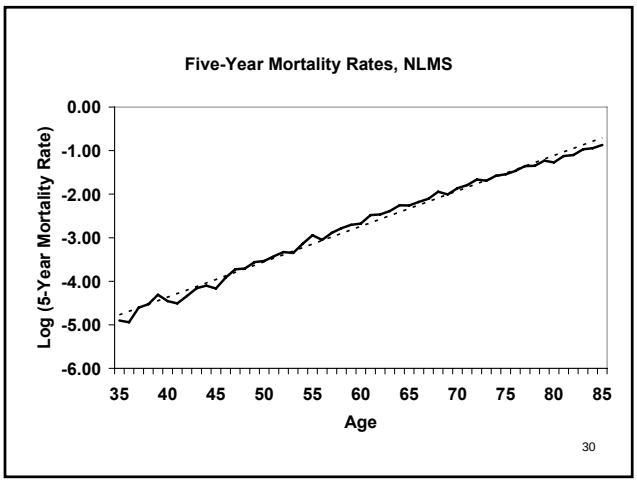

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Gompertz Equation

- 1825 British actuary Benjamin Gompertz
- "the number of living corresponding to ages increasing in arithmetical progression, decreased in geometrical progression."
- geometrical decrease in survival with age existed because of a geometric increase in the "force of mortality"

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- $M_a = ce^{ba}$
- M_a = mortality rate at age a
- a = age
- c = initial mortality rate
- b = Gompertz parameter – exponential rate of change in mortality with age

- Note that if $y=e^{bt}$
- Then $\ln(y) = bt$
- $\ln(M_a) = \ln(c) + ba$
- Log mortality rates are linear in age

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Income/Health Relationship

- Health improves with income
- But at a decreasing rate
  - $dH/dI > 0$
  - $d^2H/dI^2 < 0$
- Relationship is true for
  - Nearly all measures of health
  - For all subgroups (by sex, race, age, etc)
  - For nearly all populations
  - For nearly all time period
  - For nearly all countries
- Similar relationship with education

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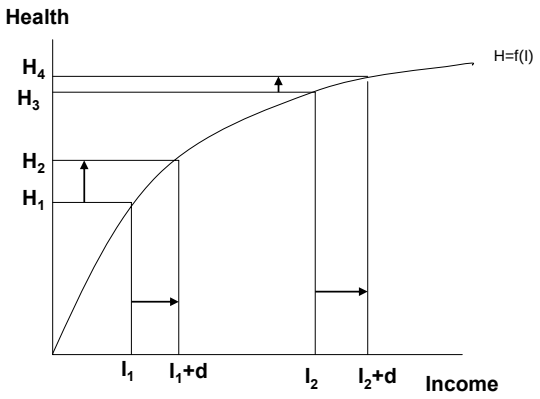

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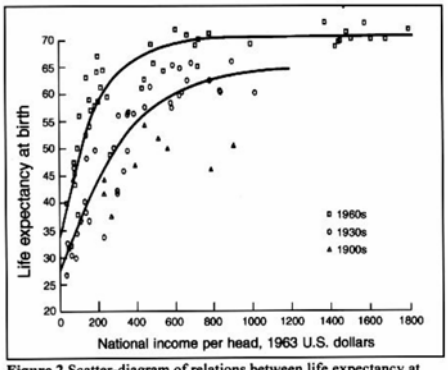

Figure 2 Scatter-diagram of relations between life expectancy at birth and national income per head for nations in the 1900s, 1930s, and 1960s. Source: Preston (1975).

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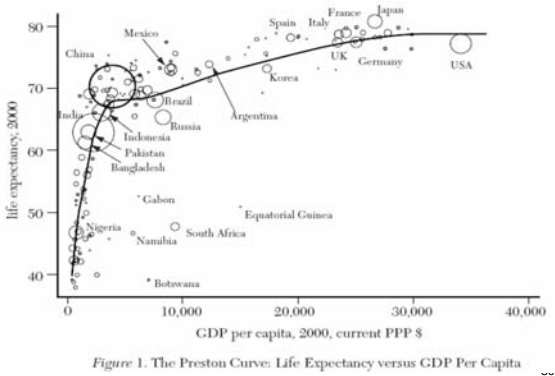

Figure 1. The Preston Curve: Life Expectancy versus GDP Per Capita

Percent Died within 5 years of Survey, Males NLMS

Income Group	35-54 years of age		55-64 years of age		65-74 years of age	
0 to $25,000	3.1	-42%	10.8	-37%	20.6	-25%
$25,001 to $50,000	1.8	-22%	6.8	-25%	15.3	-19%
$50,001 +	1.4		5.1		12.3	

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Percent Died within 5 years of Survey, Males NLMS

Education Group	35-54 years of age	55-64 years of age	65-74 years of age
Less than high school	3.8	11.7	22.1
High school graduate	2.4	8.5	18.7
College graduate	1.4	6.5	13.7

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Percent Died within 5 years of Survey, Females NLMS

Education Group	35-54 years of age	55-64 years of age	65-74 years of age
Less than high school	2.0	6.0	11.7
High school graduate	1.3	4.3	9.7
College graduate	0.9	4.0	8.0

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30-55 year olds, BRFSS 2004 (% answering yes)

Income Level	Fair or poor health	No exer in past 30 days	Current smoker	Obese	Binge drink in past 30
<$25K	34.5%	40.5%	35.3%	31.4%	13.7%
$25K – $50K	12.3%	24.7%	27.3%	28.1%	16.0%
>$50K	5.0%	13.4%	15.6%	21.4%	16.6%

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30-55 year olds, BRFSS 2004 (% answering yes)

Educ Level	Fair or poor health	No exer in past 30 days	Current smoker	Obese	Binge drink in past 30
<12 years	39.1%	47.8%	35.1%	30.8%	15.1%
12-15 years	14.8%	25.3%	28.7%	28.7%	16.5%
16+ years	5.2%	12.7%	11.3%	18.0%	13.8%

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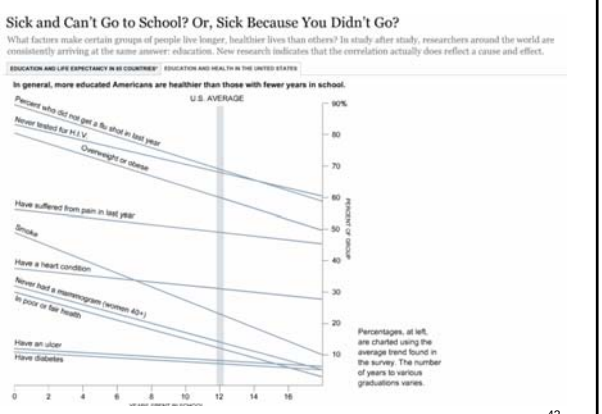

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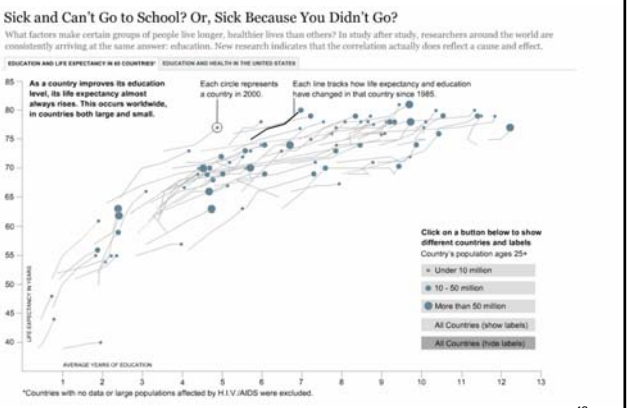

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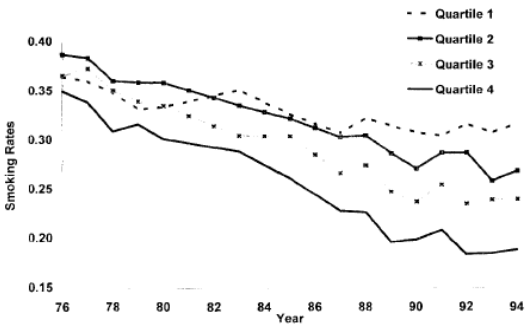

FIGURE 6. *Smoking Rates by Family Quartiles—NHIS*

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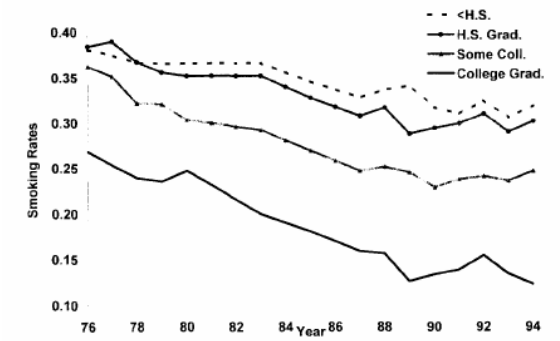

FIGURE 7. *Smoking Rates by Education Groups—NHIS*

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Deaton and Marmot Papers

- Questions to consider for class
- What are the possible mechanisms through which income (or education) can improve health?
- What data supports or refutes each of these hypotheses?
  - List possible explanations
  - Give some evidence for and against
  - Decide whether the pathway is a causal mechanism

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What do we mean by causal pathway?

- If causal, we assume that health is determined by income
  - For example, H=f(Income)
- Therefore, dH/dI>0
  - An exogenous change in income will alter health
- Example: Suppose we change social security benefits – if income is causal, should alter mortality of the elderly

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Random assignment clinical trial

- New drugs that lower cholesterol
- Recruit N people with high cholesterol
  - ½ in treatment (receive active ingredient)
  - ½ in control (placebo)
- Measure cholesterol levels before the start of treatment
- Then again after a specified time

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Difference in Difference

	Before Treatment	3 months later	Difference
Group 1 (Treatment)	M_{t1}	M_{t2}	$\Delta M_t = M_{t2} - M_{t1}$
Group 2 (Control)	M_{c1}	M_{c2}	$\Delta M_c = M_{c2} - M_{c1}$
Difference			$\Delta\Delta M$ $\Delta M_t - \Delta M_c$

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Why is it hard to determine whether the income/health relationship is causal

- Many factors that determine high income
  - Drive/ambition/intelligence/risk taking/luck/background
- Many of these same factors can also impact health
- Therefore, we do not know whether income is causing better health, or some third factor that is unmeasured

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What can explain the income/health relationship

- Insurance?
- Maybe explained by poor health habits
- Work/neighborhood characteristics?
- Just explaining education/health relationship
- Could be reverse causation – low income is caused by poor health?

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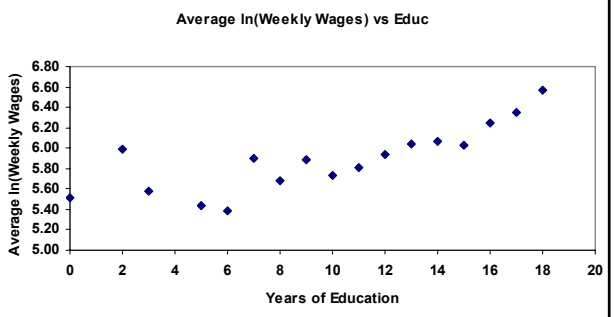

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It is not just missing education

	Difference in mortality compared to people with >$50K in income	
Income	Do not control for education	Control for education
<$5000	5.3 % points higher	4.7% points higher
$5K - $10K	3.3	2.7
$10K-$15K	2.3	1.9
$15K-$20K	1.3	1.0
$20K-$25K	0.9	0.7
$25K-$50K	0.7	0.6

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Uninsurance Rates, 2003

- By age
  - 18-34 25%
  - 35-54 15%
  - 55-64 11%
- By labor income
  - <$20K 34%
  - $20K - $40K 17%
  - >$40K 6%
- Poverty status
  - <100% FPL 50%
  - 100-200% FPL 41%
  - 200-300% FPL 22%
  - 300-400% FPL 13%
  - >400% FPL 6%
- By work status
  - Full time/full year 15%
  - Full time/part year 29%
  - Part time/full year 23%
  - Part time/part year 24%

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Why is it not insurance?

-
-
-

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Poor health habits

- Definitely true – the poor have worse health habits than the rich
- Poor have
  - Higher smoking, lower exercise, higher obesity, higher fat diets, eat less fiber, higher cholesterol levels, etc.
- Once you control for poor health habits, does not dampen the income/health relationship much

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Reverse causation

- Could also be the case that poor health impacts income
- Health shocks reduce ability to work, lowering income
- Therefore, much of the observed relationship could be due to reverse causation.

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Table 3

Economic Effects of New Health Onset

	Wealth	*OOP Expenses*	*Total Medical Expenses*
HRS			
Mild onset	−3,620	635	2,555
Severe onset	−16,846	2,266	28,963
AHEAD			
Any onset	−10,481	1,026	NA
HRS severe onset only			
With health insurance	−17,417	1,912	26,957
Without health insurance	−17,282	4,576	42,166
HRS severe onset only			
Below median income	−11,348	2,439	29,829
Above median income	−25,371	2,014	28,085
AHEAD any onset			
Below median income	−4,427	915	NA
Above median income	−17,040	1,101	NA

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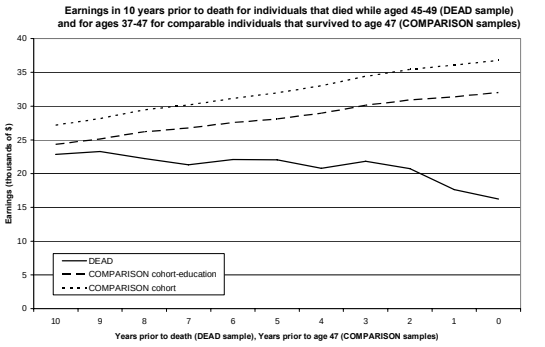

Note: the COMPARISON samples were constructed computing average annual earnings for ages 37 to 47, for individuals that survived up to age 47. In the COMPARISON cohort sample, individuals were weighted in order to match the distribution by cohort in the DEAD sample. In the COMPARISON cohort-education sample, individuals were weighted to match the distribution by cohort and education in the DEAD sample.

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Evidence against reverse causation story

- Can look at mortality rates and control for income and education
- If the primary driver of income/health relationship are poor health shocks (people get sick and cannot work), we should see the income/health relationship diminish over time
  - Poor health shocks are mostly temporary, so the relationship should diminish over time as we follow people

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- Double income, mortality increases by
  - 27% in one year
  - 25% in 2 years
  - 25% 3-5 years
  - 17% in 5-9 years

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Why might education be causal?

- Educated may better understand the production of health
  - That exercise is good, smoking is bad, high fiber is good
  - Everyone knows smoking is bad for you, yet low educated still smoke at very high rates
- Educated may also better able to invest in health

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- Patience is an important characteristic for predicting future income
  - Patience=high discount rate
  - A patient person will invest now for return in the future
  - The inpatient will not
  - Without investments in skill, wages will be low
- The same can be said for in health
- Patient may invest more in health
- Maybe education is simply picking up patience

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Paradox

- At the individual level, income appears to be 'protective'
  - Those with higher incomes have lower mortality
- At the country level, once income passes a certain threshold, appears to be little benefit to more income
- Why?

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- How might there be a reverse causation between health and income? Might it be the case that poor health reduces income?
- What psycho-social factors does Marmot argue explain the income/health relationship?

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Two facts

- Within country, strong relationship between income/health, education/health
  - True at all levels of income
  - Even when income is at a high level, mortality falls with higher incomes
- Between countries, once income crosses certain threshold, little relationship
  - Marmot places that number at $50K
  - Look at Graph, somewhere around $30K/capita
- What can explain these facts?

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Whitehall study

- Longitudinal data of British civil servants
  - High income, stable employment, good neighborhoods, universal health insurance
- Even in this incredibly homogenous, well to do group, relative standing matters
- Mortality is correlated with employment grade

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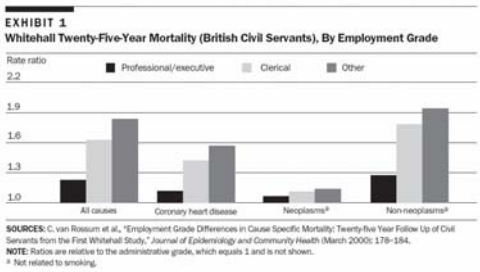

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What might explain this relationship?

- Social standing matters – that is – relative position within a community
- Why?
  - Stress of being left behind, not keeping up with the Jones, not being in control of your destiny
  - Maybe take comfort in cigarettes, alcohol, dish of ice cream
- Income is a measure of social standing. No picking up causal impact of income, but rather, social standing

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This may explain cross-country/within country results

- Within a country, income is measuring relative social standing
- We should expect to see a strong + relationship between income and health
- However when comparing across countries income means little since people in US compare themselves to people in the US, people in Korea use Koreans as their frame of reference

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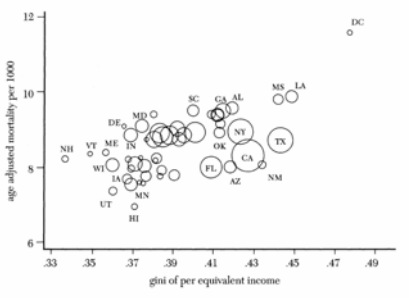

Figure 6. Income Inequality and Age-Adjusted Mortality, U.S. States, 1990

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Example

- Suppose all income in a country is increased by 10% over a 10 year period
- If income is causal, then mortality for all people should fall
- Suppose relative standing matters
- Then there should be little change in mortality since relative ranking has not changed

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Table 1. Baseline Characteristics*

Characteristic	Winners (n = 235)	Nominees (n = 527)	Controls (n = 887)
	← % →		
Birth year			
Before 1900	14	15	17
1900–1919	33	18	28
1920–1939	28	34	30
1940–1959	19	24	19
1960–1979	6	8	6
1980–1999	0	0	0
Male sex	50	51	56
White ethnicity	97	96	97
Birth in the United States	69	69	74
Change in birth name	29	23	9
Age at making of first film			
<10 y	2	3	2
10–19 y	15	18	11
20–29 y	51	50	45
30–39 y	26	21	29
40–49 y	5	6	8
≥50 y	1	2	4

* Data may not add to 100% because of rounding.

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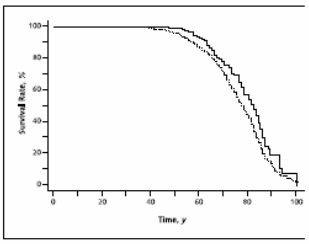
Figure. Survival in Academy Award–winning actors and actresses (*solid line*) and controls (performers who were never nominated) (*dotted line*), plotted by using the Kaplan–Meier technique.



Analysis is based on log-rank test comparing 235 winners (99 deaths) with 887 controls (452 deaths). The total numbers of performers available for analysis were 1122 at 0 years, 1056 at 40 years, 762 at 60 years, and 240 at 80 years. $P = 0.003$ for winners vs. controls.

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Table 3. Analysis of Death Rates

Analysis	Relative Reduction in Mortality Rate (95% CI), %*
Winners compared with controls	
Basic analysis	28 (10–42)
Adjusted for birth year	27 (9–41)
Adjusted for sex	27 (10–42)
Adjusted for ethnicity	27 (10–42)
Adjusted for all 3 demographic factors	26 (8–40)
Adjusted for birth country	27 (10–42)
Adjusted for possible name change	27 (8–41)
Adjusted for age at first film	26 (7–40)
Adjusted for total films in career	27 (9–42)
Adjusted for all 4 professional factors	25 (5–40)
Adjusted for all 7 factors	23 (2–38)
Winners compared with nominees	
Basic analysis	25 (5–41)
Adjusted for birth year	24 (4–40)
Adjusted for sex	27 (7–42)
Adjusted for ethnicity	25 (5–41)
Adjusted for all 3 demographic factors	26 (6–42)
Adjusted for birth country	26 (6–41)
Adjusted for possible name change	26 (6–42)
Adjusted for age at first film	25 (5–41)
Adjusted for total films in career	23 (2–39)
Adjusted for all 4 professional factors	24 (3–40)
Adjusted for all 7 factors	22 (0–38)

* Proportional hazards analysis.

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