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Mortality

Nan Astone, PhD
Johns Hopkins University
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
  - Compare and contrast the different explanations for mortality decline using evidence for each
Section A

Measures of Mortality
Crude Death Rate (CDR)

Deaths during year $t$

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

\[
\text{Number of deaths at age } x \\
\hline \\
\text{Population aged } x
\]
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).
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

<table>
<thead>
<tr>
<th></th>
<th>CDR</th>
<th>Direct (U.S.)</th>
<th>Indirect (U.S.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>U.S. 1960</strong></td>
<td>9.5</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td><strong>Japan 1960</strong></td>
<td>7.6</td>
<td>11.0</td>
<td>10.9</td>
</tr>
<tr>
<td><strong>El Salvador 1960</strong></td>
<td>11.3</td>
<td>13.2</td>
<td>20.1</td>
</tr>
<tr>
<td><strong>Chile 1960</strong></td>
<td>12.9</td>
<td>15.8</td>
<td>20.5</td>
</tr>
<tr>
<td><strong>Taiwan 1960</strong></td>
<td>6.9</td>
<td>13.2</td>
<td>14.6</td>
</tr>
</tbody>
</table>
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.
You can see why, when you observe how much the age structure of the U.S. had changed.

Changed the Estimates of Health Disparities Somewhat

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

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

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

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:

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

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).

Trends in Age-Specific Death Rates

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

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

- 1931-1935
- 1941-1945
- 1951-1955
- 1961-1965
- 1971-1975
- 1981-1985

Ratio (M/F) of mortality rates vs. Age
Section C

Epidemiological Transition
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- **Distinguish among Horiuchi’s different mortality transitions**
- Compare and contrast the different explanations for mortality decline using evidence for each
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)
Age-standardized death rates (females) by broad cause, England and Wales

- Deaths of unknown cause redistributed proportionately

<table>
<thead>
<tr>
<th></th>
<th>1861 rate</th>
<th>%</th>
<th>1960 rate</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communicable</td>
<td>16.7</td>
<td>71.7</td>
<td>1.0</td>
<td>14.1</td>
</tr>
<tr>
<td>Non-communicable</td>
<td>6.0</td>
<td>25.7</td>
<td>6.0</td>
<td>81.4</td>
</tr>
<tr>
<td>Injuries</td>
<td>0.6</td>
<td>2.7</td>
<td>0.3</td>
<td>4.7</td>
</tr>
</tbody>
</table>
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
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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- **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)*
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
Relation between life expectancy and per capita income in the 20th century

![Graph showing the relationship between life expectancy and income per capita over the 20th century. The graph includes data points for different years, labeled as 'About 1900', 'About 1930', '1960', and '1990'. The x-axis represents income per capita in 1991 international dollars, ranging from 0 to 25,000, and the y-axis represents life expectancy in years, ranging from 30 to 80. The data points and trend lines indicate an increasing life expectancy with rising income per capita.]
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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

<table>
<thead>
<tr>
<th>Year</th>
<th>Compulsory vaccination law of 1874</th>
<th>No immediate measure</th>
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<tbody>
<tr>
<td></td>
<td>Prussia</td>
<td>Bavaria</td>
</tr>
<tr>
<td>1868</td>
<td>620</td>
<td>120</td>
</tr>
<tr>
<td>1869</td>
<td>432</td>
<td>250</td>
</tr>
<tr>
<td>1870</td>
<td>188</td>
<td>190</td>
</tr>
<tr>
<td>1871</td>
<td>194</td>
<td>101</td>
</tr>
<tr>
<td>1872</td>
<td>175</td>
<td>75</td>
</tr>
<tr>
<td>1873</td>
<td>2,432</td>
<td>1,045</td>
</tr>
<tr>
<td>1874</td>
<td>2,624</td>
<td>611</td>
</tr>
<tr>
<td>1875</td>
<td>356</td>
<td>176</td>
</tr>
<tr>
<td>1876</td>
<td>95</td>
<td>47</td>
</tr>
<tr>
<td>1877</td>
<td>36</td>
<td>17</td>
</tr>
<tr>
<td>1878</td>
<td>31</td>
<td>13</td>
</tr>
<tr>
<td>1879</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>1880</td>
<td>7</td>
<td>13</td>
</tr>
</tbody>
</table>

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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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