Global Burden of Disease Study
and Disability Adjusted Life Years
Mortality Indices
Man Dies at 48 Years of Age

Mortality Rate

\[
\text{Death} \quad 48 \\
\text{Males Deaths, Aged 45-49} \\
\text{100,000 Male Population, Aged 45-49}
\]

Source population

Years of Potential Life Lost before Aged 75 (YPLL-75)

\[
\text{Birth} \quad 48 \quad \text{YPLL-75 = (75 - 48) = 27} \quad 75 \\
\text{Males YPLL-75} \\
\text{100,000 Male Population, Aged 0-75}
\]

Source population

So what is the problem with YPLL?

- Political
- Social
- Economic

Does not count those over 75 years
Don't count in public health policy decisions?

Voters in 2004 Presidential Election

- Eligible voters: 215,694,000
- Voters: 122,295,345

Highest voting age is 65-74

72%
Elderly are Highly Regarded in Families

Figure 1: Remaining Lifetime Per Capita Expenditure by Age, Male versus Female, with/without Adjustment for Female’s Longer Life Expectancy (Year 2000 Dollars)

About 32-35% of lifetime expenditure is spent after age 75 in women and men.

Morbidity and Mortality Indices

• Mortality indices
  ▪ Mortality rate
  ▪ Years of potential life lost (PYLL or YPLL)

• Morbidity and mortality indices
  ▪ Days of healthy life lost (DHLL)
  ▪ Disability-adjusted life years (DALYs)

HISTORY

DHLL (and DHLG)

• Arose from Ghana’s systematic assessment of national health problems which occurred during the late 1970s.
• Added a morbidity component to the YPLL
• Encouraged policy comparisons among many diseases
HISTORY (continued)

DHLL Dissemination and Expansion

• "Health Sector Priority Review" initiated in 1988 by the World Bank
• Purpose was to…
  ▪ Assess the significance to public health of individual diseases
  ▪ Determine what is known about the cost and effectiveness of relevant interventions for their control


Leprosy

Myo Thet Htoon, Jeanne Bertolli, and Lies D. Kosasih

Leprosy has been referred to as one of the oldest diseases known to humankind. The earliest written records describing true leprosy come from India and there it was known as mulinta. It is believed that from India it spread outward to China and Japan whereas the paucibacillary form (I, II, and III) is generally less infectious and is bacteriologically negative.

Onset of leprosy is usually gradual, and the early signs may not be apparent for quite some time after infection. The


A Supercalc microcomputer spreadsheet model developed by Ralph R. Frerichs of the Department of Epidemiology, School of Public Health, University of California at Los Angeles, will be used to evaluate the cost-effectiveness of a leprosy control program. The model is based on earlier work done in Ghana by the Ghana Health Assessment Project Team (1981). The model output is direct cost per year of healthy life gained. No attempt is made in the model to quantify indirect costs (or savings from preventing indirect costs) in monetary terms. The cost per YLQoL was calculated for two different components of a control program, that is, drug therapy and treatment of complications, first individually and then in combination. The parameters of the model are:

- Average age at onset (Ao)
- Average life expectancy at onset (L)
- Average age at death for those who die of the disease (Ad)
- Case-fatality proportion (CF)
- Proportion of disablement prior to death of those who die of the disease (Dp)
- Proportion of those who do not die of the disease but who are permanently disabled (Dp)
- Average level of disablement of the permanently disabled (Dp)
- Temporary days of disability (T)
- Level of temporary disablement (TPD)
- Incidence (I)

**HISTORY (continued)**

**DALYs**

Included in the "Health Sector Priority Review" were…

- Christopher Murray (Harvard School of Public Health) who introduced the DALY (disability-adjusted life years) as a common measure of effectiveness for the review to use across interventions dealing with diverse diseases
- Alan Lopez (World Health Organization) prepared estimates of child death by cause that were consistent with death totals provided by demographers at the World Bank

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**Disability Adjusted Life Years (DALYs)**

Expansion of methods described in "Health Sector Priority Review" initiated in 1988 by the World Bank

Harvard School of Public Health

World Health Organization

Two Components

$$\text{DALY} = \text{YLL} + \text{YDL}$$

- Years of life lost
- Subtracts observed from expected
- Similar to YPLL

- Years of disability lost
  - Years of life lived with mental or physical disability
  - Multiply years with disability times a value between 0 and 1, depending on the level or degree of disability

Source: Fauci, AS et al. Emerging Infectious Diseases: a 10-Year Perspective from the National Institute of Allergy and Infectious Diseases. Emerging Infectious Diseases 11(4), 519-525, 2005

Describe
Worldwide Burden of Infectious Diseases

Figure 2. Leading causes of disability life years (DALYs) due to infectious and parasitic diseases (2002 estimates). Lower respiratory infections, HIV/AIDS, diarrheal diseases, and malaria are among the infectious diseases that contribute to the most DALYs lost each year throughout the world (6).

Source: Fauci, AS et al. Emerging Infectious Diseases: a 10-Year Perspective from the National Institute of Allergy and Infectious Diseases, Emerging Infectious Diseases 11(4), 519-525, 2005

YLL
(years of life lost due to death)

Use mortality data (as with YPLL)

Expected age of death minus observed age of death

- "Expected" not a cutpoint such as aged 75
- Based on a life table showing societal life expectancy at time of person's death
Life Table Software -- MORTPAK

The United Nations Population Division
Department of Economic and Social Affairs

The United Nations Population Division is pleased to announce the release of MORTPAK for Windows, version 4.0 of its popular software package for demographic measurement. The MORTPAK software package for demographic measurement has been widely used throughout research institutions in developing and developed countries since its introduction in 1998.


The applications MATCH, COMPAR and BESTFIT construct model life tables and compare or graduate empirical data with respect to a model life table. The procedure MATCH not only generates any United Nations or Coale and Demeny model life table but also enables the entering of a user-designated mortality pattern which then can be adjusted to correspond to any desired level.

The YLL component of DALYs usually relies on the...

Coale and Demeny Model life table West level 25

- Based on life table for Japanese women

### Standard Life Expectancies at Each Age

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Life expectancy (years)</th>
<th>YLLs due to a death at each age</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>0</td>
<td>83.99</td>
<td>80.00</td>
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<tr>
<td>1</td>
<td>81.64</td>
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<td>66.41</td>
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<td>20</td>
<td>65.90</td>
<td>63.44</td>
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<td>25</td>
<td>62.17</td>
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<tr>
<td>100</td>
<td>32.72</td>
<td>31.77</td>
</tr>
</tbody>
</table>

**Source:** Table 1.1 in Murray CJL, Lopez AD (eds). The Global Burden of Disease, Harvard University Press, 1996, p. 17.

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Economists typically discount the future

- Over time, money is worth less due to inflation
- Over time, years of life are worth less due to discounting

Assume a 3% discount rate (as used for the YLL)

- the net present value (i.e., now) of 33.99 years of future losses is 21.13 years

- Close, but not the same as 17.69 years shown in the table in “YLL” column

For a 50 year old death...

**Female**

| Age at death | YLL = 33.99 | 83.99 |

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There is another adjustment
* the age weights represent a social preference that values a year lived by a young adult more heavily than one lived by a very young child or an older adult

**Source:** Figure 1.16 in Murray CJL, and Lopez AD (eds). *The Global Burden of Disease*. World Health Organization, 1996, p. 60.

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**Relative Value of Preventing a Death at Different Ages**

**Four Group Valuation Exercises**

**Source:** Figure 1.13 in Murray CJL, and Lopez AD (eds). *The Global Burden of Disease*. World Health Organization, 1996, p. 55.
Age Weights

A year lost at ages above the line are worth > 1 year

Age Weighting and Discounting

To be consistent with GBD methods, all DALYs were also age weighted using an exponential function of the form:

\[ Ce^{-Bx} \]

where C and B are constants equal to 0.1658 and 0.04, respectively (Figure 1), and \( x \) is the value for a particular year of age. All DALYs calculated in this analysis were discounted at the recommended rate of 3% per year.\(^{6,30}\)

* the age weights represent a social preference that values a year lived by a young adult more heavily than one lived by a very young child or an older adult

Death of a 50 Year Old - GBD Statistics

Death of a 50 Year Old - GBD Statistics

Death of a 50 Year Old - GBD Statistics
After adjusting for...

- a 3% discount rate of future lost years
- Age weights that reflect a social preference for young adult year

\[ YLL_{50} = 17.69 \text{ years} \]

For a 50 year old death....

**Female**

<table>
<thead>
<tr>
<th>Age at death</th>
<th>YLL = 17.69</th>
<th>Years reduced with 3% discount and age weight = 16.30</th>
<th>83.99</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td></td>
<td></td>
<td>29</td>
</tr>
</tbody>
</table>

Age Weight Formula for Each Lost Year due to Death or Disability

\[ C \times e^{-\beta x} \]

- \( C = 0.1658 \) (a constant)
- \( x = \text{age of death} \)
- \( \beta = 0.04 \) (a constant)

**Death at age 70**

\[ 70 \quad 70.5 \quad 71 \]

1.00 year

\[ (0.1658)(70.5)(e^{-0.04(70.5)}) = 0.70 \text{ year} \]
**Possible Error in GBD Table 1.1 or RRF Calculations**

\[
\frac{\text{GBD} - \text{RRF}}{\text{GBD}} \times 100 = \% \text{ error}
\]

\[
= \frac{7.48 - 7.39}{7.48} \times 100 = 1.15\%
\]

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**Source:** Table 1.1 Standard life expectancies at each age and YLLs due to a death at each age used in the GBD. In Murray CJL, Lopez AD (eds). The Global Burden of Disease, Harvard University Press, 1996, p. 17.
Errors in Prediction of YLL in Table 1.1 (GBD-96, p 17)

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Females</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>1</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>5</td>
<td>0.15%</td>
<td>0.15%</td>
</tr>
<tr>
<td>10</td>
<td>0.30%</td>
<td>0.30%</td>
</tr>
<tr>
<td>20</td>
<td>0.60%</td>
<td>0.60%</td>
</tr>
<tr>
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<td>1.20%</td>
<td>1.20%</td>
</tr>
<tr>
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<td>2.40%</td>
<td>2.40%</td>
</tr>
<tr>
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<td>4.80%</td>
<td>4.80%</td>
</tr>
<tr>
<td>60</td>
<td>9.60%</td>
<td>9.60%</td>
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<tr>
<td>70</td>
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</tr>
<tr>
<td>80</td>
<td>38.40%</td>
<td>38.40%</td>
</tr>
<tr>
<td>90</td>
<td>76.80%</td>
<td>76.80%</td>
</tr>
<tr>
<td>100</td>
<td>153.60%</td>
<td>153.60%</td>
</tr>
</tbody>
</table>

Spreadsheet for Deriving YLL for DALYs (upper left)