Lexis diagram

9. 11. 2022

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Motivation

$$mortality\ rates = \frac{Deaths}{Population\ exposure}$$

Outline

- Time in demography
- Lexis diagram
- Sets of events
- Approaches in demographic analysis
- Sets of points
- Exercise 1
- Estimation of initial population and exposures
- Exercise 2

Readings

TESÁRKOVÁ, Klára Hulíková; KURTINOVÁ, Olga. *Lexis in Demography*. Springer International Publishing, 2018. Pages 11–14 & 46–48.

CASELLI, Graziella; VALLIN, Jacques; WUNSCH, Guillaume. *Demography: Analysis and Synthesis, Four Volume Set: A Treatise in Population*. Elsevier, 2005. Part II, Chapter 6, pages 55–61.

ROWLAND, Donald T. *Demographic methods and concepts*. OUP Oxford, 2003.

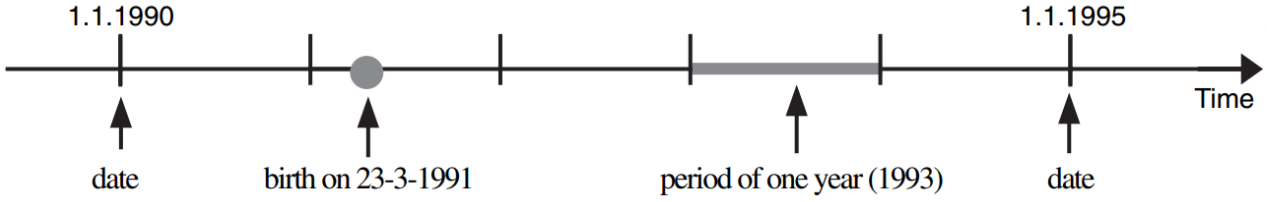
https://papp.iussp.org/sessions/papp101_s02/PAPP101_s02_090_010.html

RAU, Roland, et al. Visualizing mortality dynamics in the Lexis diagram. 2017. Online: https://link.springer.com/content/pdf/10.1007/978-3-319-64820-0.pdf

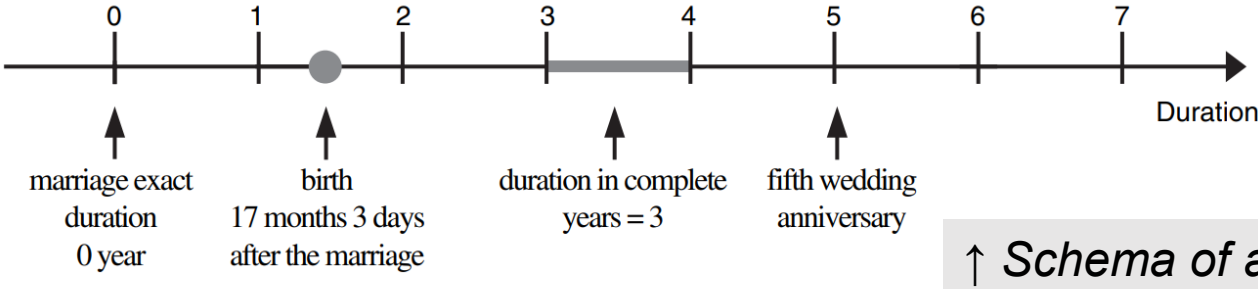
More sources in reading list

Time in Demography

- Time is the most important variable in demography
- We distinguish between absolute time and relative time.
- **Absolute time** = exact position on the timeline (dates of events)
- **Relative time** = duration, time elapsed between two events, f. e: time spend in marriage ~ time elapsed between marriage and divorce/death etc., age ~ time spend between birth and death



Example: Todays date: 9. 11. 2022
Age of a person born on 8. 11. 2000 is
22 years and 1 day (exact age)
22 years (completed age)
22 years (reached age)

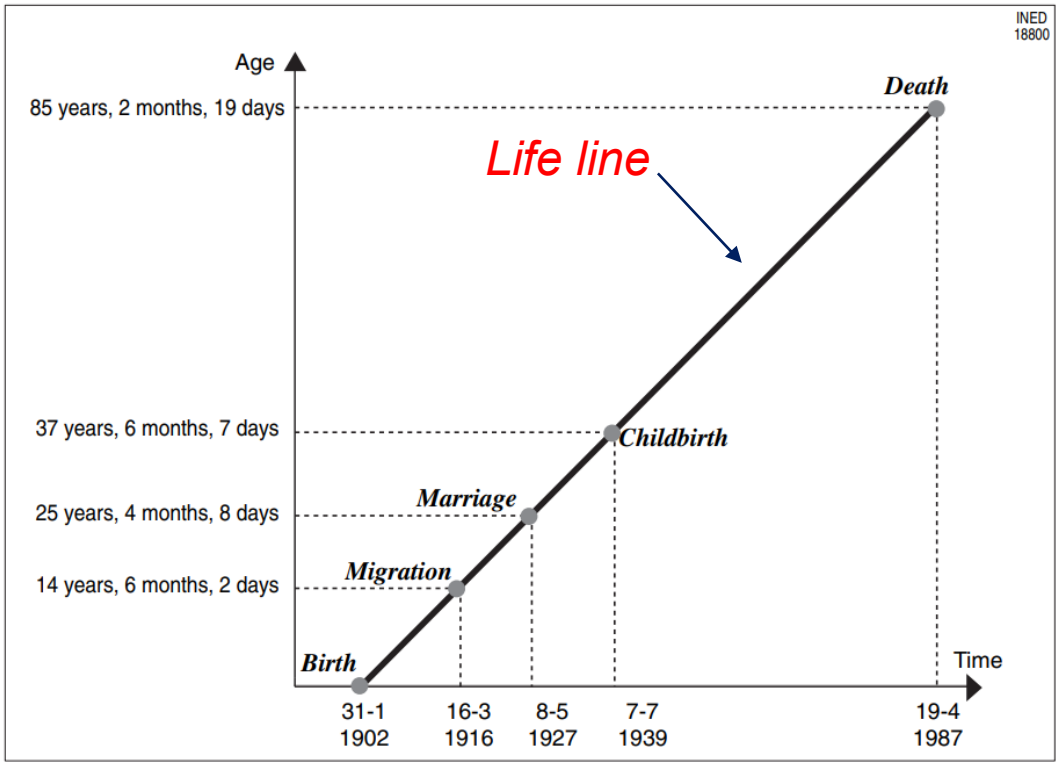


Age of a person born on 10. 11. 2000 is
21 years and 364 days (exact age)
21 years (completed age)
22 years (reached age)

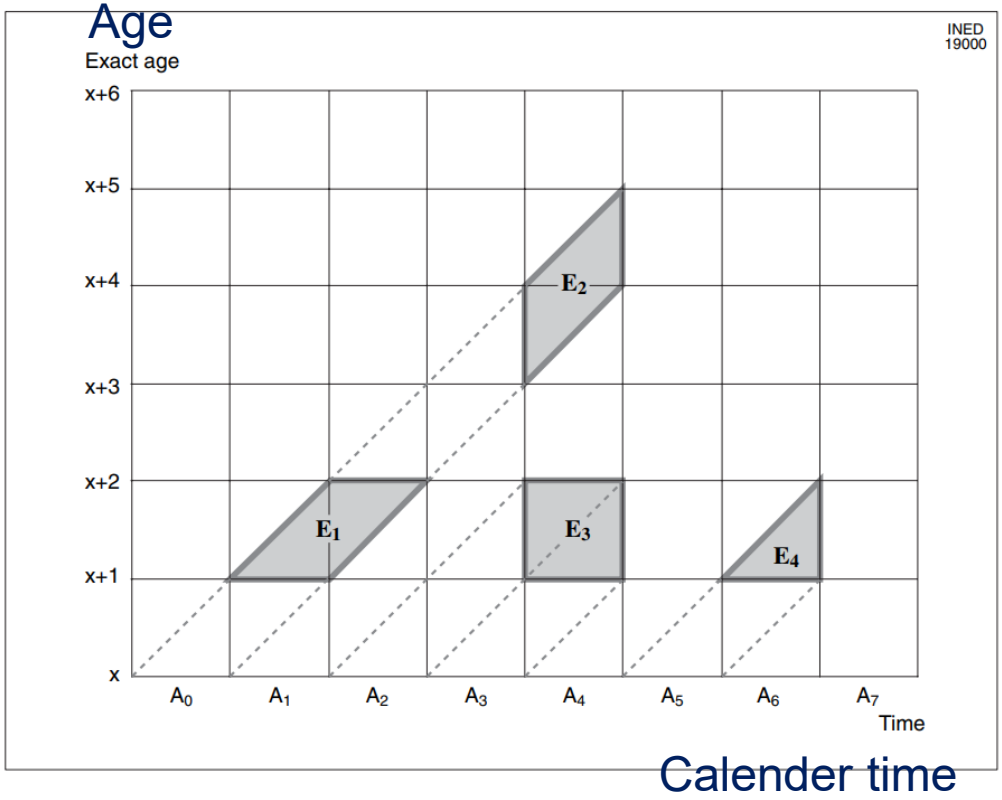
↑ *Schema of absolute and relative time* **[2]**

Lexis diagram

- Lexis diagram is a way to express the relationship between all dimensions of the time in one (coordinate) system



Representation, on a Lexis diagram of a lifeline, with an event point (migration, marriage) and a terminal death point **[2]** ↑

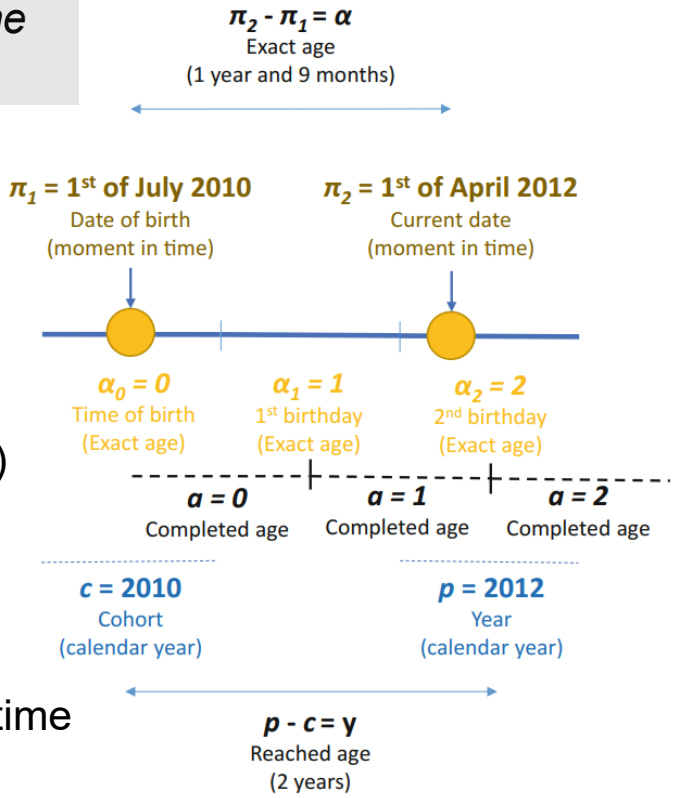


Different possible annual classification modes in Lexis diagram **[2]** ↑

Time in Demography

- Calendar (time of observation)
- Age (time duration from the initial to the studied event)
  - Completed age
  - Reached age
  - Exact age
- Cohort (time of the initial event)

Schema of the example of completed, exact, and reached age, moments of time and time intervals **[1]** →



Example: Todays date: 9. 11. 2022

Age of a person born on 8. 11. 2000 is

22 years and 1 day (exact age)
22 years (completed age)
22 years (reached age)

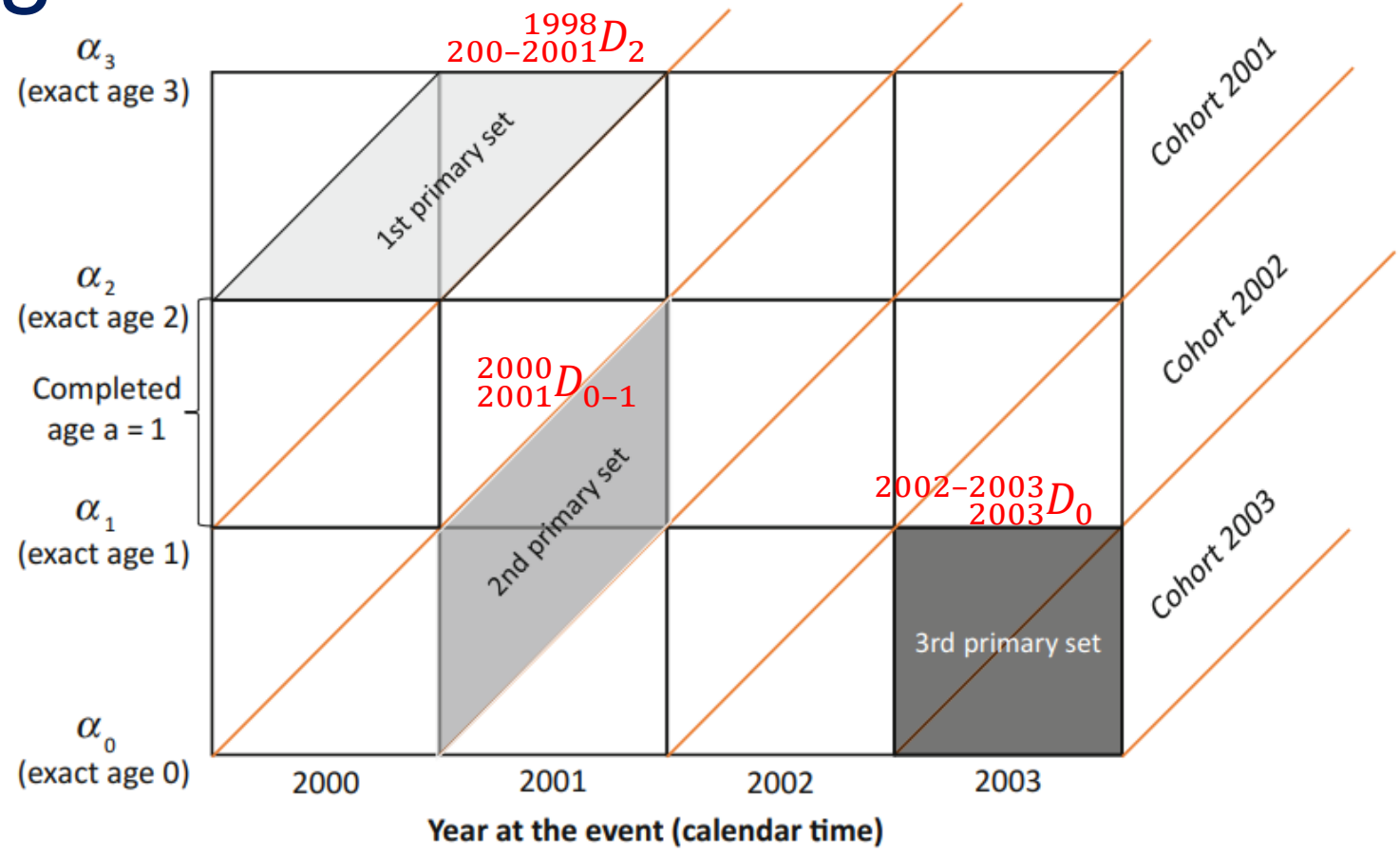
Age of a person born on 10. 11. 2000 is

21 years and 364 days (exact age)
21 years (completed age)
22 years (reached age)

p	calender time (period)
c	cohort
y	age (years) reached
a	age completed
α	exact age
π	particular moment in time
σ	moment of birth

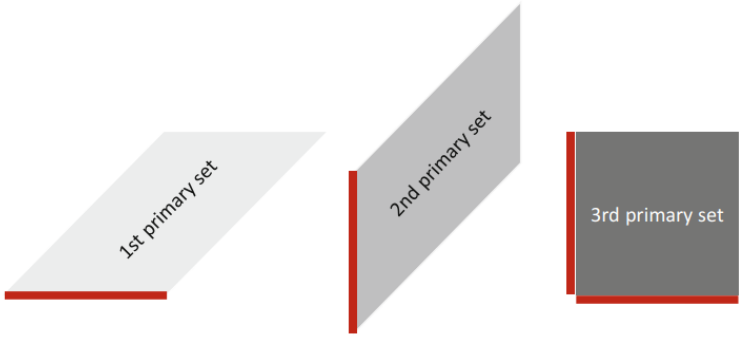
Lexis diagram – sets of events

Sets of events in Lexis diagram **[1]** →

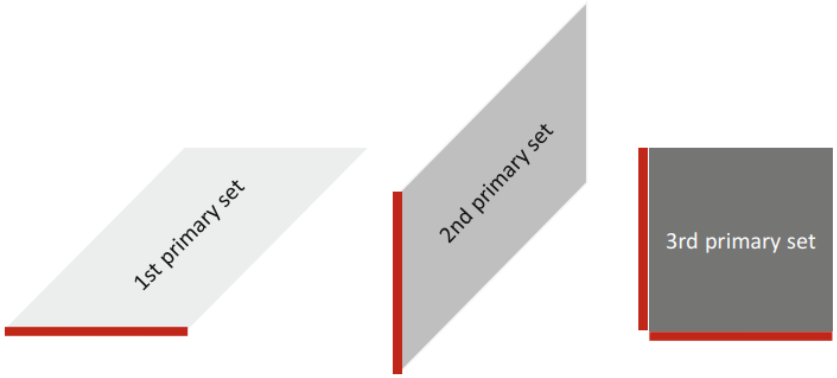


Standard notation:

$$^{another\ attribute}_{cohort\ \ age}\boldsymbol{D}_{period}$$



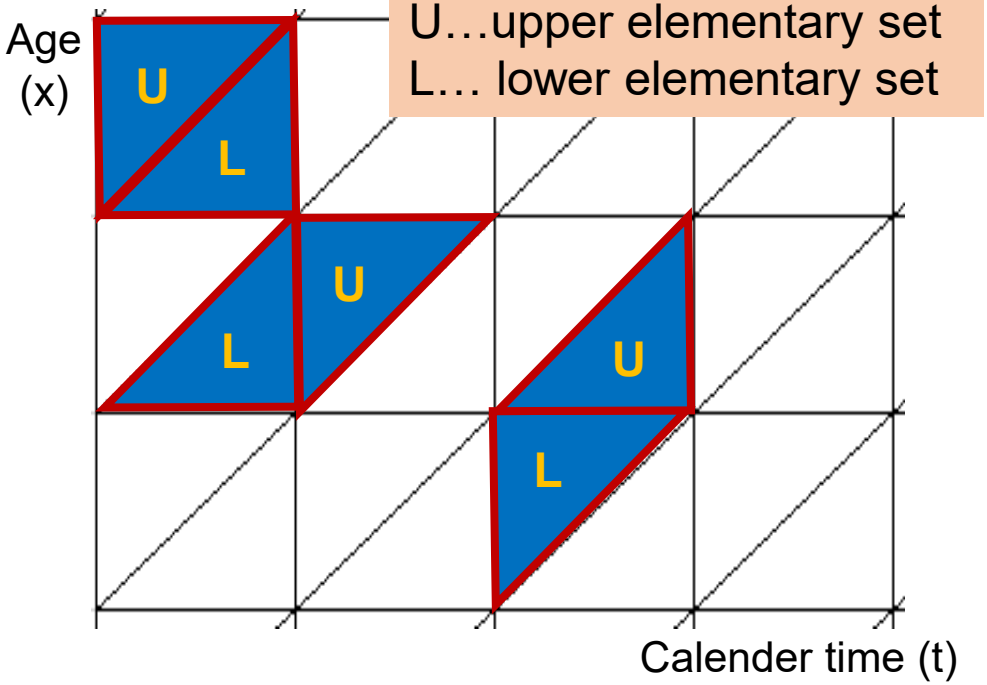
Lexis diagram – sets of events

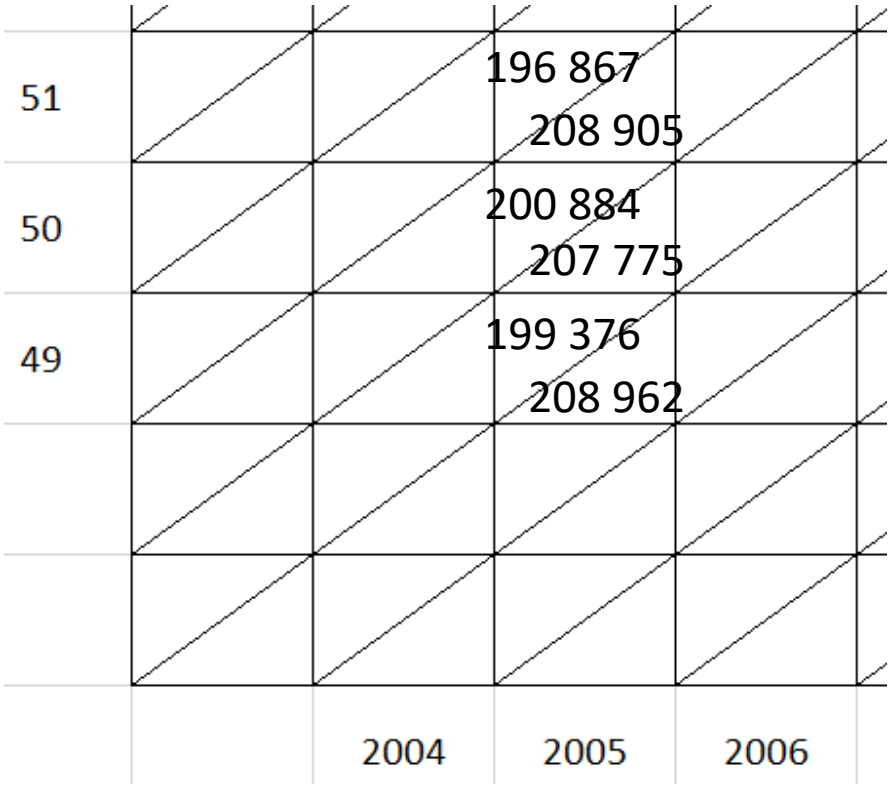


Year	Age	Cohort	Death counts
2005	49	1956	208962
2005	49	1955	199376
2005	50	1955	207775
2005	50	1954	200884
2005	51	1954	208905
2005	51	1953	196867

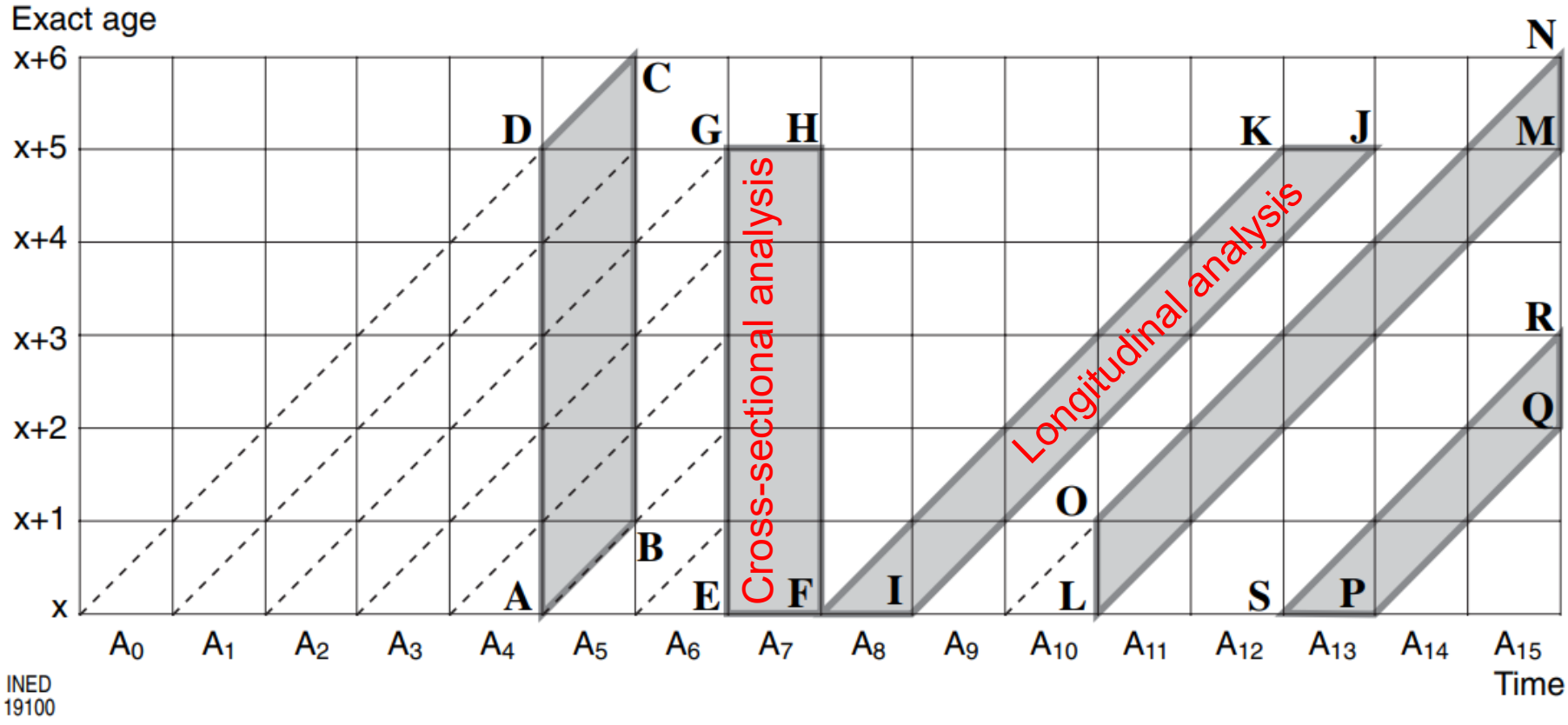
If sets are defined by a unique period, cohort and age, we than talk about the elementary sets of events.

U…upper elementary set
L… lower elementary set





Approaches to demographic analysis

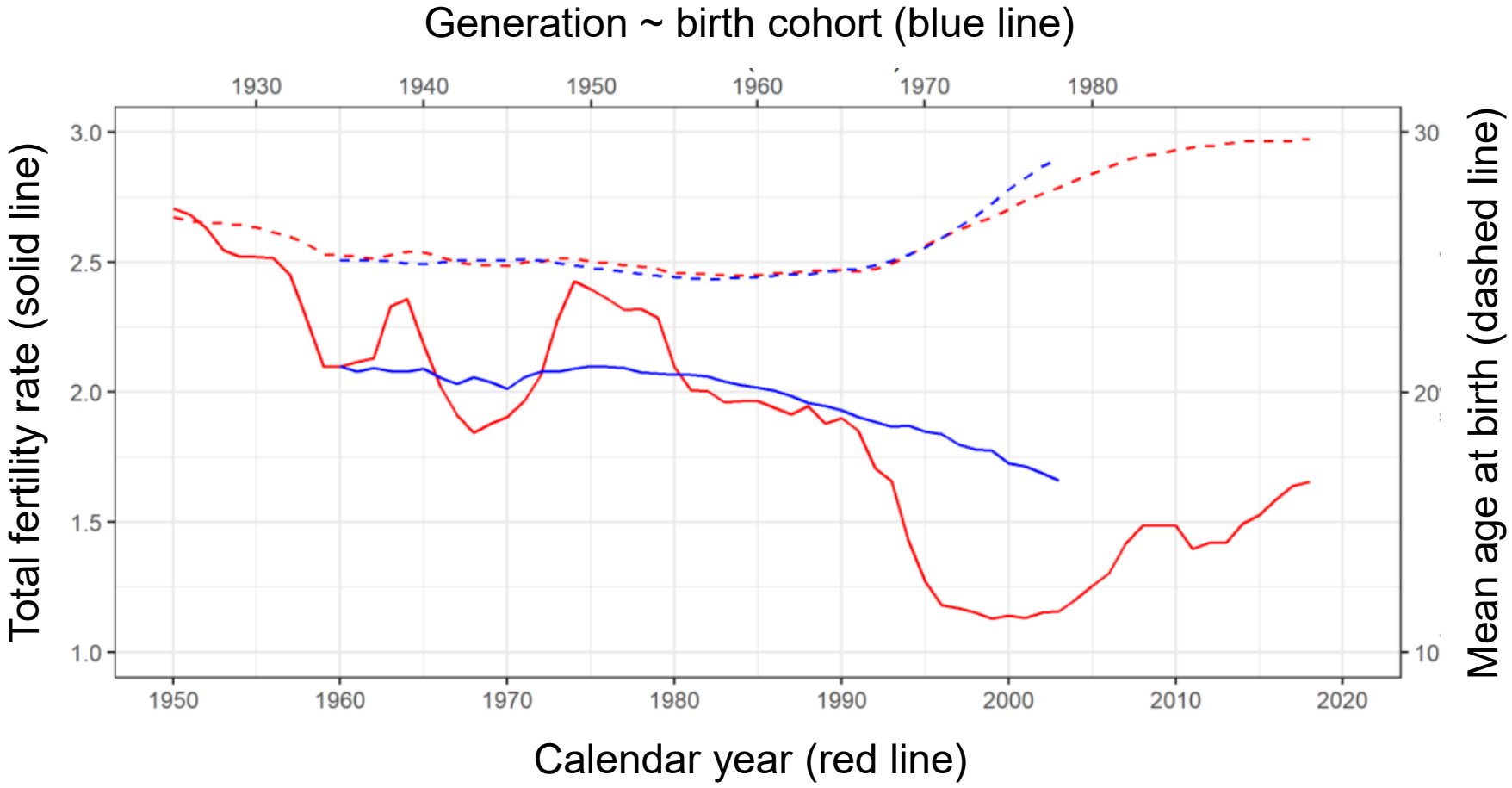


Longitudinal analysis: We follow and analyse a single cohort throughout their lives (analysis by cohort, on a same sample).

Cross-sectional analysis: We analyse distinct cohorts during a year (or multiple years) (analysis by calendar year, on different samples).

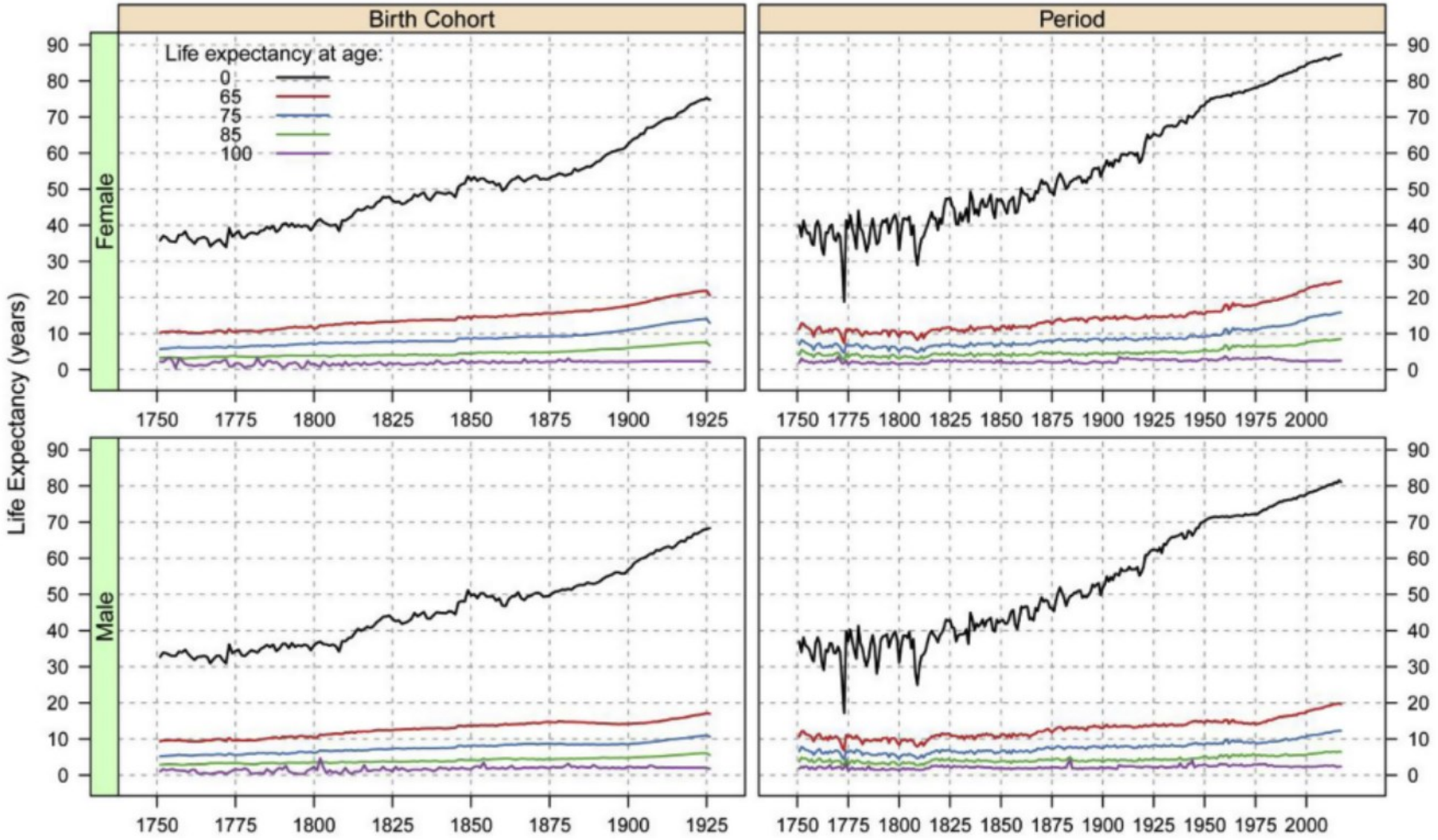
Approaches to demographic analysis

Depending on whether we apply longitudinal or cross-sectional approach, we obtain *different* results, in terms of interpretation as well as quantity of the measures.



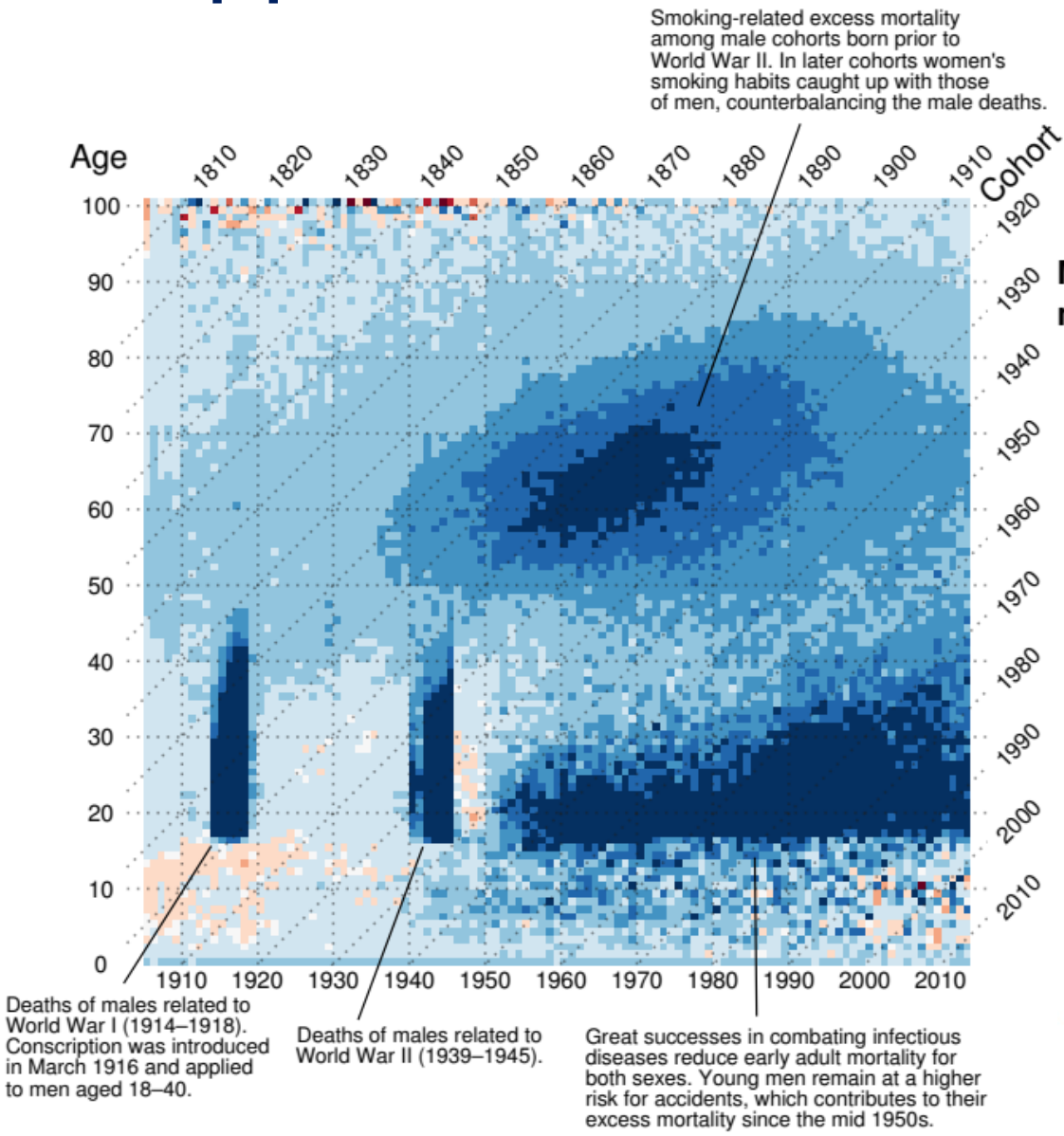
Period and cohort-specific (cross-sectional) trends in fertility in Czechia **[3]**

Approaches to demographic analysis



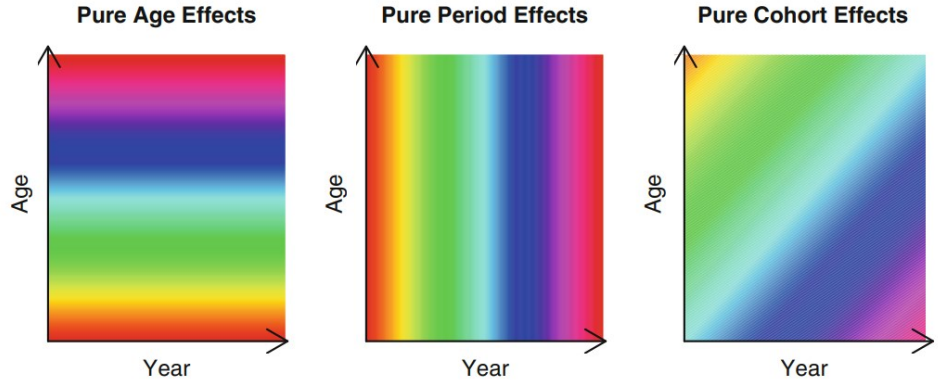
Period and cohort-specific (cross-sectional) trends in life expectancy in high income countries **[4]**

Approaches to demographic analysis



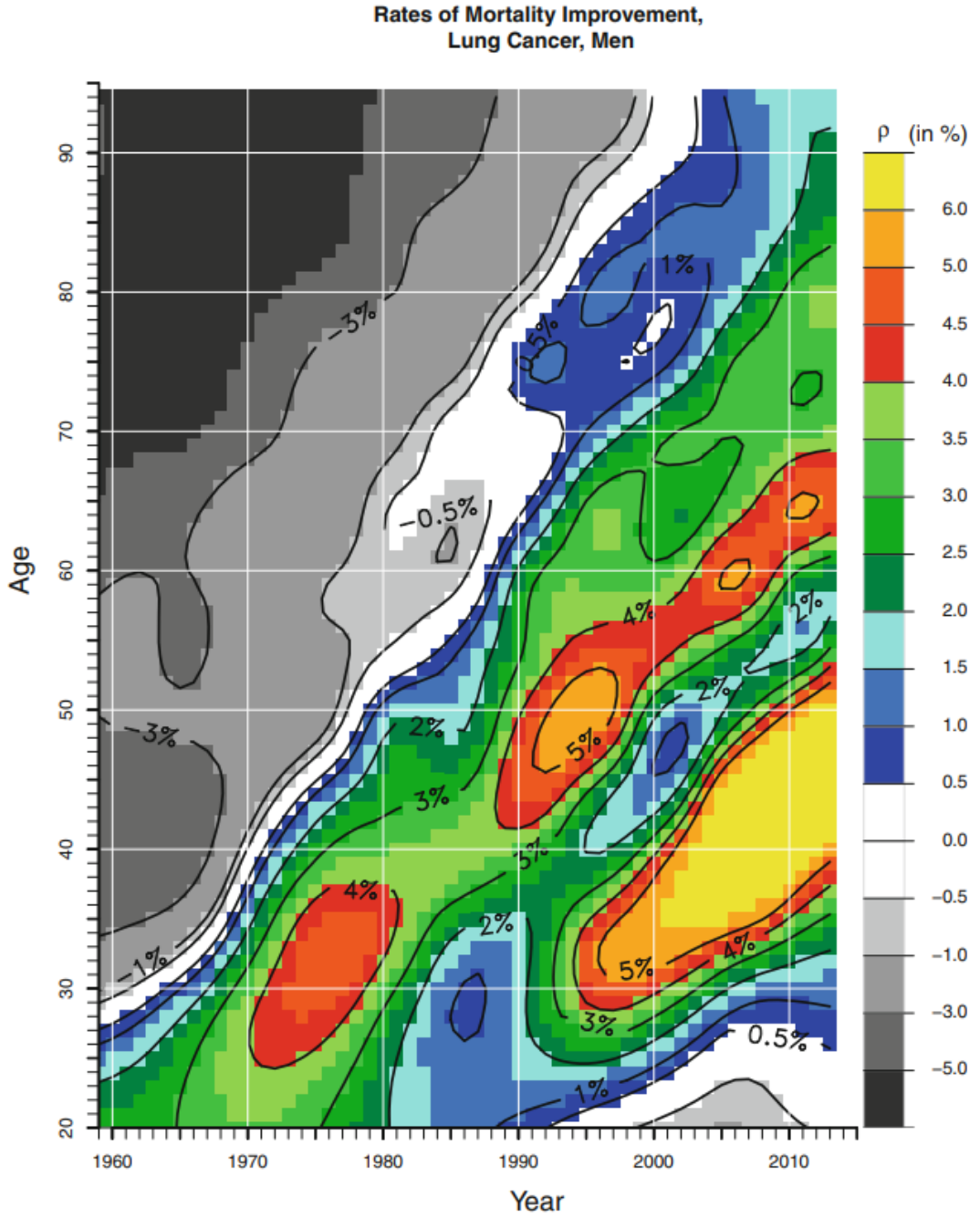
← Lexis surface plot as a tool to identify age, period and cohort effects. Ratio between male and female age-specific mortality rates in England and Wales, 1841–2013 **[5]**

"Ideal" age-, period-, and cohort-effects on the Lexis surface **[6]** ↓



Approaches to demographic analysis

Rates of mortality improvement for lung cancer for men in the United States aged 20– 95 between 1959 and 2013 **[6]** →



Exercise 1

a. Draw to the Lexis diagram population of males at ages 20, 21, 22 and 23 years to the date 1. 1. 2014.

b. Draw to the Lexis diagram population of females at ages 20, 21, 22 and 23 years to the date 1. 7. 2014.

c. Draw to the Lexis diagram population living at exact age 61 in years 2005, 2006 and 2007.

d. Draw to the Lexis diagram total number of births by the age of mother (ages 15, 16 and 17) in 2008.

e. Draw to the Lexis diagram number of marriages of divorced men by the time elapsed since the divorce (1, 2 and 3 years) in 1997.

g. Draw to the Lexis diagram deaths of females by age (70, 71 and 72) and cohort in 2014.

h. Draw to the Lexis diagram number of divorces in 2005 by the length of duration of marriage (0, 1 and 2 years) and by the year of marriage.

i. Draw to the Lexis diagram deaths by 5-year age groups (30–34, 35–39, 40–44) in 2006.

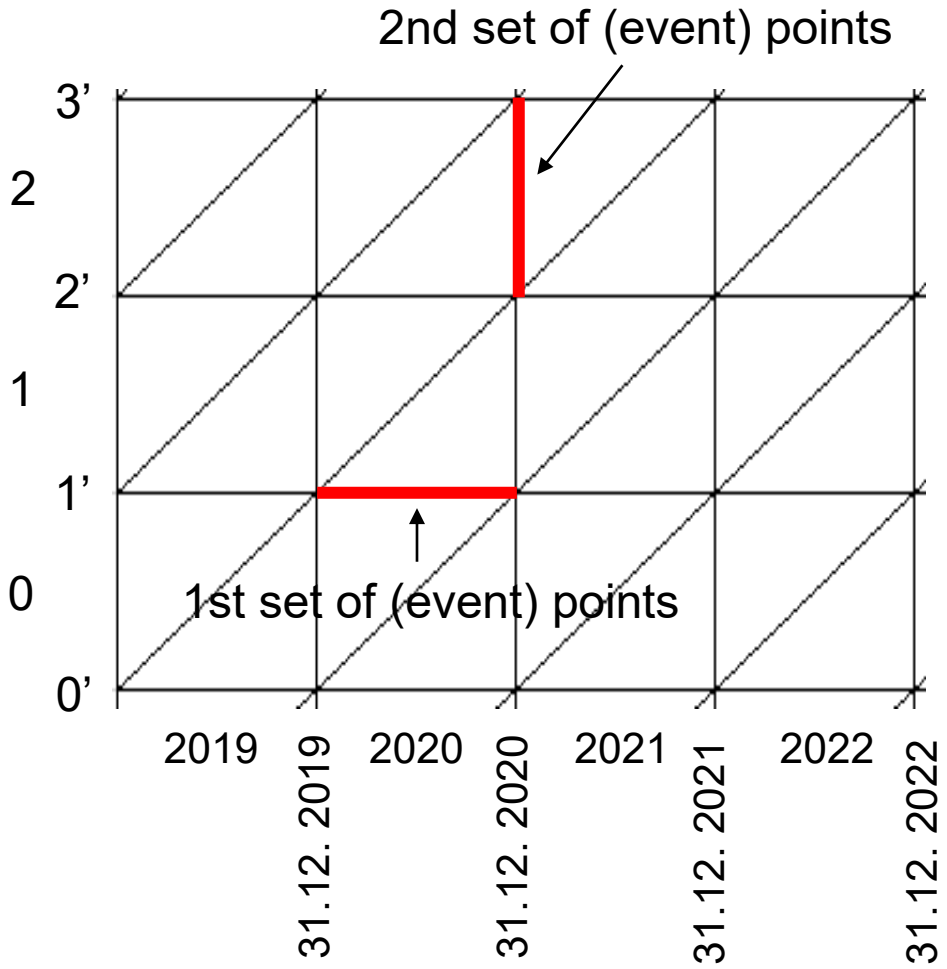
m. Draw to the Lexis diagram number of male infant deaths by age (0, 1, 2 and 3 months) in 2010.

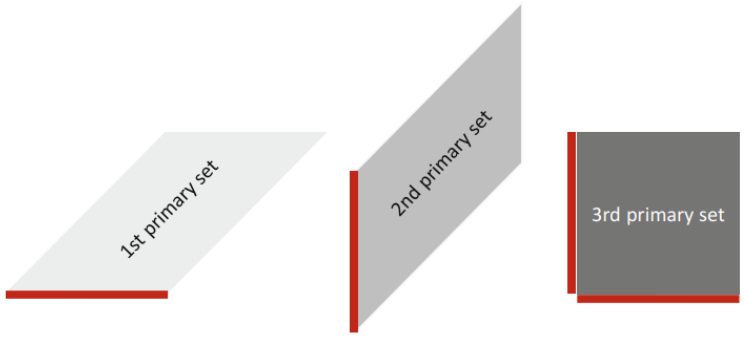
n. Draw to the Lexis diagram male population by age (0, 1–4) to 1.7.2000 and 1.7.2001.

r. Draw to the Lexis diagram number of marriages in 1997 by the birth cohort of a bride (1978, 1979, 1980).

Lexis diagram – sets of (event) points

- 1st set of points is a set of individuals being exactly *x* years old during a single year
- 2nd set of points is a set of individuals being *x* years of reached age on exact date
- 2. set of events refers to age reached during a year



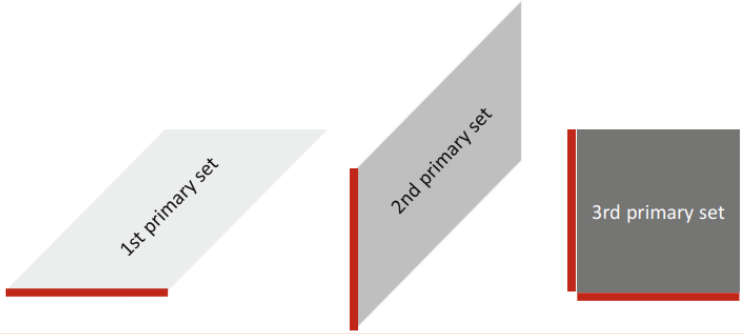


Lexis diagram – estimations of initial population and exposures

- To calculate demographic measures (probabilities, rates, indices…) we need to estimate the initial population size or the population exposed (f. e. the mid-year population) to the occurrence of the event.
- For each type of set of events, the initial population size, as well as the exposed population is defined differently.
- Lexis diagram is helpful to depict the initial population or population exposure in accordance with the sets of events.

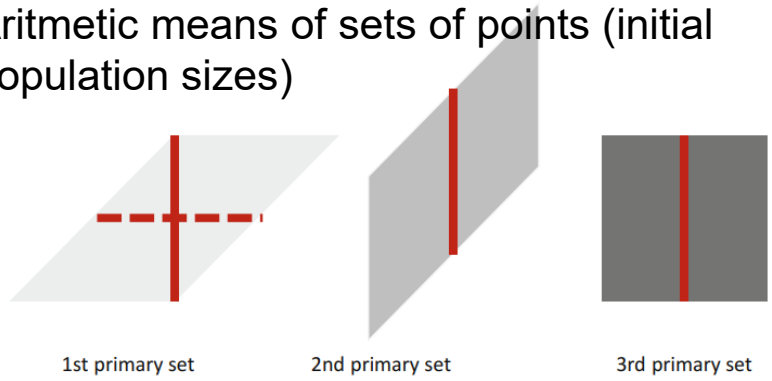
Lexis diagram – estimations of initial population and exposures

Definition of the initial population size **[1]** ↓



Estimation of the exposed population **[1]** ↓

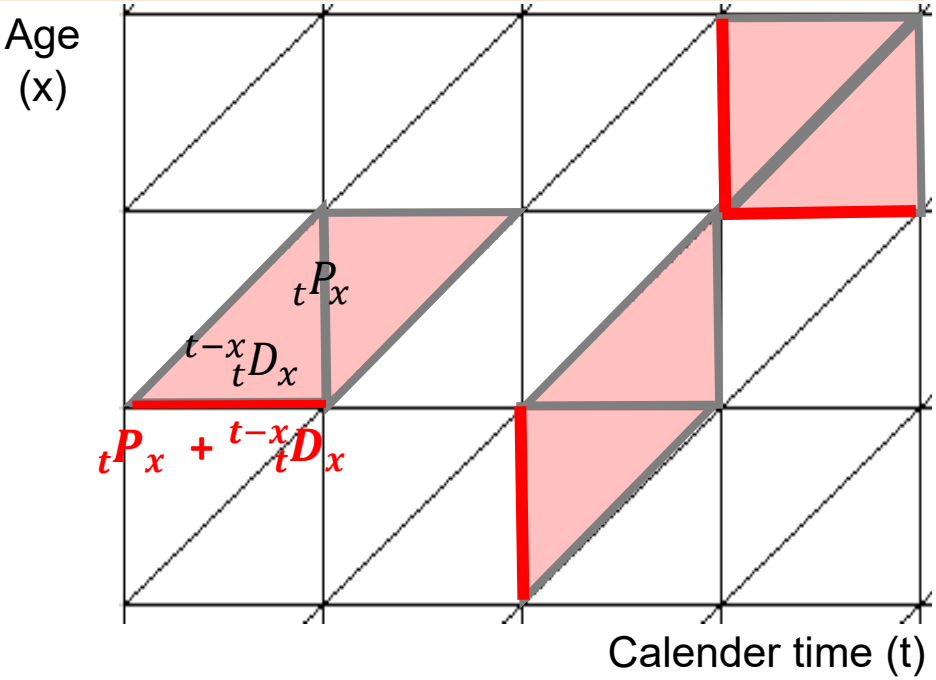
Aritmetic means of sets of points (initial population sizes)

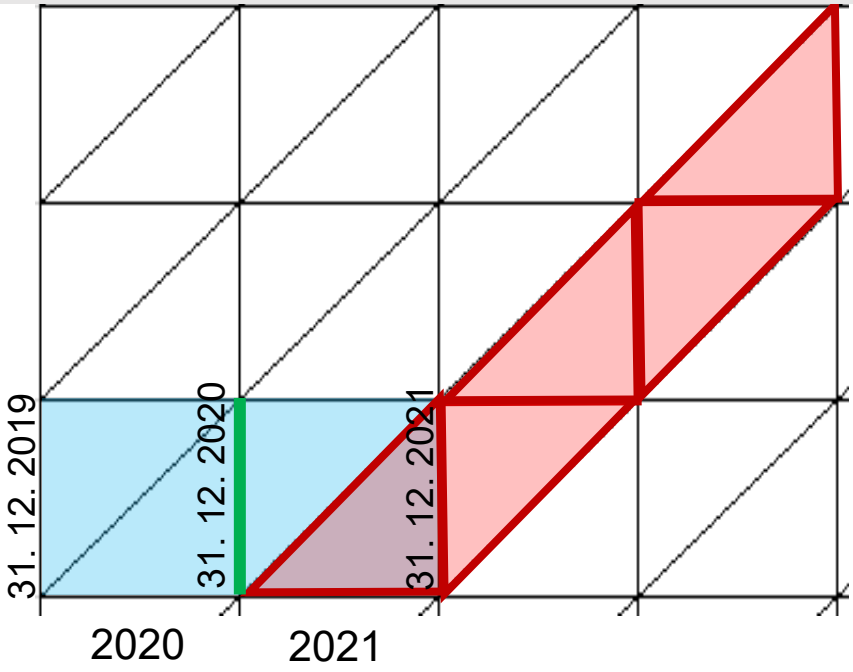


${}_tP_x$ population on 31.12. in year t

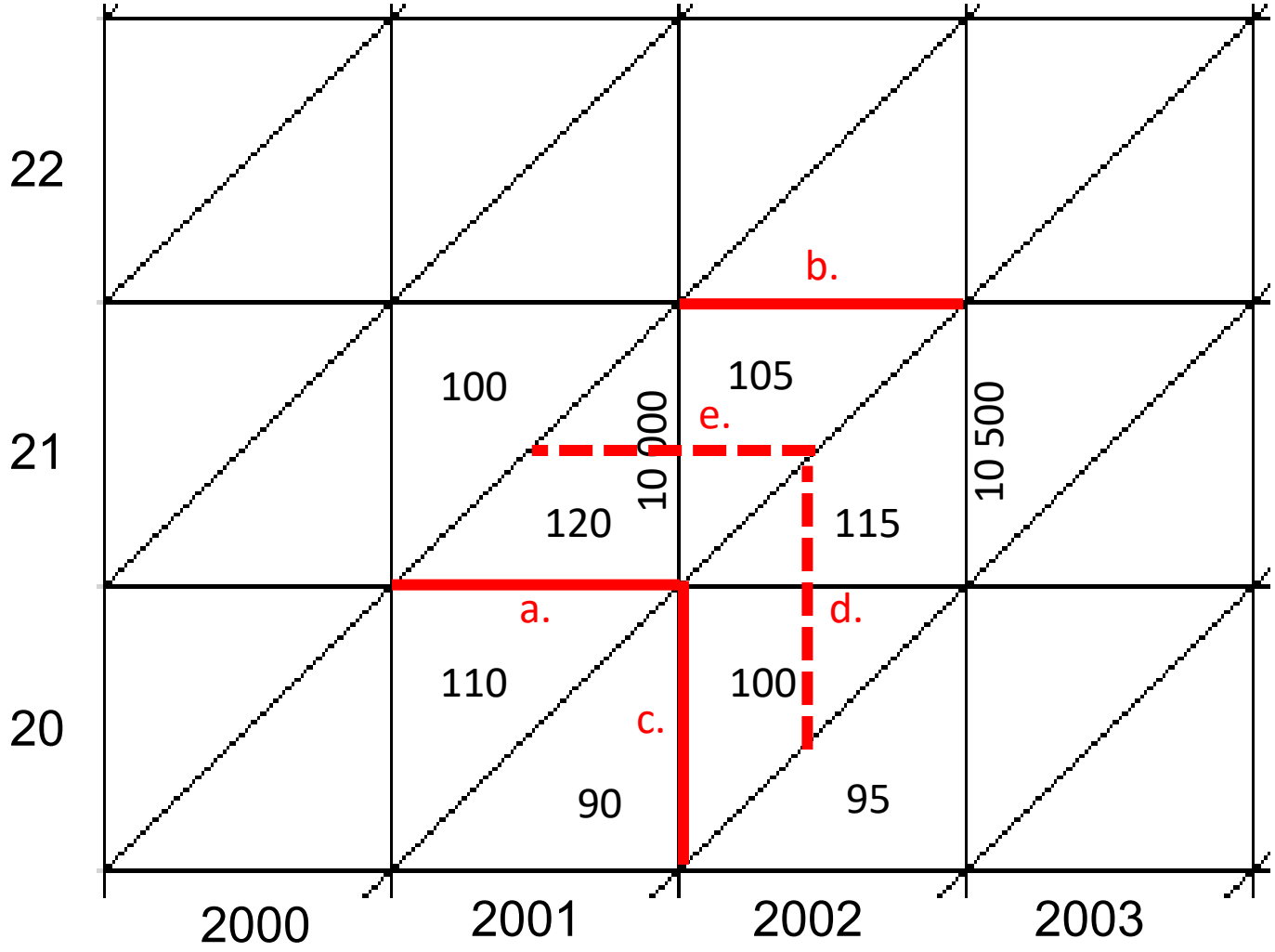
${}^{t-x}{}_tD_x$ deaths at age x, during year t, of members of generation t-x

Estimation of the exposed population for multiple years ↓





Exercise 2


22
21
20
2000
2001
2002
2003
100
105
120
115
110
100
90
95
10 000
10 500
a.
b.
c.
d.
e.

Sources

[1] TESÁRKOVÁ, Klára Hulíková; KURTINOVÁ, Olga. *Lexis in Demography*. Springer International Publishing, 2018. Pages 11–14 & 46–48.

[2] CASELLI, Graziella; VALLIN, Jacques; WUNSCH, Guillaume. *Demography: Analysis and Synthesis, Four Volume Set: A Treatise in Population*. Elsevier, 2005. Part II, Chapter 6, pages 55–61.

[3] SLABÁ, Jitka. Časování plodnosti napříč generacemi českých žen narozených v letech 1966-1990. Praha, 2021. Dizertační práce. Univerzita Karlova, Přírodovědecká fakulta, Katedra demografie a geodemografie. Vedoucí práce Kocourková, Jiřina.

[4] BELTRÁN-SÁNCHEZ, Hiram; SUBRAMANIAN, S. V. Period and cohort-specific trends in life expectancy at different ages: Analysis of survival in high-income countries. *SSM-population health*, 2019, 8: 100422.

[5] SCHÖLEY, Jonas; WILLEKENS, Frans. Visualizing compositional data on the Lexis surface. *Demographic Research*, 2017, 36: 627-658.

[6] RAU, Roland, et al. Visualizing mortality dynamics in the Lexis diagram. 2017. Online: https://link.springer.com/content/pdf/10.1007/978-3-319-64820-0.pdf