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SCHOOL of PUBLIC HEALTH

Mortality

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Objectives of the Lecture

- At the end of listening to this lecture and reading the accompanying book chapter, students should be able to:
  - Identify basic measures of mortality
  - Describe how the age, sex, and cause structure of mortality shifts with overall mortality level
  - Distinguish among Horiuchi's different mortality transitions
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Section A

Measures of Mortality

Crude Death Rate (CDR)

$$\frac{\text{Deaths during year } t}{\text{Mid-year population during year } t}$$

Crude Death Rate (CDR)

- Mortality as a component of population growth
- Heavily influenced by the age structure—cannot compare across populations

Age-Specific Death Rates (ASDRs)

- Death rates for specific ages

$$\frac{\text{Number of deaths at age } x}{\text{Population aged } x}$$

The Life Table

- A way of summarizing ASDRs that is totally unaffected by the age distribution and therefore comparable across population
- Most widely known and used of these life table quantities is *The Expectation of Life at Birth* (or any other age)

Standardization for Comparison of CDRs

- Direct standardization
  - If you have age-specific death rates for the population of interest, you can apply them to the age structure of a "standard" population and calculate an age-adjusted death rate for the given population that may be compared to the standard and any other age-standardized death rate oriented to the same standard
  - Can standardize several populations to the same standard and compare them to each other
  - Weighted by the age structure of the standard population

Standardization for Comparison of CDRs

- Indirect standardization
  - If you have the age distribution of the given population and the total number of deaths in the given population, you can calculate an age-adjusted death rate for the given population that may be compared to the standard population
  - Cannot compare indirectly age-adjusted populations to each other
  - Weighted by the age structure of the given population

Standardization for Comparison

- Warning: direct and indirect methods of standardization give different results because in each case a different set of weights is being used
- Very dependent on selection of the standard

Example of Standardization

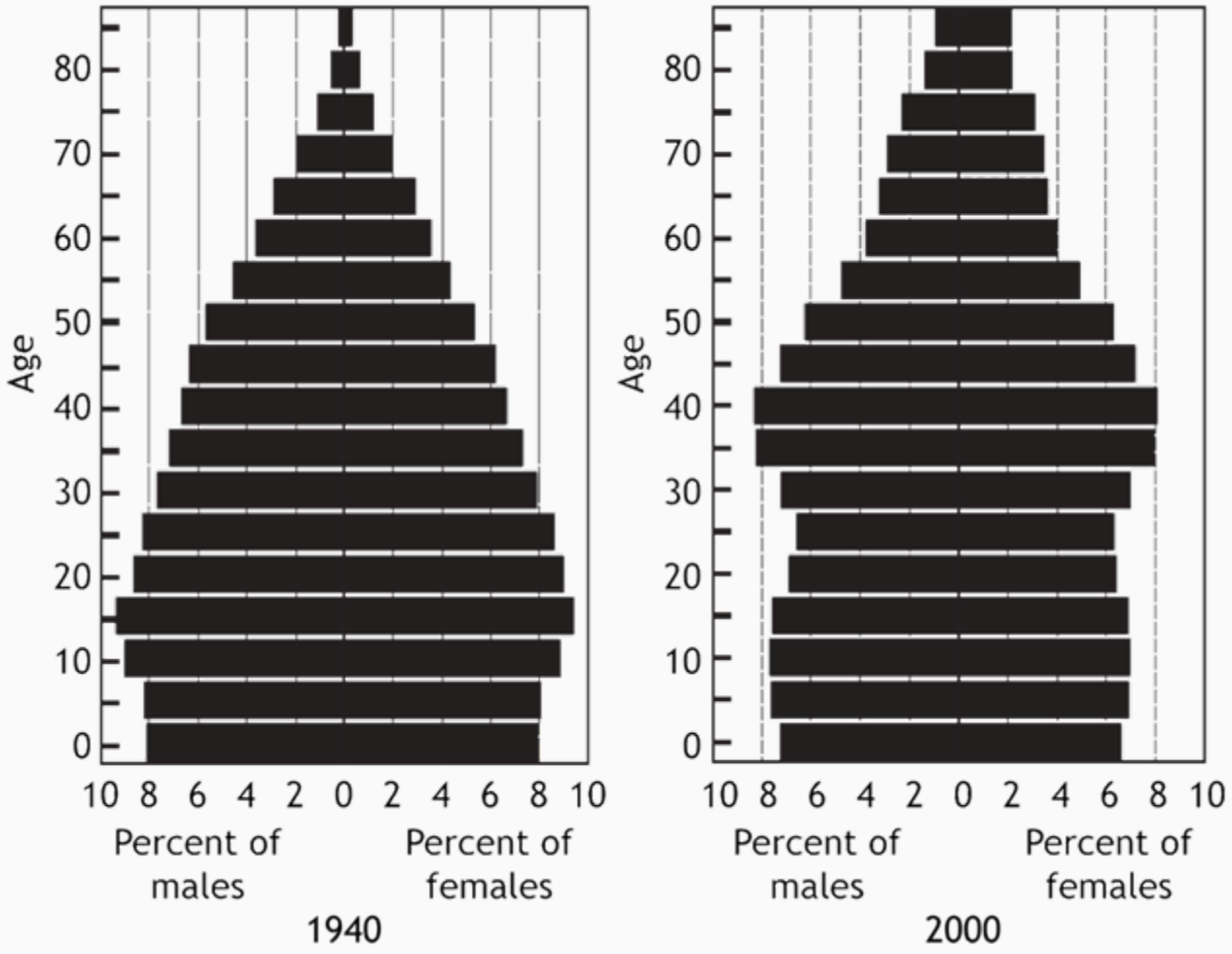
	CDR	Direct (U.S.)	Indirect (U.S.)
U.S. 1960	9.5	—	—
Japan 1960	7.6	11.0	10.9
El Salvador 1960	11.3	13.2	20.1
Chile 1960	12.9	15.8	20.5
Taiwan 1960	6.9	13.2	14.6

Example of Controversy over Standardization

- In 2000, the National Center for Health Statistics (a branch of the Centers for Disease Control) changed the standard population that the Center uses to age-adjust U.S. death rates from the 1940 to the 2000 population

How the Age Structure of the U.S. Had Changed

- You can see why, when you observe how much the age structure of the U.S. had changed



Source: Anderson, R. N., and Rosenberg, H. M. (1998). Age standardization of death rates: implementation of the year 2000 standard. *Natl Vital Rep, 47,* 3, p. 4. Public Domain.

Changed the Estimates of Health Disparities Somewhat

- Age-specific and age-adjusted death rates by race: United States, 1995

Rate	White death rate	Black death rate	Ratio
Age-adjusted rates			
1940 standard	476.9	765.7	1.6
2000 standard	890.0	1,224.5	1.4
Age-specific rates			
0–24 years	73.0	149.1	2.0
25–64 years	365.4	691.1	1.9
65 years and over	5,049.3	5,679.2	1.1

Age-adjusted death rates are per 100,000 standard population. Age-specific rates are per 100,000 population in specified age group.

Source: Anderson, R. N., and Rosenberg, H. M. (1998). Age standardization of death rates: implementation of the year 2000 standard. *Natl Vital Rep, 47,* 3, p. 10.

Very Controversial at the Time

- There was a great deal of fear that careless comparison of mortality rates (and other health indicators) over time, without close attention to the standard population that was used, would provide empirical support for claims that health disparities were narrowing
- See, for example:
  - Krieger, Nancy, and Williams, David R. (2001). Changing to the 2000 standard million: are declining racial/ethnic and socioeconomic inequalities in health real progress or statistical illusion? *American Journal of Public Health, 91,* 8, 1209–1213.

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Section B

How Does Mortality Vary by Age and Sex, and How Have Age and Sex Differences Changed as Mortality Has Declined over Historical Time?

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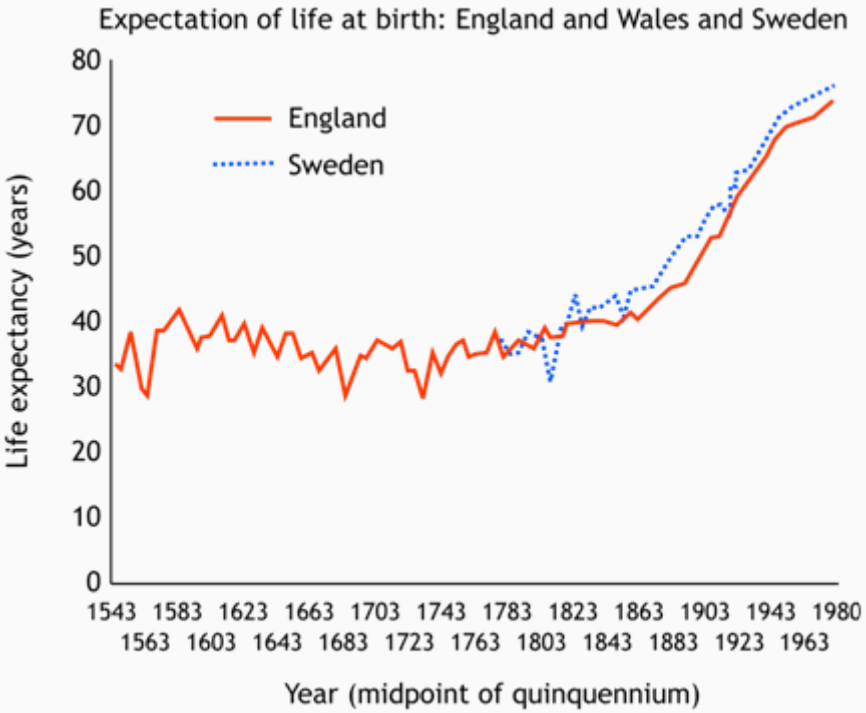
Long Haul of Human Mortality

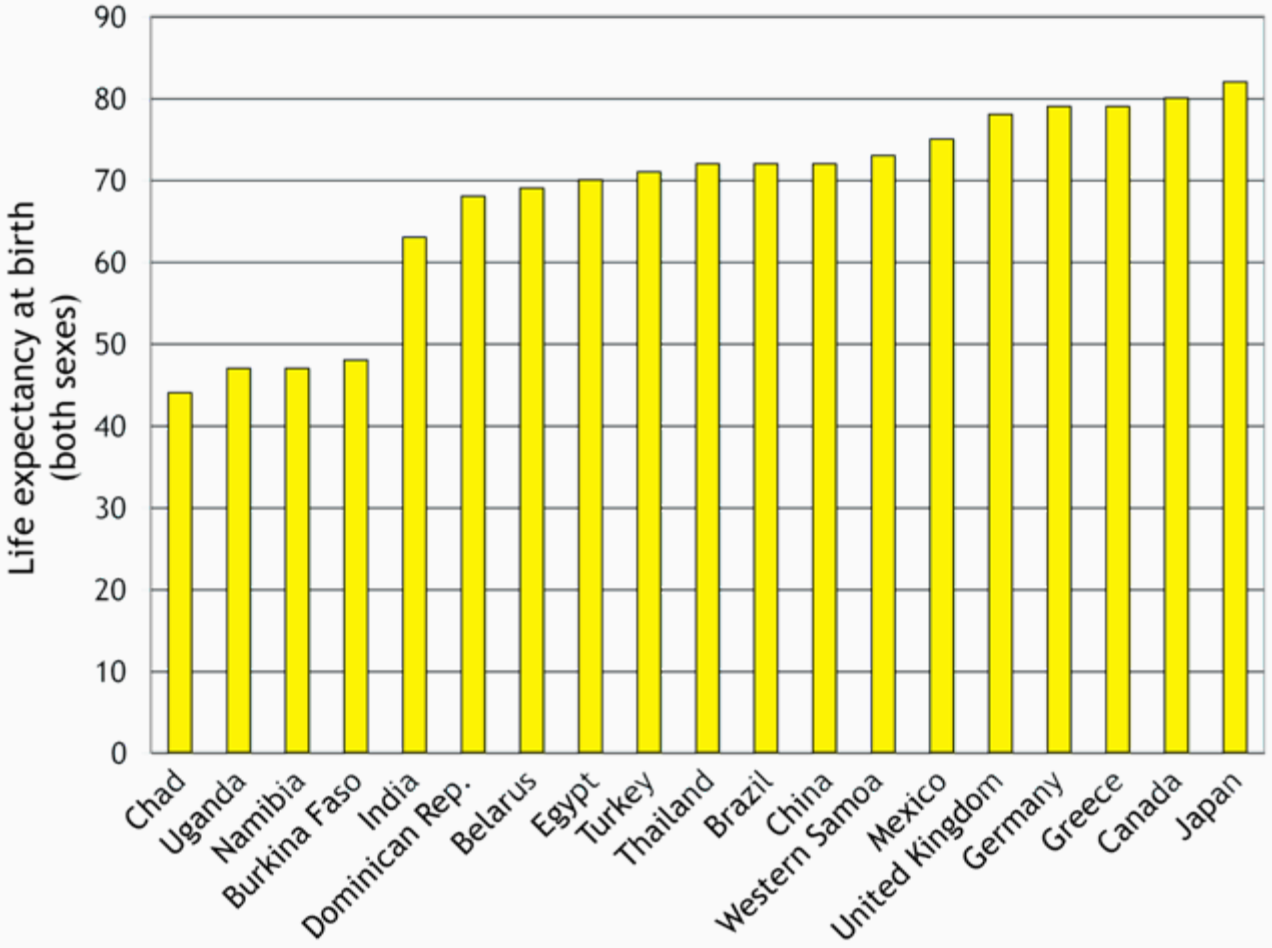
- In Western Europe, averaged between 30 and 40 years until mid-19th century
- Since 1850, there has been a sharp and sustained increase
- There has been a steady decline in overall mortality all over the world over the course of the 20th century, especially in the latter half of the century



Source: Preston, Samuel H. (1995). Human mortality throughout history and prehistory. In Julian L. Simon (Ed.), *The state of humanity* (pp. 30–36). Cambridge, Massachusetts: Blackwell.

High Levels of Variation Persist

- Despite the widespread increase in life expectancy, very high levels of variation persist

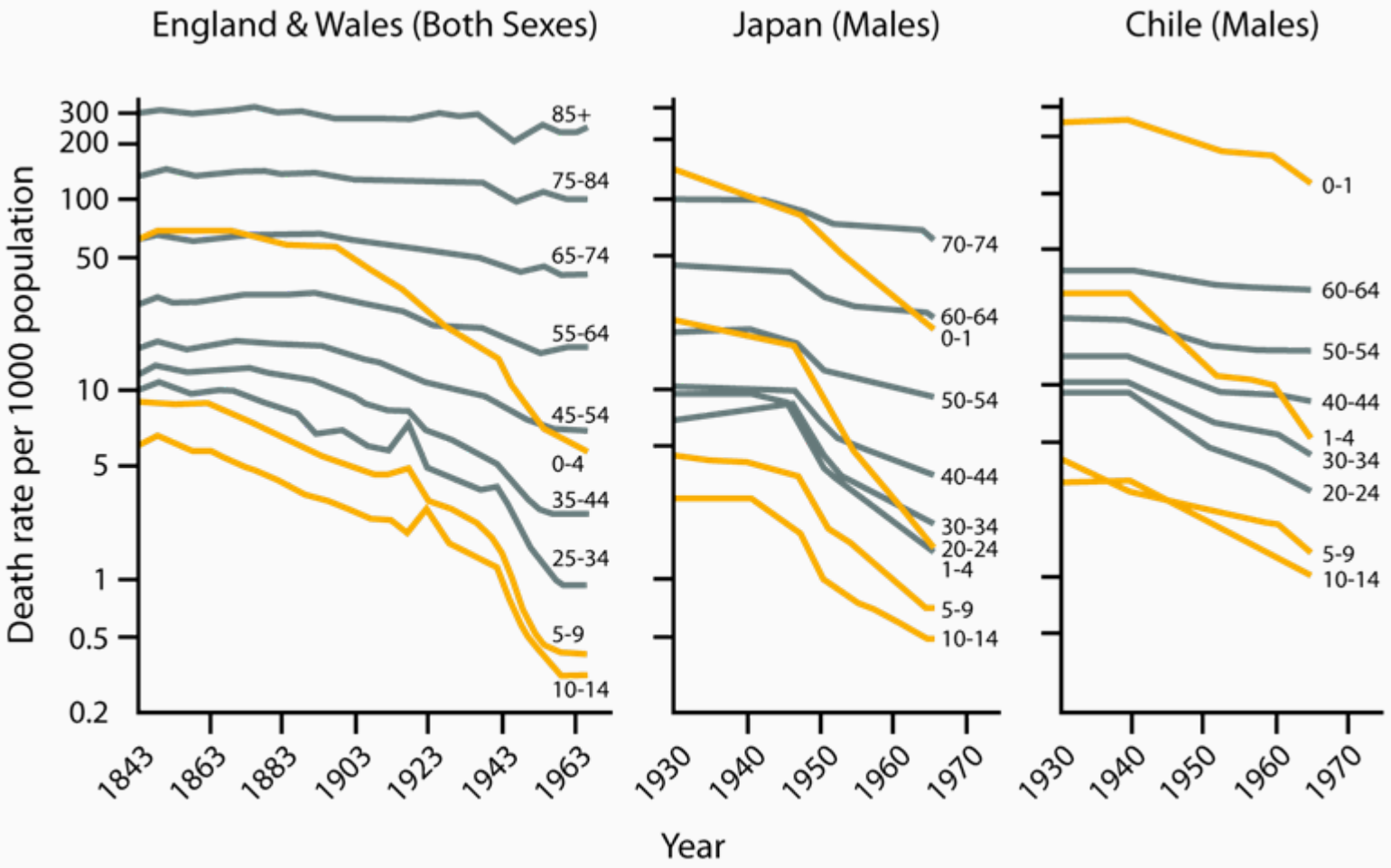


Trends in Age-Specific Death Rates

- In almost all cases, death rates from 5 to 14 are very low, and this does not change with declining mortality
- As overall mortality goes down, the most dramatic changes occur among infants and young children (1–4)

Source: Omran, Abdel R. (1971). The epidemiological transition: A theory of the epidemiology of population change. *The Millbank Memorial Fund Quarterly, 49,* 4, 509–538.

Trends in Age-Specific Death Rates



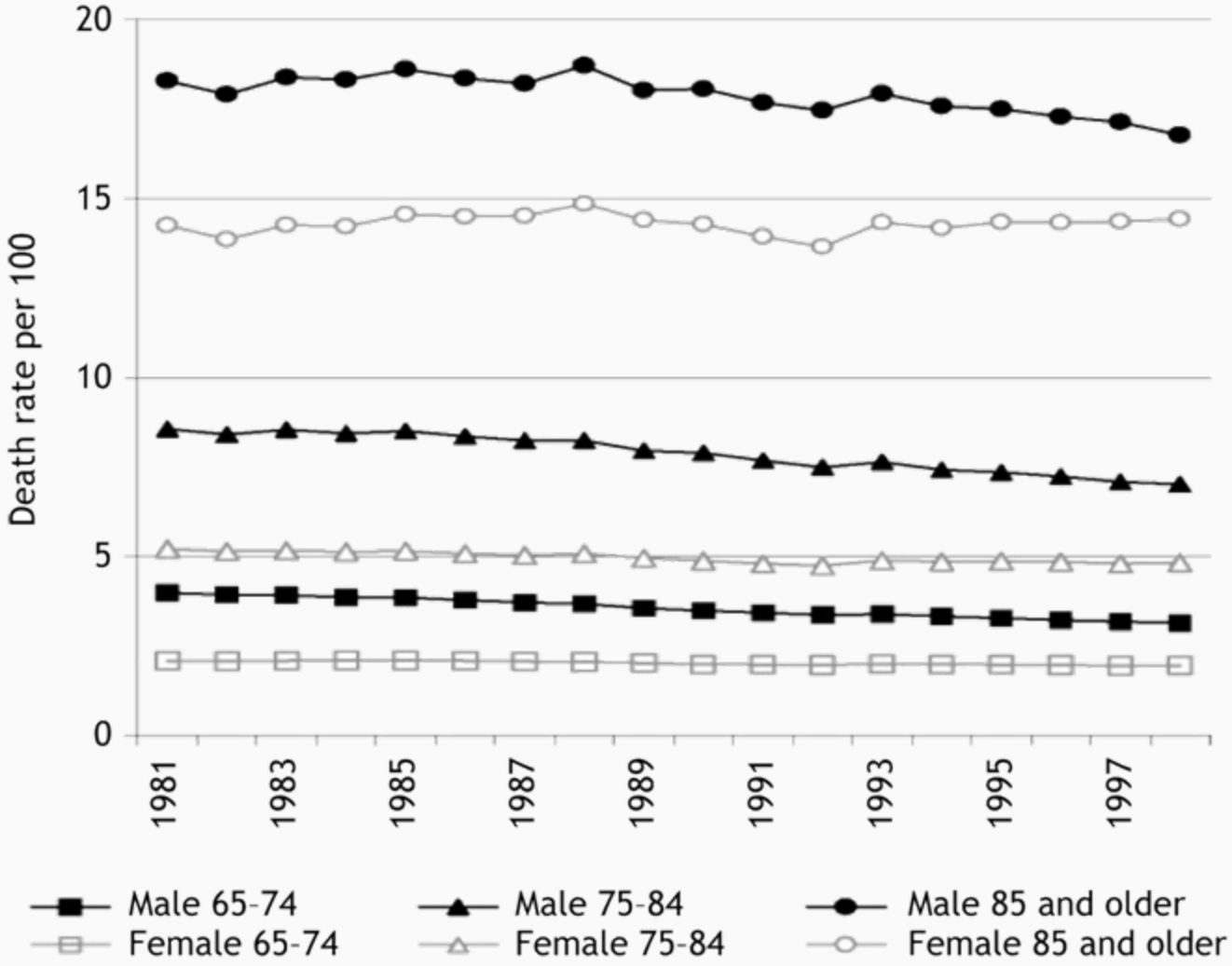
Adapted by CTLT from Omran, Abdel R. (1971). The epidemiological transition: A theory of the epidemiology of population change. The Millbank Menorial Fund Quarterly, 49, 4, p. 523.

CTLT

Trends in Age-Specific Death Rates among U.S. Elderly

- During the 20th century, mortality among the elderly declined in fits and starts
  - Period from 1954 to 1968—very slowly
  - Period from 1968 to early 1980s—fast
    - This was also a period of decline in reports of health among the elderly
- Last two decades have been mixed
  - Men, steady decline
  - Women, stable

Death Rates, All Causes, 1981–1998

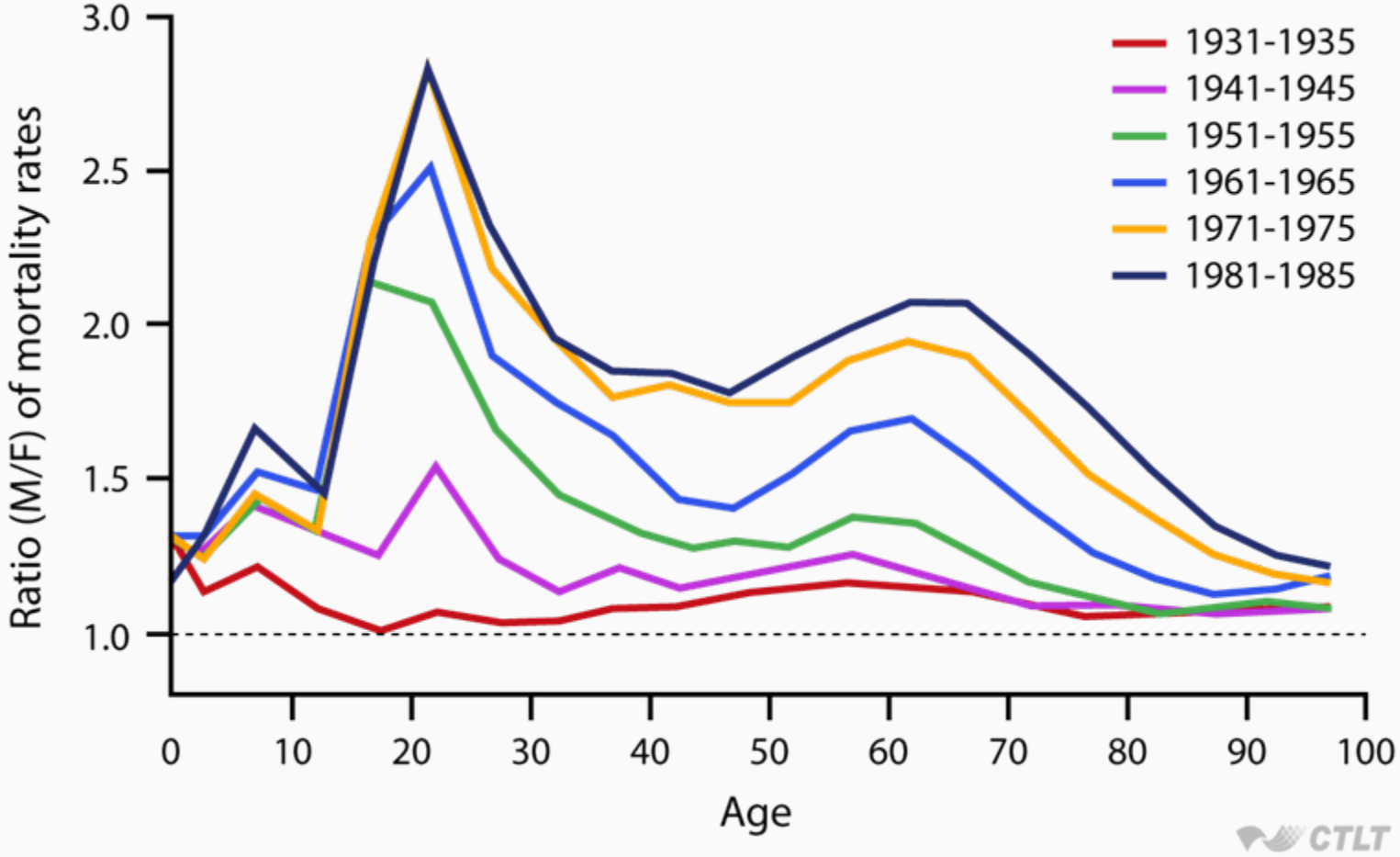


Source: Crimmins, Eileen. (2004). Trends in elderly health. *Annual Review of Public Health, 25*, p. 84.

Ratio of Male-to-Female Death Rates

- Next slide has data from Sweden over the course of the 20th century (1930s to 1980s)
- Very close to 1 in the 1930s
- Increases as mortality declines, especially 15–24 and 45–65

Ratio of Male-to-Female Death Rates—Sweden



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Section C

Epidemiological Transition

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Omran (1971)

- The epidemiological transition

> "As mortality has changed, the cause-structure has shifted from a preponderance of deaths due to infectious and parasitic causes to a preponderance of deaths due to degenerative causes or injuries. This change, which is associated with the change in age pattern of mortality, is called the epidemiologic transition."
>
> — *Omran (1971)*

Cause of Death

- Age-standardized death rates (females) by broad cause, England and Wales
  - Deaths of unknown cause redistributed proportionately

	1861 rate	%	1960 rate	%
Communicable	16.7	71.7	1.0	14.1
Non-communicable	6.0	25.7	6.0	81.4
Injuries	0.6	2.7	0.3	4.7

Horiuchi's Transitions

- Horiuchi (1999) expands on Omran's (1971) original concept of a single "epidemiologic transition." Horiuchi argues that shifts in level of mortality are associated with fundamental changes in pattern of mortality by age and cause. Moves from one mortality regime to another can be called "epidemiologic transitions."

Horiuchi's Transitions

- Horiuchi proposes three transitions that have occurred (or are still)
  1. External injuries to infectious diseases
  2. Infectious diseases to degenerative diseases (Omran's)
  3. Decline of cardiovascular mortality

Horiuchi's Transitions

- Possible future transitions
  - Decline of cancer mortality
  - Slowing of senescence

Horiuchi's Transitions

- Reverse transitions
  - Reversals may occur from time to time—for example, the increase of tuberculosis mortality with increased urbanization in the 19th century, and HIV/AIDS in the late 20th century
  - The third transition (decline of cardiovascular mortality) may be postponed by unhealthy lifestyles, particularly smoking, associated with increased affluence and increasing rates of degenerative disease mortality

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Section D

Why Did/Does Mortality Go Down?

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Explanations for Mortality Decline

- Improved therapeutic medical interventions
- Increased living standards (McKeown, 1976)
- Improved water and sanitation (Preston and van de Walle, 1978)
- Improved preventive medical interventions (Razzell)
- Spread of knowledge to public concerning disease prevention (Preston and Haines, 1991)

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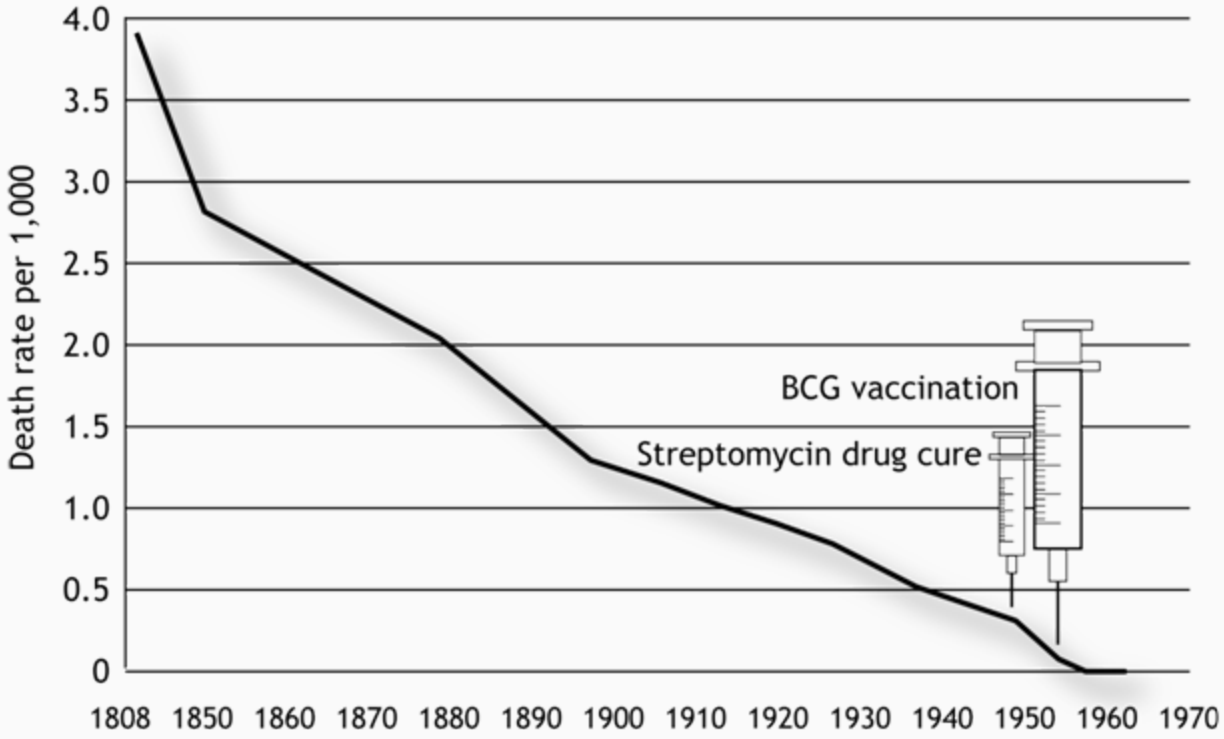
The Decline of TB

- Decline in TB before drugs



Source: Nuffield Provincial Hospital Trust.

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McKeown's Theory

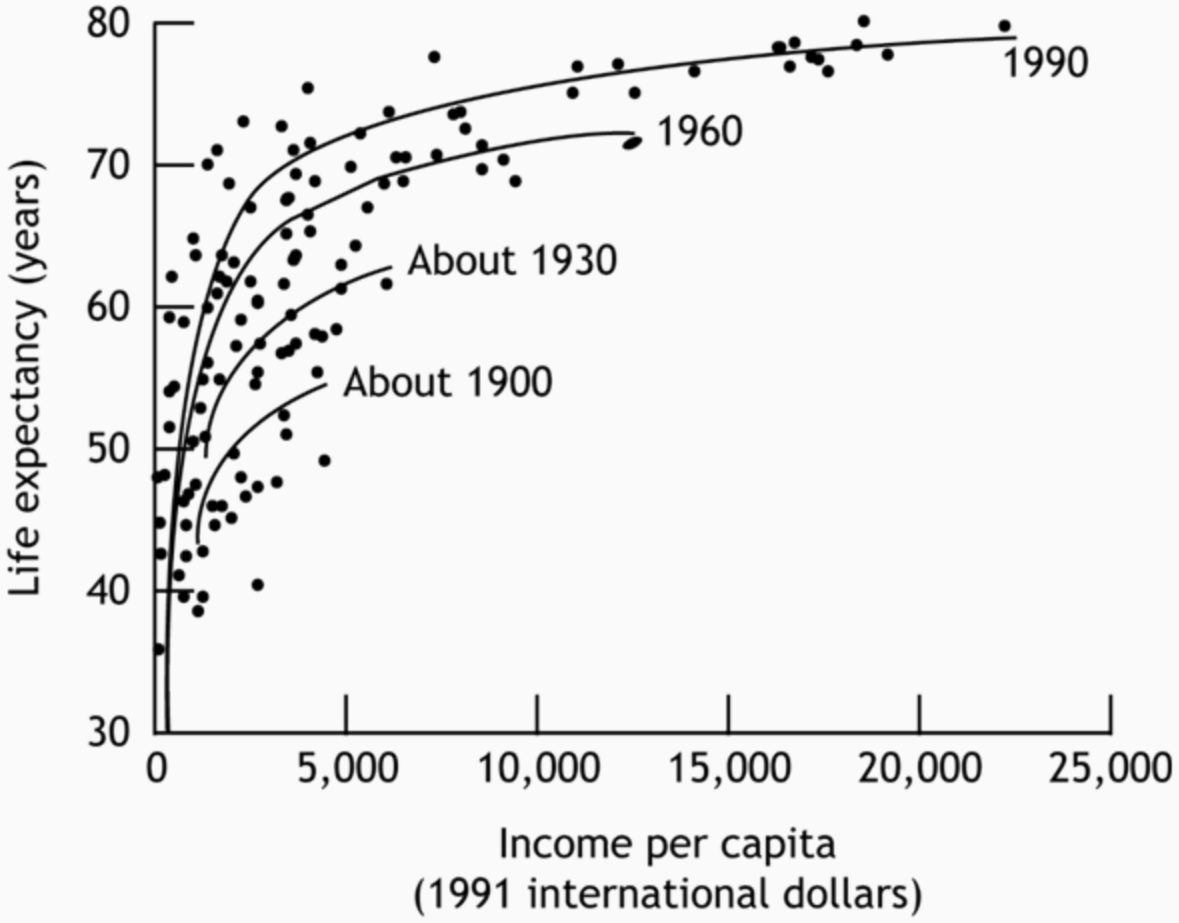
- Most medical therapies and immunizations were not available for infectious diseases until the 1900s, when many diseases were already declining
- Suggests important role for better nutrition, living standards, and hygiene
  - Airborne diseases (TB) declining, unaffected by public health measures
    - TB responds to better nutrition and less crowded housing
    - Nutrition, living standards may have been more important than public health
  - Fogel has offered direct evidence that economic growth during the 19th and 20th centuries was linked to better nutritional intake as reflected by population height

Arguments Against McKeown

- Preston
  - Relationship between mortality and SES has shifted over time
    - Something made the shift happen

Relationship between Life Expectancy and Income

- Relation between life expectancy and per capita income in the 20th century



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Preston and Van der Walle

- Studied cities, not nations
- Did not perceive themselves as contradicting McKeown
- Emphasized sanitary conditions over nutrition and broad standards of living

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Razzell and Others Emphasize Smallpox Measures

- Smallpox deaths per million population before and after the epidemic in the 1870s in Germany and Austria

	Compulsory vaccination law of 1874			No immediate measure
	Prussia	Bavaria	Württemberg	Austria
1868	620	120	133	368
1869	432	250	63	484
1870	188	190	19	370
1871	194	101	74	374
1872	175	75	293	293
1873	2,432	1,045	1,130	383
1874	2,624	611	637	1,866
1875	356	176	30	3,094
1876	95	47	3	1,725
1877	36	17	1	576
1878	31	13	2	406
1879	3	17	0	555
1880	7	13	0	631

Source: Mercer, A. J. (1985). Smallpox and epidemiological-demographic change in Europe: the role of vaccination. *Population Studies, 39,* 287–307.

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Public Knowledge of Disease Prevention

- Preston and Haines (1991) analyzed U.S. census data for 1900 and found very limited effects of socioeconomic condition on household levels of infant and child mortality
- By 1930, education of mother is the dominant correlate of household-level child mortality
- Preston and Haines argue that spread of knowledge, particularly of disease transmission, and particularly in an enabling political and social environment (Caldwell, 1986) was the key factor in child mortality reduction
- The existence today of large differentials in child mortality by maternal education in the developing world suggests the importance of similar mechanisms

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