MEASURING THE IMPACT OF ILLNESS

Years of Potential Life Lost

I. SOCIAL UTILITY OF PREVENTED DEATHS

A. The aging cycle

1. Birth to aged 21 (or end of education period)
   a. Person is dependent on society (and parents)
      (1) Education, medical and possibly social assistance
   b. Society (and parents) invests in future benefits

2. Aged 21 to aged 65 (or 70)
   a. Person is producing goods or services
   b. Society (and possibly parents) receives return on investment
   c. Person invests in future self-benefits

3. Aged 65 (or 70) to death
   a. Person is dependent on society (and friends)
      (1) Medical and social assistance
   b. Person receives returns from prior investments
      (1) Social Security, pension plans, savings plans, etc.

B. The value to society of one life over another

1. Usually expressed via societal politics
   a. In most societies, children who have yet to live their life are valued more than old persons who have already lived a long life
   b. In an agrarian society, agricultural workers may be valued more than urban residents
   c. In a technologically advanced nation, highly skilled workers may be valued more than low-skilled workers

2. Resources are allocated according to the ascribed value of the prevented death
   a. Examples
(1) More funds may be allocated to neonatal intensive care units than coronary intensive care units

(2) More funds may be spent on zoonotic and other diseases affecting agricultural workers than on more common diseases in urban areas

(3) More funds may be spent on care and prevention programs for employed home-owners or renters than for the homeless and unemployed

C. Vital statistics should reflect the value placed on a life

1. A childhood death should count more than a death later in life
   a. Assumes the young are valued more than older persons

2. A death during the working years should count more than a death after retirement
   a. Assumes workers are value more than retirees

II. MORTALITY RATES

A. Mortality rates excessively reflect the death experience of older age groups

1. Minor changes in the mortality experience of older age groups have a greater effect on the total mortality rate than major changes in younger age groups

B. Example (heart disease)

1. Impact of a hypertension control program on heart disease mortality in major city of a developing country (same age structure before and after intervention)

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Annual heart disease death rate per 10,000 population</th>
<th>Proportion of population</th>
<th>Contribution to total death rate per 10,000</th>
<th>Percent reduction due to intervention</th>
<th>Contribution to new total death rate per 10,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30</td>
<td>5.0</td>
<td>0.50</td>
<td>2.5</td>
<td>50.0</td>
<td>1.25</td>
</tr>
<tr>
<td>30-49</td>
<td>50.0</td>
<td>0.30</td>
<td>15.0</td>
<td>40.0</td>
<td>9.00</td>
</tr>
<tr>
<td>50-69</td>
<td>500.0</td>
<td>0.15</td>
<td>75.0</td>
<td>10.0</td>
<td>67.50</td>
</tr>
<tr>
<td>70+</td>
<td>2000.0</td>
<td>0.05</td>
<td>100.0</td>
<td>0.0</td>
<td>100.00</td>
</tr>
<tr>
<td>Total</td>
<td>192.5</td>
<td>1.00</td>
<td>192.5</td>
<td>7.7</td>
<td>177.75</td>
</tr>
</tbody>
</table>

a. Calculations for Line 1 in table (Age Group <30)

   \[
   \frac{5.0}{10,000} \times 0.50 = \frac{2.5}{10,000} \quad \text{the contribution of those aged < 30 years to the total death rate (BEFORE)}
   \]

   \[
   \frac{2.5}{10,000} \times (1-0.50) = \frac{1.25}{10,000} \quad \text{the contribution of those aged < 30 years to the total death rate AFTER an intervention program has reduced the mortality in this age group by 50 percent.}
   \]

b. Calculations for Line 5 (Total rate Before and After; see Figures 11-2 and 11-3)

   Column C: 2.5 + 15.0 + 75.0 + 100.0 = 192.50

   Column E: 1.25 + 9.00 + 67.50 + 100.00 = 177.75

   7.7 percent reduction in the total mortality rate
2. Even though there are large reductions in the risk of death in the younger years, this does not show up using the conventional mortality rate that shows only a 7.7% reduction in the population.

**Figure 11-1.** Percentage of population by age group.

**Figure 11-2a.** Percentage reduction, by age group, due to intervention.

**Figure 11-2b.** Heart disease death rate, by age group, before and after intervention.

3. Note that age is not a confounding variable in this intervention trial
   a. the age structure in Figure 11-1 is the same before and after the intervention.
C. The measure of deaths should reflect the loss of **future** life rather than just the loss of current life

1. Loss of future life is greater among the young than among the old (see Figure 11-4)

2. More years of potential life are lost when a younger person dies than when an older person dies
III. YEARS OF POTENTIAL LIFE LOST (YPLL)

A. Definition of YPLL

![Figure 11-6. Years of potential life lost before a defined endpoint.]

1. Years of potential life lost due to premature death

2. Calculation

\[ YPLL = \text{Defined Endpoint (in years)} - \text{Age at Death (in years)} \]

Note: requires no data on the population at risk other than information routinely found on death certificates

B. Endpoint for calculations

1. Average life expectancy at the time of death
   a. Comparison with "background" life expectancy
      (1) Derived from age- and sex-specific life tables
   b. Implication is that persons who died would have had the same risk of subsequent death as other persons of similar age and sex
   c. Calculation
      \[ YPLL = \text{Life Expectancy at Age of Death (in years)} - \text{Age at Death (in years)} \]
2. Fixed cut-off at age 75 (i.e., 0-75)
   
a. Assumes all persons should live to age 75 years
   
   (1) Deaths prior to this age are deemed "premature"
   
b. Approach used by the United States Centers for Disease Control (CDC)
   
c. Logic for selecting endpoint
   
   (1) For persons older than 75 years, the underlying cause of death may be difficult to determine
   
   (2) Persons over 75 may no longer be productive contributors to society
   
   (3) Deaths after age 75 may not be readily preventable or manageable
   
d. Calculation
   
   (1) If age at time of death is 75 or more...
       \[ YPLL = 0 \]
   
   (2) If age at time of death is birth (i.e., 0) through 74 years...
       \[ YPLL = 75 - (\text{age at death} + 0.5) \]
       
       **Note:** since age at death is age at last birthday, 0.5 is added to age at death; not necessary if exact age is used
   
   (3) For each mutually exclusive cause of death
   
       (a) Sum the YPLL for all deaths in the population of interest
   
3. Fixed cutoff at age less than 1 year and 70 years or older (i.e., 1-70)
   
a. Approach used by Romeder and McWhinnie (1977)
   
b. Logic for selecting endpoint
   
   (1) Age 65 is too young since persons are still productive at this age
   
   (2) The loss of an infant is not valued as highly by society as the death of older children or adults
   
       (a) The death of a single infant would count for as many lost years as the premature death of two adults at age 35 years
   
           (i) Infant \( (70 - .5 = 69.5 \ YPLL) \)
ii) Adult (70 - 35.5 = 34.5 YPLL)

c. Calculation of number of YPLL

(1) If age at time of death is 70 or more...
\[ YPLL = 0 \]

(2) If age at time of death is 365 days or less
\[ YPLL = 0 \]

(3) If age at time of death is 366 days through 69 years...
\[ YPLL = 70 - (\text{age at death} + 0.5) \]

C. Calculation of cause-specific percentage of total YPLL

1. Requires no data on the population at risk other than information routinely found on death certificates

\[ YPLL\% = \frac{\text{sum of cause-specific YPLL}}{\text{sum of all-causes YPLL}} \times 100 \]

2. Same concept as the proportionate mortality ratio (PMR)

D. Calculation of cause-specific rate of YPLL

1. Requires information from death certificates and from Census on population of interest

\[ \text{Rate of YPLL (per 1,000 population)} = \frac{\text{sum of cause-specific YPLL}}{\text{no. in pop., aged 0 or 1 to cut-off age}} \times 1,000 \]

E. Calculation of standardized rate of YPLL

1. Requires information from death certificates and from Census on population of interest

2. Direct method of standardization

a. For a specified cause of death, sum the products of the stratum-specific YPLL rates times the weights from the reference population

\[ \text{Sum for all strata} \left[ \frac{\text{YPLL in stratum i}}{\text{Pop. in stratum i}} \times \frac{\text{Pop. in stratum i in Reference}}{\text{Pop. aged 0 or 1 to cut-off age in Reference}} \right] \]

the "rates" the "weights"

3. Example: death due to heart disease in Community A versus Community B

a. Hypothesis: People are less likely to experience a premature death due to heart disease in Community A (the reference community) than in Community B
b. Implied model (see Figure 11-6)

![Figure 11-7. Model for implied association between community and premature death due to heart disease.](image)

(1) Tables for analysis of age-adjusted YPLL

(a) Standardize the **rates** in Community A to the **weights** in Community A

i) Community A is the *reference population* so the two sets of rates will be mutually standardized to Community A

a) What would the YPLL rate be in Community B if it had the same age-structure as Community A (the reference)

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Annual YPLL 1-70 per 10,000 in Com. A</th>
<th>Proportion of population in Com. A</th>
<th>Contribution of YPLL rate in Com. A to total YPLL rate in Com. A</th>
<th>Contribution of population in Reference to adjusted YPLL rate in Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30</td>
<td>275</td>
<td>0.50</td>
<td>137.5</td>
<td>137.5</td>
</tr>
<tr>
<td>30-49</td>
<td>1,500</td>
<td>0.30</td>
<td>450.0</td>
<td>450.0</td>
</tr>
<tr>
<td>50-69</td>
<td>5,000</td>
<td>0.15</td>
<td>750.0</td>
<td>750.0</td>
</tr>
<tr>
<td>70+</td>
<td>0</td>
<td>0.05</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

\[ \text{Proportion to total of YPLL rate in Reference} = \frac{1.00}{1.0} = 1.0 \]

\[ \text{Contribution of YPLL rate in Reference} = 1,337.5 \]

\[ \text{Contribution of the Community A age-specific rate to the total YPLL rate in Community A} \]

\[ \text{Contribution of the Community A age-specific rate to the total YPLL rate in the reference population (in this case, also Community A)} \]

Note: the reference is Community A

\[ \text{Note: the rates} \]

\[ \text{Note: the weights} \]

ii) Calculations for age group < 30 (line 1)

\[ \frac{275}{10,000} \times 0.50 = \frac{137.5}{10,000} \]

The contribution of the Community A age-specific rate to the total YPLL rate in Community A

\[ \frac{275}{10,000} \times 0.50 = \frac{137.5}{10,000} \]

The contribution of the Community A age-specific rate to the total YPLL rate in the reference population (in this case, also Community A)
iii) 1,337.5 YPLL per 10,000 population is the standardized rate in Community A

   a) Adjusted to the population distribution in Community A

   b) This is the same as the total (or crude) rate in Community A

(b) Standardize the rates in Community B to the weights in Community A

   i) Community A is the reference population

   ii) What would be the YPLL rate in Community B if it had the same age-structure as Community A (the reference)

   **Note:** the reference is still Community A

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Annual YPLL 1-70 per 10,000 in Com. B</th>
<th>Proportion of population in Com. B</th>
<th>Contribution to total YPLL rate in Com. B</th>
<th>Proportion of population in Reference*</th>
<th>Contribution to adjusted YPLL rate in Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30</td>
<td>270</td>
<td>0.30</td>
<td>81.0</td>
<td>0.50</td>
<td>135.0</td>
</tr>
<tr>
<td>30-49</td>
<td>1,200</td>
<td>0.30</td>
<td>360.0</td>
<td>0.30</td>
<td>360.0</td>
</tr>
<tr>
<td>50-69</td>
<td>5,500</td>
<td>0.25</td>
<td>1,375.0</td>
<td>0.15</td>
<td>825.0</td>
</tr>
<tr>
<td>70+</td>
<td>0</td>
<td>0.15</td>
<td>0.0</td>
<td>0.05</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.00</td>
<td>1,816.0</td>
<td>1.00</td>
<td>1,320.0</td>
</tr>
</tbody>
</table>

# - the "rates"
* - the "weights"
(270/10,000) x .30 = 81.0/10,000
The contribution of the Community B age-specific rate to the total YPLL rate in Community B

(270/10,000) x .50 = 135.0/10,000
The contribution of the Community B age-specific rate to the total YPLL rate in the reference population (in this case, Community A)

iv) 1,320.0 YPLL per 10,000 population is the age-standardized rate in Community B

   a) This is not the same as the total (or crude) rate in Community B since it has been standardized to Community A which has a different age structure

(2) Findings

   a) The total (or crude) YPLL rate is 26% less in Community A than B

   i) 1,337.5 YPLL per 10,000 population, aged 1-70 years, in Community A versus 1,816.0 YPLL per 10,000 in Community B

   b) The age-adjusted YPLL rate is 1.3% greater in Community A than B

   i) 1,337.5 YPLL per 10,000 in Community A versus 1,320.0 in Community B

(3) Conclusions

   a) After taking into account the age distribution of the population...

   i) People in Community A lose 1.3 percent more years of potential life due to heart disease than comparable people in Community B

IV. USE OF YPLL

A. Descriptive statistics

   1. Determine relative importance of causes of premature mortality

      a. With the exception of infants if cutoff is <1

   2. Compare one region to another, if standardized for age and other confounding variables

B. Program planning

   1. Provides a single measure for comparing the impact of various intervention or prevention programs
a. Objective is to minimize YPLL
b. Administrator compares the theoretical impact of all proposed programs on YPLL due to death for whatever cause

(1) Compares returns (i.e., reduction in YPLL) on financial investment (i.e., budget allocation) of programs aimed at one disease compared to another

2. Focuses attention on "lost years" valued by the society

a. Death at an early age and during maximum productive years

V. LIMITATION OF YPLL WITH CUT-OFF AGE

A. Implies that deaths under age 1 or over the cut-off age (i.e., either 65 or 70) are not important for consideration in the allocation of resources

1. Society may value highly the very young and the old

2. Suggests that death prior to an arbitrary age cut-point based on the worker productivity cycle (i.e., the retirement age) is the best indicator of "premature" death

   a. With safer environment and availability of better medical care, life expectancy tends to increase

      (1) Productive years for persons in society also increase

B. Does not take into account the effects of disability

1. Diseases of high disability but low mortality

   a. i.e., poliomyelitis

2. Diseases of high disability prior to death

   a. i.e., chronic renal disease