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# Mortality measures

## Workshop on data analysis and report writing for civil registration based vital statistics

*Nadi, Fiji*
*30 January – 03 February 2023*

Bloomberg Philanthropies | DATA FOR HEALTH INITIATIVE | Pacific Community / Communauté du Pacifique | Australian Bureau of Statistics | UNITED NATIONS ESCAP Economic and Social Commission for Asia and the Pacific

# Measures of all-cause mortality

- Absolute number of deaths
- **Crude death rates**
- **Age-specific death rates**
- **Age-standardized death rates**
- Life expectancy

# Introduction

Mortality rate:

A measure of the frequency of occurrence of death in a defined population during a specified interval.

These rates provide a starting point for examining the health of a population

# The Crude Death Rate (CDR)

- The most frequently used measure of general mortality
- CDR = the number of deaths in a defined period (usually a calendar year) per 1,000 people (sometimes 100,000 people)
- It is defined as “crude” because does not account for the age composition of a population.

# The Crude Death Rate (CDR)

- Why we use the CDR:
  - easy to understand
  - requires the least amount of information
  - helps use understand mortality's "contribution" to population growth
  - Can help to understand the burden of mortality from particular causes
  - Helps with planning – health, nursing homes etc

# Crude death rate formula

$$\text{Crude Death Rate} = \frac{\text{Number of deaths in a year}}{\text{Mid} - \text{year population}} \cdot 1000$$

# Crude Death Rate in small populations

- Generally, CDR = the number of deaths occurring in a year divided by the population at midyear, times 1,000.

- If we aggregate over 5 years, divide the average number of deaths over this period by the population size at the midpoint of these 5 years.

- $\text{CDR} = \dfrac{\dfrac{\text{Total number of deaths in period of interest}}{\text{number of years in the period of interest}}}{\text{mid-point population for the period of interest}} \text{ x } 1000$

# Crude Death Rate in small populations

- Number of deaths from 2013-2017 is 1250
- Divide numerator by 5
- we will need to divide this by our midpoint population.
- Our midpoint is July 1, 2015. (Why?)
- Let's assume the population was 15,645 on July 1, 2015. We then perform the calculation:
- **1000 * ((1250/5)/15,645) to get a CDR of 15.6**
- We can say there were 15.6 deaths per 1,000 population in 2013-2017.

# Sex-specific mortality rates

**Expect:**

- sex-specific mortality rate for males to be higher than for females.
  - Deviations from this pattern could indicate that women and girls face severe disadvantages in terms of health and nutrition.
  - Alternatively, there may be problems with data completeness and quality with systematic underreporting of female deaths.

# Lower limits of the CDR

- Demographers have demonstrated that there is generally a lower limit for the CDR of around 5 per 1000.

- Any CDR below 5 per 1000 should be treated with extreme caution as such a figure is strongly suggestive of INCOMPLETE death registration.

- For low numbers of deaths or incomplete reporting think about if it is appropriate to produce rates (could be misleading)

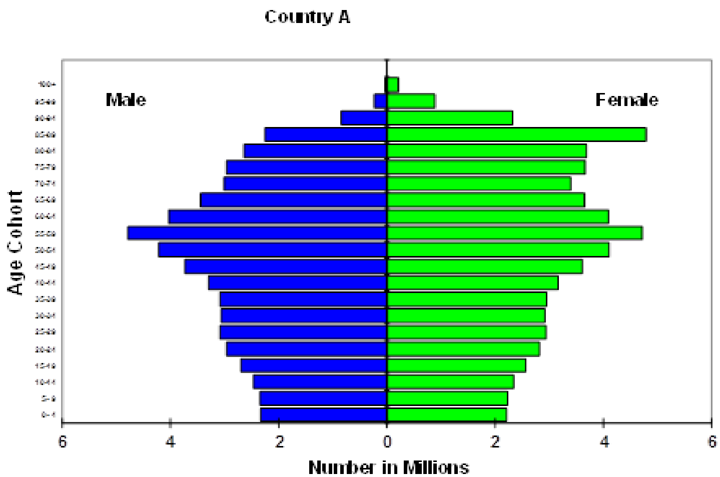
- All mortality rates can be reported with confidence intervals which give an indication of how much variation in the rate could be expected.

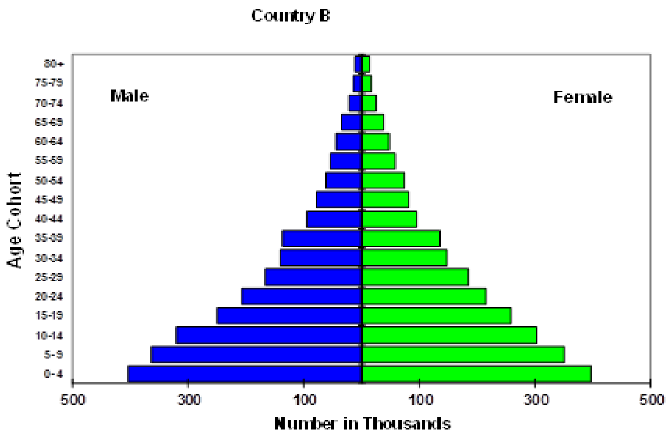
# Limitations to crude death rate measures

❖ The CDR is also influenced by the population age structure.

❖ Populations with a large proportion of young children or a high proportion of elderly people will have relatively higher crude death rates because mortality risks are highest at very young and the oldest ages.

❖ Options include age-specific death rates and age-standardization



# Age specific mortality rates

- An **age-specific death rate (ASDR)** is the number of deaths per 1,000 people of a given age group in a given time period

- Use this when an age group is disproportionately affected (e.g. for maternal deaths use ages of child-bearing women)

- ASDR (25-29) in 2020= $\frac{\text{Deaths } 25-29 \text{ in } 2020}{\text{Mid}- \text{ year population } 25-29 \text{ in } 2020}$ x 1000

- Similar to CDRs if using a five year average divide the numerator by the number of years

- ASDRs help us to know how old people are when they die

| Age group | No. Deaths | Popn | ASDR |
|---|---|---|---|
| **25-29** | 25 | 2500 | =25/2500*1000 = 10 deaths per 1,000 people |

# Confidence intervals

The confidence intervals for a crude (or age-specific) death rate can be calculated as:

$$CI(CDR)_{95\%} = CDR \pm 1.96 \times \frac{CDR}{\sqrt{\sum d}}$$

Where: *CDR* = crude death rate

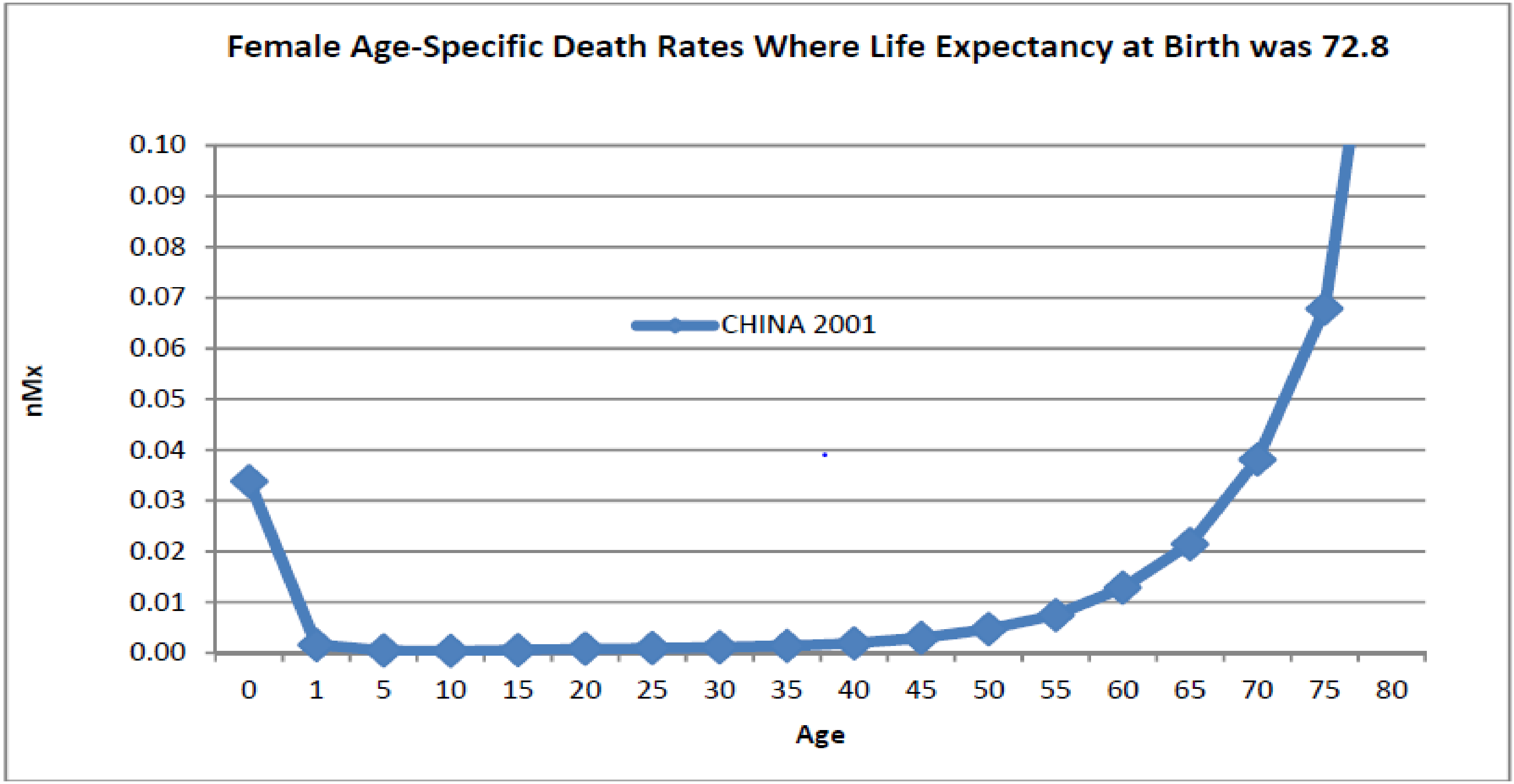
*d* = number of deaths

- the observed rate is assumed to have natural variability in the numerator count (e.g. deaths) but not in the population denominator count.

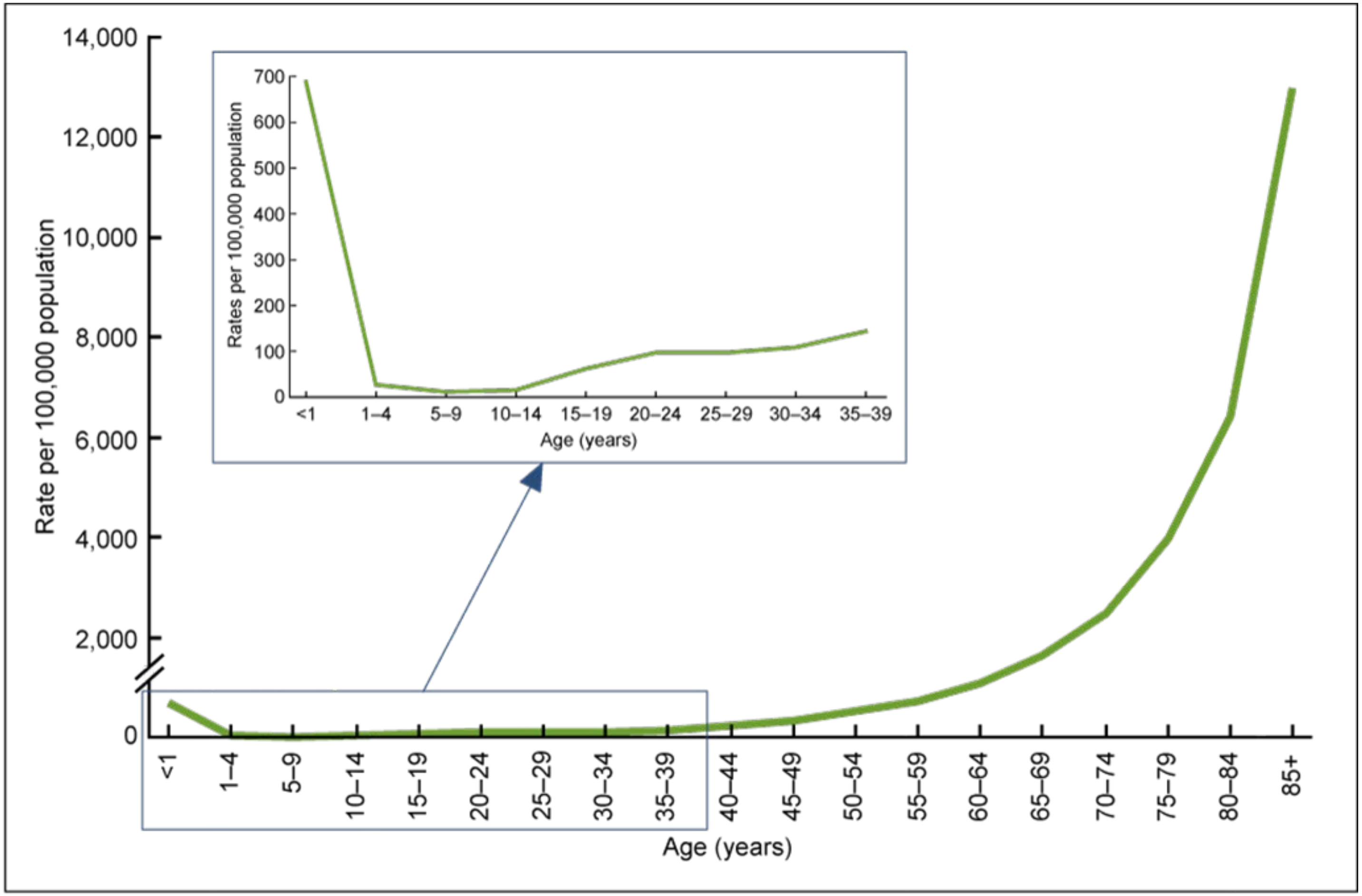
# Graphing age-specific mortality

- The typical pattern for age-specific mortality is J-shaped
  - Mortality is relatively high among infants and young children, after which it declines rapidly, reaching its lowest usually around the 10-14 year age group.
  - It then gradually starts to edge up as young adult women are at risk for mortality due to childbirth and young adult men are at risk due to accidents and incidental causes such as suicide.
  - Mortality continues to increase into the older adult age groups and generally starts to rise more rapidly among the oldest age groups in the population. As a general rule, mortality rates start to increase exponentially beyond age 35 or so.

# Graphing age-specific mortality



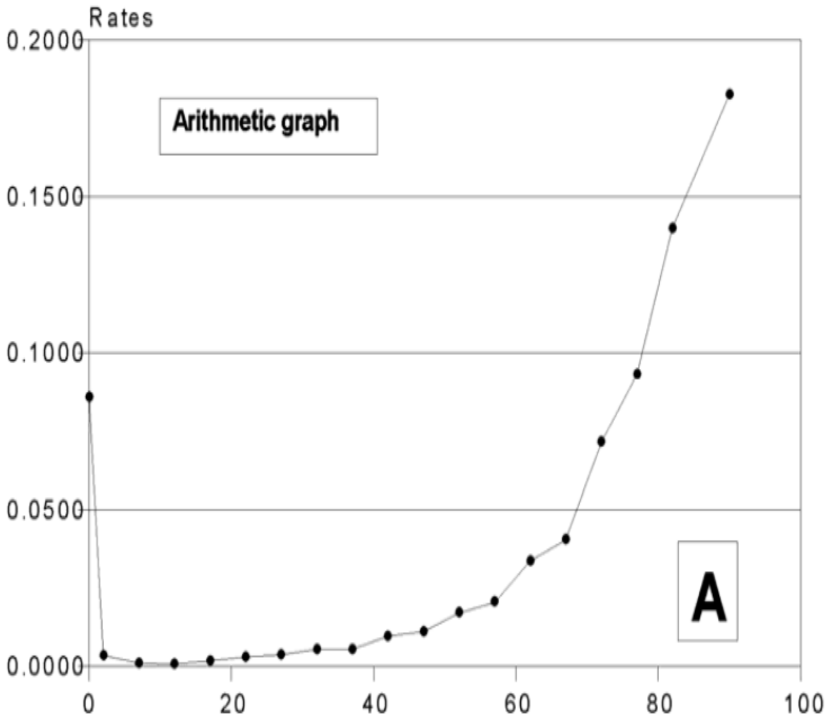
# Graphing age-specific mortality

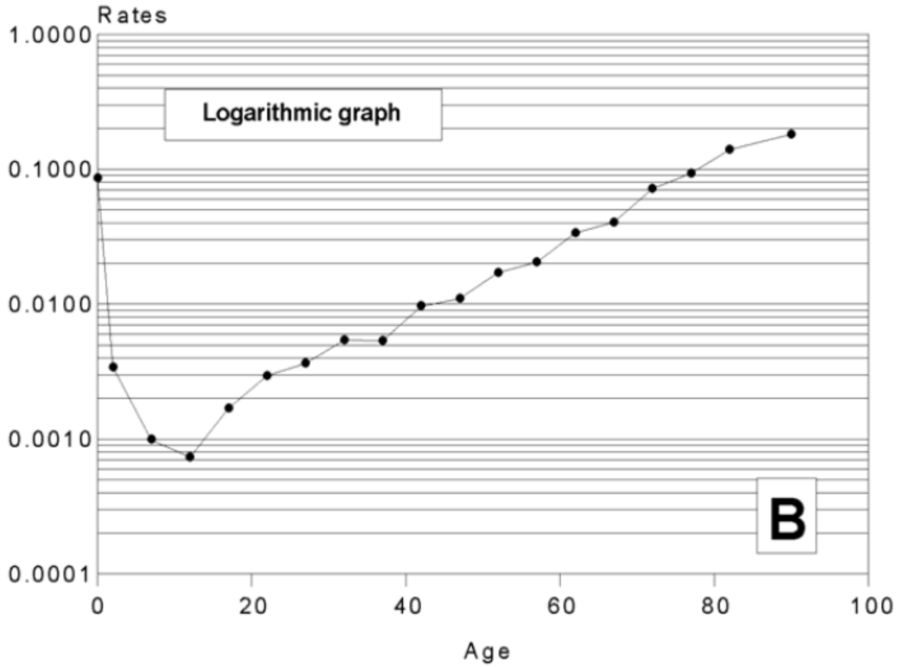



SOURCE: National Vital Statistics System, Mortality.

Graphing age-specific rates on a normal numeric scale is problematic –note the loss of detail.

# Graphing age-specific mortality



# Graphing using log scale

- The primary purpose of graphing the natural log of ASMRs is to examine the data for irregular or implausible changes from age to age.

- In countries with high maternal or injury mortality in young adults, death rates will rise steeply around age 15 years, peak at age 25, and decline to a new low at about age 35 years old.

- From about age 35 onwards, they rise linearly with age.

- A departure from this linear pattern in adult death rates suggests that deaths are being selectively (by age) underreported or that there is misreporting of the correct age of death

# Age standardised mortality rate

- The age structure of the population can affect mortality indicators such as the crude death rate, making comparisons between populations unfeasible.

- To compare mortality between populations, or within the same population over time, we take our age-specific mortality rates and apply them to a standardized population.

- The direct standardization process eliminates the effect of the age structure by using a single age structure as a standard for all populations being compared.

- THIS IS A MODELLED RATE TO ENABLE COMPARISON

# 2 Australian Examples: population distributions between groups and over time

**Example 1:** A key goal in Australia is to reduce the inequalities faced by Aboriginal and Torres Strait Islander people and provide life outcomes that are equal to all Australians.

Mortality rates are a key indicator (reduced death rates, increased life expectancy, lower numbers of deaths from preventable causes including suicide)

- Crude death rate for Aboriginal and Torres Strait Islander people is 4.7.
- Crude death rate for non-Indigenous Australians is 6.7.
- Do the age structures of these populations affect comparisons? Maybe.

## 2 Australian Examples: population distributions between groups and over time

**Example 2:** There is interest in how mortality rates track over time and what this says about improvements in mortality.

Of note, there have been changes in life expectancy, decreases in deaths due to circulatory diseases and infectious diseases.

- Crude death rate for people who died in Australia in 1968 was 9.1.
- Crude death rate for people who died in Australia in 2021 was 6.7.
- Do the age structures of these populations affect comparisons? Maybe.

# Example: population distributions

| Age groups | Aboriginal and Torres Strait Islander people (% of people in each age group) | Non-Indigenous people (% of people in each group) |
|---|---|---|
| 0-4 | 11.3 | 6.0 |
| 5-9 | 11.1 | 6.2 |
| 10-14 | 10.9 | 6.0 |
| 15-19 | 10.1 | 5.8 |
| 20-24 | 9.1 | 6.7 |
| 25-29 | 8.3 | 7.3 |
| 30-34 | 6.7 | 7.3 |
| 35-39 | 5.6 | 7.0 |
| 40-44 | 5.0 | 6.3 |
| 45-49 | 5.4 | 6.7 |
| 50-54 | 4.7 | 6.1 |
| 55-59 | 4.0 | 6.3 |
| 60-64 | 3.1 | 5.6 |
| 65-69 | 2.2 | 5.0 |
| 70-74 | 1.4 | 4.3 |
| 75+ | 1.3 | 7.2 |

# Example: population distributions

| Age groups | Population in 1968 (% of people in each group) | Population in 2021 (% of people in each age group) |
|---|---|---|
| 0 | 1.9 | 1.2 |
| 1-4 | 7.6 | 4.7 |
| 5-9 | 10.1 | 6.3 |
| 10-14 | 9.4 | 6.3 |
| 15-19 | 8.9 | 5.8 |
| 20-24 | 8.3 | 6.3 |
| 25-29 | 6.6 | 7.1 |
| 30-34 | 6 | 7.4 |
| 35-39 | 6.2 | 7.3 |
| 40-44 | 6.5 | 6.4 |
| 45-49 | 6.1 | 6.4 |
| 50-54 | 5.3 | 6.3 |
| 55-59 | 4.8 | 6 |
| 60-64 | 3.8 | 5.7 |
| 65-69 | 3 | 5 |
| 70-74 | 2.3 | 4.5 |
| 75-79 | 1.7 | 3.1 |
| 80-84 | 0.9 | 2.1 |
| 85+ | 0.5 | 2.1 |

# Age standardised mortality rate

Method: To standardise our population we would apply the age group percentage listed under the world average to our total population.

For the purposes of this course, we will use the WHO World Standard Population Distribution

Table 7.4 WHO World Standard Population distribution

| Table 4. WHO World Standard Population Distribution (%), based on world average population between 2000-2025 | |
|---|---|
| Age group | World Average 2000-2025 |
| 0-4 | 8.86 |
| 5-9 | 8.69 |
| 10-14 | 8.60 |
| 15-19 | 8.47 |
| 20-24 | 8.22 |
| 25-29 | 7.93 |
| 30-34 | 7.61 |
| 35-39 | 7.15 |
| 40-44 | 6.59 |
| 45-49 | 6.04 |
| 50-54 | 5.37 |
| 55-59 | 4.55 |
| 60-64 | 3.72 |
| 65-69 | 2.96 |
| 70-74 | 2.21 |
| 75-79 | 1.52 |
| 80-84 | 0.91 |
| 85-89 | 0.44 |
| 90-94 | 0.15 |
| 95-99 | 0.04 |
| 100+ | 0.005 |
| Total | 100 |

# Age-standardised mortality rate formula

| *Direct method* |
|---|
| $SR = \dfrac{\sum (r_i P_i)}{\sum P_i}$ |

SR is the age-standardised rate for the population being studied

$r_i$ is the age-group specific rate for age group i in the population being studied

$P_i$ is the population of age group i in the standard population

# Our examples and outcomes of age-standardisation

| | Aboriginal and Torres Strait Islander people | Non-Indigenous people | Rate Ratio |
|---|---|---|---|
| CDR | 4.7 | 6.6 | 0.7 |
| SDR | 9.5 | 5.2 | 1.8 |
| | | | |
| | 1,968 | 2021 | Rate Ratio |
| CDR | 9.1 | 6.7 | 1.4 |
| SDR | 13.8 | 5.1 | 2.7 |

# Principles for age-standardisation

- 1. Denominators should never be less than 30 (population size).
- 2. Numerators should try and be at least 20. Can go to 10 in some circumstances but never calculated for smaller numbers. Combine years/cohorts etc to form a more robust numerator.
- 3. Ideally age-specific rates should be calculated on 5 year age bands. E.g. 0-4, 5-9, 75+ etc.  Can go to 10 year age bands if required. Never produce age-standardised rates on 20 year age bands, these are too broad. (think about upper limits
- 4. Age-standardised rates should not be used in isolation. Use counts of death, rate ratios, age-specific rates to provide as much information as possible.
- 5. For conditions restricted to specific age groups (e.g. infants) use age of interest.

# When to use each rate?

- All rates are important in different contexts
- Age-specific rates can be important for demographics of interest (e.g. child mortality, maternal mortality and certain causes of death).
- Anywhere that a comparison is required and populations have different age structures age-standardisation should be applied
- If a burden of disease needs to be understood in a specific time point with no comparisons then a crude rate is important (it represents actual mortality for the period)

# Cause-specific rates

- Causes of death can also be analysed using rates
- Concepts are similar but by cause
- Usually output by 100,000 people due to small numbers
- Generally grouped by ICD-10 codes
- Talk to facilitators if you are including causes of death in your report

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# Q&A