Standardization

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For clarification: even if the page isn't highlighted or in a box doesn't mean that you shouldn't study it, the focuses on the important things needed in details, all the rest is for studying and understanding

<u>Important notes are in red boxes.</u>

- **Understand how the calculation happened.**
- **When to use direct and indirect.**
- **Understand the concept of both direct & indirect standardization**

Demography

- "Study of populations, especially with reference to size and density, fertility, mortality, growth, age distribution, migration, and vital statistics, and the interaction of all these with social and economic conditions" John Last

Population size

- The scale and nature of health problems are determined by the size and characteristics of the population in which they occur.

- Population size is determined by the outcome of the continuous interplay of birth, death, migration according to the following model:

- $P2 = P1 + B - D + IM - EM$

- (P = population, B = births, D = deaths, IM immigrants, EM = emigrants)

- Natural increase occurs when $B > D$ therefore $P2 > P1$

- Natural decrease occurs when $D > B$ therefore $P2 < P1$

Population doubling time

- The population can only increase if the number of births exceeds the number of deaths

- Population growth rates are described either in terms of annual percentage increase or in term of population doubling time (PDT)

- PDT: Number of years it will take for the population to double in size

Population doubling time

- PDT=

$$\frac{70}{\text{Annual percentage increase}}$$

For example:

Population growing at 2% per annum will double in size in 35 years

Population growing at 3% per annum will double in size in 23 years

Sources of demographic information

- 1. Census:

a. Decennial: poll count on 100% sample held every 10 years

b. Midcensus sample: poll count on 10% sample held every 10 years between censuses

Sources of demographic information

1. Census:

Limitations:

- Censuses are costly and slow.

- Census data are at least four years out of date

- Research has shown that Censuses in developed countries are accurate and complete. On the other hand Censuses in developing countries are held but are likely to be inaccurate and incomplete.

Sources of demographic information

2. Population registers:

More or less equivalent to continuous census.

3. Registration of vital events:

Births, Death, marriage, stillbirth, adoption, divorce

4. Sample household survey

5. Governmental and private record system

Health services, education, armed forces, social security, insurance

Types of population data

1. Population size
2. Mortality- death rates
3. Fatality: Birth rate, fertility
4. Residential mobility
5. Composition
6. Geographic distribution of the population
7. Population characteristics – marital and family status, education, occupation, income

Population pyramids

- Age and sex composition of a population influences its pattern of mortality and natality more than any other factor

- These characteristics pyramid shapes occur naturally

Spike

Wedge

Barrel
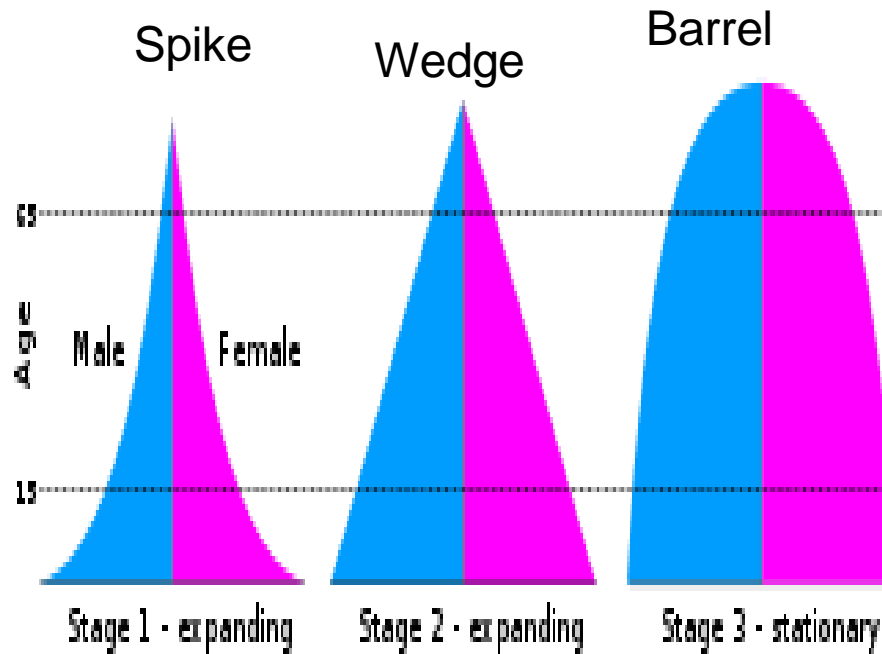
Common shapes of population pyramids

65

Age

Male   Female

15

Stage 1 - expanding

Stage 2 - expanding

Stage 3 - stationary

Population pyramids

The spike shape:

- is characterised by a wide base that narrows rapidly depicting a high BR and high DR at all ages

- High BR. High DR, low growth rate

- Typical of an under-developed country in primitive demographic equilibrium

Population pyramids

Barrel shape:

- Characterised by a narrow base with little further narrowing until the apex, depicting low BR and low DR at younger ages
- Typical of developed country in evolved demographic equilibrium

Population pyramids

Wedge shape:

- Wide base and gradual arrowing depicting high BR and low DR, high growth rate
- Typical of a country in demographic transition with rapidly growing population, marked imbalance of its dependency ratio and severe socio-economic stress

Population pyramids- Jordan

Algeria - 2010

Male / Female

Population (in millions) — Age Group — Population (in millions)

Algeria - 2025

Algeria - 2050
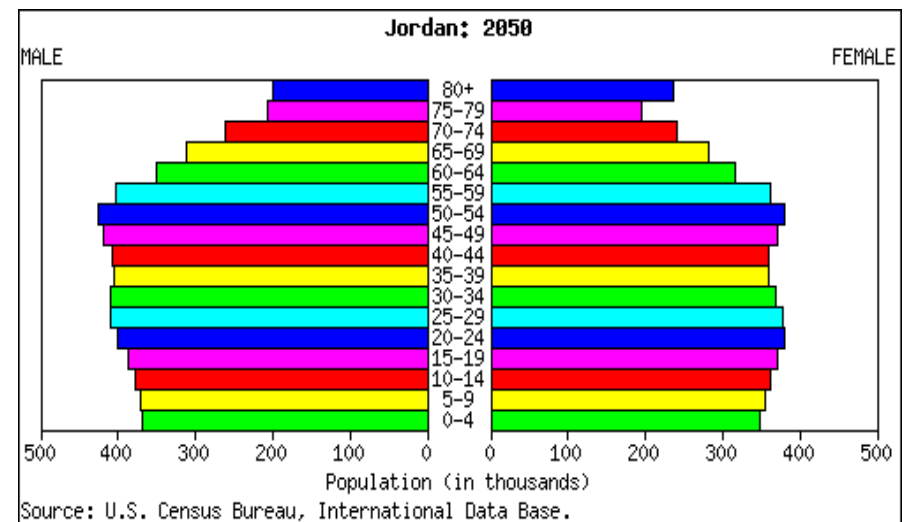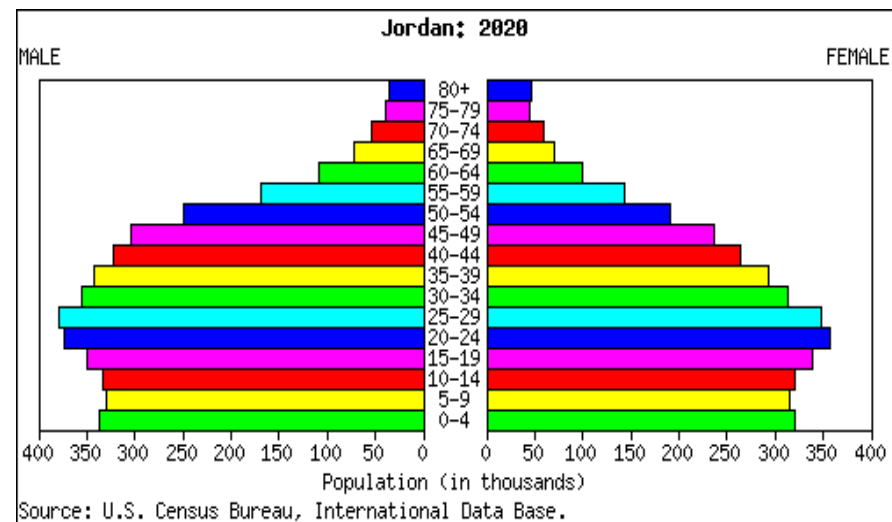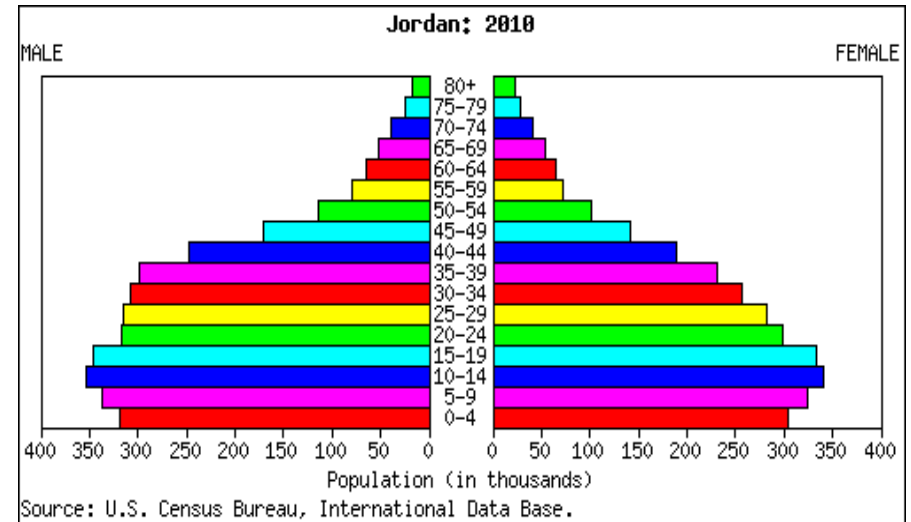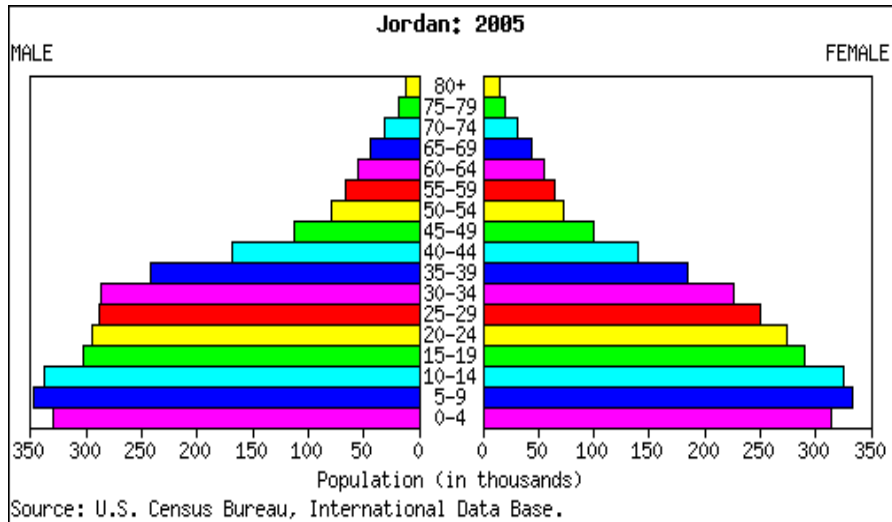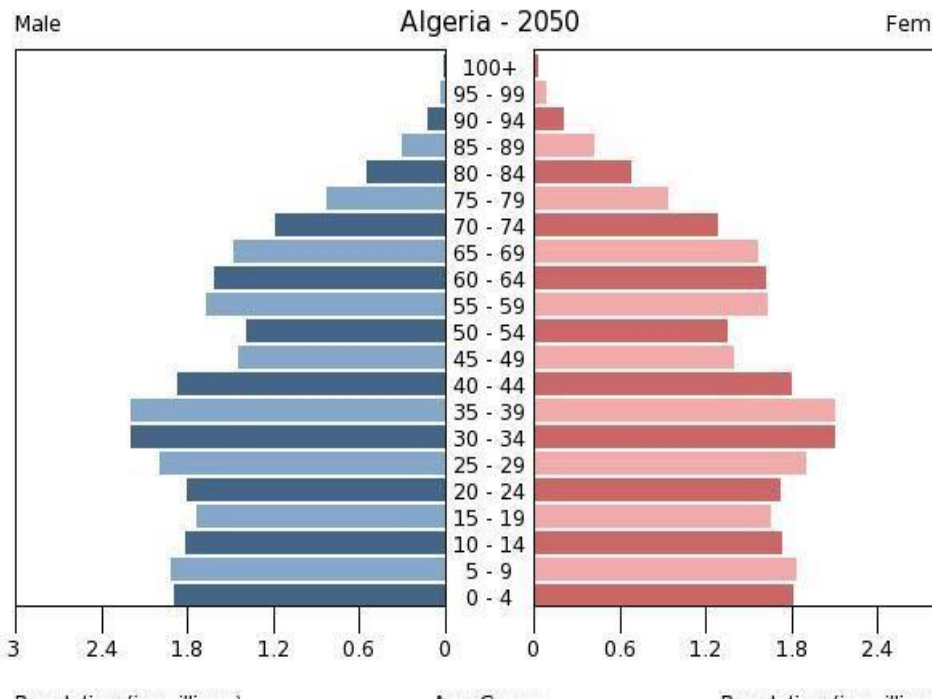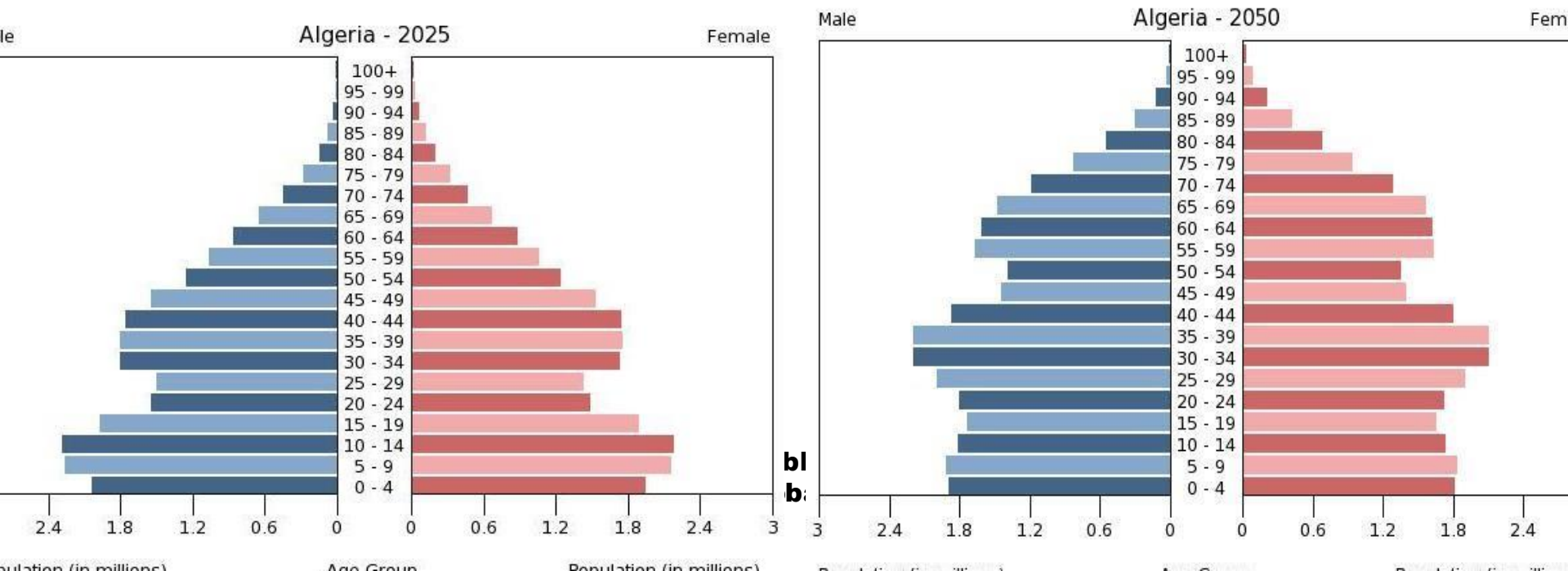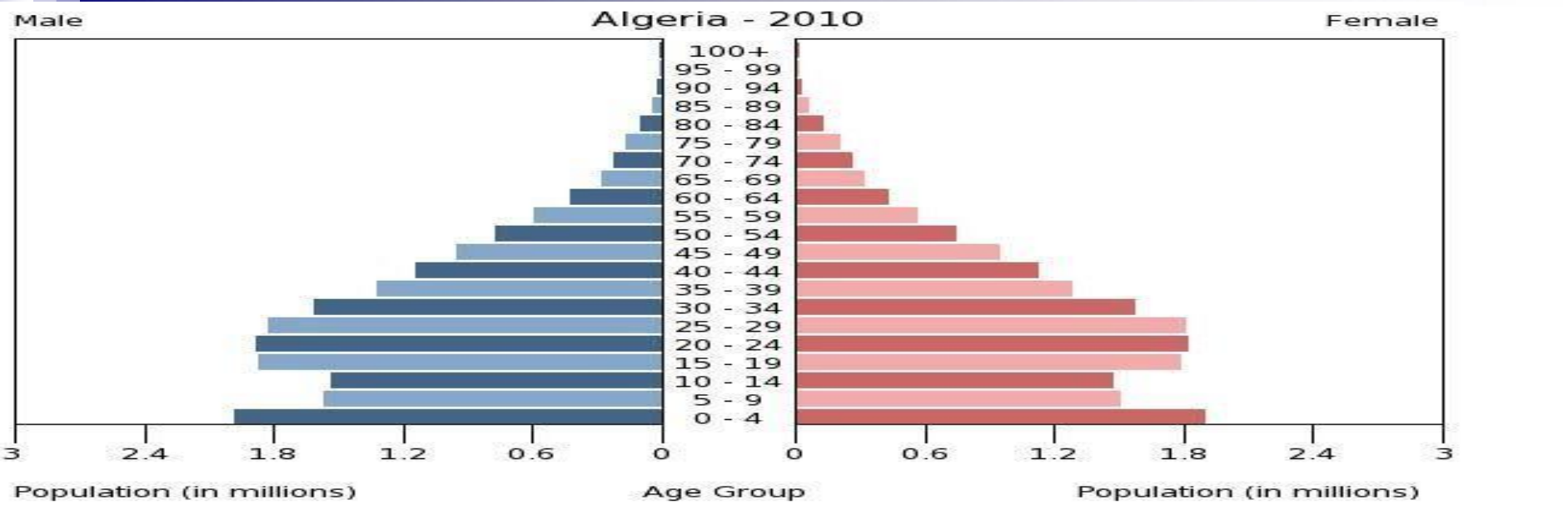
Factors affecting mortality

1. Age structure: main determinant
2. Environment
3. Economic development
4. Technological advance
5. Medical services/science and development of public health

Common causes of death

- Primitive society: Plaque, Cholera, typhus, smallpox, i.e. epidemic infectious diseases
- Developing society: Endemic infectious diseases- dysntery, tuberculosis, pneumonia
- Modern societies: Chronic diseases mainly cancer and ischamic heart disease

Population health status comparison

- Crude death rate
- Age specific death rate
- Standarised death rate
- Standarised mortality ration (SMR)
- PYLL Index (Potential Years Life Lost)

Comparing disease and health event rates

- **Disease and mortality rates can be used to compare:**
    - disease/mortality rates between populations
    - the same population over time.
- **When comparing rates we should be aware of the characteristics of the population(s) that may affect the rates.**
- **The age and sex structure of two populations being examined may differ and these differences will affect the rates.**

Standardisation of rates

■ **Crude rates do not allow comparison in Space (region or countries) or time**

For example for *death rates**, the differences observed between two populations'* *crude death rates* *could only be due to the* *demographic* *differences between the population studied.*
A population with a higher proportion of elderly people will have a higher number of total death than a young population.

Standardized mortality rate

- **we know that:**
    - death is closely related to age
    - the age structure of the a some groups could be different to that of the total population
- **Therefore we need to adjust for the effect of the age structure to make a meaningful comparison.**
- **This can be done using** standardization

Methods of Standardisation

■ There are two methods of standardisation commonly used in epidemiological studies, and these are characterized by whether the standard used is a population distribution **(direct method)** or a set of specific rates **(indirect method).** Both direct and indirect standardisation involves the calculation of numbers of expected events (e.g. deaths), which are compared to the number of observed events.

Age is a factor that is frequently adjusted for in epidemiological investigations, particularly in comparative mortality studies, since the age structure of a population will greatly affect the population's overall mortality. To illustrate the methods of both direct and indirect standardisation, the age specific mortality rates for two hypothetical populations are compared below.

■**Standardisation of rates is a method of weighting the rates on one factor which has an influence on the rate, such as age or sex. Once the influence of that factor has been eliminated with the standardisation the rates can be compared.**

Two methods of standardisation of rates

Direct   **Indirect**

Methods of Standardisation

■   There are two methods of standardisation commonly used in epidemiological studies, and these are characterized by whether the standard used is a population distribution **(direct method)** or a set of specific rates **(indirect method).**

■   Both direct and indirect standardisation involves the calculation of numbers of expected events (e.g. deaths), which are compared to the number of observed events.

> • **Understand the concept and the how the calculations happened (steps).**
> • **Understand the examples.**

Direct Standardisation

- **is used to compare large populations**

- **uses a standard reference population to compare both populations**

- **applies the age-specific disease/death rates of the population of interest to the standard population**

- **allows us to compare death rates, by calculating what their death rates would be if the populations of interest had the same age population structure as the reference population.**

Direct standardisation

Direct standardisation uses a standard *population demographic structure*.

- one of the populations studied
- or a combination of both.

The result obtained is an **age standardised rate** which would represent the rate in the study population if the age structure of that population was the same as the reference population. The standardised rates can then be compared, but this **standardised rates have no absolute meaning**, they are only meaningful in the context of the reference population used. Using a different reference population will give a different standardised rate.

Calculation

$$\text{Age standardized rate} = \left(\begin{array}{l} \text{Overall rate in standard population if} \\ \text{the age} - \text{specific rates were the same} \\ \text{as those of the population of interest} \end{array} \right) = \frac{\sum w_i \times \lambda_i}{\sum w_i}$$

w_i are the weights
λ_i rates

Direct method of standardisation

- Table 1 presents crude mortality data for two hypothetical populations (countries A and B). The overall crude mortality rate is higher for country A (10.5 deaths per 1,000 person years) compared with country B (7 deaths per 1,000 person years), despite the age-specific mortality rates being higher among all age-groups in country B.

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Table 1. Crude mortality rates stratified by age for two hypothetical populations.

Age - group	Country A			Country B		
	No. of deaths	Population	Rate per 1,000 pyrs	No. of deaths	Population	Rate per 1,000 pyrs
0-29	7,000	6,000,000	1.2	6,300	1,500,000	4.2
30-59	20,000	5,500,000	3.6	3,000	550,000	5.5
60+	120,000	2,500,000	48	6,000	120,000	50
Total	147,000	14,000,000	10.5	15,300	2,170,000	7

Table 2. Direct method of standardisation - calculation of the number of expected deaths for countries A and B applied to a standard population.
(Here the rate is divided back by 1000 to give the basic rate; e.g. 1.2 becomes 0.0012 for the purposes of the formula.)

0-29	100,000
30-59	65,000
60+	20,000
Total	185,000

	Country A	Country B
	Expected deaths	Expected deaths
0-29	0.0012 x 100,000 = 120	0.0042 x 100,000 = 420
30-59	0.0036 x 65,000 = 234	0.0055 x 65,000 = 357.5
60+	0.048 x 20,000 = 960	0.05 x 20,000 = 1,000
Total expected deaths	1,314	1,777.5
Age adjusted rate	1,314/185,000 = 7.1 per 1,000 pyrs	1,777.5/185,000 =9.6 per 1,000 pyrs
Age standard rate ratio (B:A)= 9.6/7.1 = 1.35		

The reason for the difference between the crude mortality rates between country A and country B is that these two populations have markedly different age-structures.

Country A has a much older population than country B. For example, 18% of the population in country A are aged over 60 years compared with 6% in country B.

Direct standardization

- In the direct method of standardisation, 'age adjusted rates' are derived by applying the category specific mortality rates of each population to a single standard population (table 3). This produces age standardized mortality rates that these countries would have if they had the same age distribution as the standard population.

Direct standardization

- Note that the 'standard population' used may be the distribution of one of the populations being compared or may be an outside standard population such as the 'European' or 'World' standard population.

- The weighted average of the category-specific rates (with the weights taken from the standard population) provides for each population a single summary rate that reflects the numbers of events that would have been expected if the populations being compared had the same age distribution 1.

Direct method of standardization

- Note that while the crude rates presented in table 1 represent the actual mortality experience of countries A and B, it is not possible to use these crude rates to make a valid comparison between the two countries because they have very different age distributions.

- However, by using the direct method of standardisation (while the values of the adjusted rate do not reflect the 'true' mortality experience of countries A and B), it enables us to calculate 'hypothetical' age adjusted rates that can be used to make a valid comparison of overall mortality between the two countries.

Advantages and disadvantages of direct age standardisation

Advantages
- **The direct method preserves consistency, between the populations being compared, i.e. if each age-specific rate in area A is greater than each of the corresponding age-specific rates in area B, then the directly standardised rate for area A will always be higher than that of area B irrespective of the standard population used. Consequently it is the preferred method for comparing a number of different populations against each other.**
- **Directly standardised rates can readily be compared over time provided the same standard population is used.**

Disadvantages
- **The direct method requires that the observed events in the subject population are available broken down by age. If this information is not available the directly standardised rate cannot be calculated.**
- **For small subject populations the age-specific rates of the subject population are based on small numbers and consequently are unstable. Small changes in the number of deaths in a particular age band may result in large changes in the directly standardised rate.**

Indirect standardization and SMRs

- **allows valid comparisons between populations with different age and sex structures**

- **Adjusts for differences in age by calculating the number of deaths 'expected' in a population, based on its age structure, if it had the same mortality experience as a reference population.**

Indirect standardisation

■ **The indirect method of standardisation is mostly used in the standardisation of mortality rates (although not exclusively). It involves the calculation of the** *standardised mortality ratio* **or S.M.R.**

■ **Indirect standardisation is easier to use**

■ **permit some statistical calculations of probability (95% confidence intervals).**

■ **The information necessary to calculate the S.M.R. is also often more easily available than for the direct method.**

Indirect standardisation

- Useful in the presence of low death rate for example for younger age groups

Indirect method of standardisation

- The indirect method of standardisation is commonly used when age-specific rates are unavailable. For example if we did not know the age specific mortality rates for country B.

- In this method, instead of taking one population structure as standard and applying sets of rates to it to estimate expected events, a set of rates from a standard population (country A) is applied to each of the populations being compared to calculate standardized morbidity/mortality ratios.

The principle of its calculation uses standard age specific rates in a reference population. It then calculates the number of deaths (or cases) expected in the study population if the age specific rates in this study population were the same as in the reference population. The ratio of the number of observed death (or cases) to the number of expected and multiplied by 100 is calculated

$$SMR = \frac{Observed\ deaths}{Expected\ deaths} \times 100$$

Table 4. Indirect method of standardisation: Number of expected deaths if the population had the same age-specific mortality rates as Country A.

	Country A	Country B
	Expected deaths	Expected deaths
0-29	0.0012 x 6,000,000 = 7,200	0.0012 x 1,500,000 = 1,800
30-59	0.0036 x 5,500,000 = 19,800	0.0036 x 550,000 = 1,980
60+	0.048 x 2,500,000 = 120,000	0.048 x 120,000 = 5,760
Total expected deaths (E)	147,000	9,540
Total observed deaths (O)	147,000	15,300
Standardised Mortality Ratio O/E x 100	100	160

standardized mortality ratio (SMR),

■ An overall summary measure can then be calculated, that is, the standardized mortality ratio (SMR), which is the ratio of the observed number of deaths to the expected number of deaths.

■ SMR = Observed number of deaths (O) X 100%
        Expected number of deaths (E)

■ SMR = 160 = 1.6 X 100 = 160
      100

■ SMR is calculated as 160, which means that the number of observed deaths in Country B is 60% higher than the number we would expect if Country B had the same mortality experience as Country A.

■

Indirect Standardisation

1. Select standard (reference) population (A)
2. Identify Populations of Interest (B)
3. Identify age groups breakdown

4. Calculate the age-specific death rates for the standard population

5. Calculate expected deaths for population by multiplying the age-sex specific rates for the reference population (A) by the corresponding age-sex specific populations for study population (B)

6. Calculate total expected deaths by summing the expected deaths for study population (B)

7. The Standardized Mortality Ratio (SMR) for the study population (B) is calculated by dividing the actual number of deaths for study A population by the expected number of deaths for this population (B) x 100.

$$SMR = \frac{d}{\sum n_i R_i} \times 100$$

d is the number of deaths in the study population,
n_i is the number of people in the ith group of the study population,
R_i is the crude death rate in the ith group of the standard population.

Confidence interval for SMR
The 95% CI for an SMR is obtained by
CI=SMR±(1.96xSE)
Where SE=SMR/√d
d=number of observed deaths

The S.M.R. is a ratio, it has no unit and can take any value between 0 and infinity.

- **SMR =100**
  The study population has the same mortality rate as the reference population.

- **SMR >100**
  The study population has a mortality higher than the reference population.

e.g. SMR=120 means that the mortality in the study population is 20% higher than in the reference population

- **SMR <100**
  The study population has a mortality lower than the reference population.

e.g. SMR=50 means that the mortality in the study population is 50% less than in the reference population.

Example

Calculation of standardised mortality ratio (S.M.R.) for two occupational groups in England using the whole population of England as a reference population (Original data 1959-63)

Occupation	Number in Occupational group	Observed death	Crude death rate per 1000 per year
Farmers, foresters and fishermen	705910	20973	5.9
Armed force	301120	4282	2.8

Calculation of expected number of deaths using the age specific death rates of England as a reference

	Annual death rates/ 1000 in England	Farmers, foresters, fisher men		Armed Force	
Age		**Number in occupation**	**Expected deaths 1959-1963**	**Number in occupation**	**Expected deaths 1959-1963**
15-24	5.139715	134560	691.6	165030	848.3
25-34	5.589847	124100	693.7	73240	409.4
35-44	12.05491	132220	1593.9	42250	509.3
45-54	35.36006	160110	5661.5	15930	563.3
55-64	108.5502	154920	16816.6	4670	506.9
Total expected deaths			**25457.3**		**2837.2**

Calculation of S.M.R.

Farmers, foresters and fishermen:

SMR=20973/25457.3*100=82.4

Armed forces

SMR=4282/2837.2*100=150.9

Conclusions

Armed force.

- The SMR of the Farmers etc is lower than the one of the

- The SMR of the farmers etc is less than 100
- The SMR of the armed force is more than 100
- The mortality rate of the farmers is lower than the average for England by 17.6%. The mortality of the armed force is higher than the average in England by 50.9%.