All-cause mortality

Objectives

- Understand demographic concepts that can explain patterns in all-cause mortality data
  - Population age structures and the demographic transition
- Apply adjustment methods for incomplete data
- Apply adjustment methods for incomplete registration
- Calculate and explain trends in mortality data using demographic concepts and measures
  - Crude death rate; completeness of registration; under-five mortality rate; age-specific death rates; age-sex distribution of deaths
- Complete the minimum tables as required in the vital statistics report template

Fundamentals of all-cause mortality analysis

Recap

Numerator and denominator

- The **numerator** is the outcome of interest
  - A death
- The **denominator** is the population "at risk" of the outcome
  - We need to relate the absolute number of deaths to some measure of population from which they came (i.e. "Population-at-risk")
- **CRVS challenge**: The numerator and denominator often come from different data sources → need to have consistent definitions of:
  - Geographical boundaries – especially subnational
  - Residency status
    - *de facto*, place of residency at the time of enumeration or event
    - *de jure*, usual place of residency

Denominator - population

- Most of our mortality indicators are a measure of the relative frequency with which events occur in a population
- It is too logistically difficult to follow a distinct cohort in a large population throughout their lives
- It is easier to assume deaths equally distributed throughout year, on average
- So we use the mid-year or mid-period population as our denominator
  - Mid-year: 30 June
  - Mid-period: if the period is more than 1 calendar year (e.g. 30 Jun 2014 for the period 2013-15)

Importance of recording age and sex

- Age-specific death rates, which have numerous applications in mortality analysis, require mortality data to be disaggregated by age
- The same for analysis of mortality by sex
- In many countries where CRVS systems are still paper-based, the fact of death is reported with no information on age (and also sometimes sex)
  - This has a major negative impact on the public health value of mortality data
  - It is absolutely crucial that accurate age data are collected and reported in the CRVS system
- Age should be collected by asking for the date of birth of the decedent, rather than simply their age at death
  - This reduces age heaping, which is the over-reporting of age at death at ages with a terminal digit of 5 or 10 (e.g. 55, 60, 65, 70 years etc)

Population age structure

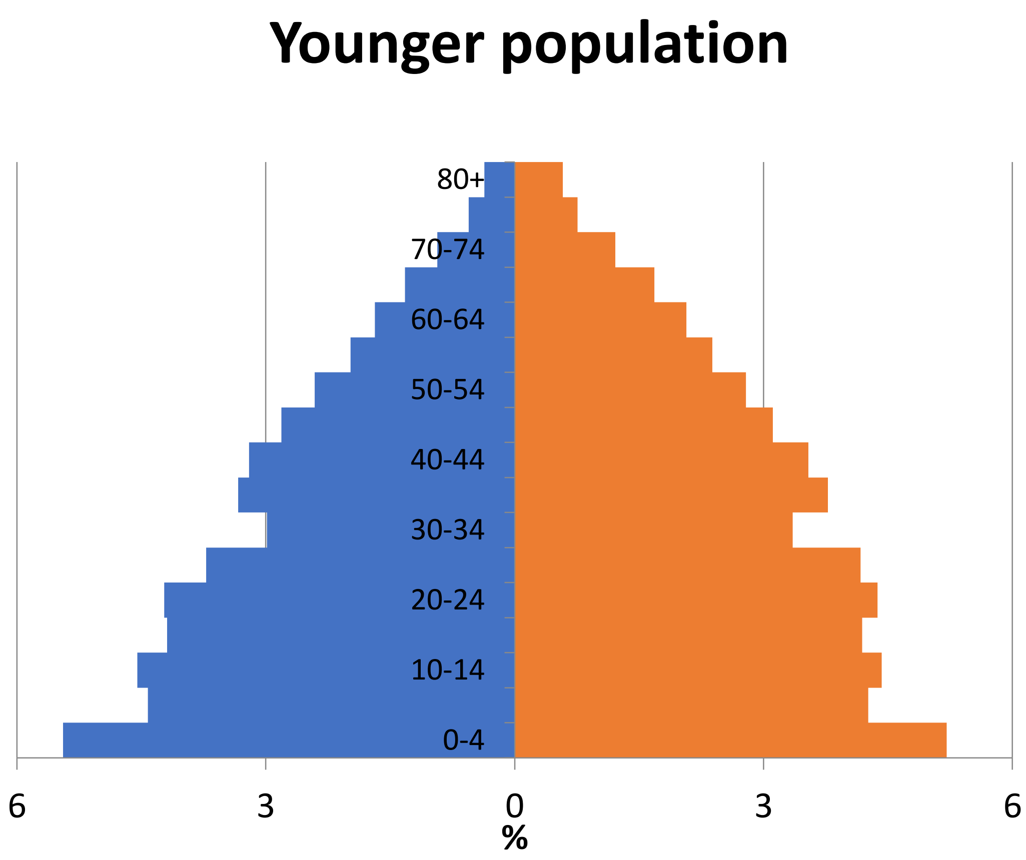
- In mortality and cause of death indicators, the denominator is often population
- Both the risk of mortality and the causes of death are strongly related with age (e.g. maternal deaths occur to women of reproductive age)
- Knowledge of the size and age structure of a population is imperative in understanding the risks of mortality in a population – **both the fact and cause of death**

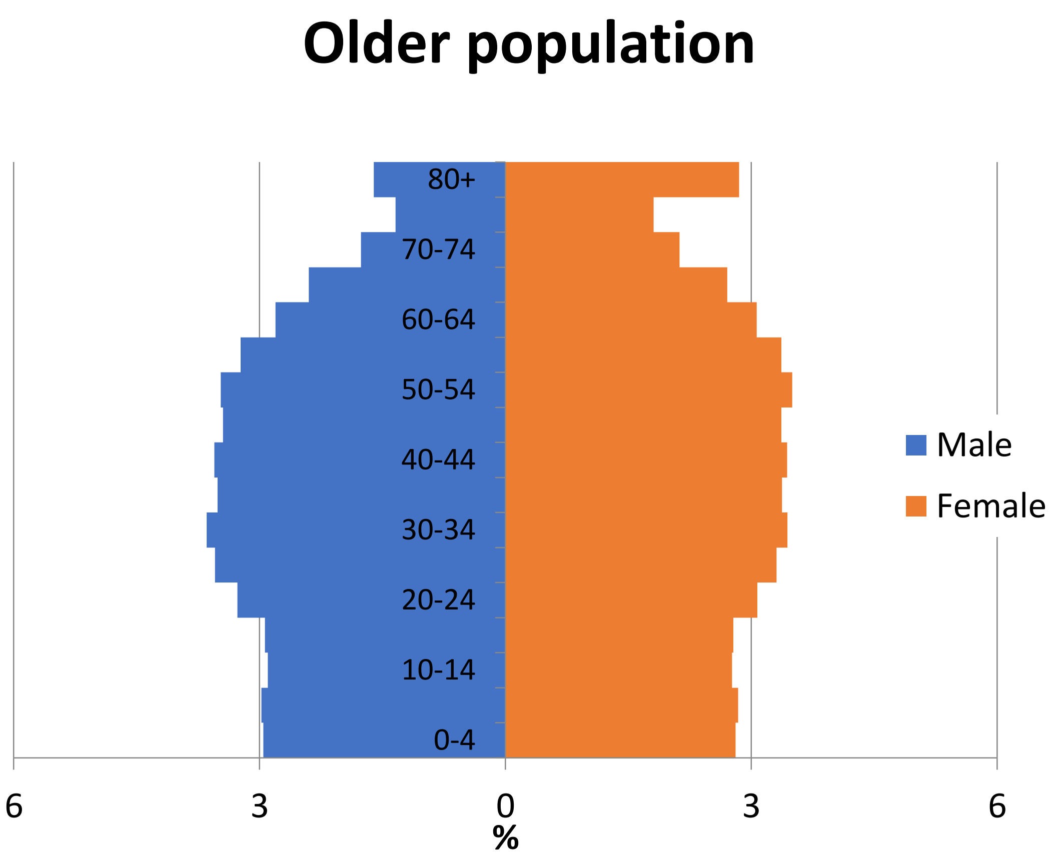
Population age structure

- Understanding population size and age structure is also important for health planning
  - How many people are likely to suffer and die from what diseases?
- In an older population, there will be a higher proportion of people of an age with the highest risk of mortality
- The risk of dying from a non-communicable disease (NCD) also increases with age
  - In an older population, the proportion of the population dying from a NCD would be higher than in a younger population (everything else being equal)

What is an effective way of visualising the structure of a population?

Population pyramids



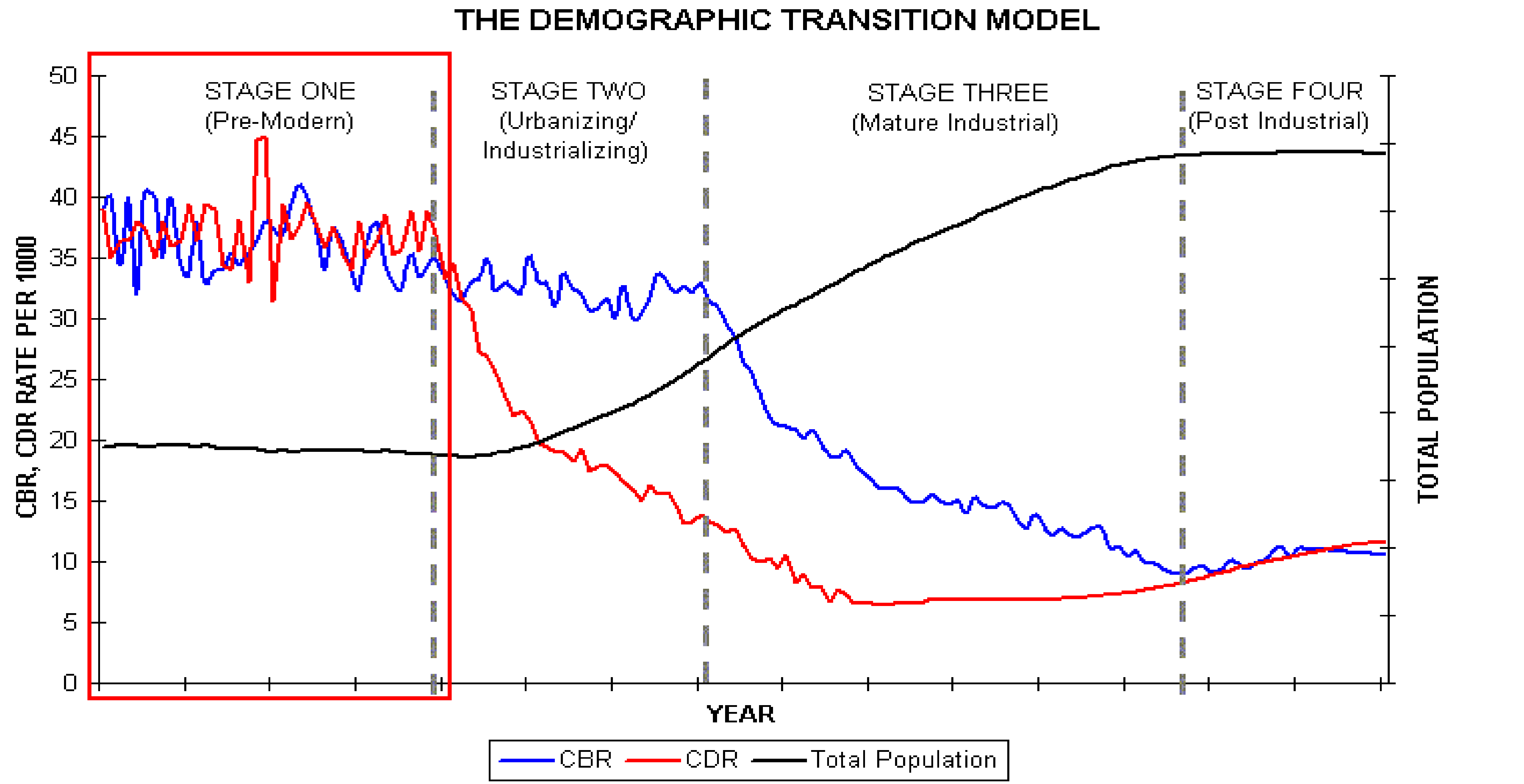


What causes populations to have different age structures?

- A younger population is caused by high birth rates and, in very traditional societies, high child mortality rates
- An older population is caused by:
  - declining births rates that gradually reduce the proportionate size of each successively younger generation to older generations
  - declining mortality rates that cause people to live to older ages
- This process of declining birth and mortality rates has occurred in most countries of the world over a long period of time
- It is described by the **demographic transition**

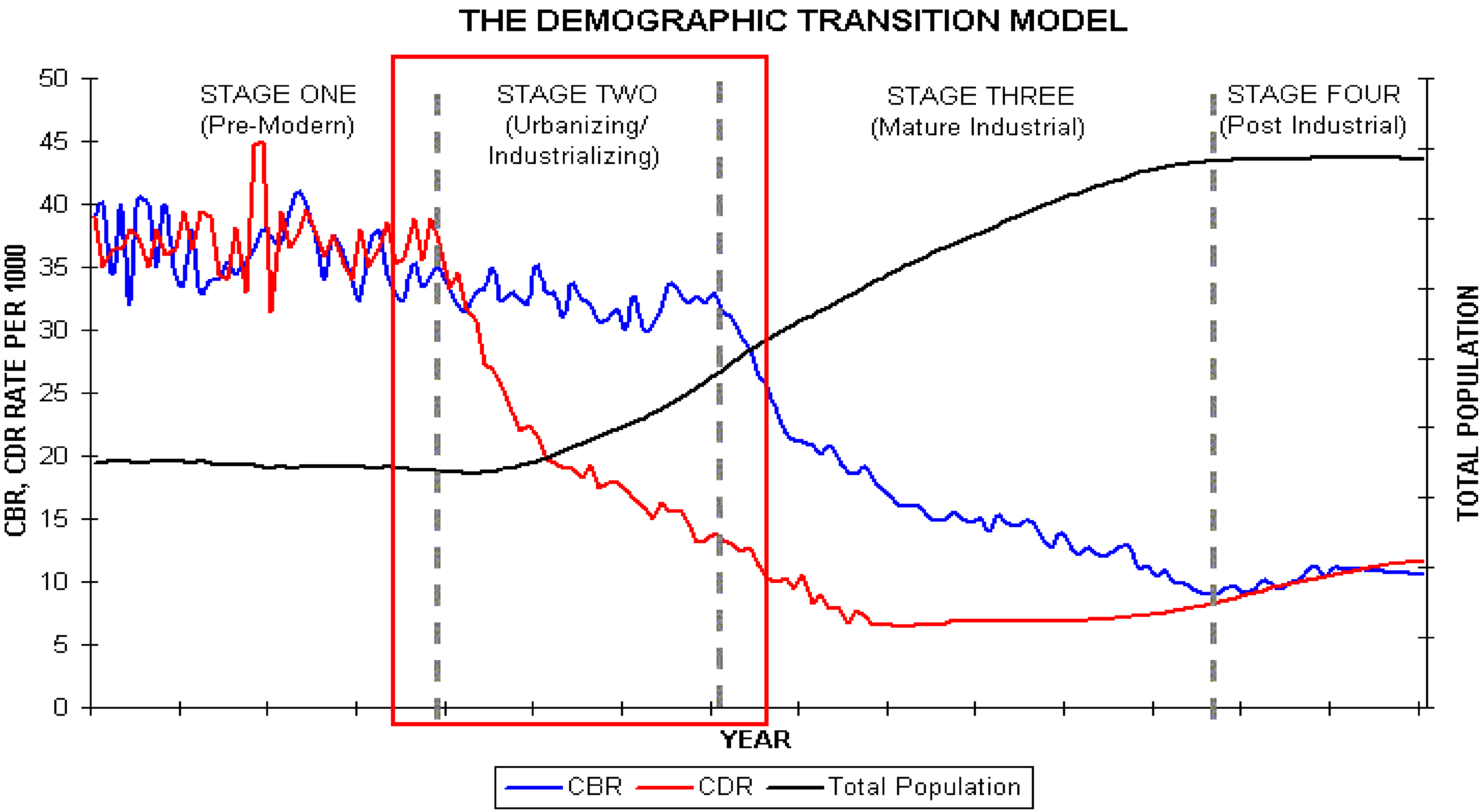
Demographic transition (4 stages)

1. High birth and death rates, no or very low population growth, and a very young population age structure
   - Common in European countries pre-Industrial Revolution, and many developing countries until more recently


THE DEMOGRAPHIC TRANSITION MODEL
STAGE ONE
(Pre-Modern)
STAGE TWO
(Urbanizing/
Industrializing)
STAGE THREE
(Mature Industrial)
STAGE FOUR
(Post Industrial)
CBR, CDR RATE PER 1000
50
45
40
35
30
25
20
15
10
5
0
TOTAL POPULATION
YEAR
CBR
CDR
Total Population

Demographic transition

2. Death rates decline
    - largely due to greater survival in childhood
    - birth rates stay high, leading to strong population growth
    - this stage was experienced in Europe in much of the 19th century, and is still present in high fertility settings in Africa and Asia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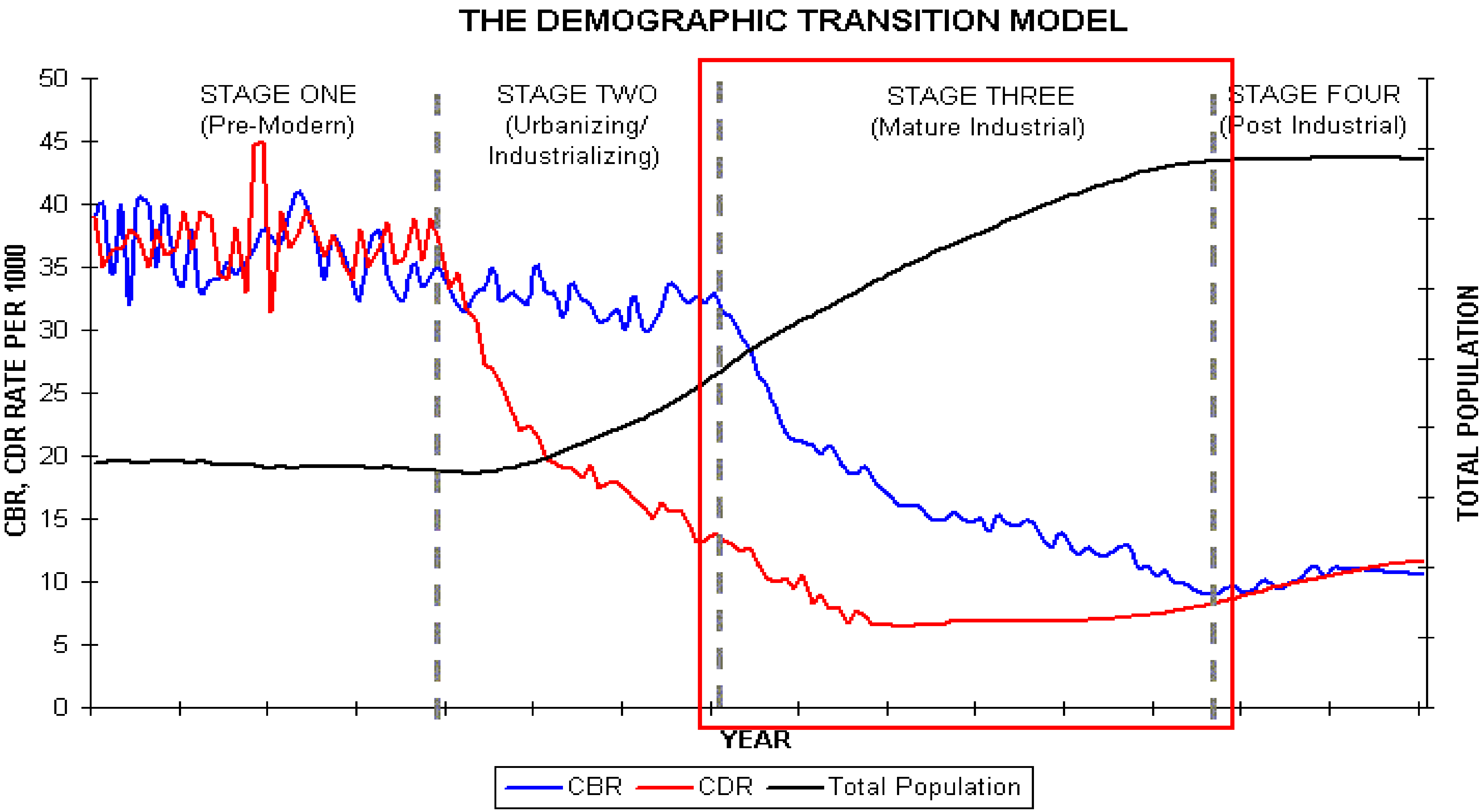
CBR, CDR RATE PER 1000
TOTAL POPULATION
0
5
10
15
20
25
30
35
40
45
50
YEAR
CBR
CDR
Total Population

Demographic transition

3. Birth rates fall significantly and population growth declines, while the population age structure becomes older
    - lower mortality reduces the need to have high numbers of children to compensate for those who die
    - greater urbanisation changes the value placed on children as a source of labour,
    - female education level increases and provided greater opportunities aside from childbearing,
    - birth control more widely used (especially in more recent decades)
    - many lower-to-middle income countries are in this stage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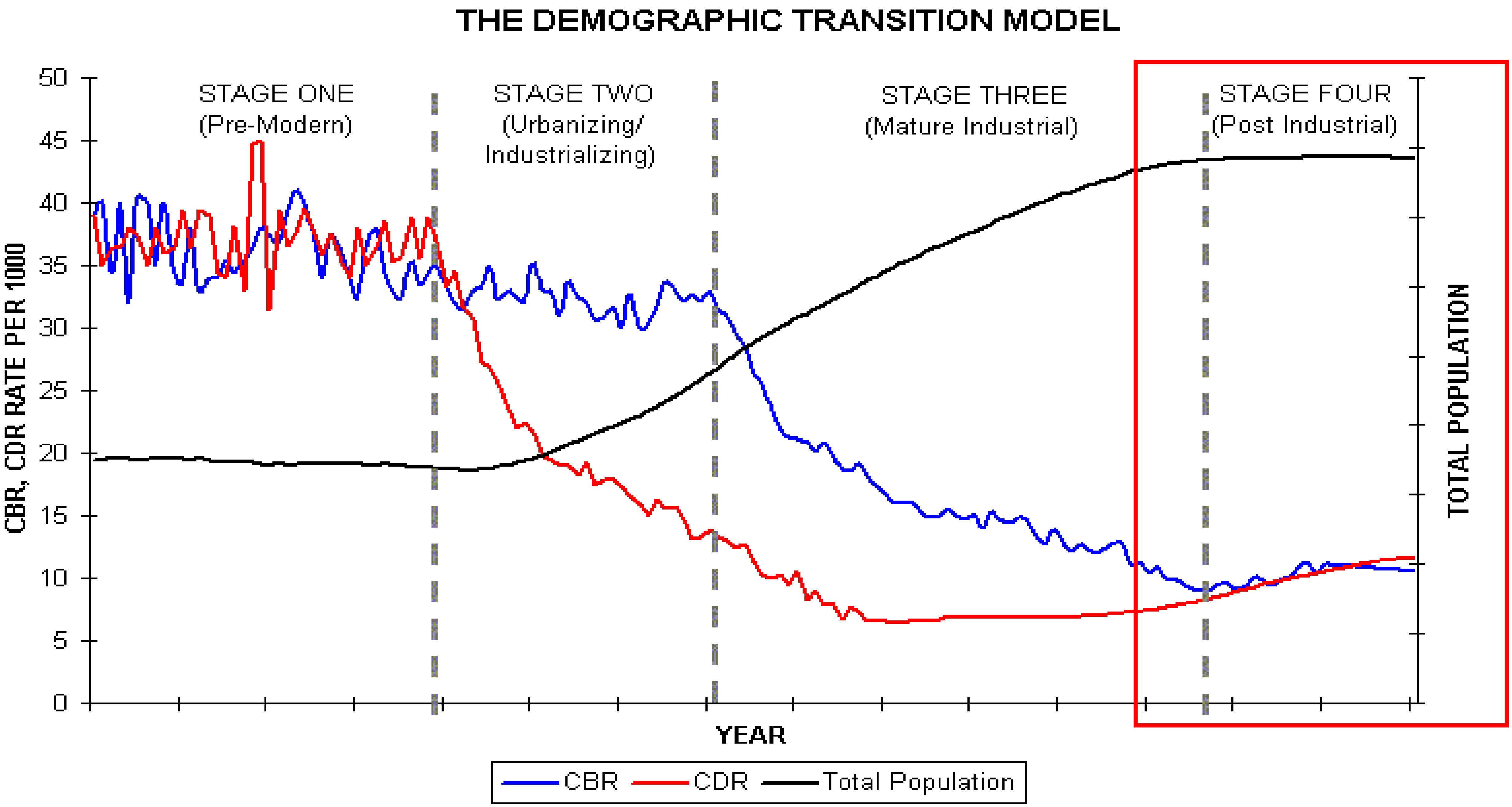
CBR
CDR
Total Population

Demographic transition

4. Low birth and death rates, low population growth and older age structure
   - this is the stage most Western countries are presently in
   - some researchers have also suggested that a fifth stage is present, as found in the very low fertility and old age structures in Japan and parts of Europe and Asia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40
45
50
YEAR
TOTAL POPULATION
CBR
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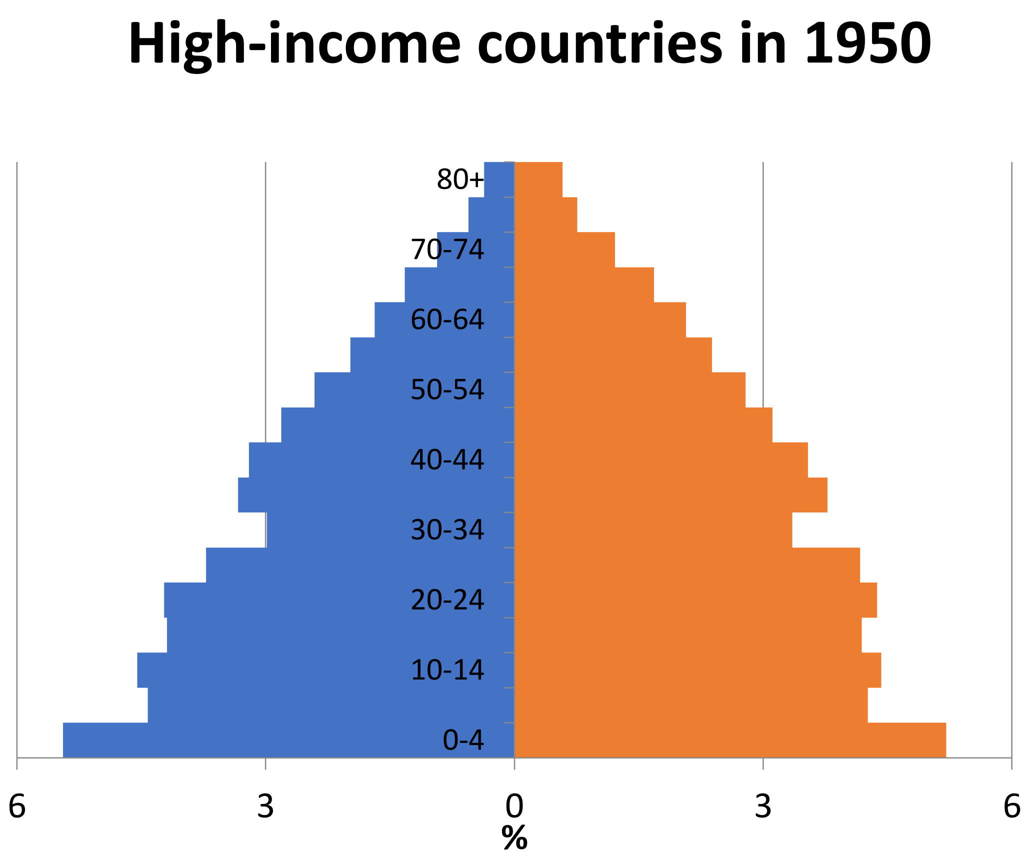
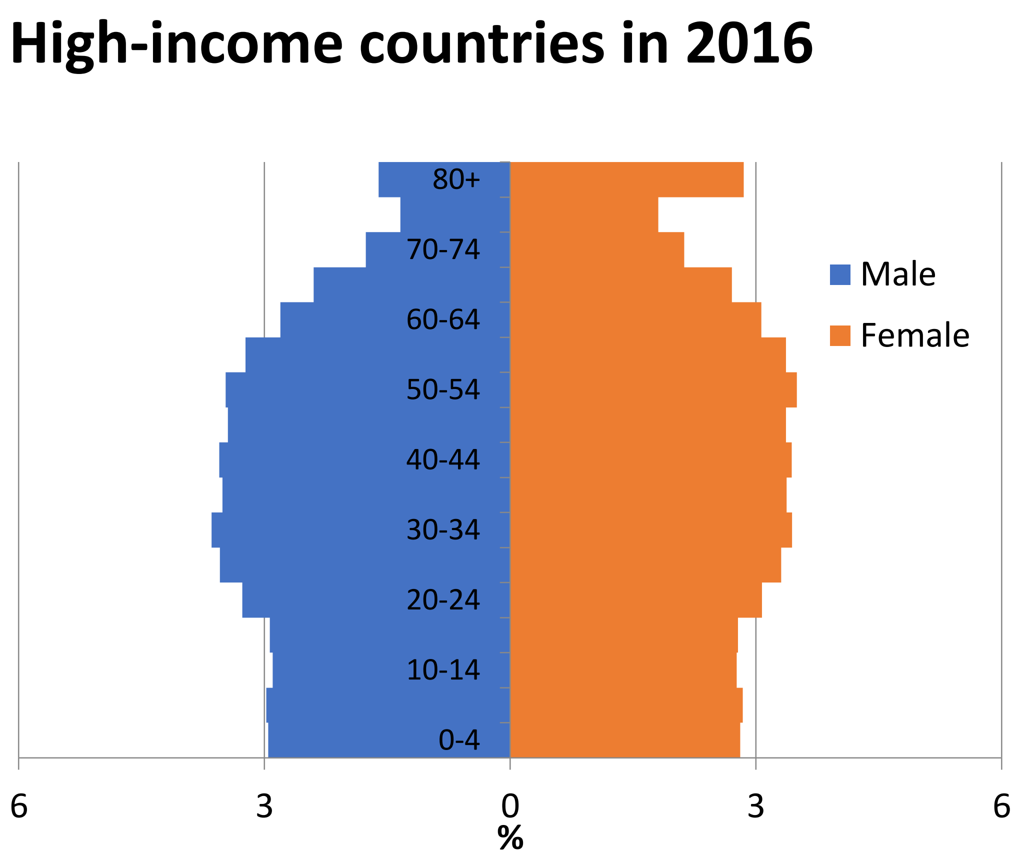
Total Population

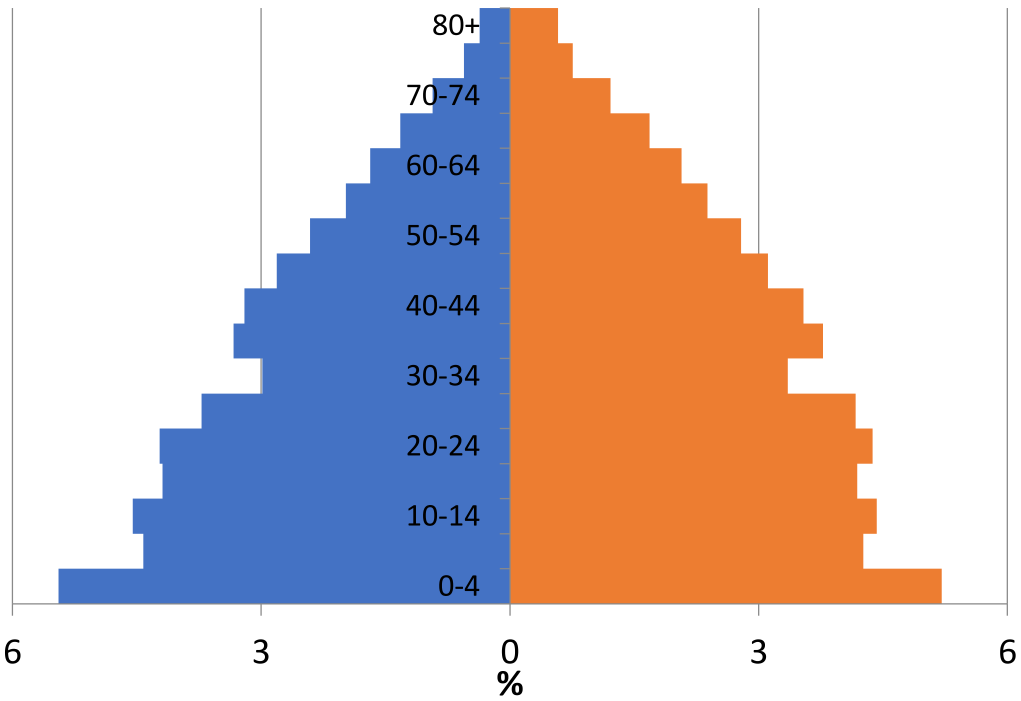
Demographic transition: high-income countries over time



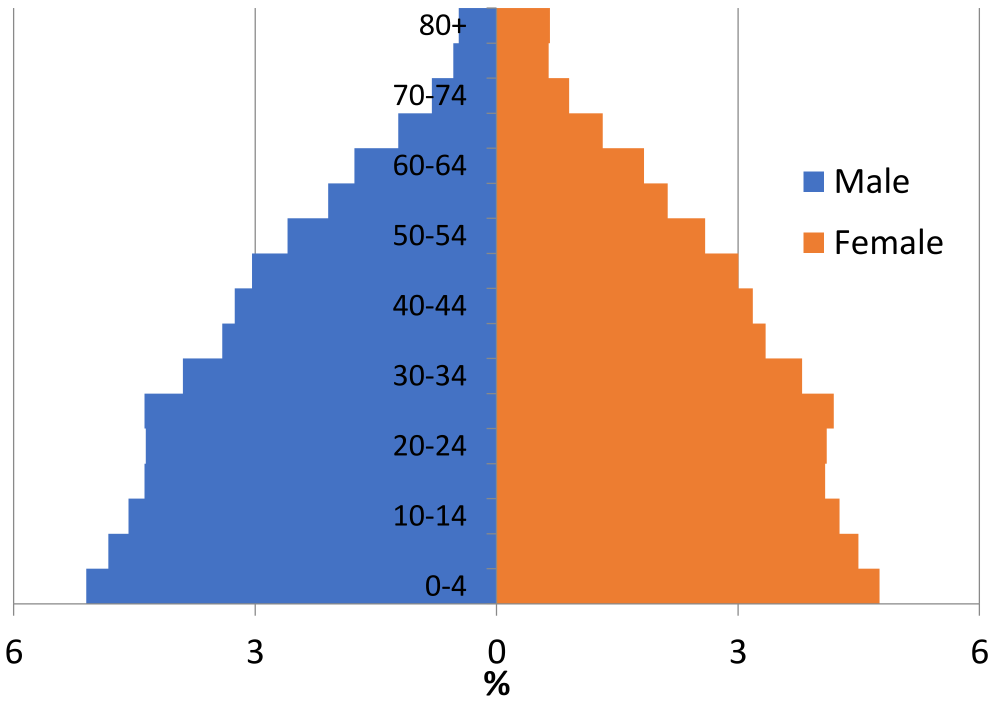


Demographic transition between countries and over time

High-income countries in 1950



LMICs in 2016



Which stage of the demographic transition do you think your country is in, and why?

All-cause mortality concepts and measures

Explaining trends in your mortality data

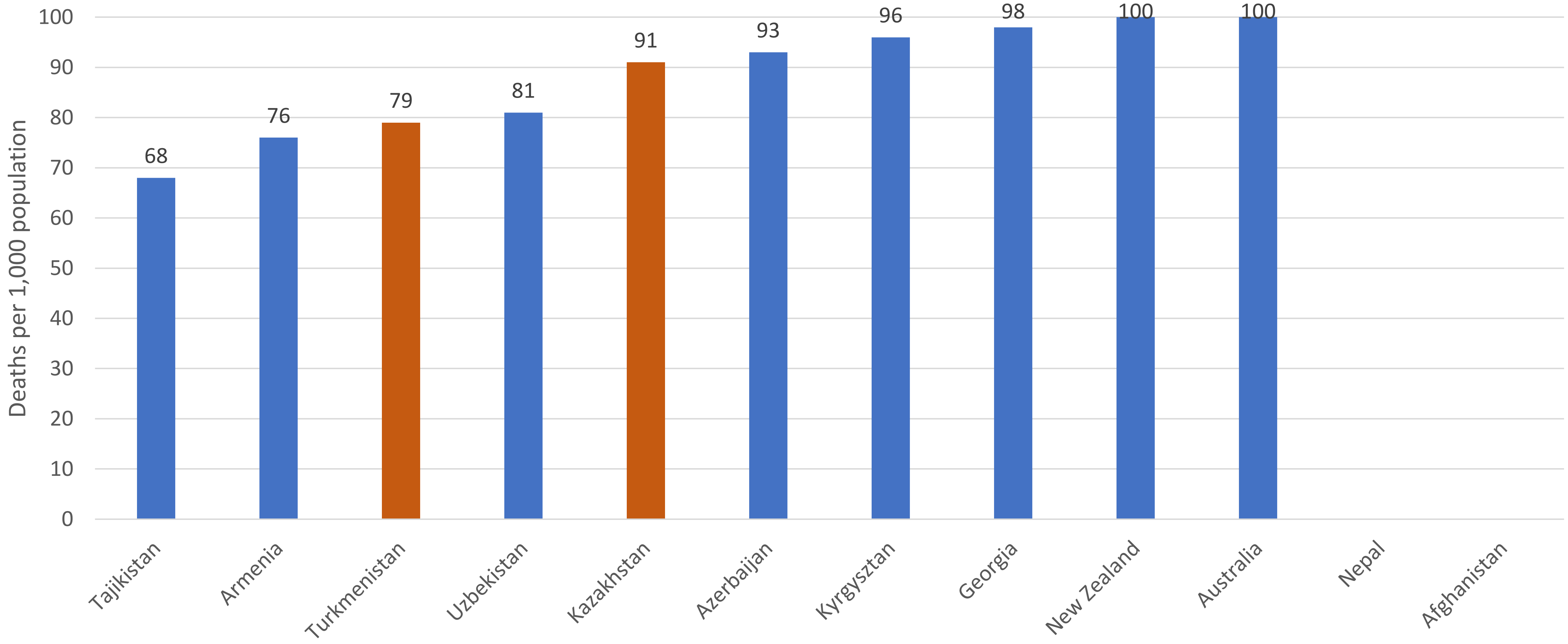
A good vital statistics report will not only report on key measures, it will assess their plausibility – always remember to ask yourself, *does this look right for my country or region?*

Completeness of registration

- Completeness refers to the percentage of actual deaths in a population that are registered
- Routine assessment of registration completeness is a **core function** of a CRVS system
  - Incomplete registration data lead to incorrect vital statistics
- Estimation of the completeness of registration can also help in **monitoring the performance of the CRVS system**
  - How completeness differs between geographic areas or demographic groups
  - Help target interventions to improve registration completeness

$$\text{Completeness of death registration (\%)} = \frac{\text{Number of registered deaths}}{\text{Actual number of deaths}} * 100$$

Estimates of death registration coverage (with COD): What do you think?



Source: WHO Global Health Observatory data repository, available at http://apps.who.int/gho/data/view.main.HS10v

Completeness of registration

- There are a range of methods that can be used to estimate the completeness of registration
  - Direct methods
  - Indirect methods
  - Estimating total actual deaths from a range of data sources
  - Empirical methods
- Where possible, estimation of completeness should be made separately for males and females and, if possible, for different age groups
- Depending on the method used, completeness results may or may not be available for different age groups

Direct methods

- Direct or capture-recapture methods: matching of registration data to another *independent* data source(s) that report the birth or death (eg. matching registered deaths to deaths reported in a HDSS site)
- In many populations with operational CRVS systems, there are other sources of information on vital events such as births and deaths. These data sources can include:
  - An existing routine reporting system or government records (eg health centre or hospital, baptism or burial records, school enrolment)
  - A health and demographic surveillance (HDSS) site
  - A household survey
  - A population **census**

Direct methods – example

		Vital registration		
		YES	NO	TOTAL
Survey	YES	106	37	143
	NO	40	14	54
	TOTAL	146	51	197

$$\text{Completeness of registration} = \frac{106+40}{197} = 74.1\%$$

OR

$$= \frac{106}{106+37} = 74.1\%$$

Indirect methods

- Indirect or death distribution methods estimate completeness based on:
  - available data on the age pattern of the population obtained other data sources (eg. a Population Census)
  - the age pattern of deaths from the CRVS system
  - specific assumptions about the dynamics of the population (e.g. constant mortality and fertility levels, constant population growth, no or little migration)
- Bennett-Horiuchi method has been found to be the most accurate of the existing indirect methods when combined with an estimate of the relative completeness of the reporting of population in the two censuses by the Generalised Growth Balance method

Indirect methods (all require the number of registered deaths as an input)

Method	Assumption	Population data required
Growth balance methods		
Brass Growth Balance	Stable population	Population by age group
Generalised Growth Balance	Closed population	Population by age group from two censuses (or at two points in time from another source)
Synthetic extinct generations methods		
Preston-Coale	Stable population	Population by age group, population growth rate
Bennett-Horiuchi (also known as Synthetic Extinct Generations)	Closed population	Population by age group from two censuses (or at two points in time from another source)

Adjusting for incompleteness of registration

1. Use age- and sex-specific estimates of completeness using direct methods
2. Adjust 45q15 (adult mortality) for incompleteness, then use 5q0 and 45q15 in a model life table
3. Adjust incomplete data at older ages using Gompertz function

Age- and sex-specific estimates of completeness from a capture-recapture study

District of Pekalongan, Indonesia, males, 2007	Registration data (1)	Completeness (2)	Actual (estimated)
Deaths (Total)	**828**	**72.4%**	
Deaths (Age 0-14)	61	53.8%	
Deaths (Age 15-59)	205	72.1%	
Deaths (Age 60+)	562	75.7%	
Crude death rate	**6.3 / 1,000**	**72.4%**	
Life expectancy	**69.6**		
Under-five mortality rate			
Adult mortality rate			

Age- and sex-specific estimates of completeness from a capture-recapture study

District of Pekalongan, Indonesia, males, 2007	Registration data (1)	Completeness (2)	Actual (estimated)
Deaths (Total)	**828**	**72.4%**	**1,144**
Deaths (Age 0-14)	61	53.8%	113
Deaths (Age 15-59)	205	72.1%	284
Deaths (Age 60+)	562	75.7%	742
Crude death rate	**6.3 / 1,000**	**72.4%**	**8.7**
Life expectancy	**69.6**		**64.2**
Under-five mortality rate			**33.6**
Adult mortality rate			**271**

Are there any age groups we might want to calculate completeness for separately? Why?

Estimates of the under-five mortality rate (5q0)

- The estimate of the true under-five mortality rate can come from the IGME or GBD
- Subnational estimates are commonly available in the DHS (complete birth histories) or from the census (summary birth histories)
- You can scale these subnational estimates to national IGME or GBD estimates, to ensure national:subnational consistency of 5q0
- There are also statistical methods to plot long-term trends in 5q0
- **Completeness of under-five mortality is simply 5q0 computed from registration data divided by the estimate of the true 5q0**

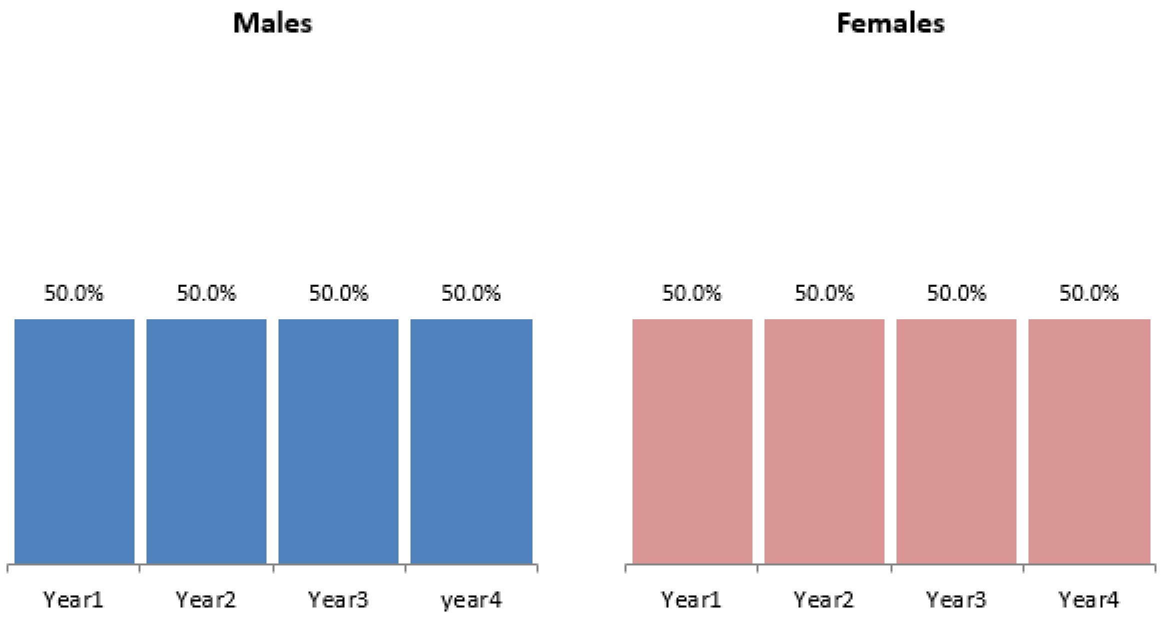
Presenting completeness of death registration in your vital statistics report

Data lab

Data lab: Practice sessions

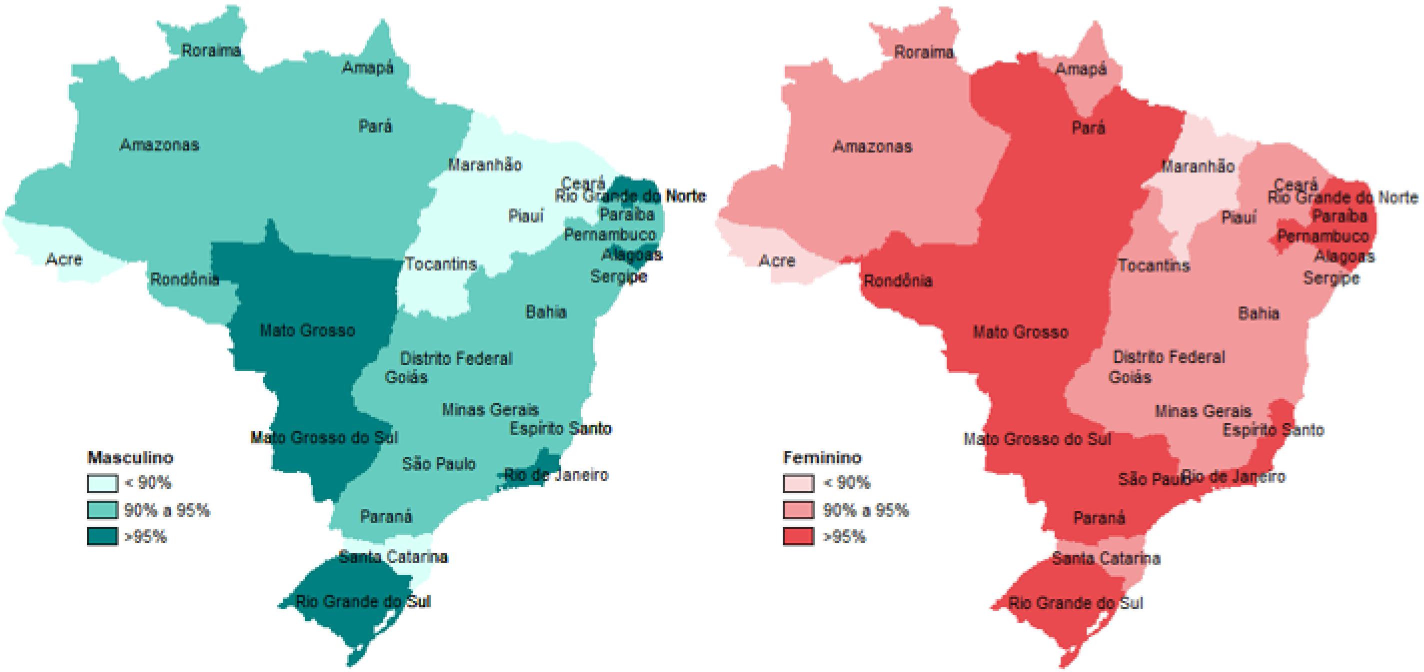
- Use excel file "All cause mortality"
- For those that would like extra time to go over some of the concepts, or who do not have a suitable dataset of their own, the first 8 tabs will take you through a data cleaning and analysis exercise (from raw data to final tables and graphs)
- For those of you who have your own data...

Data lab: Completeness of death registration by sex and year



Data lab: Completeness of death registration by sex and region

Figura 5 Cobertura de notificação dos óbitos por Estados e sexo. Brasil, 2016.



* utilizadas as estimativas GBD 2016 da mortalidade na infância por Estados para o cálculo.

Age and sex distribution of deaths

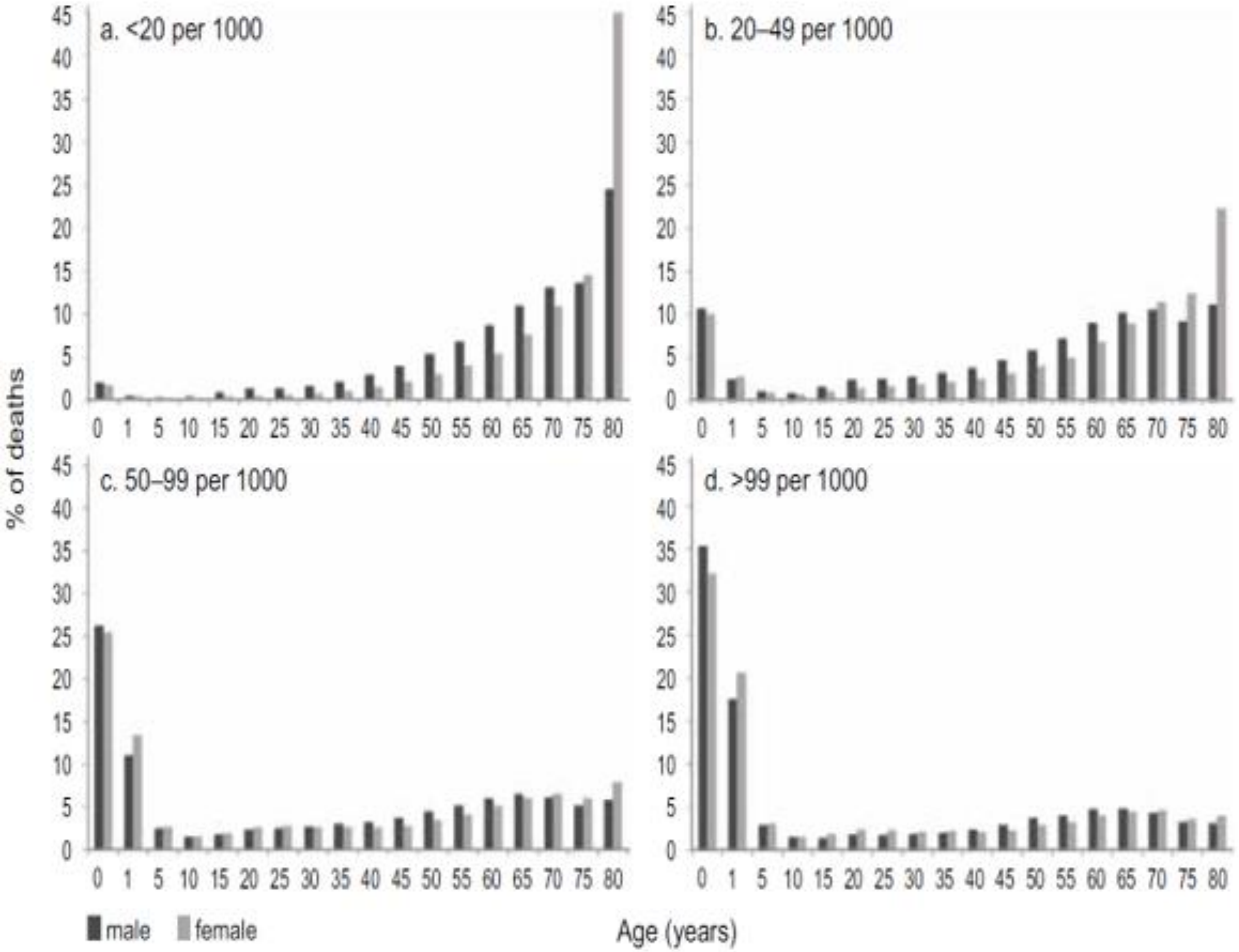
- The proportion of deaths in a population increases with age, because the ***risk*** of dying increases with age (except at the youngest ages)
- However the extent of this increase depends on the **age distribution** of the population
- There should be more deaths at ages 0-4 than at 5-9 or 10-14 age groups, because of higher risk of death under the age of 5
- Typically, there should be more female deaths at the oldest age group because more women survive to the oldest ages

Understanding the age and sex distribution of deaths

- At lower levels of socio-economic development:
  - The infant mortality rate is higher, so a higher proportion of deaths will occur at younger ages
  - Populations are younger, so there may not be such a steep increase because there is a low proportion of people at older ages (which offsets the much higher risk of mortality at older ages)
- At higher levels of socio-economic development:
  - The increase in the proportion of deaths at older ages should be steeper
  - Infant mortality is lower, and so a higher proportion of deaths occur at older ages
  - Populations are older, so this will also contribute to a steeper increase in the proportion of deaths at older ages

Age-sex distribution of deaths:

examples at various levels of infant mortality (IMR, deaths per 1,000 live births)



Essential tables from the vital statistics report template

Data lab

Data lab: Registered deaths by age and gender

		Total	Male	Female
Neonatal (< 7 days)				
Late neotatal (7-28 days)				
Post neonatal (28-265 days)				
0				
1-4				
5-9				
10-14				
15-19				
20-24				
…				
…				
95-99				
100+				
Not known				
Total				

Quality check: Are lots of your death records missing age?

- When death records are missing age, we need to estimate age at time of death
  - This also applies to births where age of mother is unknown
- Use the age distribution of deaths with known ages to determine how many of our unknown aged deaths should end up in each age group
- As age patterns are different for males and females, the re-distribution of these deaths should be done separately by sex
- Whether the re-distribution is done by year, or over an aggregated period will depend on the overall number of deaths, and the proportion for which no age is reported

Redistributing deaths by age

- Start by setting up a table of deaths by age group and sex for the year(s) where data are missing
- For the deaths for which age is known, calculate the percent distribution of these deaths by age group for each sex separately
- Multiply the percent for each age group from this distribution to the total number of deaths (including deaths of unknown age) to get the revised number of deaths by age
- Round your results to the nearest whole person (after all – we don’t get part of a person dying!)

For the deaths for which age is known, calculate the percent distribution of these deaths by age group for each sex separately

Age	Total deaths		Percentage of total excluding unknown ages (%)		Re-distributed deaths by age	
	M	F	M	F	M	F
<1 year	14	12	3.8	3.9	15	13
1-4	6	4	1.6	1.3	7	4
5-9	2	1	0.5	0.3	2	1
10-14	1	4	0.3	1.3	1	4
15-19	5	6	1.4	2.0	5	6
20-24	9	13	2.5	4.3	10	14
25-29	16	12	4.4	3.9	17	13
30-34	23	12	6.3	3.9	25	13
35-39	25	14	6.8	4.6	27	15
40-44	22	15	6.0	4.9	24	16
45-49	26	22	7.1	7.2	28	24
50-54	35	26	9.6	8.5	38	28
55-59	38	28	10.4	9.2	41	30
60-64	48	32	13.1	10.5	52	35
65-69	58	44	15.8	14.4	63	47
70-74	36	36	9.8	11.8	39	39
75+	2	24	0.5	7.9	2	26
Unknown	33	24				
TOTAL	399	329	100.0	100.0	399	329

$$= \frac{14 \text{ deaths}}{(399-33) \text{ deaths}} \times 100$$

$$= \frac{14 \text{ deaths}}{366 \text{ deaths}} \times 100$$

= 3.8%

Apply this percentage to all deaths (including deaths with unknown age)

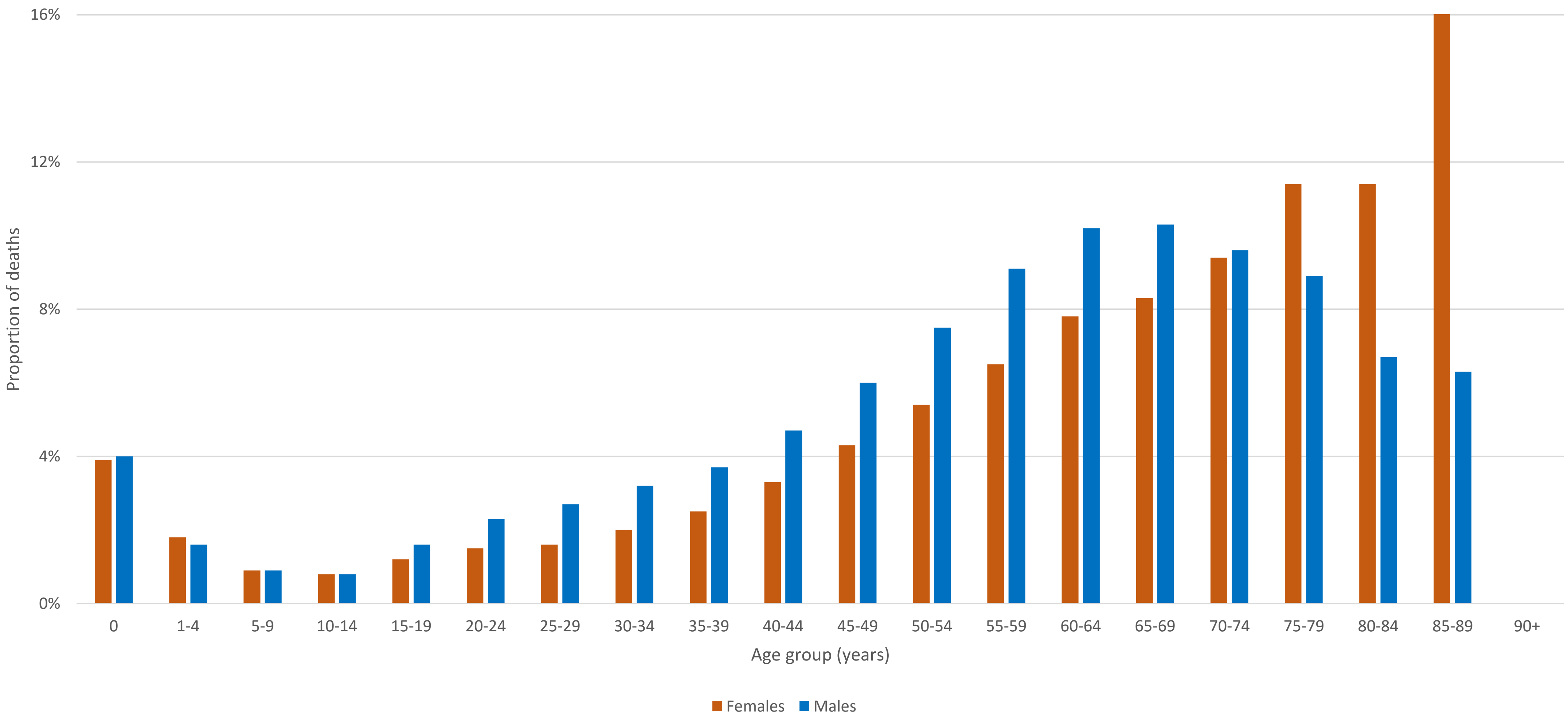
$$= \frac{3.8 \times 399}{100}$$

=15.16 deaths to males aged <1

Data lab: Registered deaths by age and gender (*redistributed*)

		Total	Male	Female
Neonatal (< 7 days)				
Late neotatal (7-28 days)				
Post neonatal (28-265 days)				
0				
1-4				
5-9				
10-14				
15-19				
20-24				
...				
...				
95-99				
100+				
Not known				
Total				

Data lab: Registered deaths by age and gender



Data lab: Registered deaths by month of death

	Total	Male	Female
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			
Not known			
Total			

Data lab: Registered deaths by place of death, and by region

	Total	Completeness	Urban	Rural	Not known
:					
2012					
2013					
2014					

	Total	Completeness	Died in medical institution	Died elsewhere	Not known
Total					
Region 1					
Region 2					
Region 3					
:					

Crude death rate (CDR)

- The crude death rate is the number of deaths in a defined period (usually a calendar year) per 1,000 people
- The level of the CDR is influenced by:
  - the level of age-specific mortality rates, and
  - the age structure of the population

$$\text{Crude death rate} = \frac{\text{Number of deaths in calendar year}}{\text{Mid−year population}} \text{ x } 1000$$

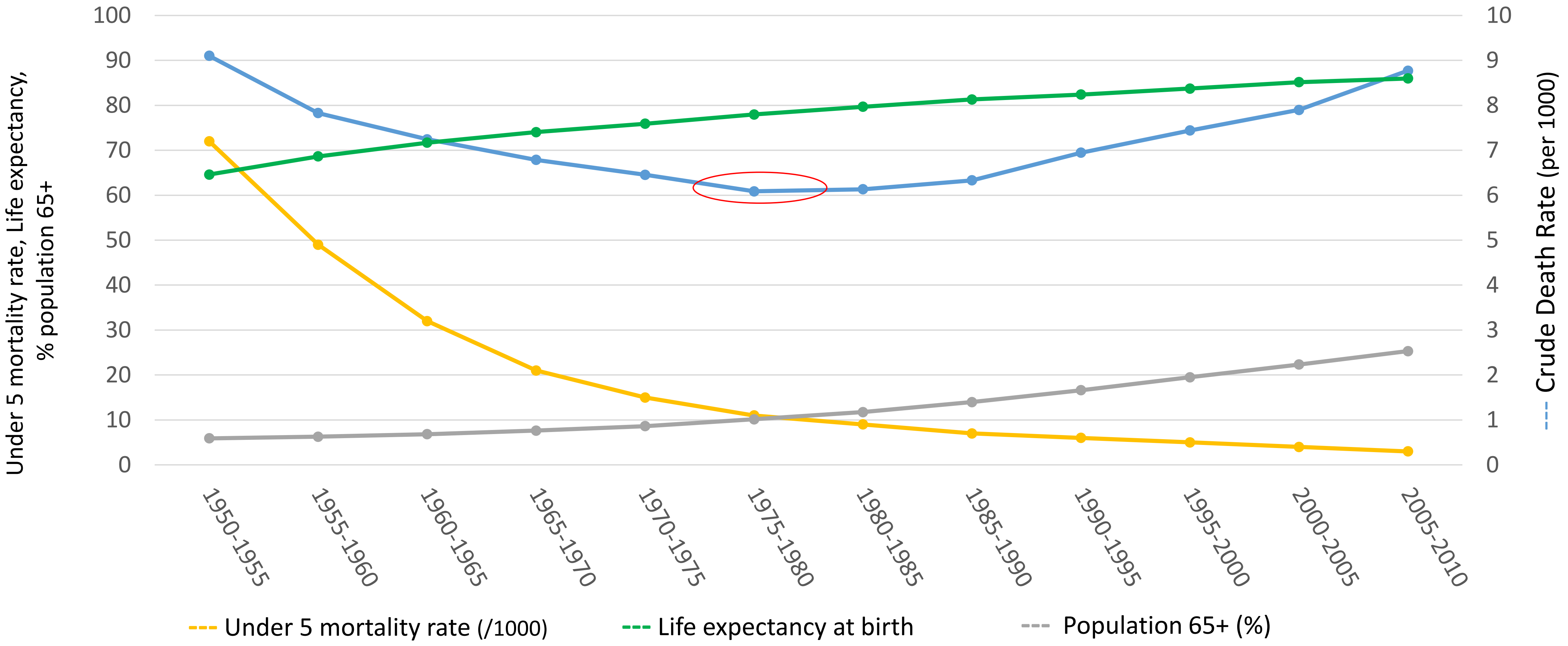
OR (if using multiple years)

$$= \frac{\text{Number of deaths in period}}{\text{Mid−period population}} \text{ x } 1000$$

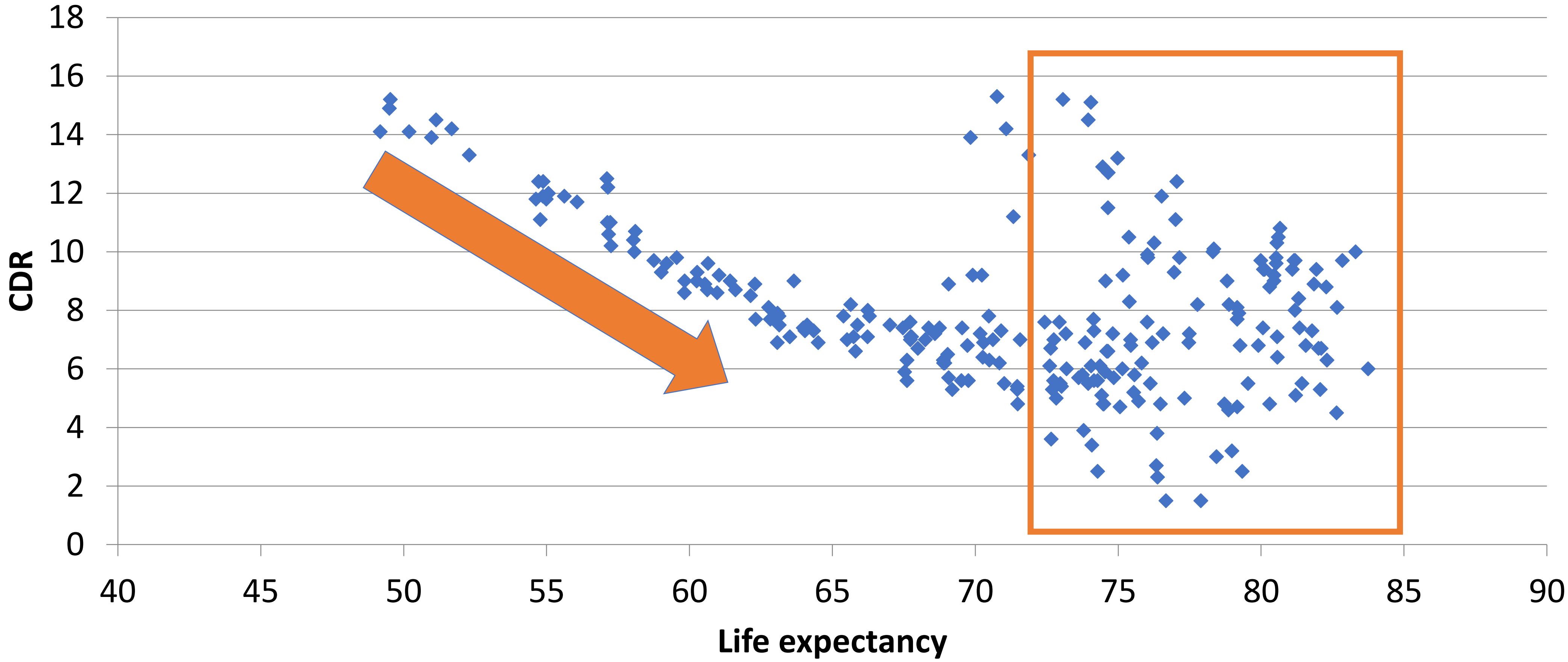
Understanding crude death rates

- At a given level of age-specific mortality rates, **an older population will result in a higher CDR**
  - Why? Because the risk of dying increases with age, if there is a higher proportion of the population at older ages it will increase the CDR
- Of course, **higher age-specific mortality rates lead to a higher CDR**
- However, **an older population is generally associated with lower age-specific mortality rates**
- So CDR does not always decline as life expectancy increases
  - An ageing population can cause CDR to increase despite life expectancy also increasing

Empirical evidence : Japanese females, 1950-2010



CDR by life expectancy, all countries

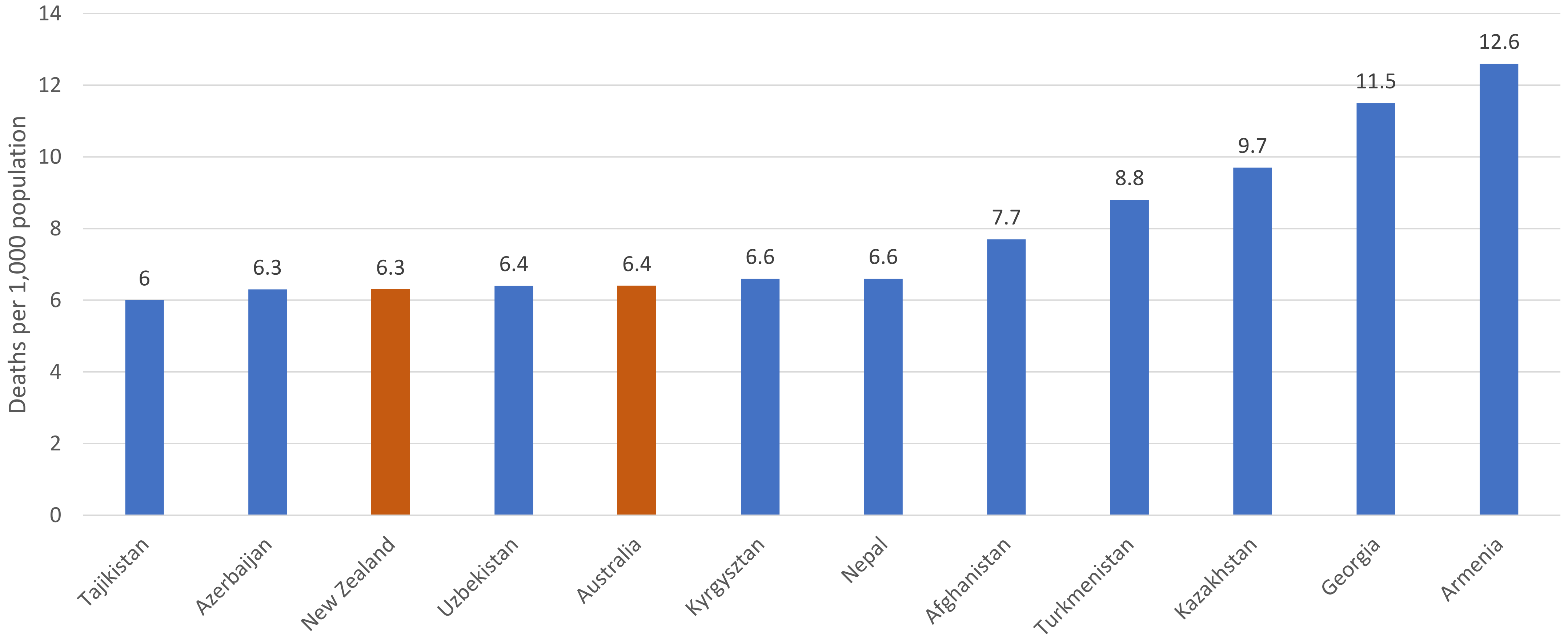


Source: UN World Population Prospects 2015

Understanding your mortality data: Explaining crude death rates

- A CDR of less than 4 or 5 per 1,000 population generally indicates incomplete death reporting
  - Only in some Gulf states with low death rates and young populations (due to high levels of fertility) have a CDR of less than 4
  - During the past 20-30 years Japan has had the lowest age-specific mortality rates but its CDR never fell below 5
- **Remember**: the CDR is a function of the level of mortality as well as the age structure of a population
  - Positively related with high level of mortality
  - Positively related with older population

Estimates of CDR (2013): What do you think?



Source: WHO Global Health Observatory data repository, available at http://apps.who.int/gho/data/view.main.CBDR2040

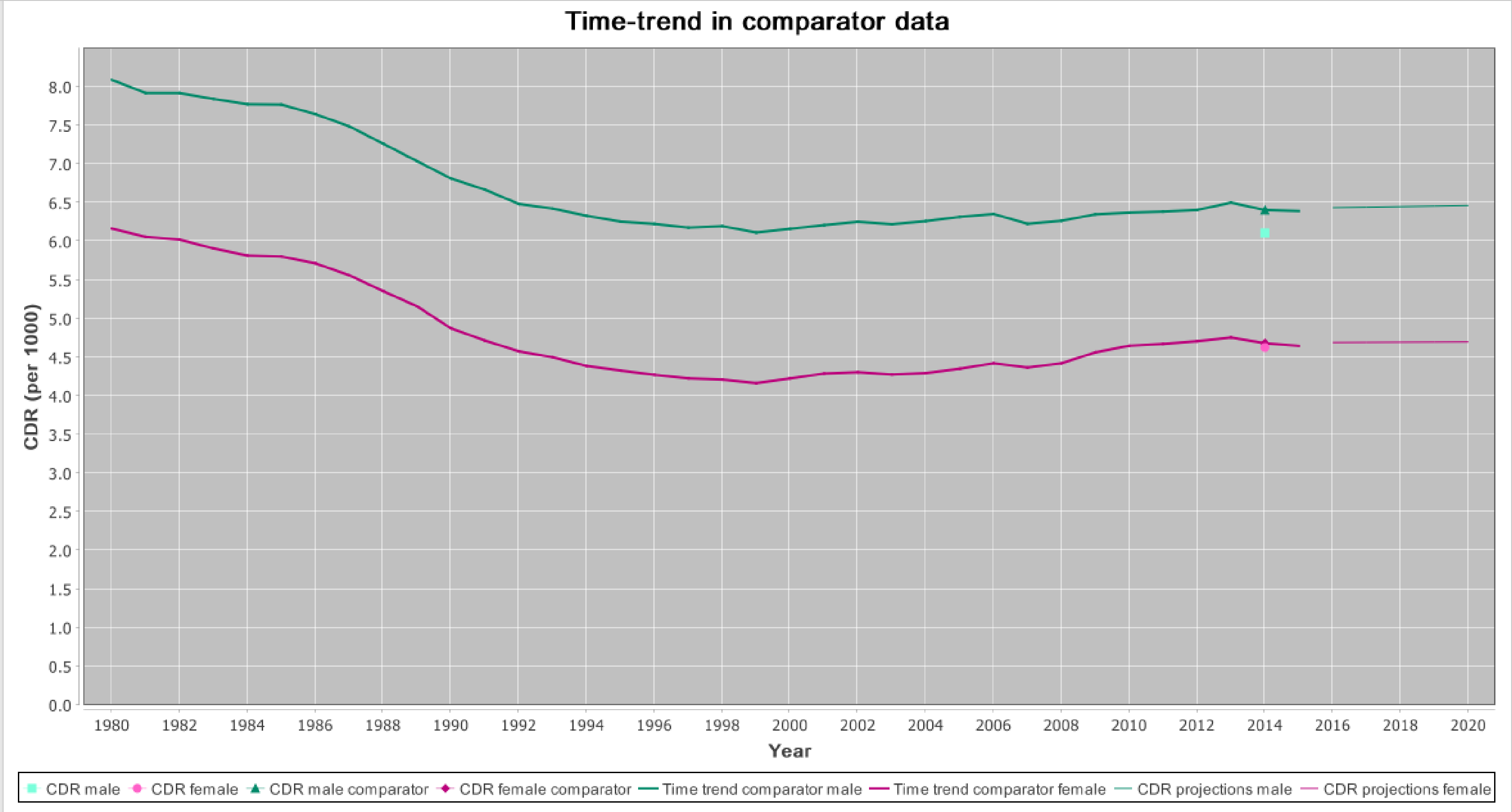
Presenting the CDR in your vital statistics report

Data lab

Data lab: CDR by key variables

- Table or graph showing differences in CDR between:
  - Males and females
  - Urban and rural
  - Regional divisions/areas

Data lab: CDR over time (and with comparator data)



Age-specific death rate

- Age-specific rates are usually expressed per 1,000 or 100,000 population in the age group

$$\text{Age} - \text{specific death rate } 25 - 29 \text{ in } 2015$$

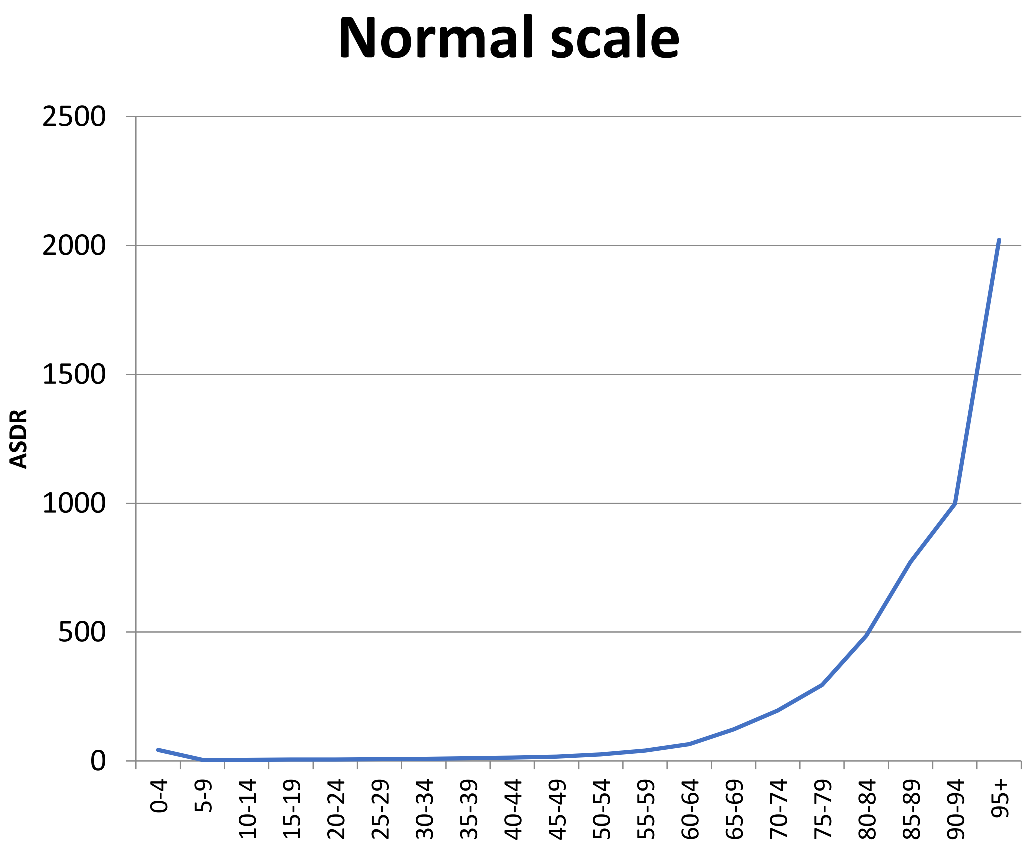
$$= \frac{\text{Deaths aged } 25 - 29 \text{ in } 2015}{\text{Population aged } 25 - 29 \text{ at } 30 \text{ June } 2015} \text{ x } 1000$$

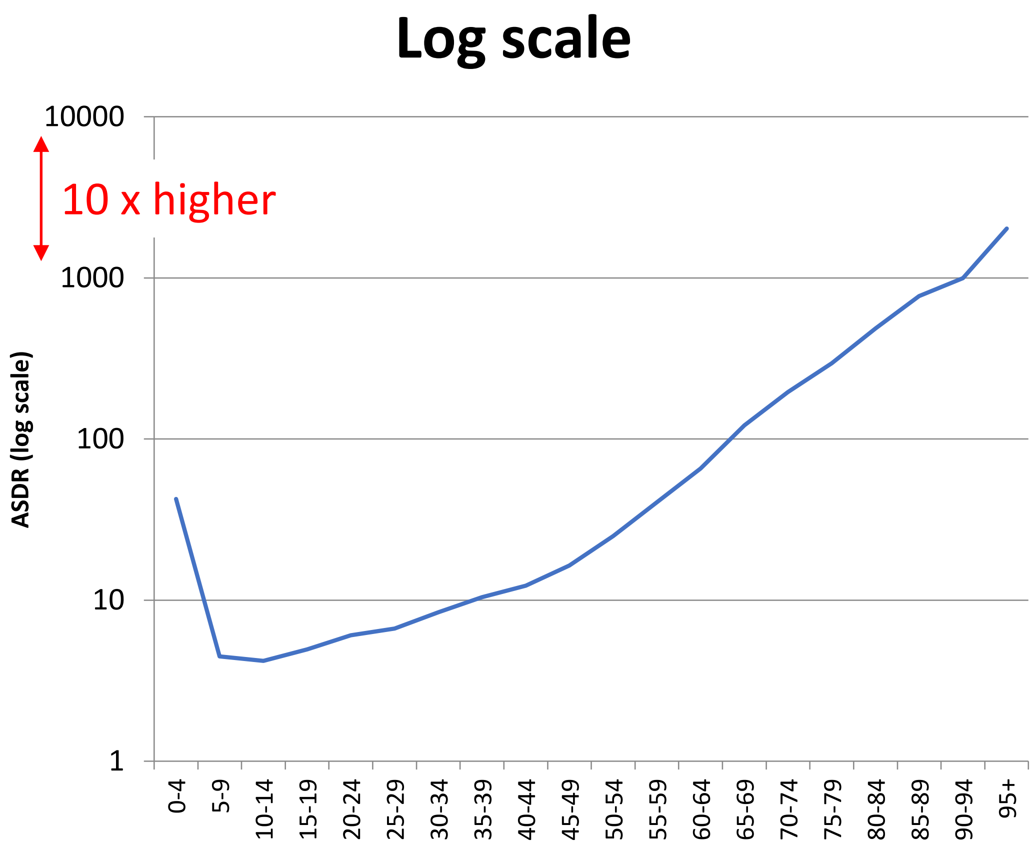
- Standard age groups for analysis: 0 (less than 1 year), 1-4, 5-9, 10-14 ….. , 80-84, 85+, or 95+ for countries where a high proportion of deaths occur at very old ages

Understanding age-specific death rates

- The Gompertz law of mortality states that age-specific mortality rates should increase exponentially (in a straight line) above ages 35 or so
- This makes sense – **the risk of dying increases as we get older**
- A graph showing the natural logarithm (***ln***) of the ASDR should show a straight line as age increases
  - this pattern is found in most populations
  - exceptions include high HIV, high maternal mortality and very high levels of injuries/accidents (generally in younger males)
- Death rates are high in infants and lowest at ages 5 – 14

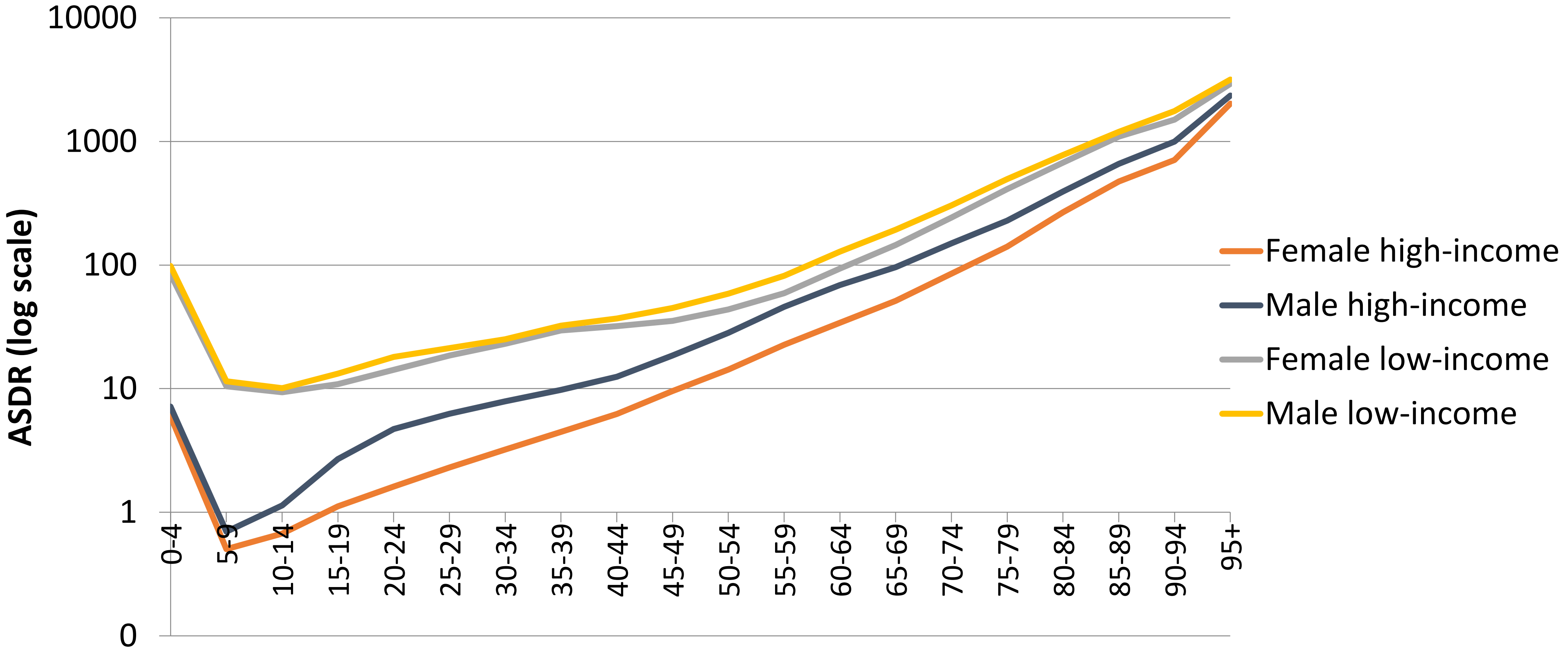
ASDR: females, middle-income countries, 2016





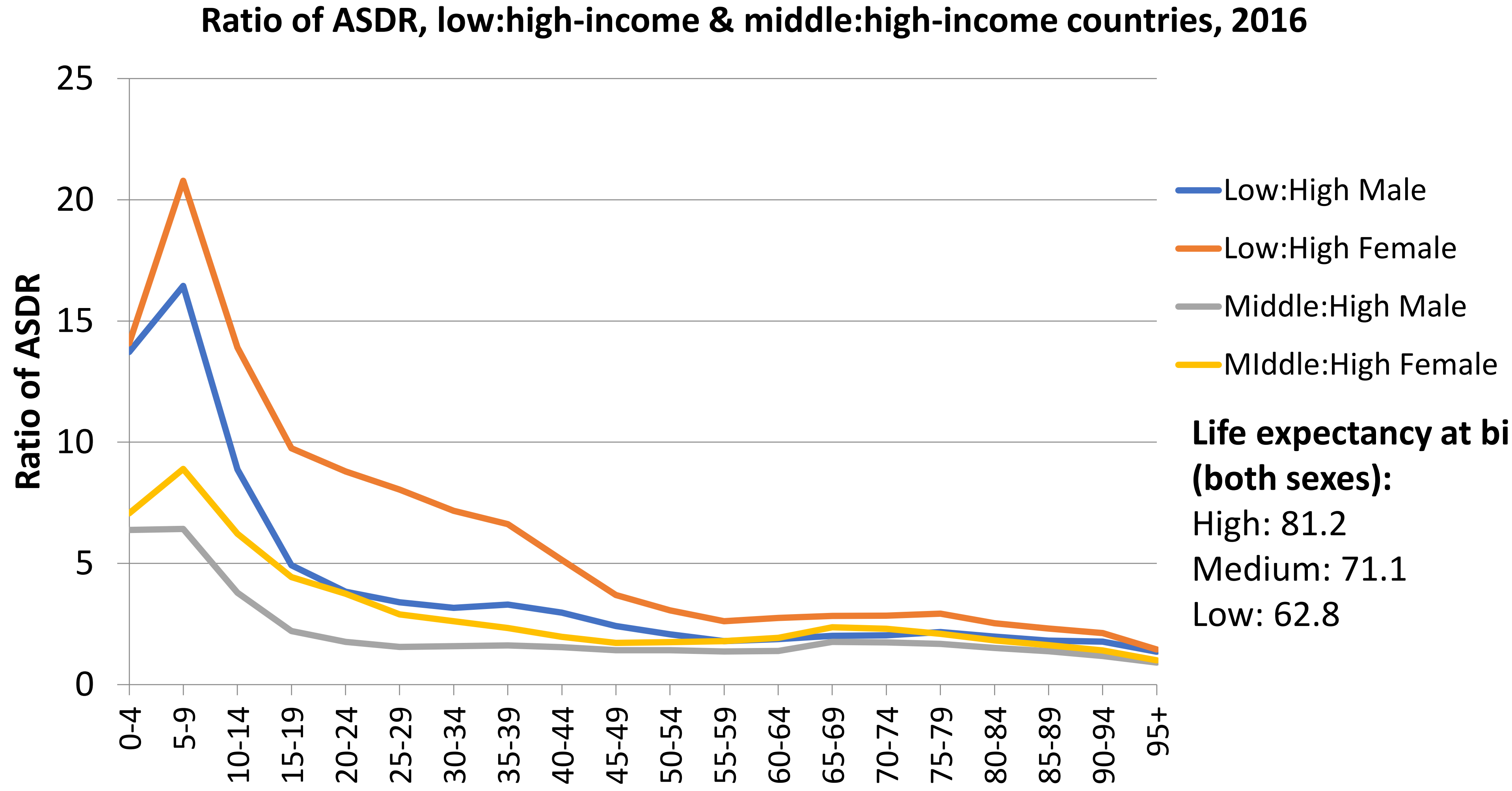
Source: UN World Population Prospects 2016

ASDR: high- and low-income countries, 2016



Source: UN World Population Prospects 2016

Age patterns of death rates differ by country income



Life expectancy at birth (both sexes):

High: 81.2

Medium: 71.1

Low: 62.8

Source: UN World Population Prospects 2016

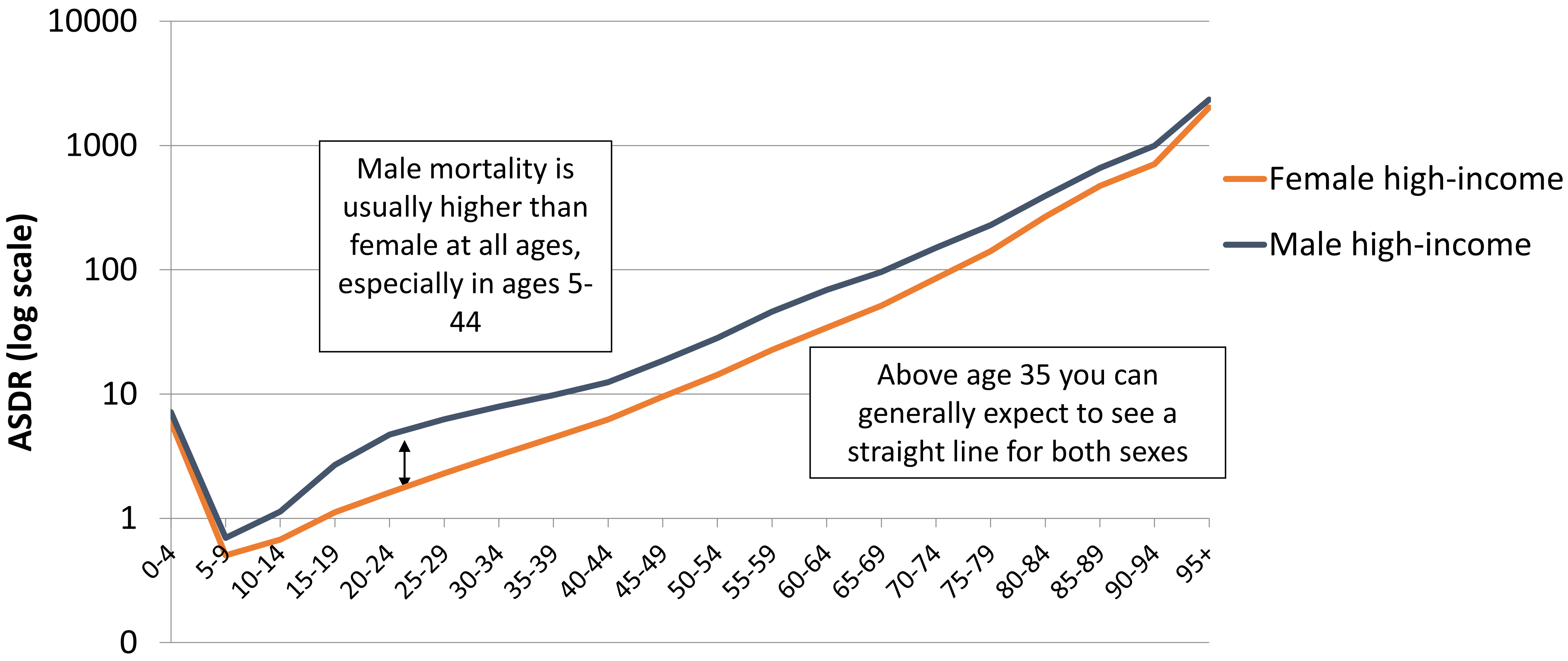
Age patterns of death rates differs by country income (level of mortality)

- Looking at the ratio of ASDR between the country's income level, we see that it is at young ages that death rates in low- and middle-income countries are particularly high when compared with high-income countries
- This just shows the ratio of death rates, not the proportion of all deaths
- Remember in the demographic transition, the child mortality declines before other ages

Understanding age-specific mortality rates between males and females

- Death rates should be higher for males than females **at all ages**
  - Particularly from ages 15-44, because of mortality from injuries and accidents, such as road traffic accidents and suicide
  - An exception is that females can have a higher death rate at the very oldest age group
- Exception
  - Societies with low female status where female death rate **can** exceed that of males at ages 0 – 50 years or so
  - Very rare

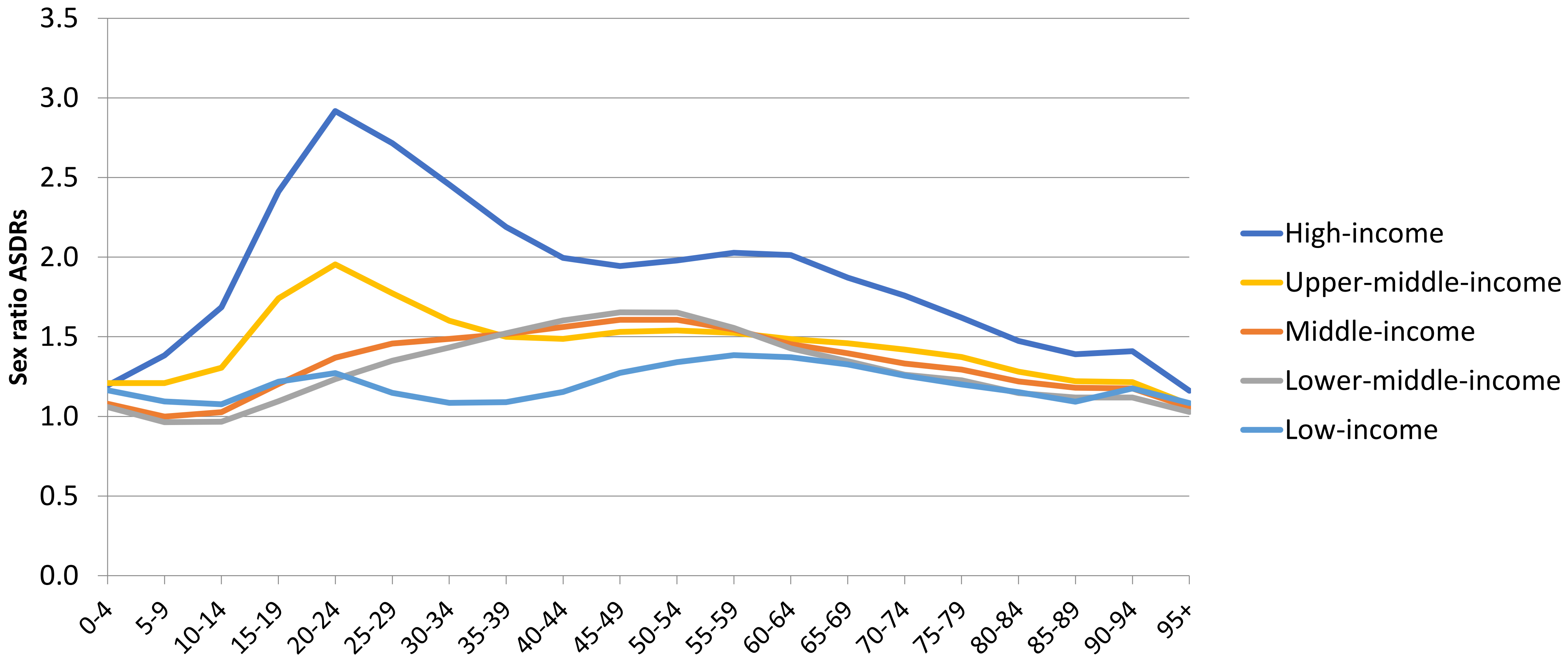
Understanding age-specific mortality rates between males and females



Sex ratio of death rates

- Remember, **male** death rates should be **higher** than female death rates at all ages
- We graph this by comparing the ratio of male to female deaths at all ages
- If death rates were the same for both sexes, the ratio would be the same (1:1)
- Excess male mortality generally peaks in the 15-34 year age groups due to accidents, suicides and violence
- Secondary (lower) peak also seen around 55-64 years due to chronic diseases

Sex ratio of ASDRs



Source: UN World Population Prospects 2015

Understanding the sex ratio of death rates

- Note the higher sex ratio for high-income countries at ages 20-44
  - Likely due to injuries being a higher proportion of deaths at these ages
  - Injuries have a particularly high sex ratio of death rates at these ages

Age-specific death rates and the sex ratio

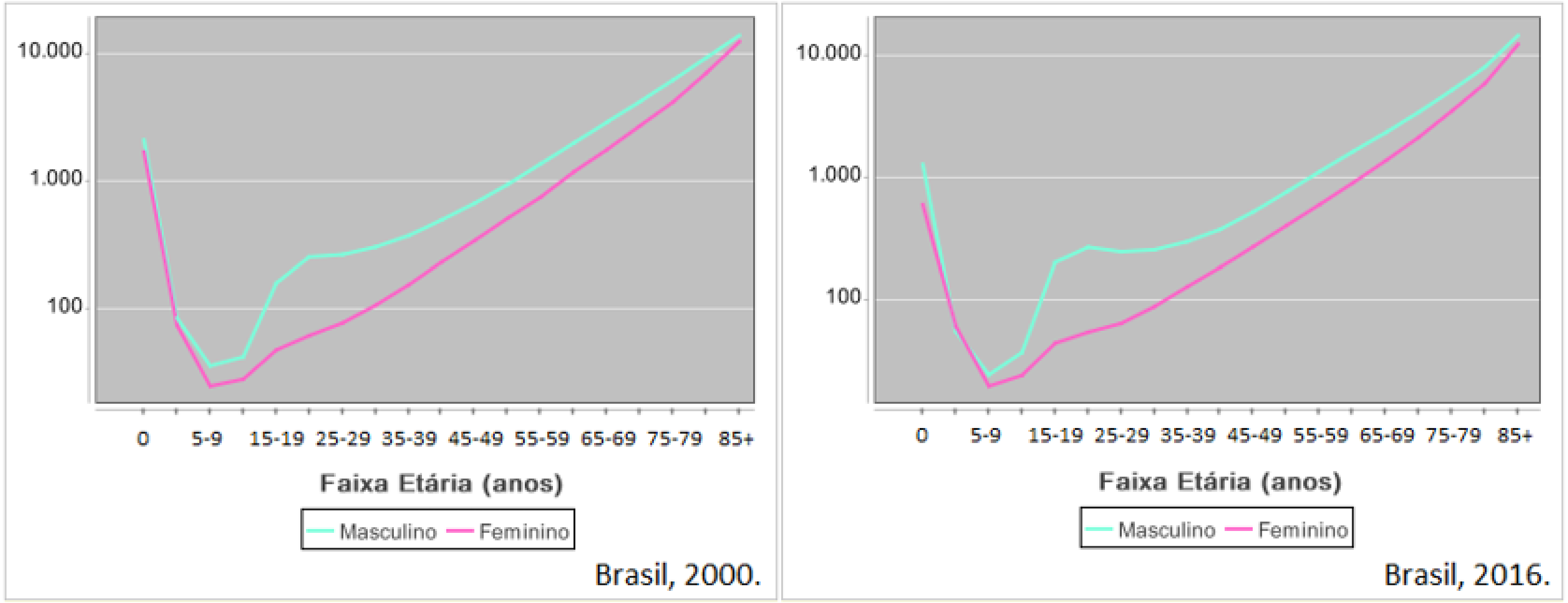
Data lab

Data lab: Practice with graphing ASDRs

- Calculate age-specific death rates for each sex from the test data set
  - Should you use adjusted or unadjusted numbers?
- Graph your results on both a regular and logarithmic graph
  - How does your data look?
  - Does it follow the mortality pattern you would expect?
- Repeat this exercise with your country data

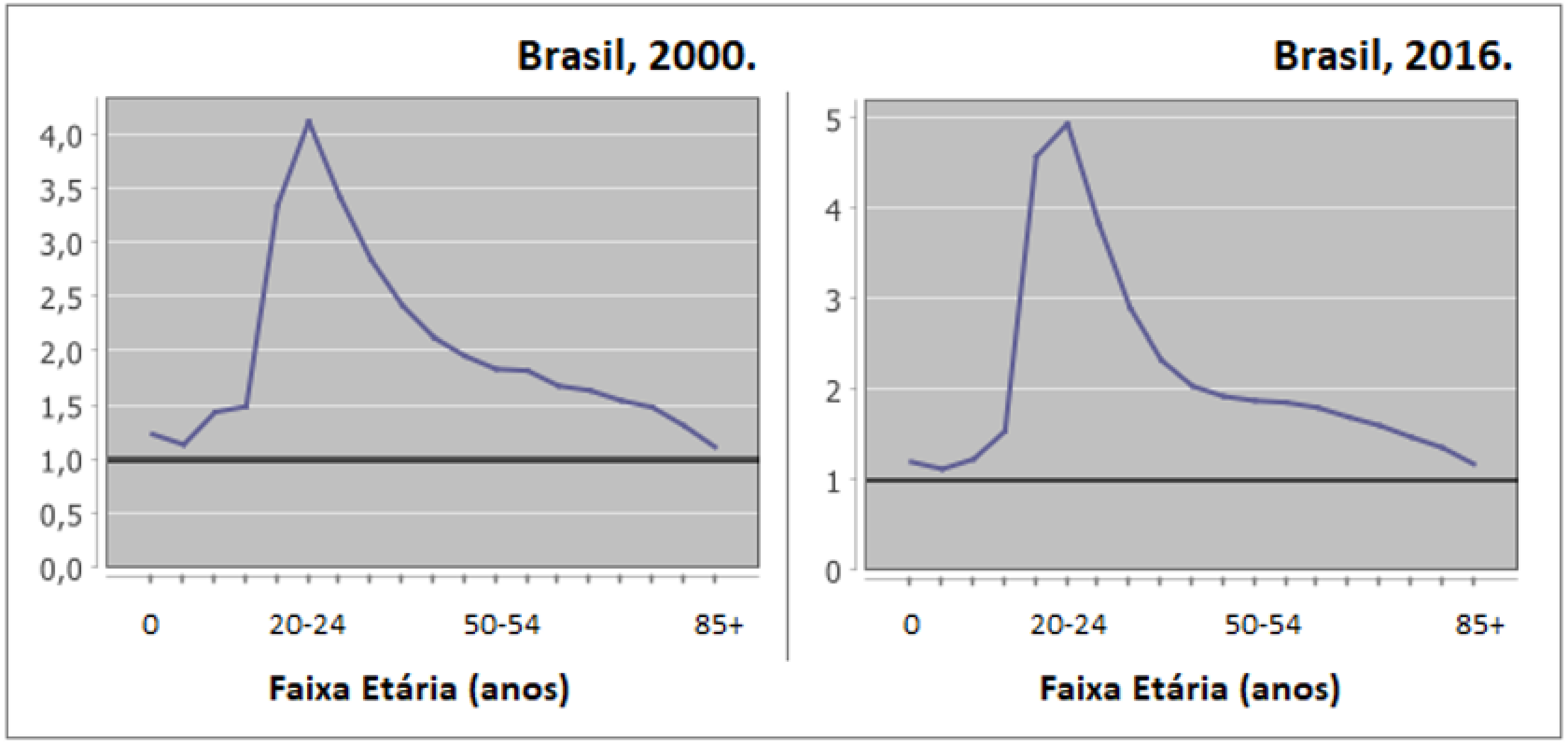
Data lab: ADSR by sex and over time

Figura 6 Taxas de mortalidade específicas (por cem mil habitantes) por idade e sexo. Brasil, 2000 e 2016.

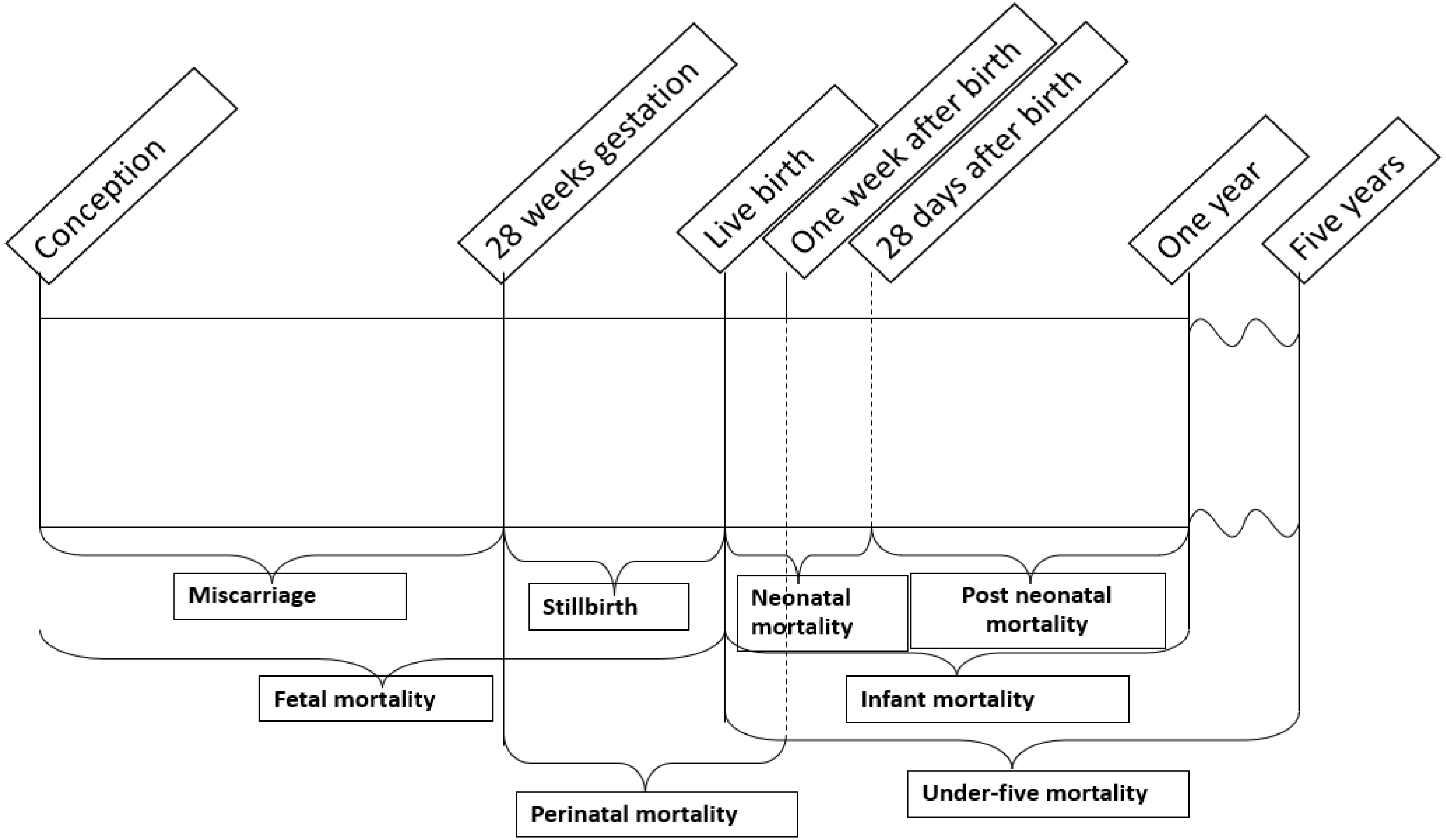


Data lab: Sex ratio over time

Figura 7 Razão homem-mulher das taxas específicas de mortalidade por idade. Brasil, 2000 e 2016.



Mortality in early life – global standards



Early age mortality rates

$$\text{Neonatal mortality rate} = \frac{\text{number of deaths of infants aged less than 28 da}ys}{\text{Live births}} \text{ x 1000}$$

$$\text{Postneonatal mortality rate} = \frac{\text{number of deaths of infants aged 28 days to less than 1 year}}{\text{Live births}} \text{ x 1000}$$

$$\text{Infant mortality rate} = \frac{\text{number of deaths of infants aged less than 1 year}}{\text{Live births}} \text{ x 1000}$$

Early age mortality rates

Child mortality rate

$$= \frac{\text{number of deaths of children aged 12 months to less than 5 years}}{\text{Number of infants surviving at age 12 months}} \text{ x 1000}$$

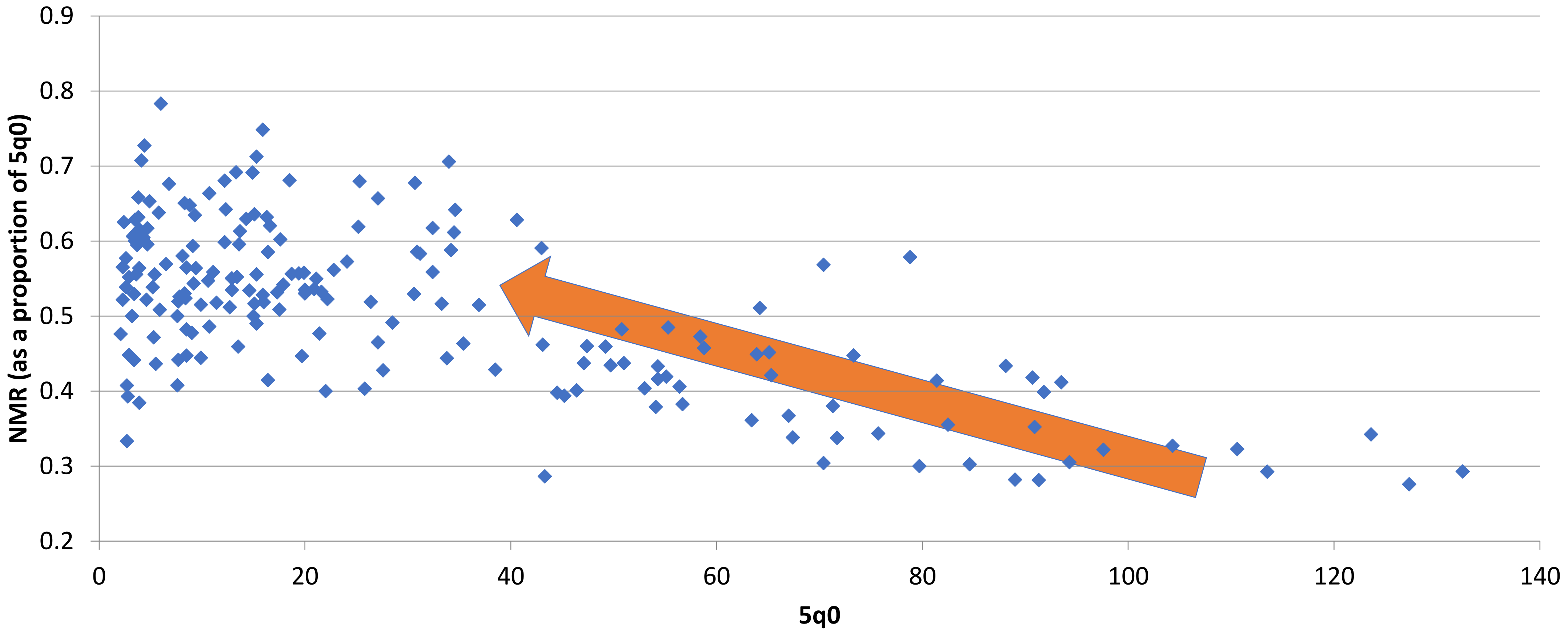
Under five mortality rate

$$= \frac{\text{number of deaths of children aged less than 5 years}}{\text{Live births}} \text{ x 1000}$$

Understanding early age mortality

- Early age mortality is summarised by the under-five mortality rate (*5q0*), which measures the probability of dying before the age of five years per 1,000 live births
- In most populations, boys have a slightly higher risk than girls of dying in the first 5 years of life, due to biological reasons
  - According to the *IGME*, on average a country's 5q0 for boys is 9% higher than for girls
  - In only 2 countries in the world is 5q0 for males lower than for females (Tonga and India)
  - *UN Inter-agency group for Child Mortality Estimation (IGME), who estimate early age mortality from a range of data sources over time, and apply statistical models of the trends in these estimates*

Neonatal mortality increases as infant mortality decreases



Age distribution of early age mortality

- A component of early age mortality is neonatal mortality, which are deaths inside the first 28 days of life
  - On average, 50% of under-five deaths occur in the neonatal period
- The causes of neonatal deaths are significantly different from deaths at other ages (less than 5 years)
  - Birth asphyxia, neonatal tetanus and birth complications
  - Interventions to reduce deaths from these causes are typically expensive, such as neonatal intensive units in hospitals
- The major cause of death at other ages less than 5 years are diarrhoea and pneumonia
  - Interventions to reduce mortality from diarrhoea and pneumonia are easier to introduce in low-resource-settings, such as oral rehydration therapy, improved hygiene and cleaner cooking fuels

Early age mortality rates

- Note that these differ from the age-specific death rates we looked at earlier
- Early age mortality rates are actually measures of the **probability of dying** over time (from live birth to a certain age, or from one age to another age)
  - Age-specific deaths rates are period rates, that is they measure deaths in a period (e.g. a calendar year) divided by the mid-year population
- We can measure early age mortality rates with data that follows an actual cohort of births through the first five years of their life, or by linking births to deaths
  - This is particularly useful for measuring the neonatal mortality rate
- We can also use **life tables** to compute early age mortality rates

Life Tables

- A primary use of age-specific mortality data is to produce life tables
- Life tables present the probability of a person dying at each age or time interval
- Major uses:
  - Analyse mortality in human populations
  - Calculate summary measures of mortality, such as life expectancy
- Can also be used for
  - Analysis of marriage – probability of divorce by year of marriage
  - Educational cohorts

Age	Years in Interval	Deaths	Population	Mortality Rate	Linearity Adjust-ment	Probability of Dying	Probability of Surviving	Individuals Surviving	Deaths in Interval	Years Lived in Interval x	Cumulative Years Lived	Life Expectancy
x	n	${}_nD_x$	${}_nN_x$	${}_nm_x$	${}_na_x$	${}_nq_x$	${}_np_x$	l_x	${}_nd_x$	${}_nL_x$	T_x	e_x
0	1	1801	127160	0.0142	0.1	0.0140	0.9860	100000	1398	98741	6893603	68.94
1-4	4	563	400018	0.0014	0.4	0.0056	0.9944	98602	553	393078	6794862	68.91
5-9	5	422	530488	0.0008	0.5	0.0040	0.9960	98048	389	489268	6401784	65.29
10-14	5	267	649495	0.0004	0.5	0.0021	0.9979	97659	201	487794	5912515	60.54
15-19	5	863	715482	0.0012	0.5	0.0060	0.9940	97459	586	485828	5424721	55.66
20-24	5	1262	685851	0.0018	0.5	0.0092	0.9908	96873	887	482145	4938894	50.98
25-29	5	1334	613755	0.0022	0.5	0.0108	0.9892	95985	1037	477333	4456749	46.43
30-34	5	1479	590358	0.0025	0.5	0.0124	0.9876	94948	1182	471785	3979416	41.91
35-39	5	1888	597361	0.0032	0.5	0.0157	0.9843	93766	1470	465154	3507631	37.41
40-44	5	2373	530890	0.0045	0.5	0.0221	0.9779	92296	2040	456379	3042477	32.96
45-49	5	3701	429071	0.0086	0.5	0.0422	0.9578	90256	3810	441753	2586098	28.65
50-54	5	3522	332871	0.0106	0.5	0.0515	0.9485	86445	4455	421089	2144345	24.81
55-59	5	2596	188952	0.0137	0.5	0.0664	0.9336	81990	5445	396337	1723256	21.02
60-64	5	2503	114956	0.0218	0.5	0.1032	0.8968	76545	7903	362966	1326919	17.34
65-69	5	3321	97190	0.0342	0.5	0.1574	0.8426	68642	10805	316197	963953	14.04
70-74	5	3854	88198	0.0437	0.5	0.1970	0.8030	57837	11392	260706	647755	11.20
75-79	5	5222	66048	0.0791	0.5	0.3301	0.6699	46445	15330	193900	387049	8.33
80-84	5	3901	29988	0.1301	0.5	0.4908	0.5092	31115	15271	117395	193150	6.21
85+		4000	19126	0.2091	0.5	1	0.0000	15843	15843	75755	75755	4.78

- Can be presented by single year or as “abridged” (i.e. for age groups)
- Single year of age provides extensive detail, but an abridged life tables is easier to interpret
- The prefix *n* indicates the length of the age group
- The suffix *x* indicates the age at the start of the age group

Life tables to estimate life expectancy and under five mortality

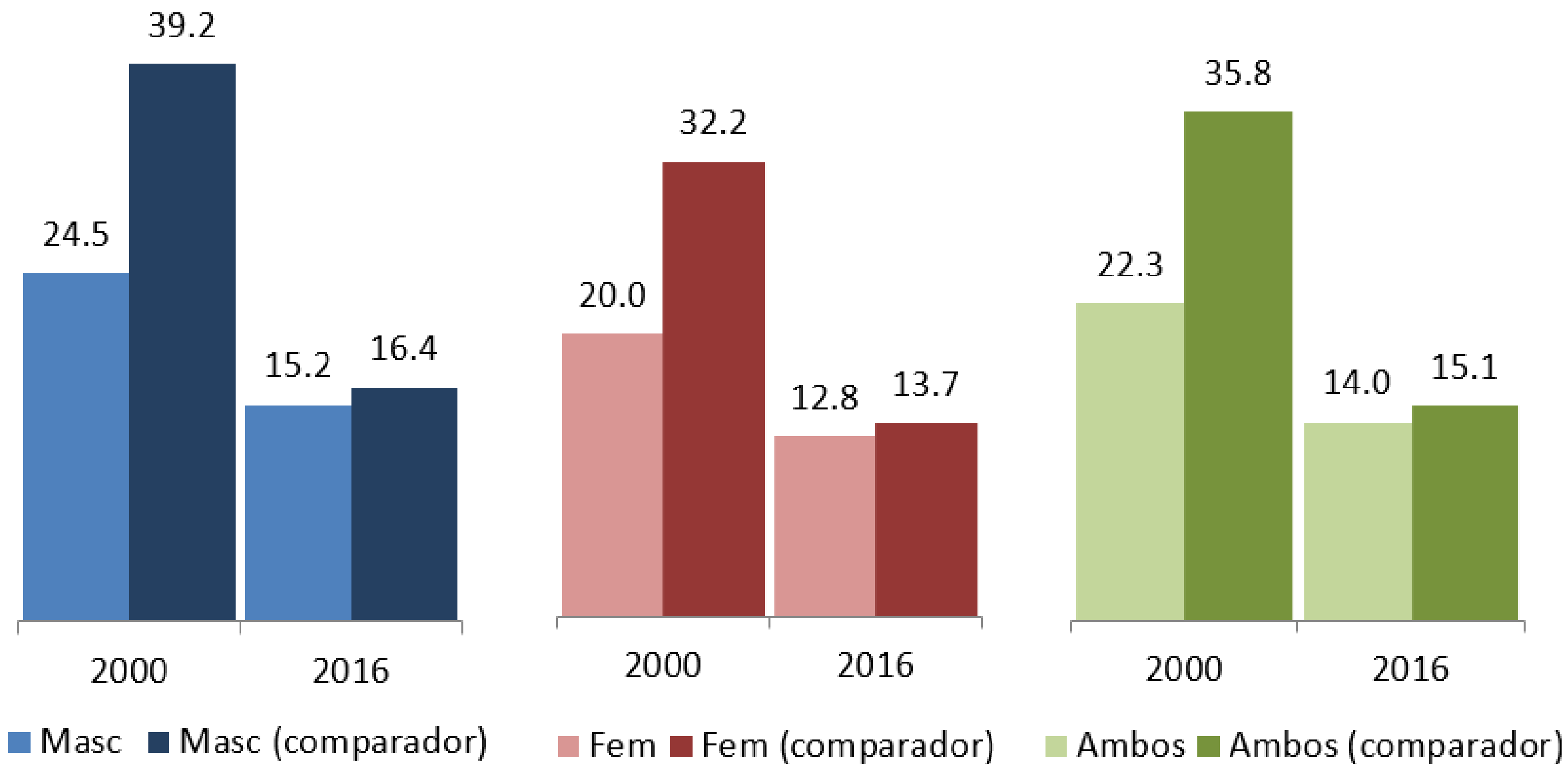
Data lab

Data lab: Practice sessions

- Use excel file "All cause mortality"
- The tab (life table) shows an example table that has been completed – go through the cells to see the formulas and how to populate the table
- The tab (life table 2) has a series of exercises for you to work through
- For those that want more information on life tables, I have a handout available as well

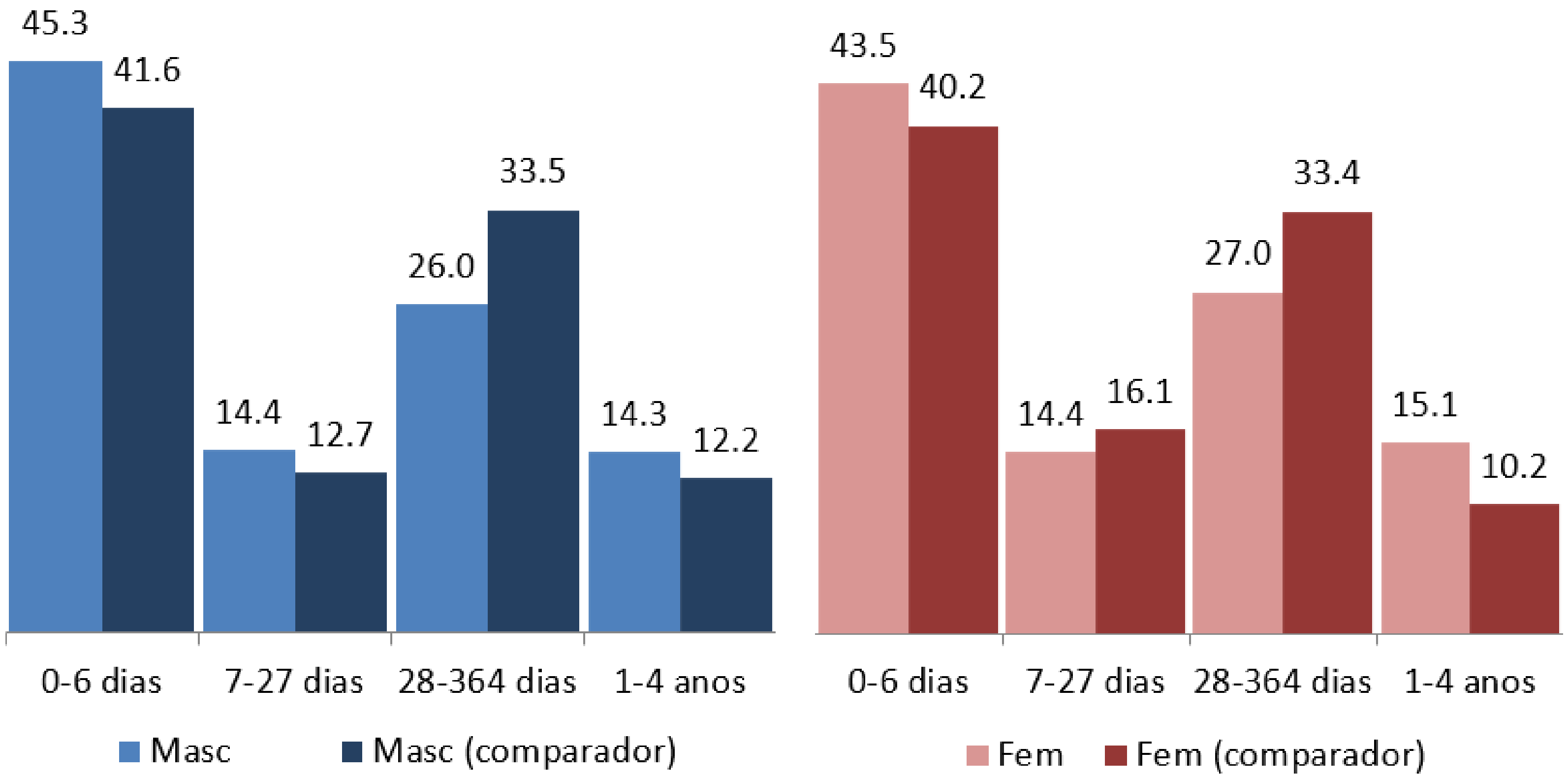
Data lab: Under-five mortality by sex and year

Figura 10 Taxa de mortalidade na infância (por mil nascidos vivos), com comparador. Brasil, 2000 e 2016.



Data lab: Under five mortality by sex and age group

Figura 11 Distribuição da mortalidade na infância por grupos de idade, com comparador. Brasil, 2016.



Additional exercise: Age standardisation

- Technique that removes the effect of age composition to allow the comparison of rates in two or more populations
- Computes death rates for each population using a **standard population**
- The UN and WHO provide standard populations for use, or you can use one of the populations you are using
  - This provides us with an ‘age standardised’ death rate for each population.
- Age standardised rate = what the death rate would have been in the population if it had had the same age distribution as the standard population
- Goal is fair comparison, but actual adjusted rate is hypothetical – it should be used in conjunction with true age-specific death rates

Example: comparing crude death rates

Australia	Saudi Arabia
6.4/1000	4.2/1000

Confounding by age: age-specific death rates

Age group (years)	Australia Age Specific Death Rates (per 1,000)	Saudi Arabia Age Specific Death Rates (per 1,000)
<15	0.5	2.2
15-44	0.8	1.7
45-54	2.4	6.2
55-64	5.5	14.7
65-74	14.8	37.0
75+	65.2	100.3

Age-specific death rates and population by age

Age group	**Australia** Age Specific Death Rates (per 1,000)	**Australia** Proportion of population in age group (%)	**Saudi Arabia** Age Specific Death Rates (per 1,000)	**Saudi Arabia** Proportion of population in age group (%)
<15	0.5	0.20	2.2	0.35
15-44	0.8	0.43	1.7	0.52
45-54	2.4	0.14	6.2	0.07
55-64	5.5	0.11	14.7	0.03
65-74	14.8	0.07	37.0	0.02
75+	65.2	0.06	100.3	0.01

Direct Standardisation

Need:

- Age-specific rates from populations of interest
- Age-specific distribution of standard population (either numbers or percentages)

WHO Standard Population 2000–2025

Age group	Percent
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

(continued in next column)

Age group	Percent
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	**100.00%**

Source: Ahmad, Boschi-Pinto, Lopez, et al. Age standardisation of rates. WHO, 2001

Steps

1
- (For each age group) Multiply age-specific death rate times the proportion (percentage) of the standard population in that age group

2
- Sum to get the directly standardised rate

3
- If percentages were used in Step 1, divide by 100

Age-specific death rates and WHO Standard Population

Age Group	**Australia** Age Specific Death Rates (per 1,000)	Proportion of WHO Standard Population in Age group	**Australia * WHO Standard Population**
<15	0.5	x **0.2615**	0.1308
15-44	0.8	**0.4597**	0.3678
45-54	2.4	**0.1141**	0.2738
55-64	5.5	**0.0827**	0.4549
65-74	14.8	**0.0517**	0.7652
75+	65.2	**0.0303**	1.9756

Standardised crude death rates

Age Group	Australia* WHO std	Saudi Arabia * WHO std
<15	+ 0.1308	+ 0.5753
15-44	+ 0.3678	+ 0.7815
45-54	+ 0.2738	+ 0.7074
55-64	+ 0.4549	+ 1.2157
65-74	+ 0.7652	+ 1.9129
75+	+ 1.9756	+ 3.0391
TOTAL (CDR)	= **3.9679**	= **8.2319**

Age standardisation

Data lab

Data lab: Practice sessions

- Use excel file “All cause mortality”
- The last tab (‘age standardisation’) has a series of exercises you can work through

Acknowledgements

- Data analysis and report writing workshop for CRVS in the Asia Pacific (January and April 2019), developed by Chalapati Rao and Renee Sorchik, ESCAP
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