The Production of Health from a Historical Perspective

ECON 43565

Bill Evans

Fall 2018

1

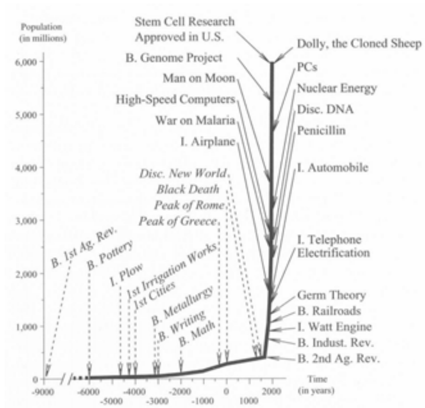


Figure 2.1 The Growth of World Population and Some Major Events in the History of Technology.

2

Population over time

- Surprisingly stable population over long period of history
- As we will see in a moment – driven by stable mortality rates
- World population
  - Time of Christ, 300 million
  - Vikings, 1000 years later, about the same
  - 1700, 600 million
  - Today, 6 billion

3

- Pop(t) = population in year t
- Deaths(t), Births(t) similarly defined

- Dynamics for world
- Pop(t+1) = Pop(t) + births(t) – deaths(t)

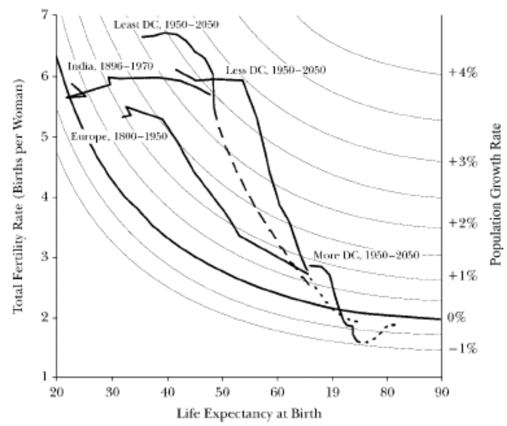
- Dynamics for country
- Pop(t+1) = Pop(t) + births(t) – deaths(t) + netMig(t)

4

Demographic transition

- As industrialization takes hold, countries move from a high death/birth era to one of lower birth/death rates
- Birth rates/death rates move in unison

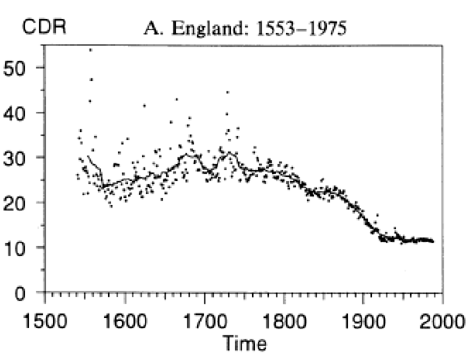
5



6

- Pop(t+1) = Pop(t) + births(t) – deaths(t)
- The rise in population must be driven by a reduction in mortality rates
- Historically, death rates did not decline much until the end of the late 19th century
- What drove the big decline in death rates?

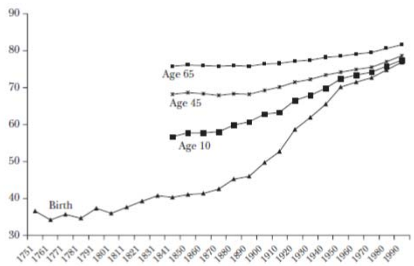
7



Crude death rate: deaths per 1000 people

8

Figure 2
Expected Age at Death, England and Wales



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.

9

McKeown

- Why the rapid increase in population (decline in mortality) in England/Wales?
- Key fact – most of the decline was due to a reduction in deaths from infectious diseases
  - 74% are attributable to microorganisms

10

Table 3.2 Reduction in Mortality England/Wales 1850-1971

Conditions attributable:	Percent of reduction
Airborne diseases	40%
Water/food borne diseases	21%
Other micro organisms	
Conditions not attributable to micro-organisms	13%
	26%

11

TABLE 3.3. *Standardized death-rates (per million) from airborne diseases: England and Wales*

	1848–54	1971	Percentage of reduction from all causes attributable to each disease
Tuberculosis (respiratory)	2,901	13	17.5
Bronchitis, pneumonia, influenza	2,239	603	9.9
Whooping cough	423	1	2.6
Measles	342	0	2.1
Scarlet fever and diphtheria	1,016	0	6.2
Smallpox	263	0	1.6
Infections of ear, pharynx, larynx	75	2	0.4
Total	7,259	619	40.3

36 *Determinants of Health*

TABLE 3.4. *Standardized death-rates (per million) from water- and food-borne diseases: England and Wales*

	1848–54	1971	Percentage of reduction from all causes attributable to each disease
Cholera, diarrhoea, dysentery	1,819	33	10.8
Tuberculosis (non-respiratory)	753	2	4.6
Typhoid, typhus	990	0	6.0
Total	3,562	35	21.4

12

- Why are people dying from infectious diseases at lower rates?
- McKeown suggests it is:
  - NOT medical care
  - NOT public health
- Question to consider: What evidence does McKeown to argue against public health as the driver??

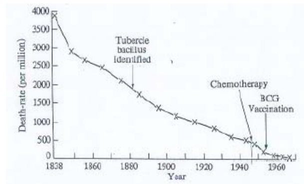


FIGURE 8.1. Respiratory tuberculosis: mean annual death-rates (standardized to 1901 population): England and Wales.

FIGURE 8.12. Whooping cough: death rates of children under 15: England and Wales.

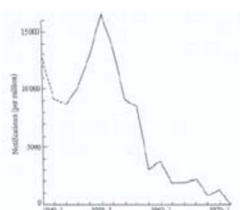


FIGURE 8.13. Whooping cough: mean annual notification rates of children under 15: England and Wales.

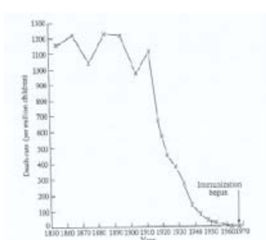


FIGURE 8.14. Measles: death rates of children under 15: England and Wales.

McKeown's argument

- What explains the decline in mortality?
- Decline in virulence of infection
- Why? Agricultural revolution
  - Limited food supply produced 'small' humans
  - People w/ small stature cannot ward off infection
  - The growth in agriculture productivity allows humans to grow and be healthier
- Evidence in McKeown?

Deaths due to infection

- Expected Deaths = P x E x I x D

- P = Population
- E = Number of times exposed to organism
- I = Probability of infection given exposure
- D = Probability of death given infection

17

Fogel

- Nobel prize winning economist from Chicago
- Wrote famous book on slavery w/ Engerman "Time on the Cross"
- Took McKeown's idea to heart and provided critical data

18

- At end of the 18th century, average height of adult in England/France was 5'4"
- Not much change throughout Europe until last half 19th century
- Height improved because of diet
- Height is an excellent predictor of disease incidence/mortality

19

TABLE 1—ESTIMATED AVERAGE FINAL HEIGHTS OF MEN WHO REACHED MATURITY BETWEEN 1750 AND 1875 IN SIX EUROPEAN POPULATIONS, BY QUARTER CENTURIES

Row	Date of maturity by century and quarter	Height (cm) Great Britain	Norway	Sweden	France	Denmark	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	168.6	169.5	165.6	165.3	—
6	20-III	175.0	178.3	177.6	172.0	176.0	170.9

Sources: Fogel (1987 table 7) for all countries except France. For France, rows 3–5 were computed from M. A. von Meerton (1989) as amended by Weir (1993), with 0.9 cm added to allow for additional growth between age 20 and maturity (Benjamin A. Gould, 1869 pp. 104–5) (cf. Gerald C. Friedman, 1982 p. 510 [footnote 14]). The entry to row 2 is derived from a linear extrapolation of Meerton's data for 1815–1836 back to 1788, with 0.9 cm added for additional growth between age 20 and maturity. The entry in row 6 is from Fogel (1987 table 7).

165 cm = 65 inches (5'5")
175 cm = 69 inches (5'9")

20

Calories available for work

- Basal metabolic rate
  - Calories necessary to keep vital organs working
  - 4/5ths of minimum calories
  - Function of body size
- Calories necessary to consume/digest food
  - 1/5th of minimum necessary
- Amount above these limits, calories available for work
- 1800-2600 calories available for work today in US
- In 1700 England, 1/3 to ¼ of the calories that are available today

21

Table 1.2 Secular Trends in the Daily Caloric Supply in France and Great Britain, 1700–1989 (calories per capita)

Year	*France*	*Great Britain*
1700		2,095
1705	1,657	
1750		2,168
1785	1,848	
1800		2,237
1803–12	1,846	
1845–54	2,480	
1850		2,362
1909–13		2,857
1935–39	2,975	
1954–55	2,783	3,231
1961		3,170
1965	3,355	3,304
1989	3,465	3,149

Source: Fogel, Floud, and Harris, n.d.

22

Table 1.3 A Comparison of Energy Available for Work Daily per Consuming Unit in France, England and Wales, and the United States, 1700–1994 (in kcal)

Year	(1) *France*	(2) *England and Wales*	(3) *United States*
1700		720	2,313[a]
1705	439		
1750		812	
1785	600		
1800		858	
1840			1,810
1850		1,014	
1870	1,671		
1880			2,709
1944			2,282
1975	2,136		
1980		1,793	
1994			2,620

[a] Prerevolutionary Virginia.

23

Interesting facts

- Caloric intake in early 18th century France similar to 1965 Rwanda, the most malnourished country on the planet at that time
- During 18th century England, 50-75% of income went to food
- Caloric consumption in 1885 England similar to modern day India

24

What is BMI?

- Body mass index
- weight in kg/Height in meters squared
  - BMI < 20 underweight
  - BMI > 25 overweight
  - BMI > 30 obese
- To calculate BMI w/ inches/pounds
  - 703*pounds/inches squared
  - 5’9” and 165 pounds, BMI of 24.3

25

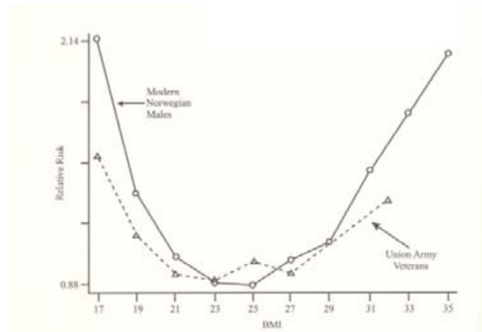


Figure 2.3 Comparison of Relative Mortality Risk by BMI among Men 50 Years of Age, Union Army Veterans around 1900 and Modern Norwegians.

Relative risk defined on next page

26

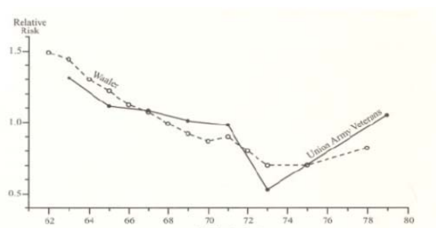
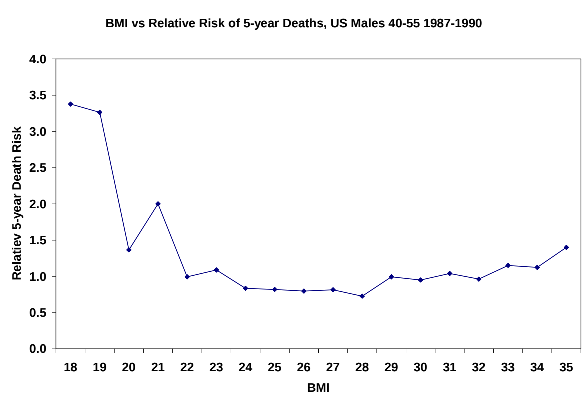


Figure 2.2 Relative Mortality Risk among Union Army Veterans and among Modern Norwegian Males.

Note: A relative risk of 1.0 means that the risk at that height was equal to the average risk of death in the entire population of males of the specified ages. Also note that the tallest data point, in both the Norwegian and Union Army cases, is not statistically significant.

27



28

- Look at the next two graphs, and consider the following questions:
- What trends in the graphs are ‘good’ for Fogel’s story
- What trends in the graphs are not so good for his hypothesis.

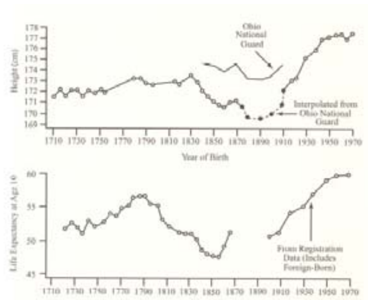


Figure 1.2 Trend in Mean Final Height of Native-Born White American Males and Trend in Their Life Expectancy at Age 10.

Slight problem for Fogel Theory

- Bones of exhumed remains can identify height
- Linear relationship between length of femur and height
- Need to know sex of skeleton

Whites: Height = 61.61 + 2.38 FL, N = 710, SEE = 3.27
Blacks: Height = 70.35 + 2.11 FL, N = 80, SEE = 3.94,

- Need to know that the person stopped growing, identified by the fusion of certain bones
- Femur makes up ¼ of adult height – more in taller people
- U-shaped pattern over time, low point 1450-1750

33

Table 1 Average heights in northern Europe estimated from adult male skeletons

Era	Place	Average height (cm)	Sample size	Source
9–11th centuries	Iceland	172.3	22	Steffensen 1958
9–17th centuries	Iceland	172.2	71	Steffensen 1958
10–11th centuries	Sweden	176.0	8	Gilberg 1976
11–12th centuries	Iceland	172.0	27	Steffensen 1958
11–17th centuries	Iceland	171.0	16	Steffensen 1958
12th century	Norway	170.2	42	Hanson 1992
12th century	Britain	168.4	233	Munter 1928
12–13th centuries	Norway	172.2	*	Huber 1968
12–16th centuries	Iceland	175.2	6	Steffensen 1958
13th century	Denmark	172.2	31	Boldsen 1984
13th century	Sweden	174.3	66	Gejvall 1960
13–14th centuries	England	171.8	*	Huber 1968
Middle Ages	Sweden	170.4	457	Steffensen 1958
Middle Ages	Denmark	172.0	190	Bennike 1985
Middle Ages	Denmark	172.6	43	Bennike 1985
Middle Ages	Norway	172.1	314	Holck and Kvaal 2000
Middle Ages	Denmark	175.2	27	Holck 1997
Middle Ages	Norway	167.2	1,792	Holck 1997
Middle Ages	Sweden	170.4	457	Werdelin 1985

34

13–16th centuries	Holland	172.5	87	Maat et al. 1998
11–16th centuries	Holland	176.2	23	Janssen and Maat 1999
11–16th centuries	Sweden	172.8[a]	499	Arcini 1999
17–18th centuries	Iceland	169.7	17	Steffensen 1958
17–18th centuries	Holland	166.0	41	Maat 1984
17–18th centuries	Holland	166.7[b]	102	Maat 1984
18th century	Iceland	167.0	4	Steffensen 1958
18th century	Norway	165.3	1,956	Holck 1997
17–19th centuries	Iceland	169.2	21	Steffensen 1958
18–19th centuries	Britain	170.3	211	Molleson and Cox 1993

35

Why health gains during middle ages?

- Favorable weather…increases crop yields
  - Temps 2^{o} C warmer 900-1300
  - Extend growing season by 3-4 weeks/year
- Little exposure to infectious/communicable diseases
  - Smaller cities (London had <40K people)
  - Little trade between countries to spread disease
- These trends change after 1200
  - little ice age
  - Increase urbanization

36

What about the role of public health?

- McKeown dismissed the importance of public health
  - Time period when there has been a big movement from more rural to urban population
  - Infections should have been more prevalent due to close proximity in people (TB etc)
- Most persistent criticism of McKeown, he understates value of public health
  - Sanitation
  - Water supply

37

Cutler and Miller

- Consider the role of public health via clean water and sanitation at turn of century
- Tell very different story – large role for public health campaigns
  - Effective at reducing infectious diseases
  - High rate of return

38

Table 1. Percentage of Deaths, by Cause, in Major Cities

Cause of Death	1900	1936
Major Infectious Diseases	39.3	17.9
Tuberculosis	11.1	5.3
Pneumonia	9.6	9.3
Diarrhea and enteritis	7.0	N/A
Typhoid fever	2.4	0.1
Meningitis	2.4	0.3
Malaria	1.2	0.1
Smallpox	0.7	0.0
Influenza	0.7	1.3
Childhood Infectious Diseases	4.2	0.5
Measles	0.7	0.0
Scarlet fever	0.5	0.1
Whooping cough	0.6	0.2
Diphtheria and croup	2.3	0.1

Note: All percentages are shares of total mortality.

Source: U.S. Census Bureau's Mortality Statistics, 1900 and 1936.

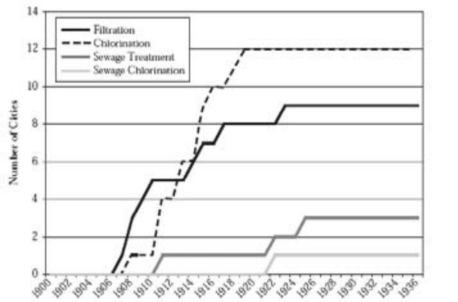
39

Numbers for 2010

- Total deaths = 2,468,435 (100%)
- Tuberculosis (569) (0.02%)
- Pneumonia 49,597 (2%)
- Influenza 500 (.02%)
- AIDS 8,369 (0.3%)
- Malaria (10)
- Scarlet fever (3)
- Whooping cough (26)

40

Figure 1. Cumulative Number of Sample Cities That Adopted Technologies, 1900 to 1936



41

Table 2. The Evolution of Total, Infant, Child, and Typhoid Fever Mortality (Deaths per 1,000) in Major Cities, 1900–1936

	1900		1920		1936	
Mortality	Mean	*SD*	Mean	*SD*	Mean	*SD*
Total Mortality	1,935	316	1,492	222	1,354	287
Infant Mortality	18,931	2,921	11,953	1,752	7,130	2,435
Child Mortality	2,818	1,360	1,260	167	522	267
Typhoid Fever Mortality	47	33	4	2	2	2

Source: U.S. Census Bureau's Mortality Statistics, 1900, 1920, and 1936.

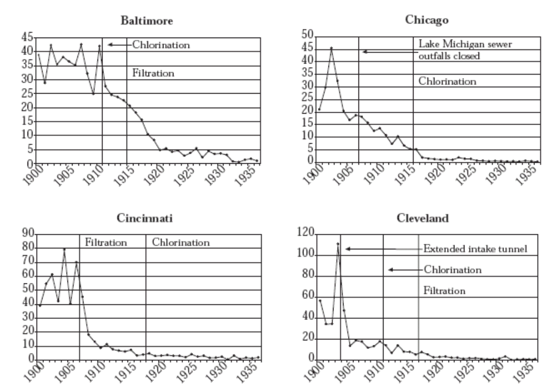
42

Table 3. Clean Water Intervention Dates

Cities	Water Filtration	Water Chlorination	Sewage Treatment	Sewage Chlorination
Baltimore, MD	1914	1911	1911	>1936
Chicago, IL	>1940	1916	1949	>1949
Cincinatti, OH	1907	1918	>1945	>1945
Cleveland, OH	1917	1911	1922	1922
Detroit, MI	1923	1913	1940	1940
Jersey City, NJ	1978	1908	>1945	>1945
Louisville, KY	1910	1915	1958	>1958
Memphis, TN	>1936	>1936	>1936	>1936
Milwaukee, WI	1939	1915	1925	1971
New Orleans, LA	1909	1915	>1945	>1945
Philadelphia, PA	1908	1913	>1945	>1945
Pittsburgh, PA	1908	1911	>1945	>1945
St. Louis, MO	1915	1919	>1945	>1945

Source: Water system censuses published in the *Journal of the American Water Works Association* (1924, 1932) and *Water Works Engineering* (1943); various articles appearing in *American City, Engineering News, Journal of the American Water Works Association,* and *Water Works Engineering* (available on request).

Figure 2. Typhoid Fever Trends (Mortality per 100,000) and Sanitary Interventions, 1900–1936



Model

$$\ln(m_{ct}) = \beta_0 + x_{ct}\beta_1 + Filter_{ct}\beta_2 + Chlor_{ct}\beta_3 + \mu_c + v_t + \varepsilon_{ct}$$

$m_{ct} = mortality\ rate\ (deaths/100{,}000)\ city\ c,\ year\ t$

$x_{ct} = other\ controls$

$Filter_{ct} = 1\ if\ city\ c\ has\ filtration\ in\ year\ t,\ 0\ otherwise$

$Chlor_{ct} = 1\ if\ city\ c\ has\ chlorination\ in\ year\ t,\ 0\ otherwise$

$\mu_c = city\ fixed\ effects$

$v_t = time\ fixed\ effects$

45

Public Health Improvements and Health Advances 13

Table 5. Effect of Clean Water Technologies on Mortality

	Dependent Variable (ln transformation)			
	Typhoid Mortality Rate	Total Mortality Rate	Infant Mortality Rate	Child Mortality Rate
Filter	–0.46*	–0.16**	–0.43**	–0.46**
	(0.23)	(0.04)	(0.09)	(0.11)
Chlorinate	–0.11	–0.02	–0.08	–0.07
	(0.16)	(0.03)	(0.08)	(0.10)
Chlorinate × Filter	0.32*	0.05*	0.06	0.03
	(0.14)	(0.02)	(0.07)	(0.09)
ln(Population)	–0.19	–0.86**	2.78**	1.69*
	(1.49)	(0.23)	(0.66)	(0.77)

46

Measure of financial effectiveness

- Benefits of a program: measured in lives
- Costs: measured in dollars
- How does one compare outcomes across projects?
- Cost/life saved
- Hold denominator constant, lower values mean larger bang per buck

47

Public Health Improvements and Health Advances 19

Table 10. Social Rates of Return

	Point Estimate	95% CI Low	95% CI High
% Mortality Reduction Due to Clean Water	0.1326	0.0373	0.2280
1915 Mortality Reduction per 100,000 Population	208	58	357
1915 Deaths Averted	1,484	418	2,551
1915 Person-Years Saved	57,922	16,301	99,543
1915 Annual Benefits in Millions of 2003 Dollars	679	191	1,167
1915 Annual Costs in Millions of 2003 Dollars	29		
Social Rate of Return	23:1	7:1	40:1
Cost per Person-Year Saved in 2003 Dollars	500	1,775	291

48

Tengs et al. (1995)

- Review of 587 "cost per life year saved" estimates
- Median was about $80K
- Subgroup medians
  - Medical, $38K
  - Injury prevention $96K
  - Toxin control, $5.6 million

49

Example cost per life year saved

• Smoke detectors	$60K
• Pneumonia vaccine	$28K
• ARVs for HIV	$50K
• CABG	$250K
• Child restraints	$1.5 Million
• State NOx rules	$8.3 million
• Methylene chloride	$12.7 million
• Benzene control	$40 billion

50