Population structures: exercise

Assignment from 7. 12. 2022

General remarks:

$\sqrt{x} = \sqrt[2]{x} = x^{\frac{1}{2}}, generally: \sqrt[n]{x} = x^{\frac{1}{n}}$ *Excel: x^(1/n)*

In excel, use natural logarithm function **ln**, not **log**. The function **log** is not the inverse function for **exp**:

=LOG(EXP(3))	=	1,303
=LN(EXP(3))	=	3,000

Infant mortality

14. 12. 2022

Bety Ukolova – ukolovae@natur.cuni.cz

Outline

- Definitions
- Factors of levels of infant mortality
- Trends in infant mortality
- Measuring intensity of infant mortality
- Exercise

Definitions

International, as well as national analysis of infant mortality and its trends might be affected by inconsistent (or over time changing) definitions of **live birth**, **stillbirth** (fetal death) and **abortion**.

Definition of live birth in European Union: The complete expulsion or extraction from its mother of a product of human conception, irrespective of the duration of pregnancy, which after such expulsion or extraction, breathes or shows any other evidence of life, such as beating of the heart, pulsation of the umbilical cord or definite movement of voluntary muscles, whether or not the umbilical cord has been cut or the placenta is attached.

Stillbirths and spontaneous abortions do not show any evidence of live. They are distinguished from each other according to following criterions:

Stillbirths (fetal death) are 20 weeks or older, or have weight of more than 500g, or are longer than 25cm. These criterions might vary by country!

Spontaneous abortions are younger than 20 weeks, or have weight of less than 500g, or are shorter than 25cm. These criterions might vary by country!

Source: [2], [0], [1]

Factors of levels of infant mortality

Generally, infant mortality is determined by **biological**, **socioeconomic** and **health-related factors**.

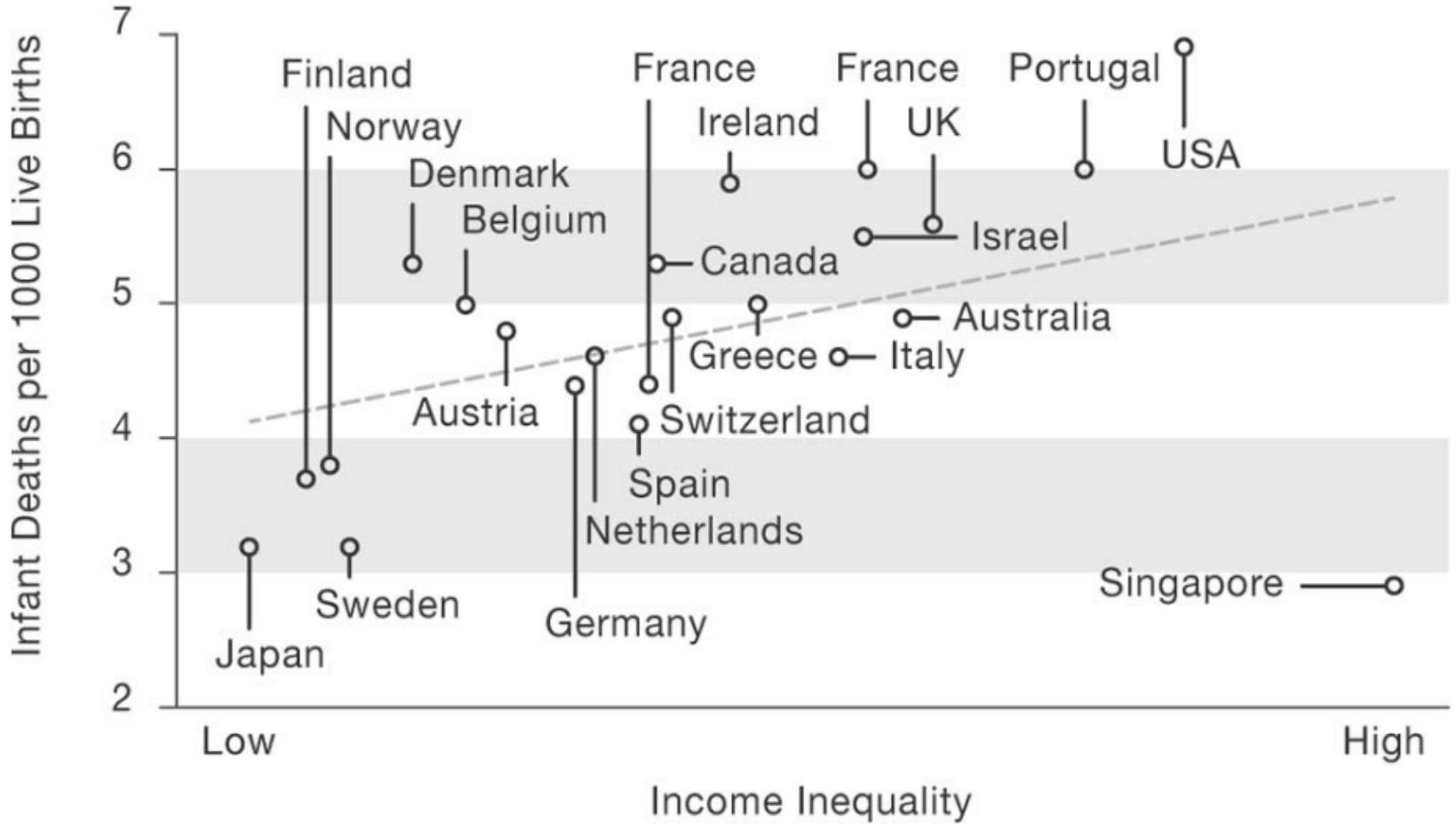
Vallin and Caselli [2] classify factors of fetus deaths in a following way:
Biologic factors: genetic abnormalities, maternal characteristics (age, parity, interbirth intervals, previous abortions and fetal deaths, maternal health status), fetal characteristics
Social factors: legitimacy, immigrant status, maternal education, social class, mother's employment situation, occupational environment
Behavioral factors: smoking, alcohol
Medical factors: medical visits

Historically, onset of industrial revolution lead to the increase in infant mortality due to worthening **hygiene**. This was followed by better living conditions, due to which infant mortality decreased. After the WWII **antibiotics** and later also specialized **medical care** and **monitoring of risky pregnancies** contributed significantly to further reductions in infant mortality.

Source: [2], [0]

Factors of levels of infant mortality

Levels of infant mortality might also reflect the laws of the country.



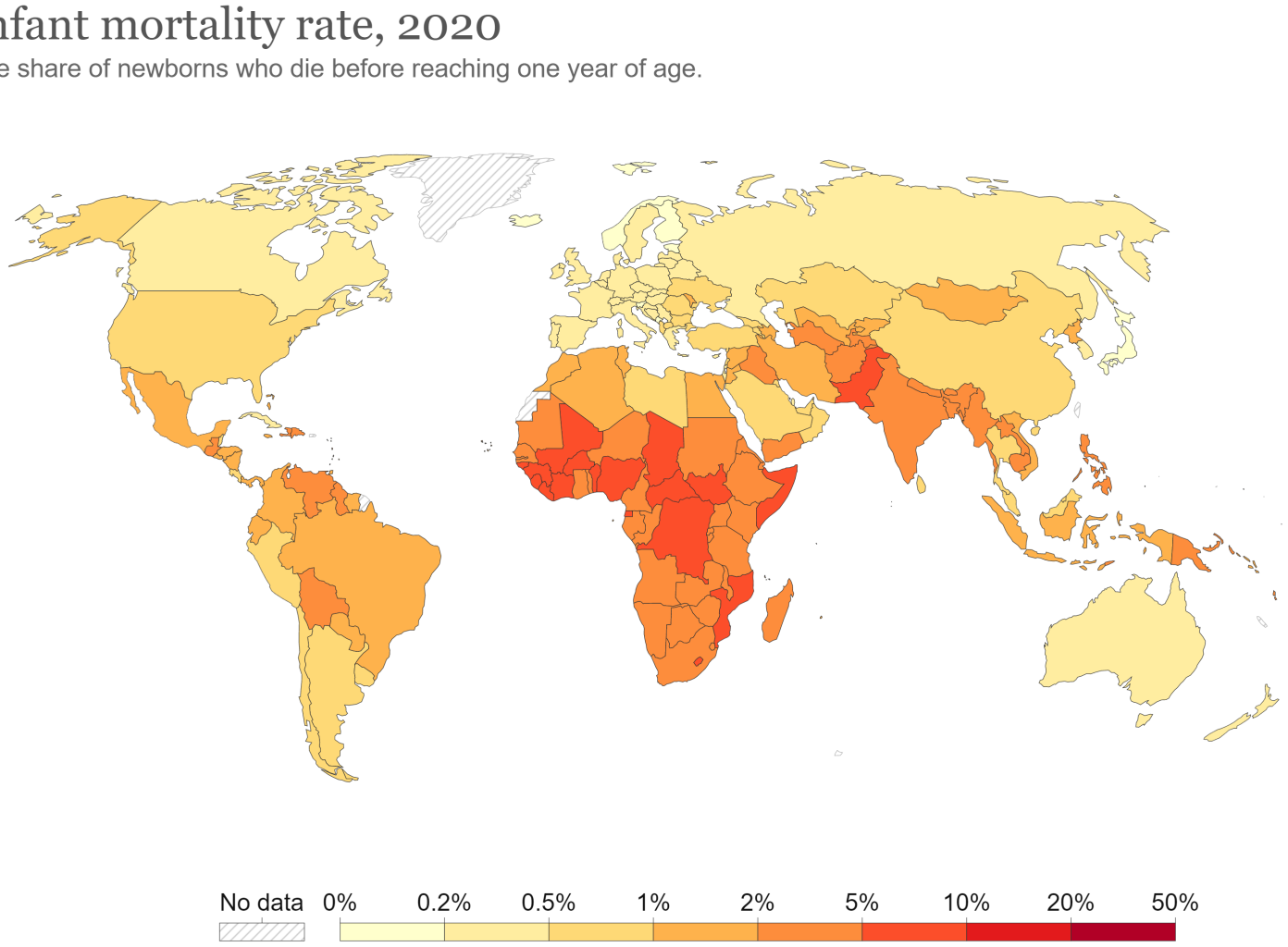
Source: [3]

Trends in infant mortality

Globally, there is a large variation between countries in rates of infant mortality.

More than 7% in 2020 (global maxima): Sierra Leone, Central African Republic, Somalia, Nigeria

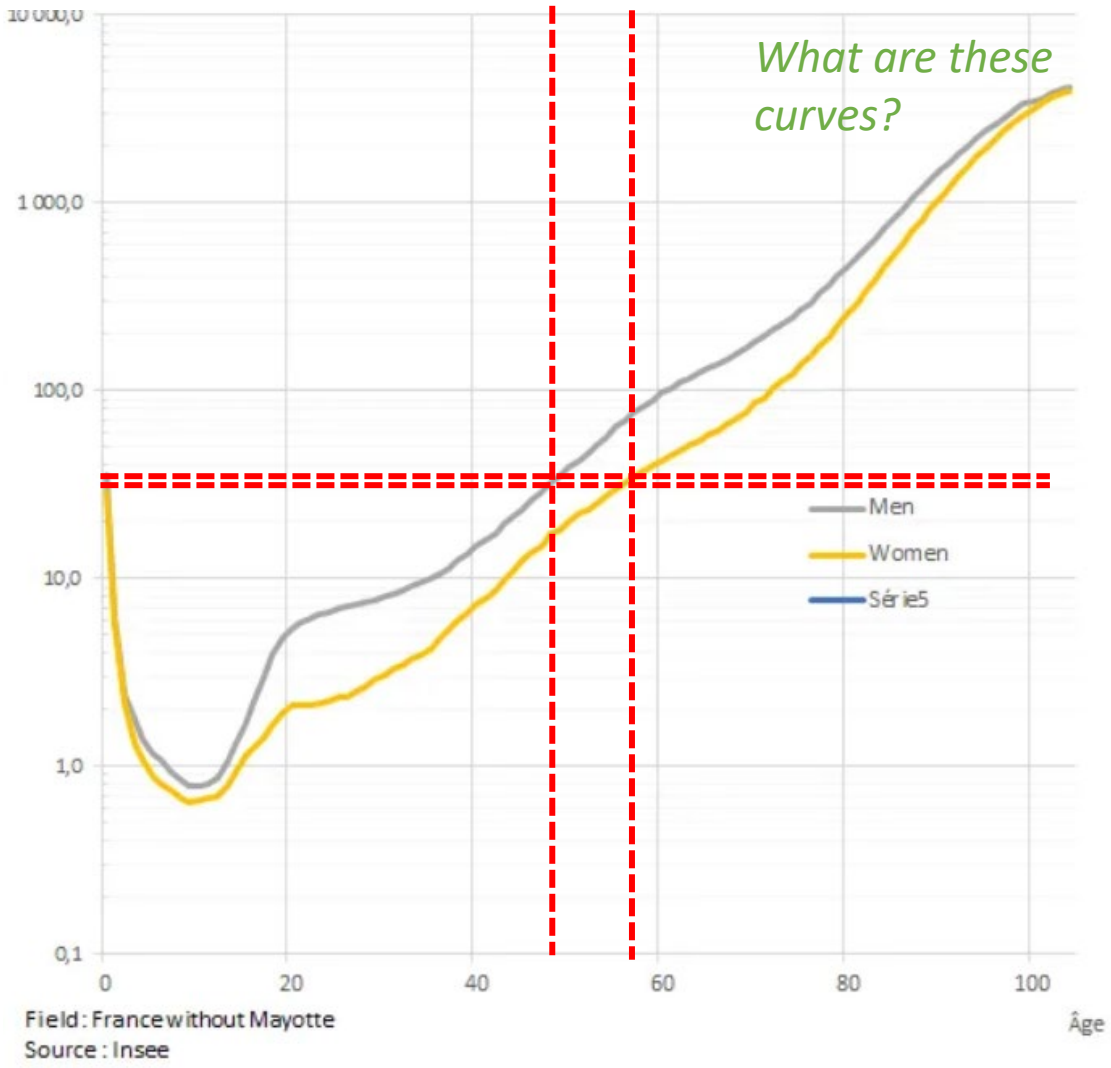
Less than 2‰ in 2020 (global minima): Iceland, Estonia, Japan, Norway, Slovenia, Finland



Source: https://ourworldindata.org/search?q=infant+mortality

Trends in infant mortality

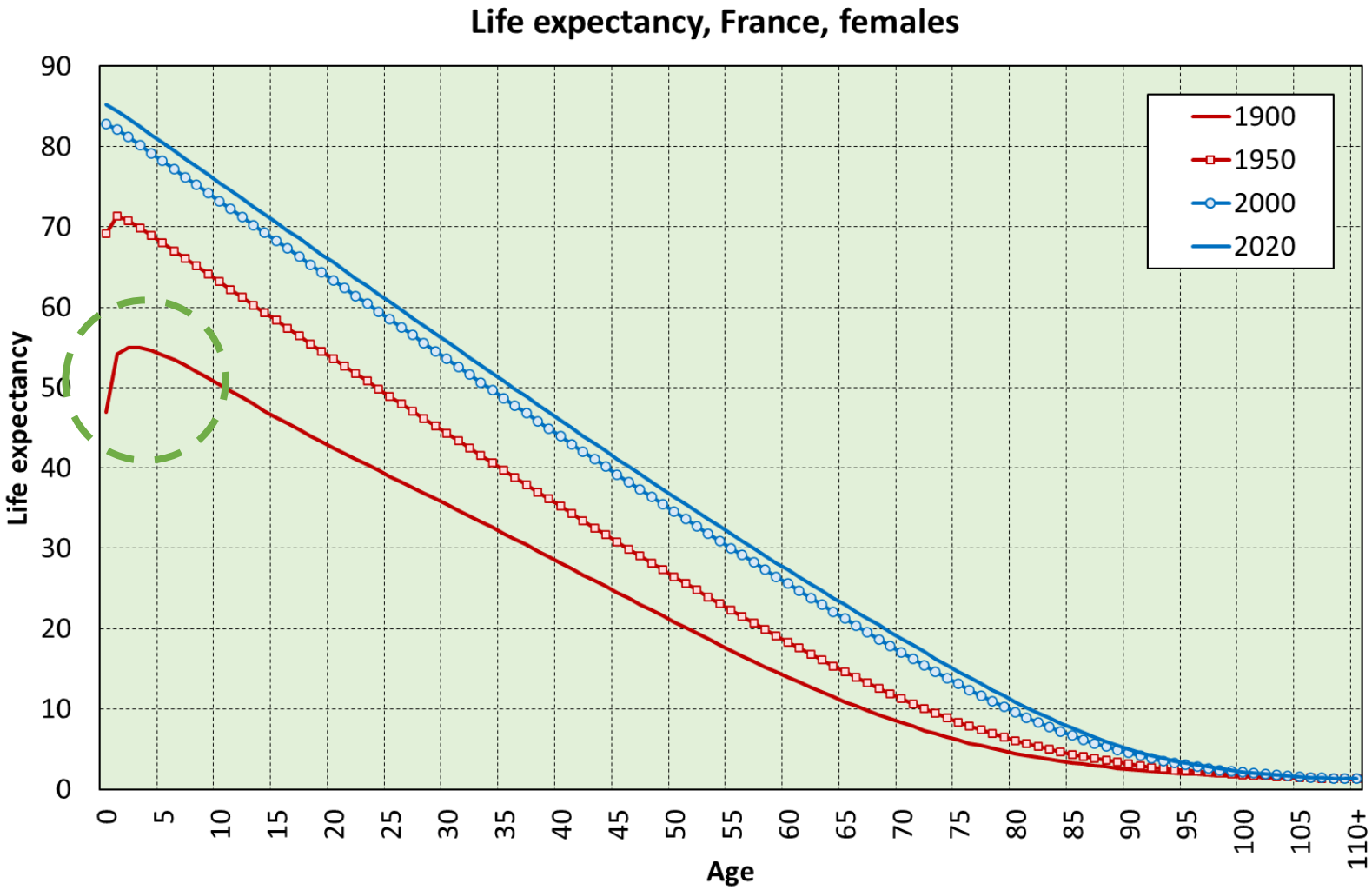
Case of France, 2012–2016: The risk of infant death is comparable to that of adults at ages 50–60.
Some types of model life tables are based on the relationship between infant and adult mortality.



Trends in infant mortality

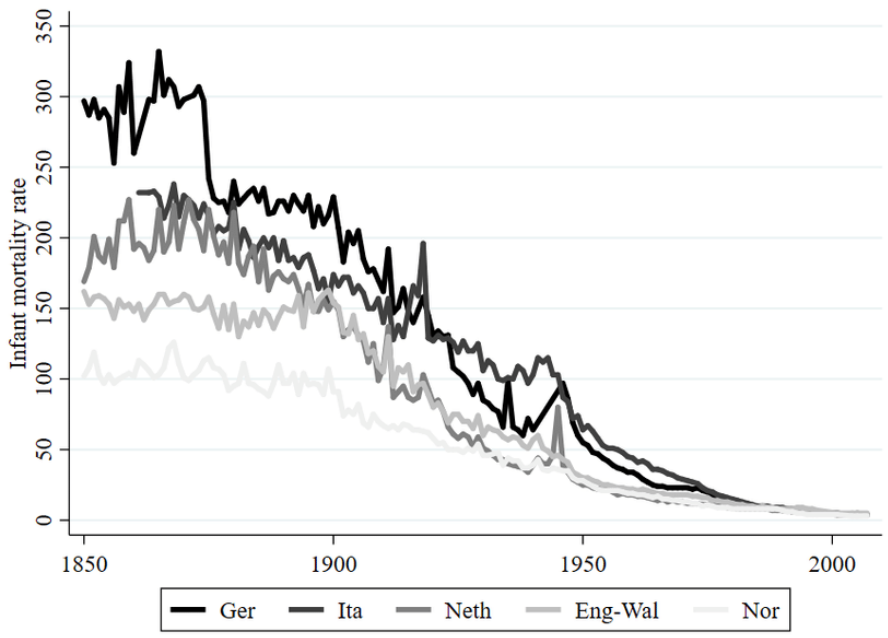
Life expectancy paradox

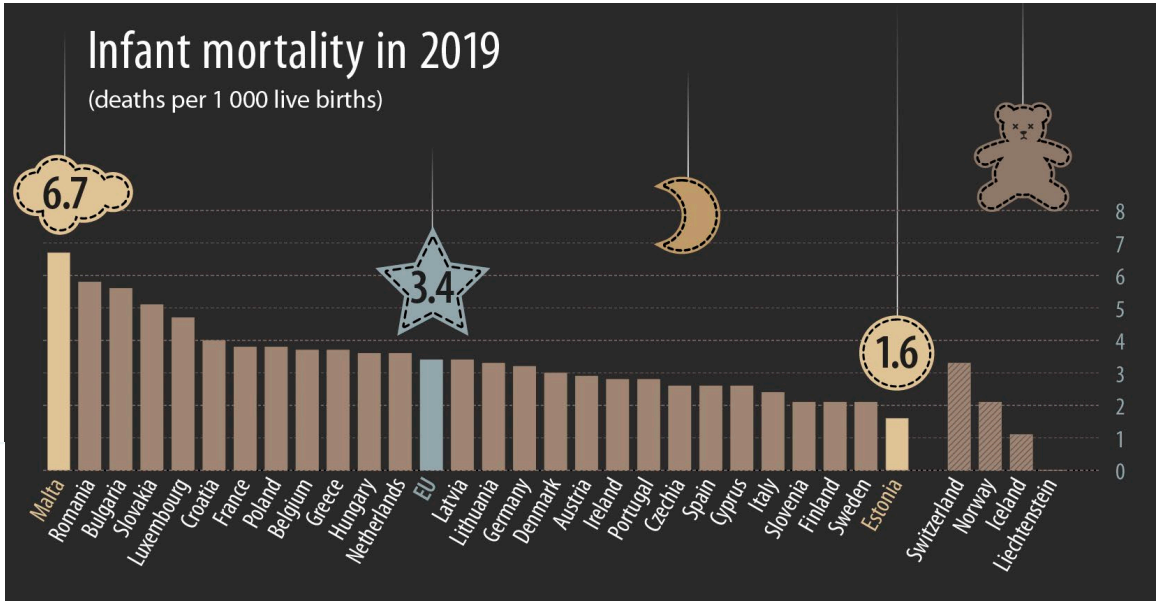
= when life expectancy at age 0 is lower than the life expectancy at ages 1–4

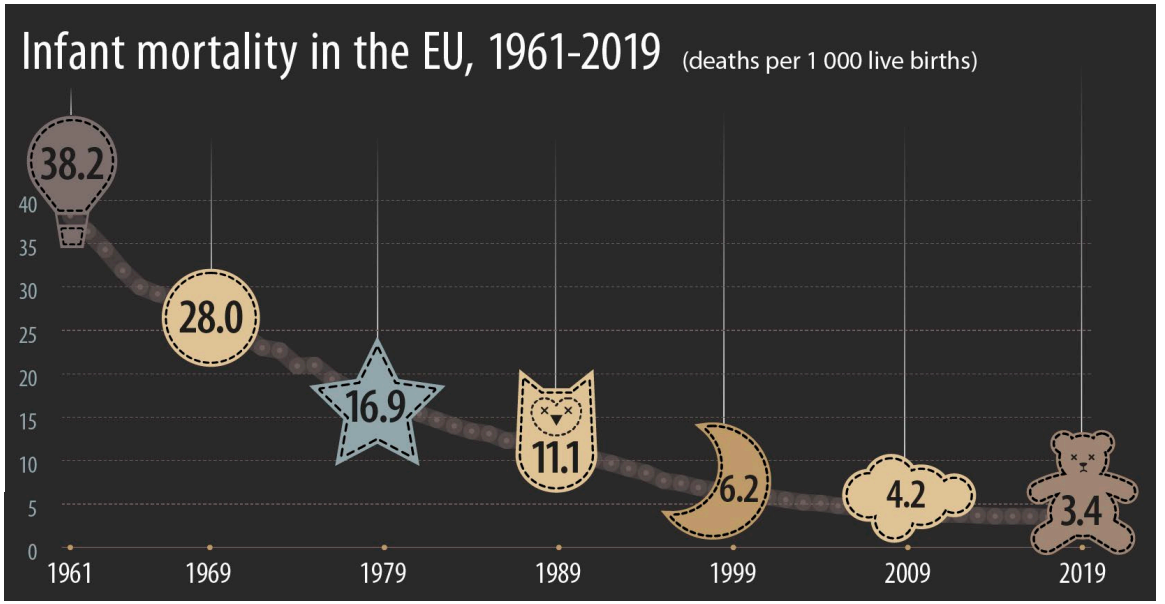


Trends in infant mortality

EU experienced decline in infant mortality since 1961. However, variation between countries in the rates of infant mortality exists in the EU.



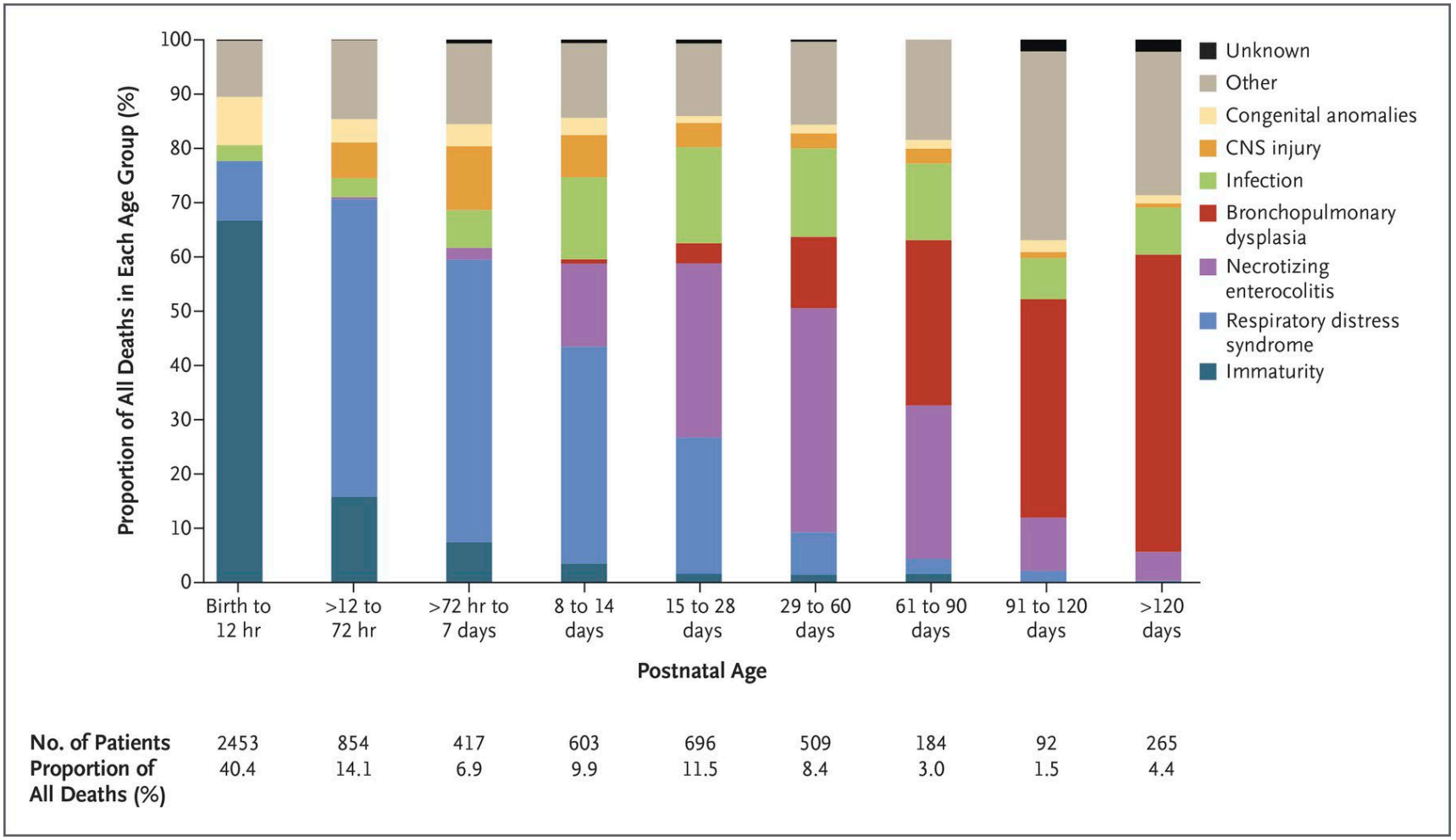




Source: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210604-1, https://www.researchgate.net/figure/Infant-mortality-rates-in-Europe-1850-2001_fig3_334093809

Trends in infant mortality

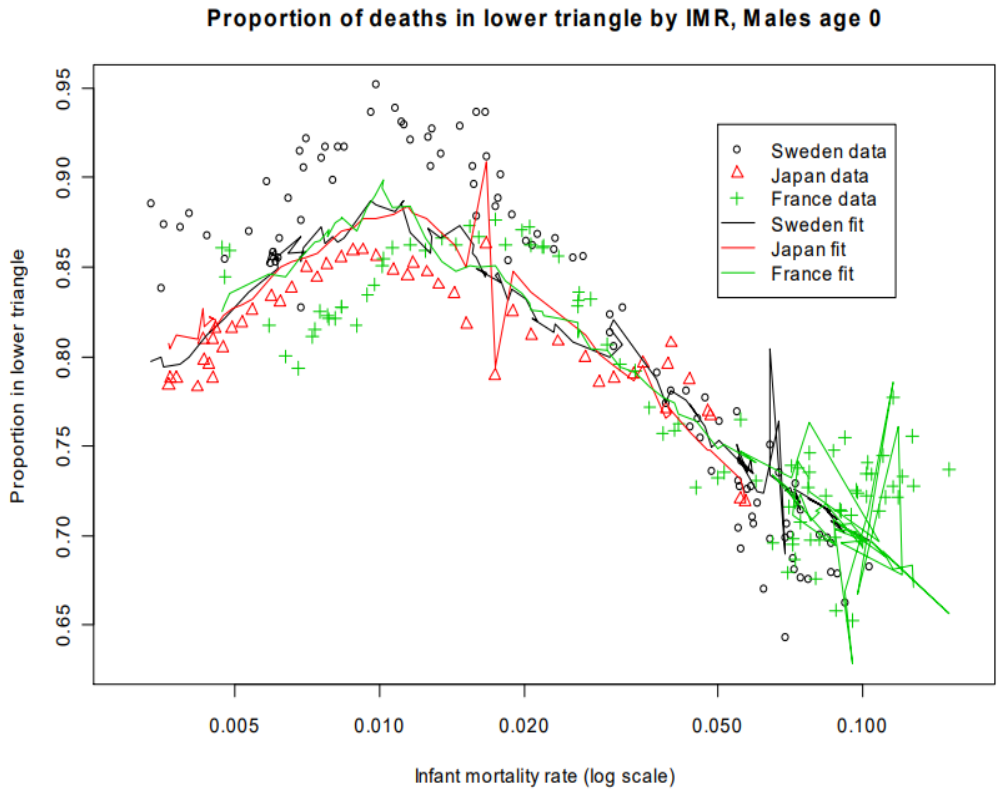
The **structure of causes of death differs by the age of infants**. Infants die from different causes of death than older age groups.

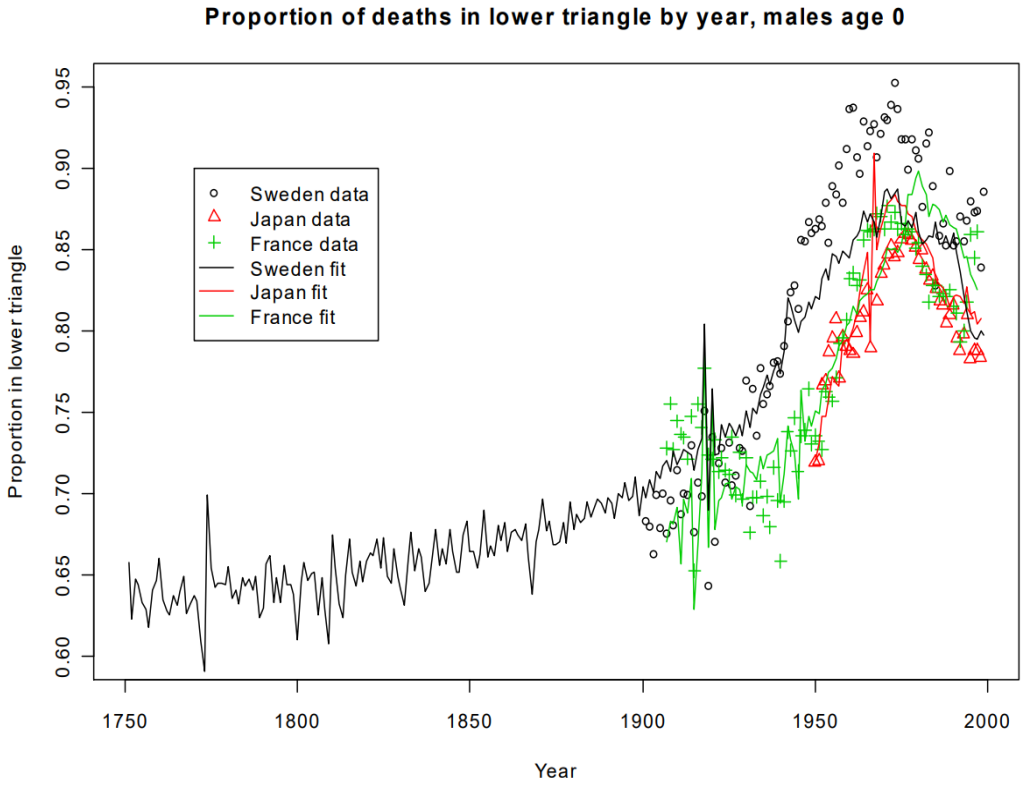


Source: https://www.nejm.org/doi/full/10.1056/nejmoa1403489

Trends in infant mortality

Rapid decrease in infant mortality was accompanied by a **concentration of infant deaths at even younger ages** (shortly after birth). In countries, which reached very low levels of infant mortality, a process of **deconcentration** of infant death from the youngest ages can be observed. In situations of high mortality levels, the concept of infant mortality is completed by that of child mortality (1–4 years), because mortality risks remain high until the age of 5.

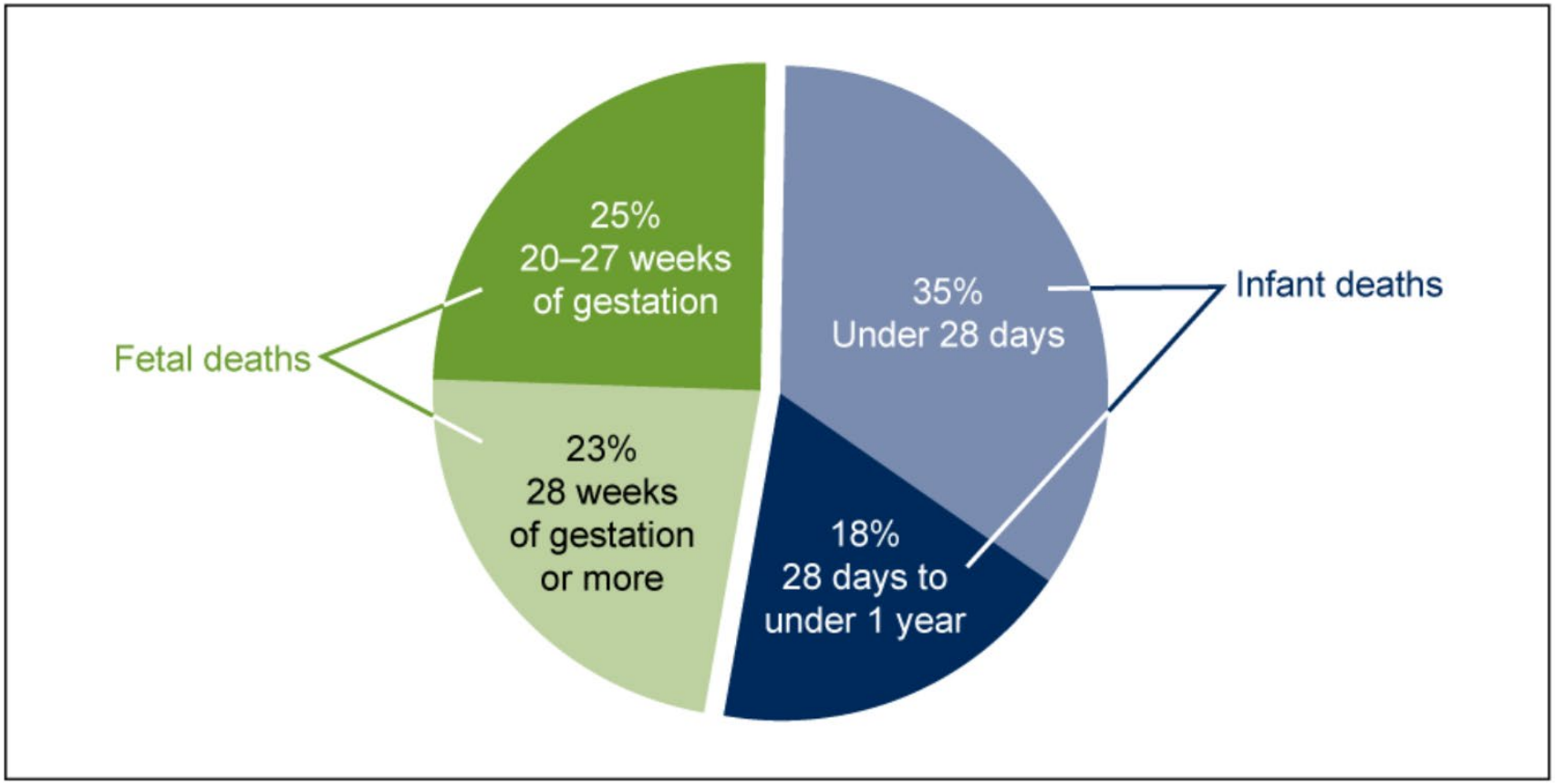




Source: https://www.mortality.org/File/GetDocument/Public/Docs/MethodsProtocolV6.pdf, [4]

Trends in infant mortality

Figure 1. Relative magnitude of fetal deaths of 20 weeks of gestation or more, and infant deaths: United States, 2005



Source: https://www.cdc.gov/nchs/products/databriefs/db16.htm

Trends in infant mortality

For further information, I would suggest to read the publications in the reading list.

Measuring intensity of infant mortality

Mortality under 1 year is very often measured by an *ad hoc* indicator, called the **infant mortality rate**, but which is very different from the rates defined in previous lectures (Valin and Caselli, page 104). Conventional infant mortality rate is computed:

$$m_0^t = \frac{D_0^t}{B^{v,t}}$$

Indicator	Definition	Affected population (denominator)
Infant mortality rate	Probability (expressed as a rate per 1000 live births) of a child born in a specific year or period dying before reaching the age of one year, if subject to age-specific mortality rates of that period.	Number of surviving children at beginning of specified age range during the specified time period

However, infant mortality rate computed from third sets of events is by its definition not a pure probability. Therefore, more accurate methods shall be applied. Those are:

a. **Quotient of infant mortality based on first primary sets of events**
b. **Quotient of infant mortality based on elementary sets of events in the third primary set of events**
c. **Raht's correction**

Source: [1], [4], [0]

Measuring intensity of infant mortality

However, infant mortality rate computed from third sets of events is by its definition not a pure probability. Therefore, more accurate methods shall be applied. Those are:

a. Quotient of infant mortality based on first primary sets of events

$m_{0,t}$ = (13 692+26 417)/260 455 (*1 000)

b. Quotient of infant mortality based on elementary sets in the third primary set of events

$m_{0,t}$ = (35 433/432 036)+(13 692/260 455) (*1 000)

c. Raht's correction

$m_{0,t}$ = ((35 433+13 692)/((1-α)*260 455+α*432 036)) (*1 000), where α is the share of deaths in lower elementary set of events

a. 153,996 ‰
b. 134,584 ‰
c. 118,408 ‰

Variability of the results is affected by different size of a cohort in 1919 and 1920.

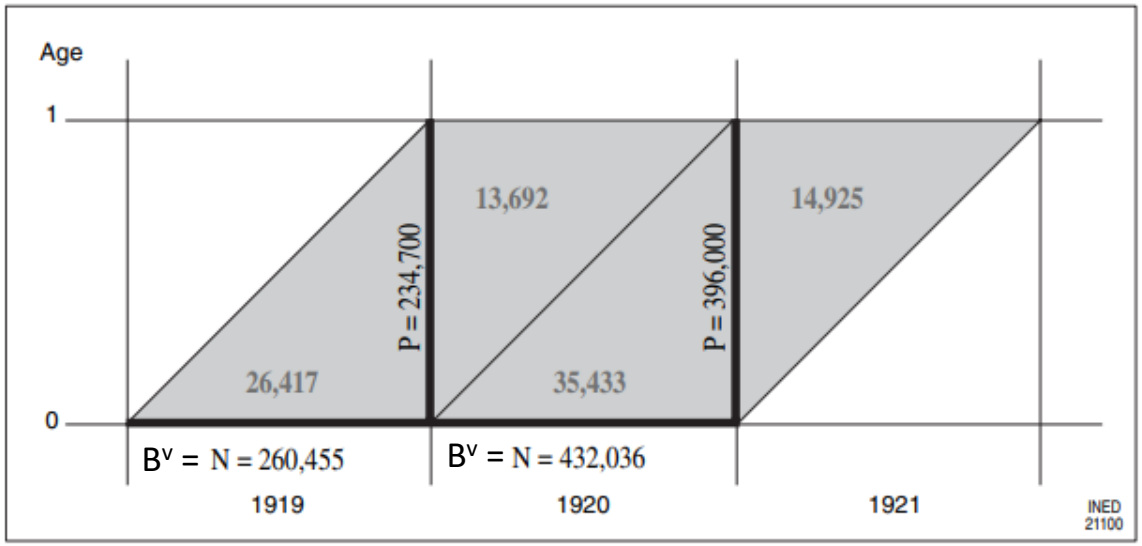
$_{period}^{cohort}D_{age}$

$_{1920}^{1920}D_0 = 35\,433$

$_{1920}^{1919}D_0 = 13\,692$

$_{1919}^{1919}D_0 = 26\,417$

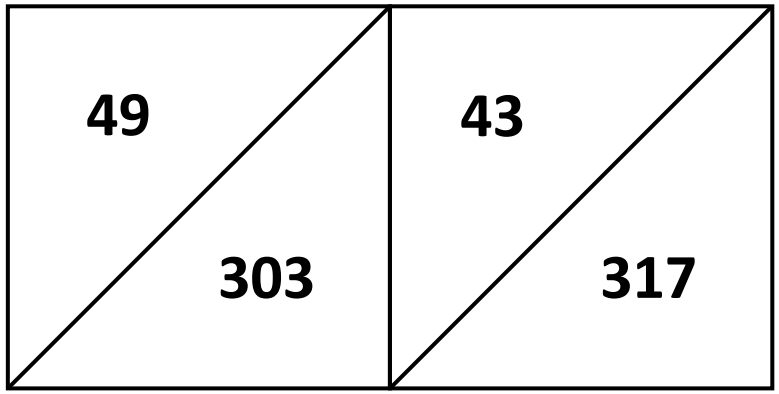
$_{1921}^{1920}D_0 = 14\,925$



Source: [4]

Measuring intensity of infant mortality

Estimate infant mortality in 2007 with three different methods given you have following data:



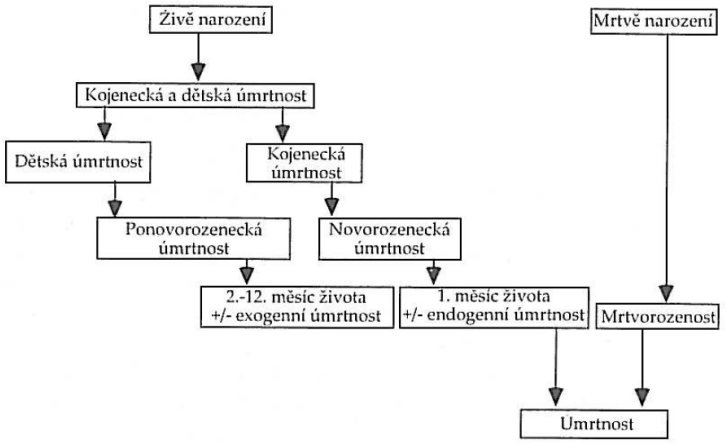
Assume alpha = 0,88

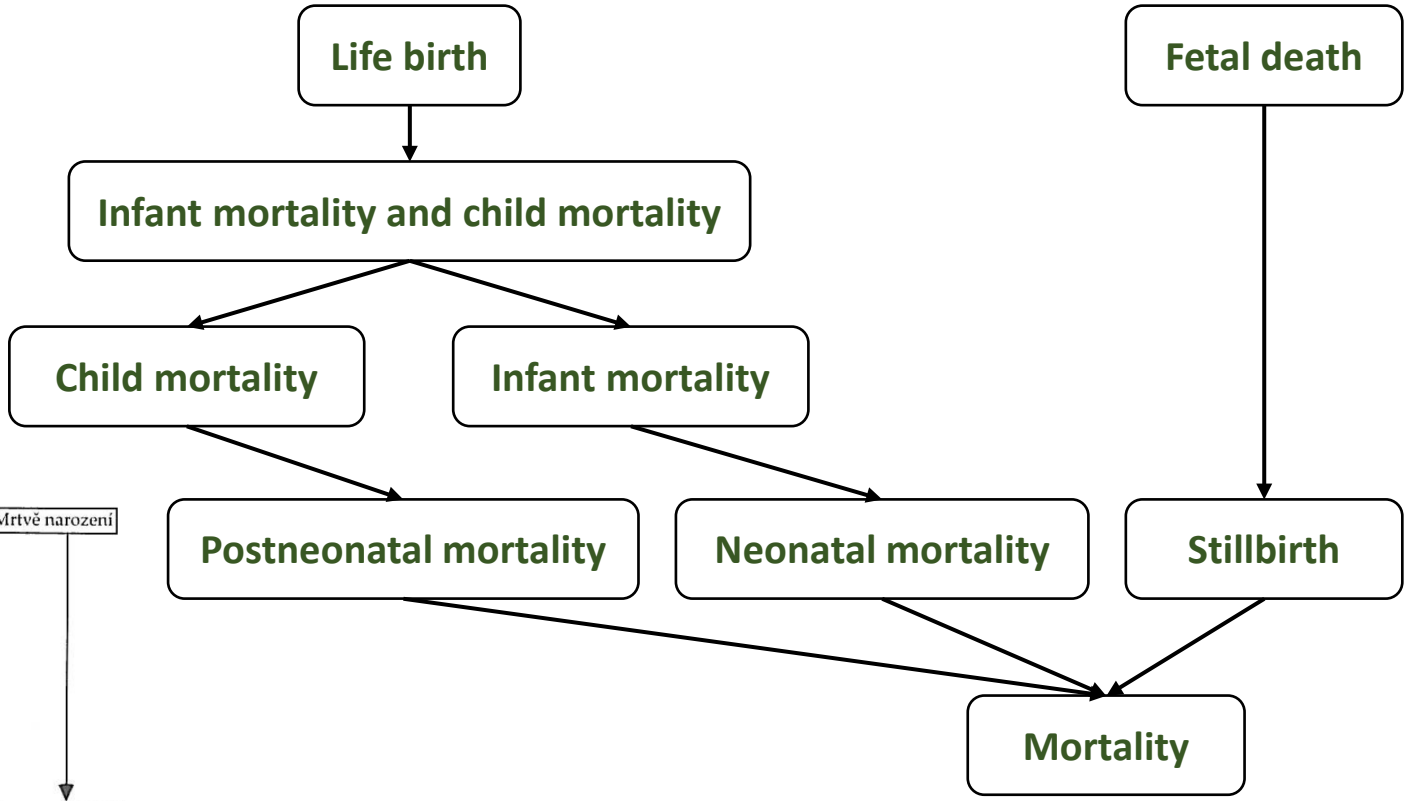
State results in ‰ with two decimals.

Measuring intensity of infant mortality

Because of the very high levels of mortality in the first hours, days, weeks of life and the difference in causes of death accounting for infant death in the earlier and later ages of infancy, the **infant mortality rate can be broken up into rate covering different periods of the first year of life**. (Swanson and Siegel, p. 298)

These two diagrams are same. They should explain the terminology of mortality during first year of life.





Source: [5], [6]

Measuring intensity of infant mortality

For different age groups we can calculate:

Neonatal mortality rate: $\frac{D_{0-27}}{B^v}$

Earl neonatal mortality rate: $\frac{D_{0-6}}{B^v}$

Late neonatal mortality rate: $\frac{D_{7-27}}{B^v}$

Postneonatal mortality rate: $\frac{D_{28-364}}{B^v}$

*Note: All above mentioned indicators are also sometimes called „**quotients**“.*

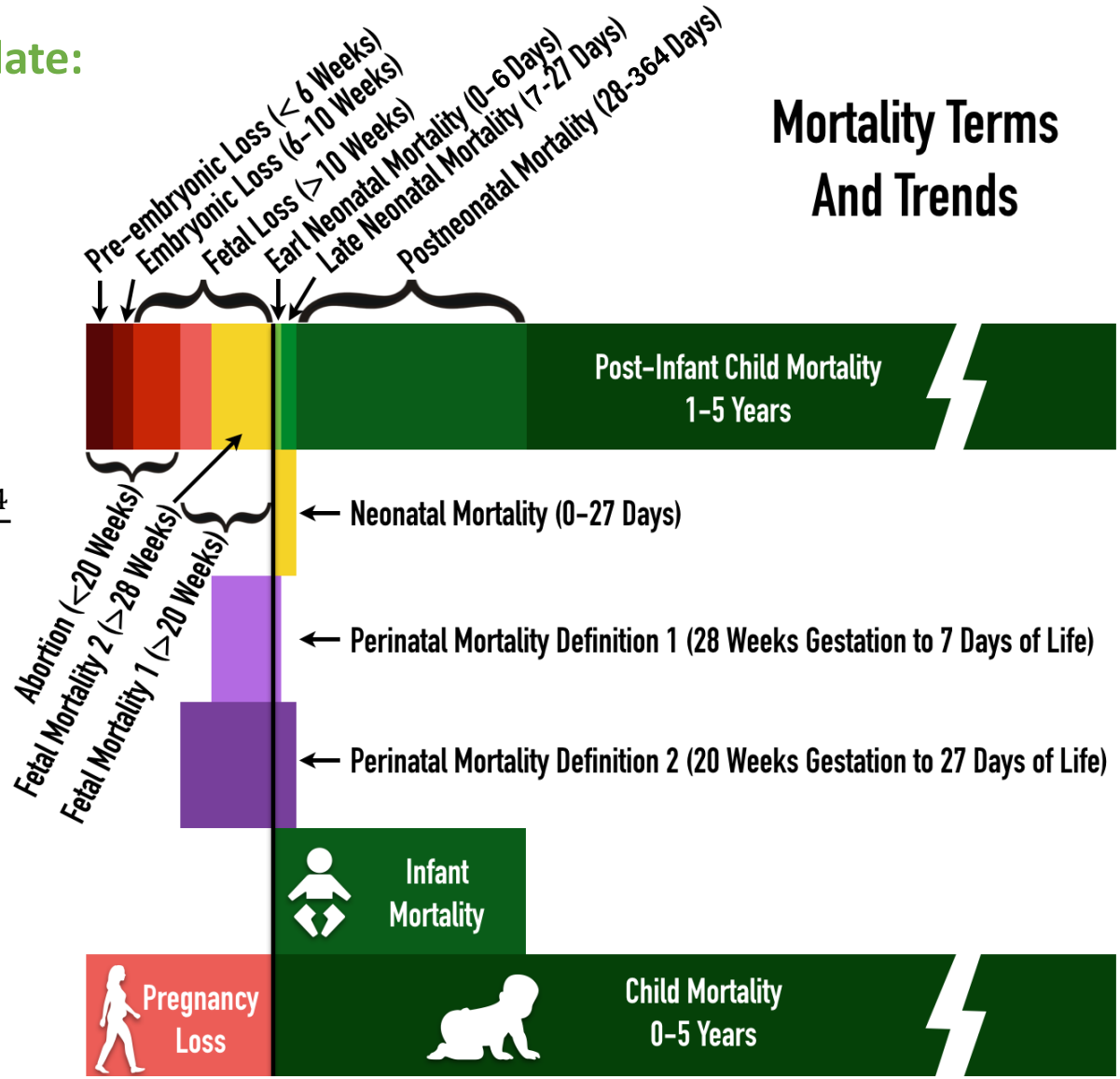
Probability of late neonatal mortality:

$$\frac{D_{7-27}}{B^v - D_{0-6}}$$

Probability of postneonatal mortality:

$$\frac{D_{28-364}}{B^v - D_{0-27}}$$

Source: [0]



Source: https://www.google.com/imgres?imgurl=http%3A%2F%2Fhowardisms.com%2Fwp-content%2Fuploads%2F2017%2F11%2FMortality-Terms.png&imgrefurl=https%3A%2F%2Fhowardisms.com%2Fobgyn%2Fchild-mortality%2F&tbnid=2V3wIA34dG1R6M&vet=12ahUKEwiB-7GHnfT7AhWCLOwKHfn4D1IQMygLegUIARC0AQ..i&docid=Bh_Y7Cka7WQbjM&w=1342&h=1598&q=infant%20mortality%20by%20days&ved=2ahUKEwiB-7GHnfT7AhWCLOwKHfn4D1IQMygLegUIARC0AQ

Measuring intensity of infant mortality

Other indicators:

Perinatal mortality rate: $\frac{B^d + D_{0-6}}{B}$

Stillbirth rate: $\frac{B^d}{B}$

Index of perinatal mortality: $\frac{B^d + D_{0-6}}{B^v}$

Stillbirth index: $\frac{B^d}{B^v}$

Child mortality (under-five mortality): $\frac{D_{0years-4years}}{B^v}$

Maternal mortality ratio: $\frac{Direct\ and\ indirect\ maternal\ deaths}{B^v}$

Note: All indicators of infant mortality should be computed in ‰ (resp. %).

Source: [0]

Measuring intensity of infant mortality

Summary:

Box 2.4 *Conventional Measures of Fetal and Early-infancy Mortality*

Fetal mortality rate:

$$\frac{\text{Fetal Deaths during year } t}{\text{Fetal Deaths + Births during year } t}$$

Perinatal mortality rate:

$$\frac{(\text{Fetal Deaths} \geq 28 \text{ weeks of pregnancy}) + (\text{Deaths} < 1 \text{week of age}) \text{ during year } t}{\text{Births} + (\text{Fetal Deaths} \geq 28 \text{ weeks}) \text{ during year } t}$$

Neonatal mortality rate:

$$\frac{\text{Deaths} < 1 \text{ month of age during year } t}{\text{Births during year } t}$$

Post-neonatal mortality rate:

$$\frac{\text{Deaths 1–11 months of age during year } t}{\text{Births during year } t}$$

Infant mortality rate:

$$\frac{\text{Deaths} < 1 \text{ year of age during year } t}{\text{Births during year } t}$$

…and three more accurate methods (slide 14 and 15)

Source: [7]

Infant mortality: exercise

Assignment 5

Data are in Moodle, file name: *Assignment_5_infant_mortality.xlsx*

Exercise 1: Compute infant mortality rates based on data given in the table below. Apply as many methods, as possible.

Cohort	Year	Deaths	Live birth
z	t	D_0	B^v
2014	2014	222	109 860
2013		41	
2013	2013	225	106 751
2012		40	

Year	Population at age 0, at 1.1.
t	${}_{1.1.}P_0$
2015	109 943
2014	106 829
2013	108 692

Infant mortality: exercise

Assignment 5

Data are in Moodle, file name: *Assignment_5_infant_mortality.xlsx*

Exercise 2:

Consider the following data:

- Live births during 1991: 142,000
- Number of infants born in 1991 who did not survive until the end of 1991: 2,900
- Number of infants born in 1991 who survived to the end of 1991, but did not reach their first birthday: 500
- Live births during 1992: 138,000
- Number of infants born in 1992 who did not survive until the end of 1992: 2,600
- Number of infants born in 1992 who survived to the end of 1992, but did not reach their first birthday: 450

(a) Represent data on the Lexis diagram

(b) Calculate the infant mortality rate (IMR) for 1992 under the assumption that you were only able to observe events occurring in 1992, and that you did not know the birth dates of infants dying during that year.

(c) Same as above, except that now you do know the birth dates of infants dying during 1992.

(d) Assume all data are known: Calculate the IMR.

(e) What is the IMR for the 1992 birth cohort?

Infant mortality: exercise

Assignment 5

Data are in Moodle, file name: *Assignment_5_infant_mortality.xlsx*

Exercise 3: Compute following indicators for England and Wales 1980–2020. Write a short comment to your results and support your comments with graphs.

a. Infant mortality rate
b. neonatal mortality rate
c. Earl neonatal mortality rate
d. Late neonatal mortality rate
e. Postneonatal mortality rate
f. Probability of late neonatal mortality
g. Probability of postneonatal mortality
h. Perinatal mortality rate
i. Stillbirth rate
j. Child mortality

Deadline: 21. 12. 4:30 am

Sources

[0] slides provided by dr. Burcin

[1] CASELLI, Graziella; VALLIN, Jacques; WUNSCH, Guillaume. *Demography: Analysis and Synthesis, Four Volume Set: A Treatise in Population*. Elsevier, 2005.

[2] Postgraduate Research Training in Reproductive Health. What is the definition of live birth? Geneva Foundation for Medical Education and Research. Online: https://www.gfmer.ch/Medical_education_En/Live_birth_definition.htm.

[3] DANNY DORLING and STUART GIETEL-BASTEN. Why Demography Matters. 2018. Cambridge: Polity Press. Pp. xiii + 258. £17.99 paper-back. ISBN: 978-0-7456-9841-0.

[4] https://www.who.int/data/inequality-monitor/publications/report_2015_rmnch

[5] SIEGEL, Jacob S. a David Arthur SWANSON. The methods and materials of demography. 2nd ed. Bingley: Emerald, 2008, xiii, 819 s. : il. ISBN 978-0-1264-1955-9. Page 283

[6] VANDESCHRICK, Christophe. Demografická analýza. Praha: Univerzita Karlova, 2000, 203 s. : tab., grafy. ISBN 80-902686-4-1.

[7] PRESTON S. H., HEUVELINE P. & GUILLOT M. *Demography : measuring and modeling population processes*. Blackwell, 2001.