Health and Disease

Public Health I

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Office Consultation (Upon Request)

Public Health I

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Seminar Outline

I. Definition of Health

II. Theory of Disease

III. Global Burden of Disease

BREAK

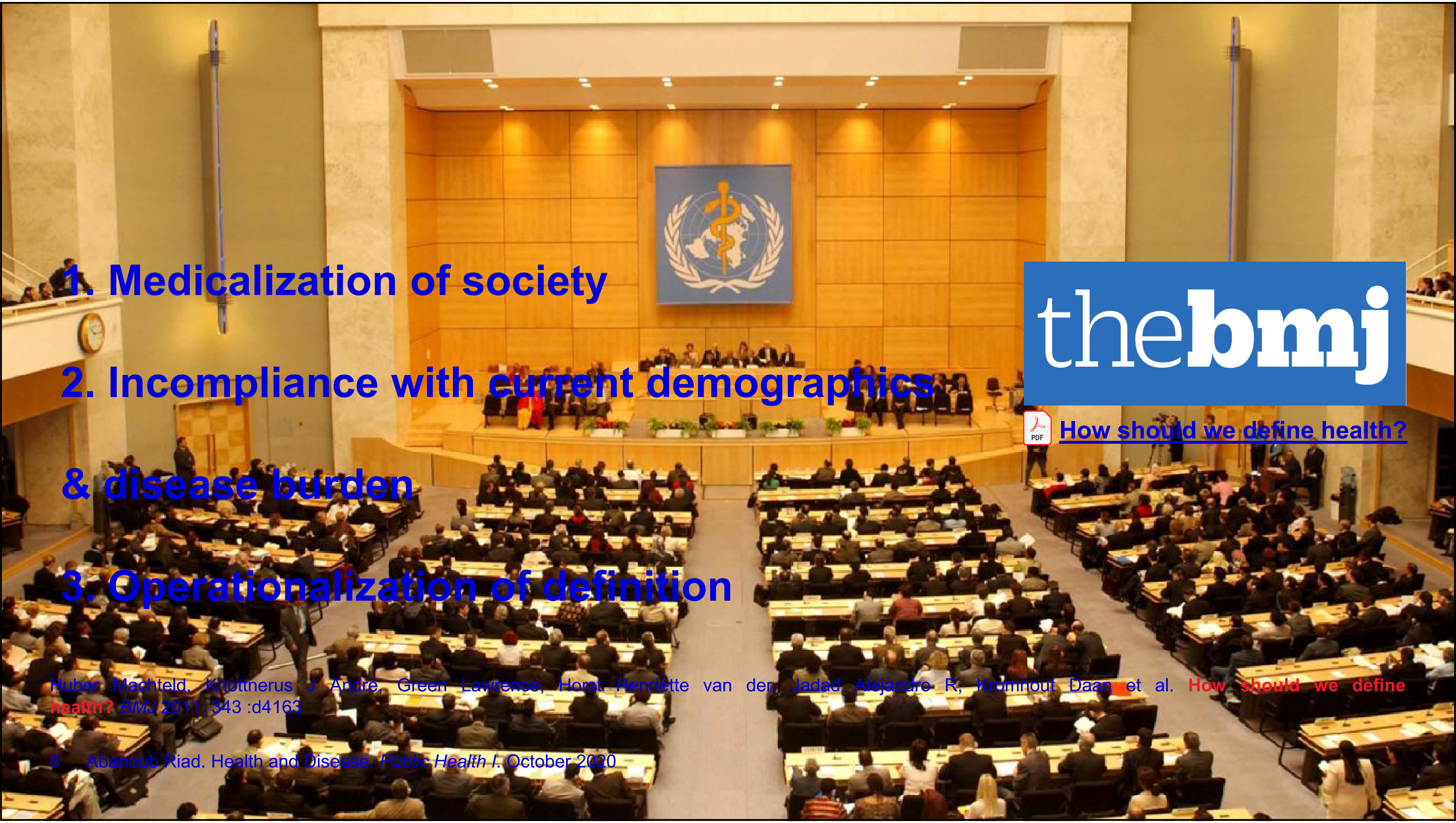
IV. Measuring Disease Frequency

V. Mortality

How do you define “Health”?

Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

Constitution of WHO as adopted by the International Health Conference, New York; signed on 22 July 1946
The definition has not been amended since 1948



1. Medicalization of society

2. Incompliance with current demographics & disease burden

3. Operationalization of definition

thebmj

[How should we define health?]

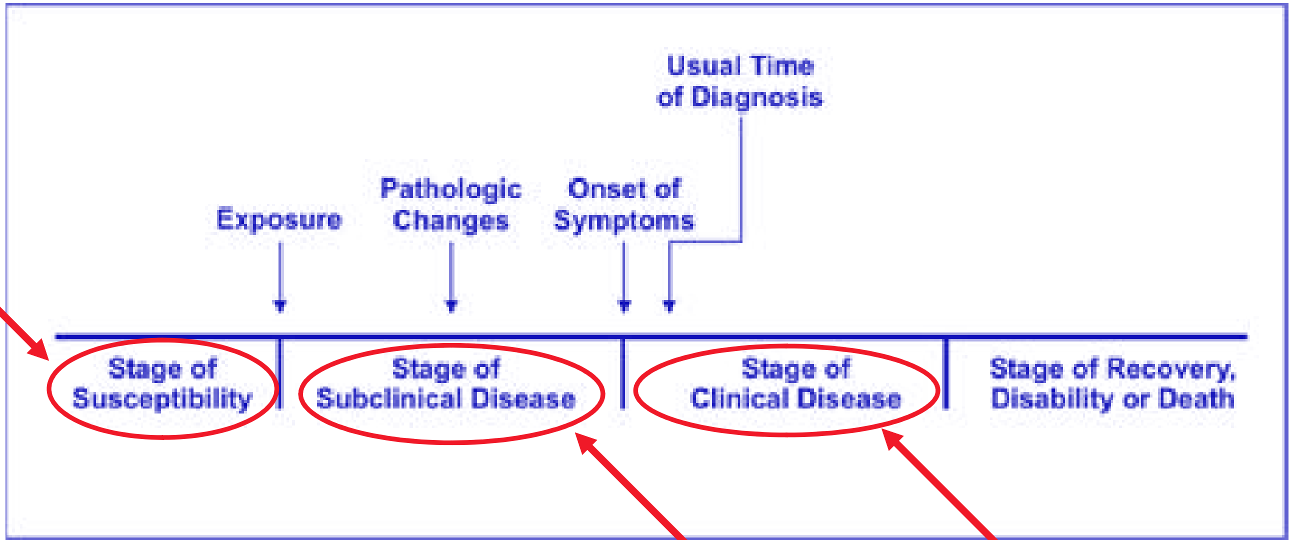
Huber Machteld, Knottnerus J André, Green Lawrence, Horst Henriëtte van der, Jadad Alejandro R, Kromhout Daan et al. **How should we define health?** *BMJ* 2011; 343 :d4163

 Abanoub Riad. Health and Disease. *Public Health I*. October 2020

Natural History of Disease

PREDISEASE

Primary Prevention



Source: Centers for Disease Control and Prevention. Principles of epidemiology. 2nd ed. Atlanta: U.S. Department of Health and Human Services;1992.

secondary Prevention

LATENT

SYMPTOMATIC

tertiary Prevention

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How disease occurs?

Supernatural Theories

1. **Demonic Theory**
2. **Punitive Theory**

Philosophical Theories

1. **Humoral Theory**
2. **Miasmatic Theory**
3. **Contagion Theory**

Scientific Theories

1. **Germ Theory**
2. **Epidemiological Triad**
3. **Epidemiological Tetrad**
4. **Wheel Theory**
5. **Web of Causation**

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How do we classify diseases?

Age (e.g. Pediatric, Geriatric)

Race **POPULATION** Occupation

Gender (e.g. Gynecologic, Productive)

Organ-specific (e.g. Liver, Kidney, Brain)

Syndromic **TARGET** Tissue-specific (Mucosal)

System-specific (e.g. Respiratory, Cardiovascular)

Communicable (Infectious) Diseases

TRANSMISSION

Non-Communicable (Chronic) Diseases

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Global Burden of Disease (GBD)

Since 1990 (350 diseases, 195 countries, +3600 researchers)

The largest study for diseases distribution and their impact.

Quantifying mortality, and morbidity.

Symbol of coordinated "global health" efforts.

http://www.healthdata.org/gbd

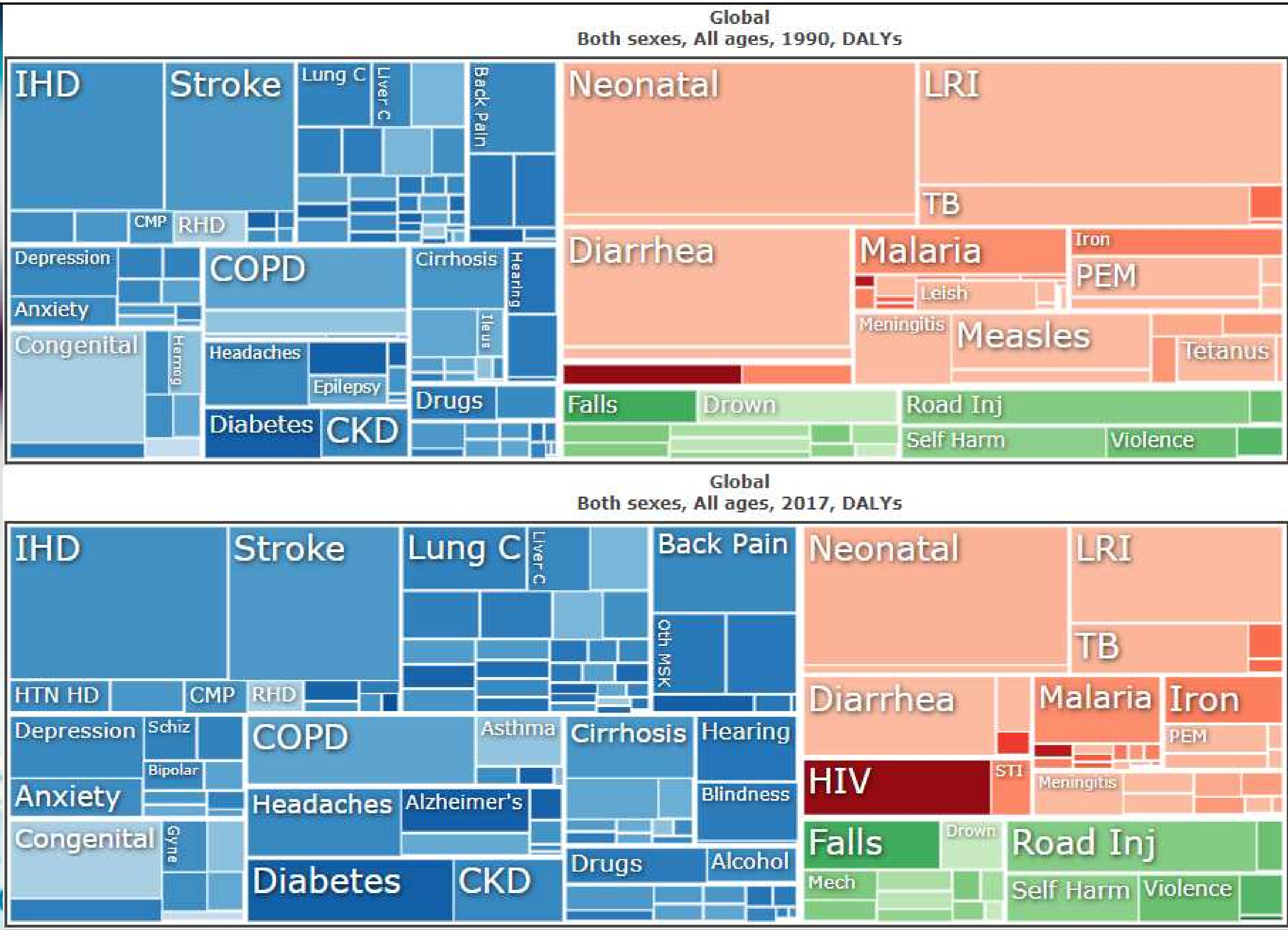
Exercise 3

Global Burden of Disease

1. **Go to: https://vizhub.healthdata.org/gbd-compare/**
2. **Click “Compare” – then “By Year”**
3. **Select “1990” for “Top Chare Settings”**
4. **What happened in the last 30 years?**

Exercise 3

Global Burden of Disease

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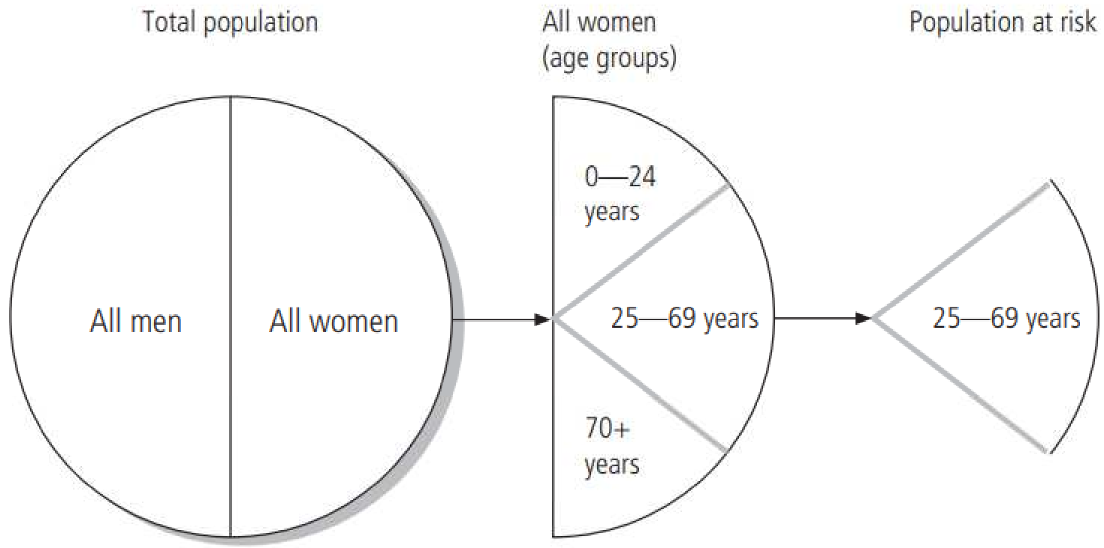
Disease Frequency

Population at Risk

Ratio vs. Rate

Incidence vs. Prevalence

Figure 2.1. Population at risk in a study of carcinoma of the cervix



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Ratio

Method for calculating a ratio

$$\frac{\textit{Number or rate of events, items, persons, etc. in one group}}{\textit{Number or rate of events, items, persons, etc. in another group}}$$

After the numerator is divided by the denominator, the result is often expressed as the result "to one" or written as the result ":1."

A ratio is the relative magnitude of two quantities or a comparison of any two values.

It is calculated by dividing one interval- or ratio-scale variable by the other.

The numerator and denominator need not be related.

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Female / Male   Gender

EXAMPLE: Calculating a Ratio — Different Categories of Same Variable

Between 1971 and 1975, as part of the National Health and Nutrition Examination Survey (NHANES), 7,381 persons ages 40–77 years were enrolled in a follow-up study.[1] At the time of enrollment, each study participant was classified as having or not having diabetes. During 1982–1984, enrollees were documented either to have died or were still alive. The results are summarized as follows.

	Original Enrollment (1971–1975)	Dead at Follow-Up (1982–1984)
Diabetic men	189	100
Nondiabetic men	3,151	811
Diabetic women	218	72
Nondiabetic women	3,823	511

Of the men enrolled in the NHANES follow-up study, 3,151 were nondiabetic and 189 were diabetic. Calculate the ratio of non-diabetic to diabetic men.

Ratio = 3,151 / 189 x 1 = 16.7:1

Population / Clinics

EXAMPLES: Calculating Ratios for Different Variables

Example A: *A city of 4,000,000 persons has 500 clinics. Calculate the ratio of clinics per person.*

500 / 4,000,000 x 10n = 0.000125 clinics per person

To get a more easily understood result, you could set 10n = 104 = 10,000. Then the ratio becomes:

0.000125 x 10,000 = 1.25 clinics per 10,000 persons

You could also divide each value by 1.25, and express this ratio as 1 clinic for every 8,000 persons.

Example B: *Delaware's infant mortality rate in 2001 was 10.7 per 1,000 live births.*[2] *New Hampshire's infant mortality rate in 2001 was 3.8 per 1,000 live births. Calculate the ratio of the infant mortality rate in Delaware to that in New Hampshire.*

10.7 / 3.8 x 1 = 2.8:1

Thus, Delaware's infant mortality rate was 2.8 times as high as New Hampshire's infant mortality rate in 2001.

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Case-to-death Ratio
(Case-fatality ratio)

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Case fatality ratio (CFR) is the proportion of individuals diagnosed with a disease who die from that disease and is therefore a measure of severity among detected cases:

$$\text{Case Fatality ratio (CFR, in\%)} = \frac{\text{Number of deaths from disease}}{\text{Number of confirmed cases of disease}} \times 100$$

Reliable CFRs that can be used to assess the deadliness of an outbreak and evaluate any implemented public health measures are generally obtained at the end of an outbreak, after all cases have been resolved (affected individuals either died or recovered). However, this calculation may not hold in an ongoing epidemic, because it makes two assumptions:

Assumption 1: The likelihood of detecting cases and deaths is consistent over the course of the outbreak.

Early in an outbreak, surveillance tends to focus more on symptomatic patients who seek care, so milder and asymptomatic cases are less likely to be detected, leading to overestimation of CFR; this overestimation may decrease as testing and active case finding increase. One method to account for this is to remove from the analysis those cases that occurred before the establishment of robust surveillance, including application of clear case definitions (a method called left censoring).

Assumption 2: All detected cases have resolved (that is, reported cases have either recovered or died).

During an ongoing epidemic, some of the active cases already detected may subsequently die, leading to underestimation of CFR estimated before their death. This effect is accentuated in fast-growing epidemics (e.g. during the exponential growth phase of COVID-19).

Calculating CFR during an ongoing epidemic

CFR calculated using the above formula during ongoing epidemics provides a conditional, estimate of CFR and is influenced by lags in report dates for cases and deaths [13]. This leads to a wide

https://www.who.int/news-room/commentaries/detail/estimating-mortality-from-covid-19

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Rate

- In epidemiology, a rate is a measure of the frequency with which an event occurs in a defined population over a specified **period of time**.
- Because rates put disease frequency in the perspective of the size of the population, rates are particularly useful for comparing disease frequency in different locations, at different times, or among different groups of persons with potentially different sized populations; that is, a rate is a **measure of risk**.

Ratio Vs. Rate

Condition	Ratio	Rate
Morbidity (Disease)	Risk ratio (Relative risk) Rate ratio Odds ratio Period prevalence	Person-time incidence rate
Mortality (Death)	Death-to-case ratio	Crude mortality rate Case-fatality rate Cause-specific mortality rate Age-specific mortality rate Maternal mortality rate Infant mortality rate
Natality (Birth)		Crude birth rate Crude fertility rate

https://www.cdc.gov/csels/dsepd/ss1978/lesson3/section1.html

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Incidence

The incidence of disease represents the **rate** of occurrence of **new** cases arising in a given **period** in a specified population

Prevalence

Prevalence is the **frequency** of **existing** cases in a defined population at a given **point** in time.

Table 2.2. Differences between incidence and prevalence

	Incidence	Prevalence
Numerator	Number of **new** cases of disease during a specified period of time	Number of **existing** cases of disease at a given point of time
Denominator	Population at risk	Population at risk
Focus	Whether the event is a new case Time of onset of the disease	Presence or absence of a disease Time period is arbitrary; rather a "snapshot" in time
Uses	Expresses the risk of becoming ill The main measure of acute diseases or conditions, but also used for chronic diseases More useful for studies of causation	Estimates the probability of the population being ill at the period of time being studied. Useful in the study of the burden of chronic diseases and implication for health services

Note: If incident cases are not resolved, but continue over time, then they become existing (prevalent) cases. In this sense, prevalence = incidence × duration.

Incidence *(I)* is calculated as follows:

$$I = \frac{\text{Number of new events in a specified period}}{\text{Number of persons exposed to risk during this period}} (\times 10^n)$$

Cumulative incidence

Cumulative incidence is a simpler measure of the occurrence of a disease or health status. Unlike incidence, it measures the denominator only at the beginning of a study.

The cumulative incidence can be calculated as follows:

$$\text{Cumulative Incidence} = \frac{\text{Number of people who get a disease during a specified period}}{\text{Number of people free of the disease in the population at risk at the beginning of the period}} (\times 10^n)$$

Prevalence *(P)* of a disease is calculated as follows:

$$P = \frac{\text{Number of people with the disease or condition at a specified time}}{\text{Number of people in the population at risk at the specified time}} (\times 10^n)$$

Figure 2.2. Factors influencing prevalence

Increased by:	Decreased by:
Longer duration of the disease	Shorter duration of the disease
Prolongation of life of patients without cure	High case-fatality rate from disease
Increase in new cases (increase in incidence)	Decrease in new cases (decrease in incidence)
In-migration of cases	In-migration of healthy people
Out-migration of healthy people	Out-migration of cases
In-migration of susceptible people	Improved cure rate of cases
Improved diagnostic facilities (better reporting)	

Interrelationships of the different measures

Prevalence is dependent on both incidence and disease duration. Provided that the prevalence *(P)* is low and does not vary significantly with time, it can be calculated approximately as:

$$P = \text{incidence} \times \text{average duration of disease}$$

Exercise 4

Prostate Cancer

Black men in the United States have a substantially higher incidence of prostate cancer than U.S. white men. Let's say there's a variant of the androgen receptor gene that's more common in black than white men in the United States — 50 % versus 30 % — that is also associated with a doubling of incidence of prostate cancer in American men of either race.

What would be the relative incidence of prostate cancer, black versus white American men, if the genetic marker were the sole risk factor for this disease that differed between the two races?

Exercise 4

Prostate Cancer in the U.S.

Exercise 4

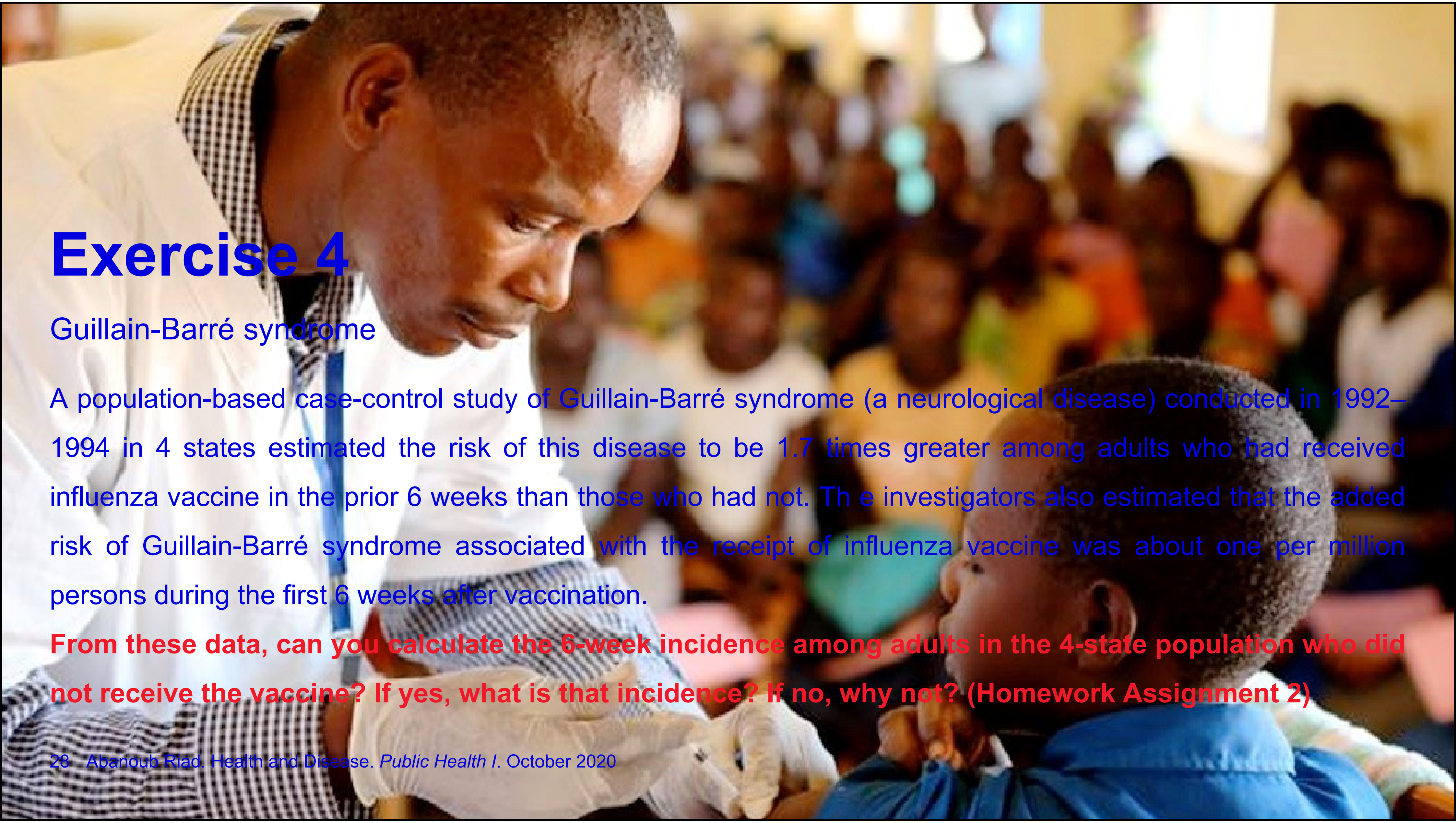
Suicide of Physicians

The rate of suicide among American physicians, relative to the corresponding rate in the population as a whole, varies by gender. Among men, the rate in physicians is 1.5 times higher, whereas among women the corresponding relative rate is 3.0. It turns out that the rate of suicide in American male and female physicians is identical.

For American men and women in general, what is the relative rate of suicide in men compared to women?

Exercise 4

Suicide of Physicians



Exercise 4

Guillain-Barré syndrome

A population-based case-control study of Guillain-Barré syndrome (a neurological disease) conducted in 1992–1994 in 4 states estimated the risk of this disease to be 1.7 times greater among adults who had received influenza vaccine in the prior 6 weeks than those who had not. Th e investigators also estimated that the added risk of Guillain-Barré syndrome associated with the receipt of influenza vaccine was about one per million persons during the first 6 weeks after vaccination.

From these data, can you calculate the 6-week incidence among adults in the 4-state population who did not receive the vaccine? If yes, what is that incidence? If no, why not? (Homework Assignment 2)

Exercise 4

Stomach Cancer

The incidence of stomach cancer in country *X* is 8.0 per 100,000 per year. The incidence rate in nearby country *Y*, with a similar age-sex-race composition as country *X*, is 10.0. You are concerned with explaining this difference. You know that 5% of people in country *Y* drink tea containing suspected carcinogen *A*, whereas nobody in country *X* drinks this tea.

In order for this to be the sole explanation of the difference in the incidence rates of stomach cancer between the two countries, how strongly must carcinogen-*A*-tea drinking be associated with stomach cancer? (Homework Assignment 2)

Mortality

- **Crude Mortality**
- **Age-specific vs. Age-standardized Mortality**
- **Proportionate Mortality**
- **Infant Mortality**
- **Maternal Mortality**
- **Adult Mortality**
- **Life Expectancy**

The death rate (or crude mortality rate) for all deaths or a specific cause of death is calculated as follows:

$$\text{Crude mortality rate} = \frac{\text{Number of deaths during a specified period}}{\text{Number of persons at risk of dying during the same period}} (\times 10^n)$$

Age-specific death rates

Death rates can be expressed for specific groups in a population which are defined by age, race, sex, occupation or geographical location, or for specific causes of death. For example, an age- and sex-specific death rate is defined as:

$$\frac{\text{Total number of deaths occurring in a specific age and sex group of the population in a defined area during a specified period}}{\text{Estimated total population of the same age and sex group of the population in the same area during the same period}} (\times 10^n)$$

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Proportionate Mortality

- Occasionally the mortality in a population is described by using proportionate mortality, which is actually a **ratio**: the number of deaths from a given cause per 100 or 1000 total deaths in the same period. Proportionate mortality does not express the risk of members of a population contracting or dying from a disease.
- Unless the crude or age-group-specific mortality rates are known, it may not be clear whether a difference between groups relates to variations in **the numerators or the denominators**.
- **Example**: Proportionate mortality rates for cancer would be much greater in high-income countries with many old people than in low- and middle-income countries with few old people, even if the actual lifetime risk of cancer is the same.

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Age-adjusted rate

Age-standardized Rate

Table 2.8. Directly standardized male death rates from respiratory infections, and the ranking of five countries using three different standard populations[30]

Country	Age-standardized rate (per 100 000)			Ranking of countries by age-standardized rate		
	Segi	European	WHO world	Segi	European	WHO world
Australia	6.3	10.1	7.9	5	5	5
Cuba	27.2	44.2	34.6	4	4	4
Mauritius	45.2	72.6	56.6	3	3	3
Singapore	71.9	120.8	93.3	2	1	1
Turkmenistan	114.2	87.9	91.2	1	2	2

Box 2.5. Direct and indirect standardization of disease rates

The direct method of standardization is more frequently used, and is done by applying the disease rates of the populations being compared to a standard population. This method yields the number of cases that would be expected if the age-specific rates in the standard population were true for the study population.

Standardized rates are used, whenever relevant, for morbidity as well as mortality. The choice of a standard population is arbitrary, but can be problematic when comparing rates of low-income and high-income countries.

Details on methods of standardizing rates can be found in: *Teaching health statistics: lesson and seminar outlines.*[31]

Table 2.9. Crude and age-standardized death rates (per 100 000) for heart disease in three selected countries (men and women combined), 2002

Country	Crude death rate	Age-standardized death rate
Brazil	79	118
Finland	240	120
USA	176	105

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Rate

Infant Mortality

Rate

Child Mortality

- The child mortality rate (**under-5 mortality rate**) is based on deaths of children aged 1–4 years, and is frequently used as a basic health indicator.
- **Injuries**, **malnutrition** and **infectious** diseases are common causes of death in this age group.
- The under-5 mortality rate describes the probability (**expressed per 1000 live births**) of a child dying before reaching 5 years of age.

The infant mortality rate is calculated as follows:

$$\textit{Infant mortality rate} = \frac{\text{Number of deaths in a year of children less than 1 year of age}}{\text{Number of live births in the same year}} \times 1000$$

Table 2.5. Under-5 mortality rates in selected countries, 2003[23]

Country	Under-5 mortality rate per 1000 live births (95% CI)	
	Males	**Females**
High-income countries		
Japan	4	4
France	5	5
Canada	6	5
USA	9	7
Middle-income countries		
Chile	10 (9–11)	9 (8–10)
Argentina	19 (18–21)	16 (15–17)
Peru	36 (31–42)	32 (27–39)
Indonesia	45 (40–49)	37 (33–40)
Low-income countries		
Cuba	8 (7–10)	6 (5–7)
Sri Lanka	17 (14–19)	13 (11–15)
Angola	276 (245–306)	243 (216–276)
Sierra Leone	297 (250–340)	270 (229–310)

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Rate

Maternal Mortality

$$\textit{Maternal mortality rate} = \frac{\text{Number of maternal deaths in a given geographic area in a given year}}{\text{Number of live births that occurred among the population of the given geographic area during the same year}} (\times 10^n)$$

Rate

Adult Mortality

Life Expectancy

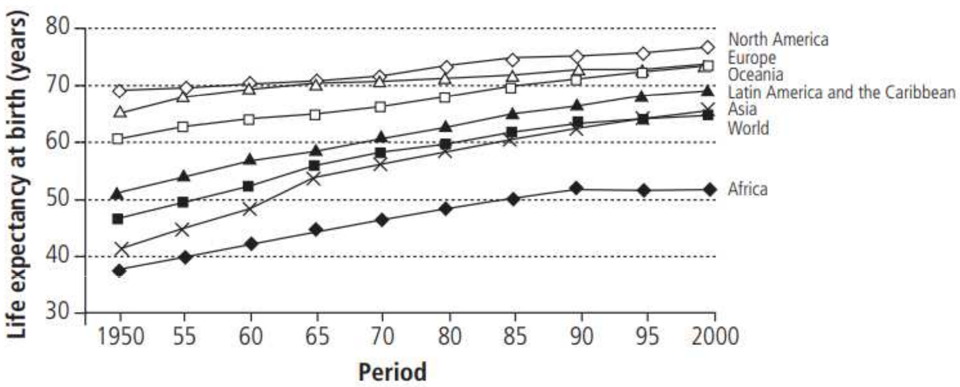
is defined as the average number of years an individual of a given age is expected to live if current mortality rates continue.

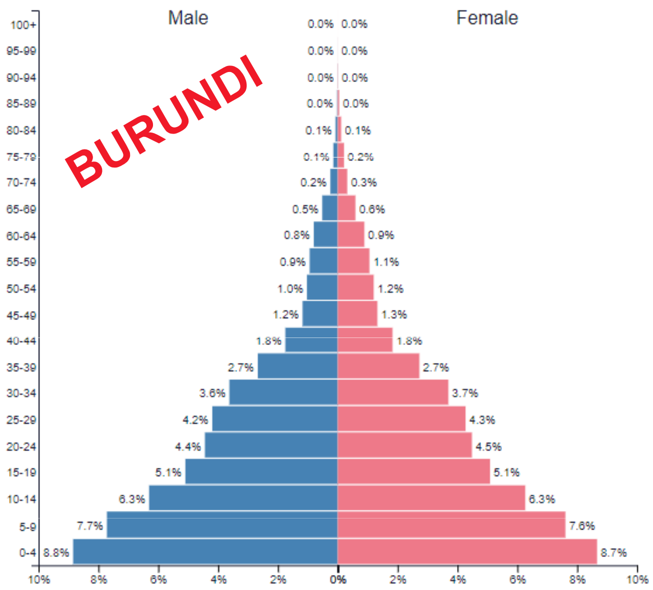
Table 2.7. Life expectancy at birth for men and women in selected countries[28]

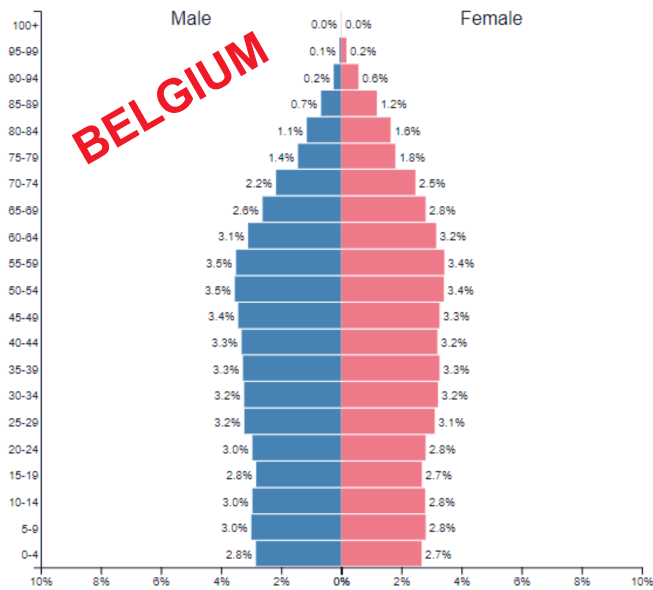
Country	Life expectancy at birth (years)	
	Women	Men
Zimbabwe	34	37
Russian Federation	72	59
Egypt	70	66
China	74	70
Mexico	77	72
USA	80	75
Japan	86	79

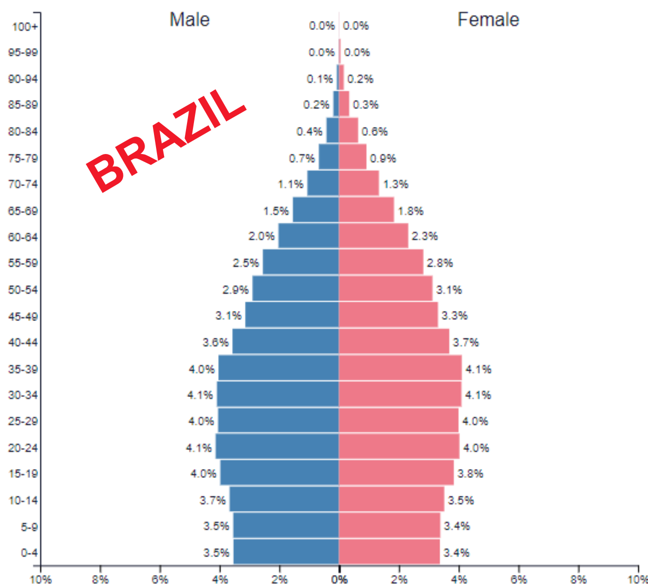
Life Expectancy

Figure 2.5. Worldwide trends in life expectancy, 1950–2000[28]









https://www.populationpyramid.net

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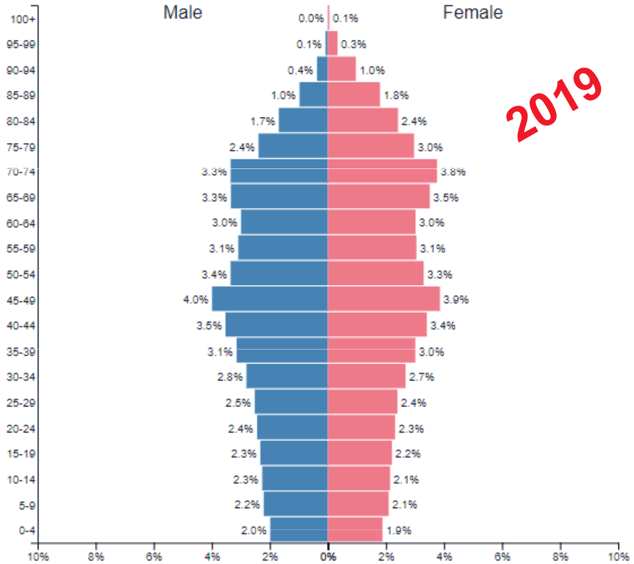
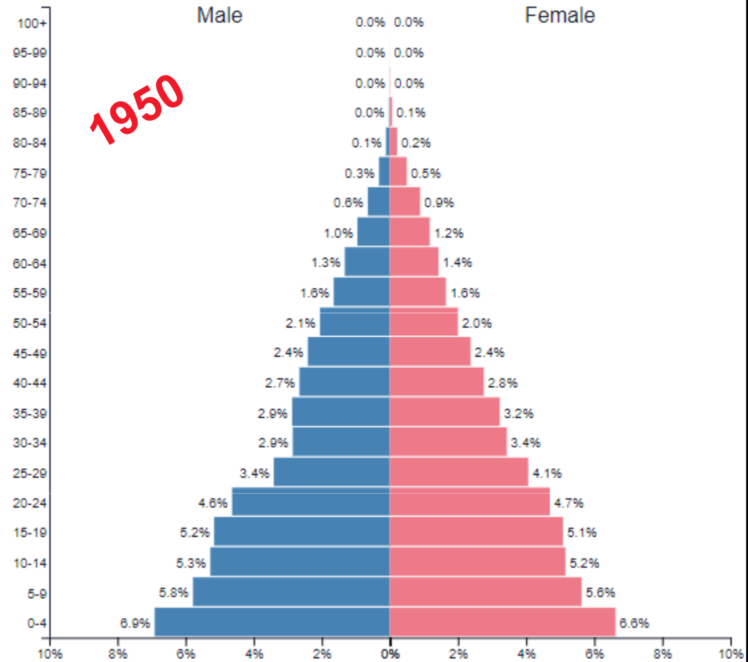
Life Expectancy

in Japan





https://www.populationpyramid.net

Exercise 5

Homicide Death Rate

In 2001, a total of 15,555 homicide deaths occurred among males and 4,753 homicide deaths occurred among females. The estimated 2001 midyear populations for males and females were 139,813,000 and 144,984,000, respectively.

1. Calculate the homicide-related death rates for males and for females.
2. What type(s) of mortality rates did you calculate in Question 1?
3. Calculate the ratio of homicide-mortality rates for males compared to females.
4. Interpret the rate you calculated in Question 3 as if you were presenting information to a policymaker.

Exercise 5

Homicide Death Rate

THANK YOU

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