Mortality and its Measurement:
Introduction and Rates

Demography Camp

Summer 2013

1 Introduction

Mortality: level of death or dying in a population

Table 1: Deaths

U.S. females	# deaths
1985	989,000
1940	626,000

Why incorrect to claim higher mortality in 1985:

- more females in 1985
- more people exposed to the chance of dying

2 Demographic Rate

A better measure would relate the number of deaths to the size of the population. This is done through concept of a **demographic rate**.

$$\textit{Demographic Rate} = \frac{\begin{array}{c}\text{Number of occurrences of an event to the population}\\ \text{at risk during a particular interval of time.}\end{array}}{\begin{array}{c}\text{Number of person years lived by the population}\\ \text{at risk during the same time interval.}\end{array}}$$

2.1 Occurrence-Exposure Rate

- Begins with the definition of some demographic event (E) e.g., a birth, death, a move from A to B, etc.
- **Numerator** = the number of occurrences of event (E) in some time period (often a calendar year)

- **Denominator** = the number of person-years lived in the same time interval by the population exposed to the risk of experiencing the event.

Can you think of any examples?

2.2 2 key concepts

1. At-risk population: population exposed to the chance of experiencing the event in question.
   - Ex. Only pregnant women are at risk of dying from maternal mortality
2. Person year: elapsed duration when one person survives for one year; or its equivalent.
   - Ex. Two individuals, each of whom survives for 6 months, together contribute one person year.

2.3 How to estimate person years when population growth is not constant?

- Total person years lived = Area under the curve
- Average population ($\bar{P}$) $\cdot$ length of the interval
- $\bar{P}$ is often approximated by mid-period (or mid-year if t_2 - t_1 = 1) population

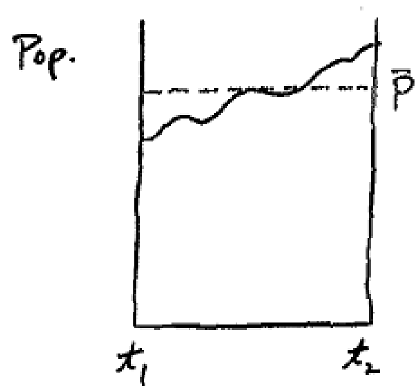

Figure 1: Mid-Year Population Estimate

2.4 Crude Death Rate

$$\textit{Crude Death Rate in year } t = \frac{\text{deaths in year t}}{\text{size of mid-year population}}$$

- CDR usually expressed per 1000 of population

Table 2: Crude Death Rates

U.S. females	CDR
1985	8.1 per 1,000 per year
1940	9.5

- Lower U.S. female mortality in 1985 than in 1940

Advantages of CDR:

- Simple to calculate
- Variation in rates across cities useful to undertakers

Disadvantages:

- Influenced by changes in age composition (more later)

Table 3: Example 1985 U.S. CDR

Florida	10.7
Utah	5.5
Alaska	4.0

There is a better measure- **Age Specific Rates**

3 Age Specific Death Rates: ${}_nM_x$

${}_nM_x$= age-specific death rate in year t between exact ages x and x+n

- **Exact age** = precise # of whole and fractional years elapsed since birth
  - x: exact age at beginning of interval
  - n: width of the interval (in years)
    - Usually omitted if n=1

Example: ${}_5M_{60}$ is the death rate between exact ages 60 and 65, or the death rate in the age group 60-64 if the concept of age last birthday is meant.

Age-specific death rates apply the CDR concept to the specific age intervals:

$$ {}_nM_x = \frac{\begin{array}{c}\text{The number of deaths in a given year to}\\ \text{persons between exact ages x and x+n}\end{array}}{\begin{array}{c}\text{The number of person years lived by the population}\\ \text{between exact x and x+n in the same year}\end{array}} = \frac{{}_nD_x}{{}_nP_x} $$

A complete set of rates covering all age groups is an age-specific **moratliy schedule**

Table 4: Example 1985 U.S. Women Death Rate (pre 1000 population)

Age	Death rate
Under 1 year	9.3
1-4	0.4
5-9	0.2
10-14	0.2
15-19	0.5
20-24	0.5
25-29	0.6
30-34	0.8
35-39	1.1
40-44	1.7
45-49	2.9
50-54	4.6
55-59	7.2
60-64	11.2
65-69	16.7
70-74	26
75-79	40.9
80-84	69.6
85 years and over	143.4

Note the typical age pattern:

- Sharp decline prior to age 5
- Minimum $\sim$ age 10
- More rapid increase age$>$ 45
- Last age group is "open" age interval

3.1 Age Patterns of Mortality Decline

When mortality declines from high to low levels:

- Death rates fall at all ages

- Largest absolute decline in infancy
- Largest relative decline 1-4, 5-9, 10-14

Table 5: Example Model West, Female. $1000 \cdot_n M_x$

Age	e 30	e 75	Absolute Decline	%Decline
<1	307.3	15.51	-292	95
1-4	50.4	0.61	-50	98.8
5-9	10.3	0.26	-10	97.5
10-14	8	0.21	-8	97.4
15-19	10.5	0.36	-10	96.6
20-24	13.2	0.51	-13	96.2
⋮				
70-74	106.4	37.8	-69	64.5
80-84	228.4	110.2	-118	51.8
90-94	508.7	294.4	-214	42.1

For the future, the largest absolute declines in death rates in low-mortality populations are likely to occur at the older ages. Why?

3.2 Digression on Infant Mortality

$$\text{Infant Mortality Rate} = \frac{\text{Deaths under age 1 in a given year}}{\text{per 1000 live births in the same year}} \neq {}_1M_0$$

$$\underset{\text{(under 1 year)}}{\text{Infant Mortality Rate}} = \underset{\text{(Under 28 days)}}{\text{Neonatal Mortality Rate}} = \underset{\text{(28 days - 1 year)}}{\text{Postneonatal Mortality Rate}}$$

Table 6: Example US 1985

	Infant Mortality	Neonatal Mortality	Postneonatal Mortality
All races	10.6	7	3.7
White	9.3	6.1	3.2
All other	15.8	10.3	5.5
Black	18.2	12.1	6.1

- Infant Mortality steadily improving
- US still lags far behind other MDCs

Table 7: Infant Mortality Rate in Select Countries

Rank (1985)	Rank (2005)	Country	IMR (1985)	IMR (2005)
1		Finland	6	3.1
2		Japan	6.2	2.8
3		Sweden	7	3.1
19	34	U.S.	10.6	6.6
		Afghanistan	205	172
		Sierra Leone	200	165
		Gambia	193	76