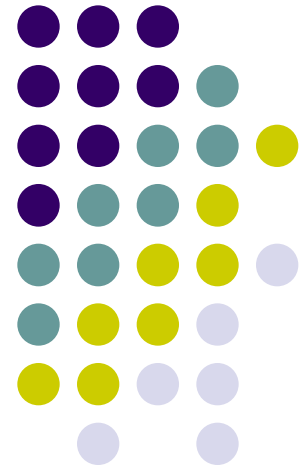


Methods - Rehearsal

Nico Keilman

Demography of developing countries ECON 3710

January 2015



Recommended reading



Rowland, Donald.T (2003). *Demographic Methods and Concepts*. Oxford: Oxford University Press.

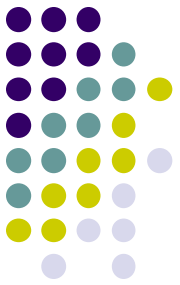
- Sections 1.5, 1.6, 6.3, 7.3 - 7.6

Population handbook at www.prb.org/pdf/PopHandbook_Eng.pdf

- Chapters 2-5, 7, 8, Appendix A

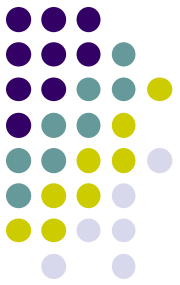
Cf. handout

Stocks vs flows



Norway:

Population size	1 Jan 2006	4 640 219
	1 Jan 2007	4 681 134
Live births	2006	58 545
Deaths	2006	41 253



Stocks: one point in time (census time, 1 January etc.)

Flows: during a certain period (one year, five years, between two censuses etc.)

Flows (population level) \leftrightarrow events (individual level)

e.g. birth, death, migration (total population), or
marriage, divorce (sub-population)

Rates

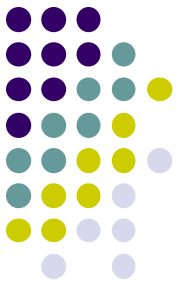


Intensity of an event is expressed by means of a RATE

Definition: Ratio of the number of events to exposure time for population at risk

Unit of measurement: # events pr. person pr. year

Cf. Poisson rate in statistics (= expected # events pr. unit of time)



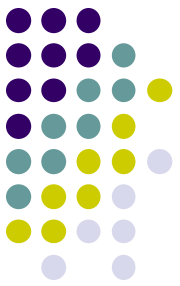
Crude death rate

Pop	1 Jan 2006	4 640 219
	1 Jan 2007	4 681 134
Deaths 2006		41 253

Mid-year population $(4640219 + 4681134)/2 = 4\,660\,676\frac{1}{2}$

Death rate = $41253/4660676\frac{1}{2} = 0.0089$ deaths per person per year
(or 8.9 per thousand persons per year)

This death rate is commonly known as the Crude Death Rate,
abbreviated as CDR



Mid-year population approximates exposure time

1 Jan 2006: 4 640 219 exposed to death risk

1 Jan 2007: 4 681 134 exposed to death risk

On average during the year

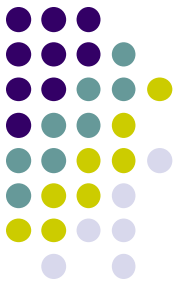
$(4640219 + 4681134)/2 = 4\,660\,676\frac{1}{2}$ persons were
exposed to death risk during one whole year

Exposure time expressed as «person years» or «person years of exposure»

When period shorter/longer than one year: multiply "mid-period" population by period length to find exposure time in years

1000 persons exposed during 1 year = 1000 person years

200 persons exposed during 5 years = 1000 person years



Crude birth rate (CBR)

Pop	1 Jan 2006	4 640 219
	1 Jan 2007	4 681 134
Live births	2006	58 545

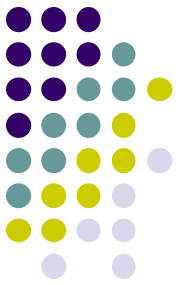
Mid-year population $(4640219 + 4681134)/2 = 4\,660\,676\frac{1}{2}$

CBR = $58545/4660676\frac{1}{2} = 0.0126$ or 12.6 per thousand

Types of demographic measures



- Rate: # events/exposure time
- Ratio: one number relative to one other number. Example: sex ratio
- Proportion (fraction, share): numerator is part of the denominator. Examples: proportion women in a population, proportion elderly
- Probability: # events in a pop/initial pop size
 - easy to compute in a population that is closed for migration
 - open population: compute rate first, and use formula that transforms rate into probability (see Table 6.5)



Crude Death Rate too crude

Risk of dying varies strongly with age

Typical age pattern of mortality

→ Death rates for separate ages/age groups

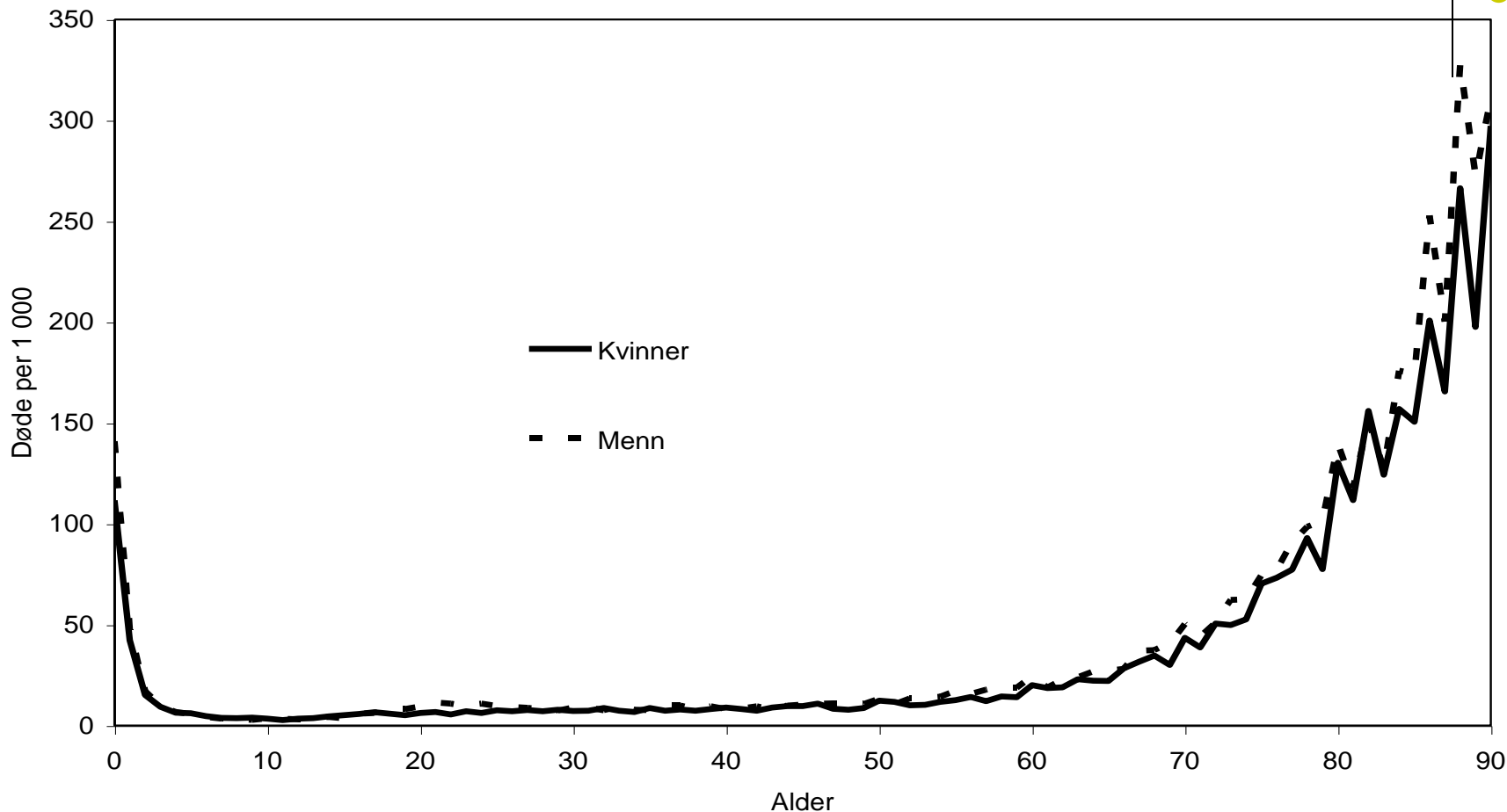
Age specific death rates (ASDR)

ASDR for age $x = 1000 \cdot \text{deaths at age } x / \text{mid. year pop age } x$

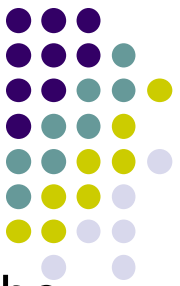
Cf. Example Russian Federation in Table 6.5

$0 \leq \text{ASDR} \leq 2000!$

Age specific death rates, Norway 1900



NB: Kvinner = women, Menn = men, alder = age,
Vertical scale: number of deaths per 1000 of mid-year population



Death probability (q) – Formula Table 6.5

Death probability: Probability to be no longer alive at the end of the year/period, given alive at the beginning of the year/period

One year: $q = \text{ASDR} / (1 + \frac{1}{2}\text{ASDR})$

n years : ${}_nq = n \cdot \text{ASDR} / (1 + \frac{1}{2} \cdot n \cdot \text{ASDR})$

Note: when computing q, start from ASDR per 1, not per 1000

Exampe Russian Federation 1995, age 75-79:

$\text{ASDR} = 106.2 \text{ pr } 1000 = 0.1062 \rightarrow {}_5q = 5 \cdot 0.1062 / (1 + \frac{1}{2} \cdot 5 \cdot 0.1062)$
 $= 0.4196 = 42.0\%$.

$0 \leq {}_nq \leq 1!$

Life table



Purpose: to summarize the life course of a hypothetical population from birth to death

Based on a given set of age-specific death rates/death probabilities
e.g. men, Malaysia, 1995 (handout) or men & women, Norway, 2013
(<http://www.ssb.no/en/befolkning/statistikker/dode/aar/2014-04-08?fane=tabell&sort=nummer&tabell=170285>)

Set of age-specific death rates / probabilities often summarized in one number:
life expectancy

Some die early, others die later. Life table extends until last person in hypothetical population has died.

Life expectancy equals mean age at death for the hypothetical population.



Life table (cont.)

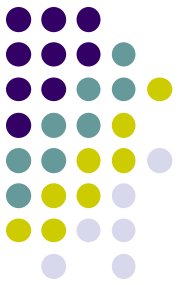
Series of columns, with rows representing ages / age groups
cf. handout (men in Malaysia 1995).

Important:

- ${}_nq_x$ proportion dying in the age interval (from x to $x+n$)
 ${}_nq_x$ column (or the death rates underlying them) is input for the life table

NB: width of interval $n=1$, $n=4$ for first two rows, $n=5$ elsewhere

- l_x number alive at the beginning of age interval ($x, x+n$) in hypothetical population



- e_x years of life remaining (e_0 is life expectancy) at age x
- e_0 summarizes, in one number, the whole set of rates/probabilities for 100 ages

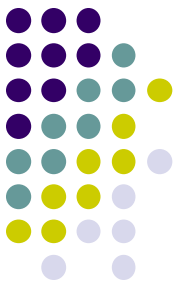
How to compute a life table is not required reading in this course (it is in ECON 1710)

Life table (cont.)



- Ordinary life tables: one-year age groups (Statistics Norway)
- Abridged life tables: five-year age groups (but 0-<1, 1-5) Malaysia

- Period life table: death rates/probabilities observed for a certain period/calendar year among persons who were born in different years
- Cohort life table: death rates/probabilities observed for a certain fixed birth cohort for various calendar years



Life expectancy in a period life table is NOT a reliable measure of future mortality

In 1949 (Nico's birth cohort), e_0 for men was 70.0 years based on data for 1949

Most recent life table (2013) gives e_0 equal to 79.7 years for men

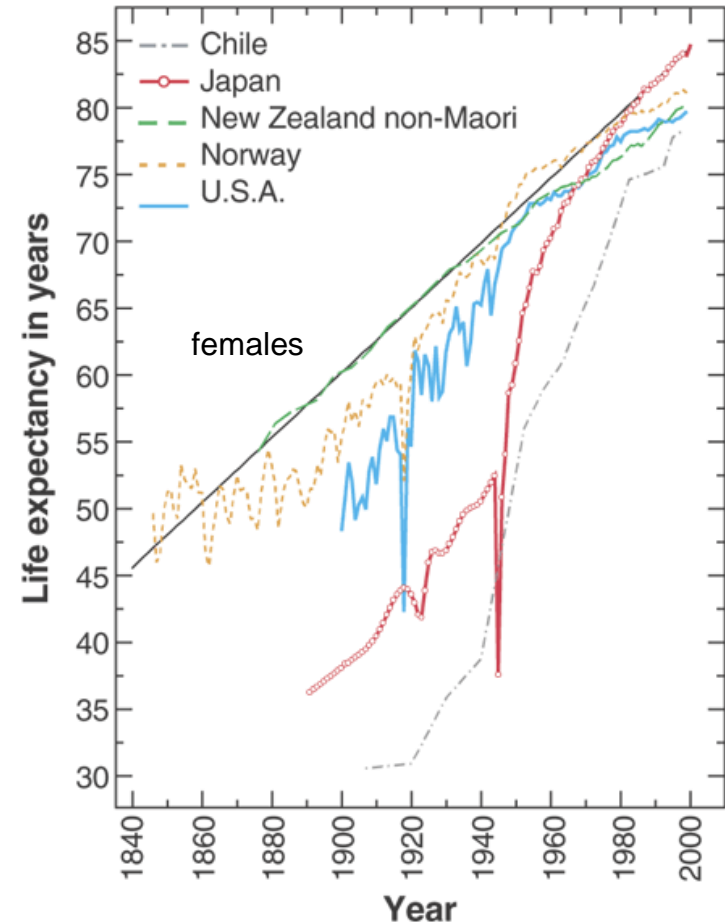
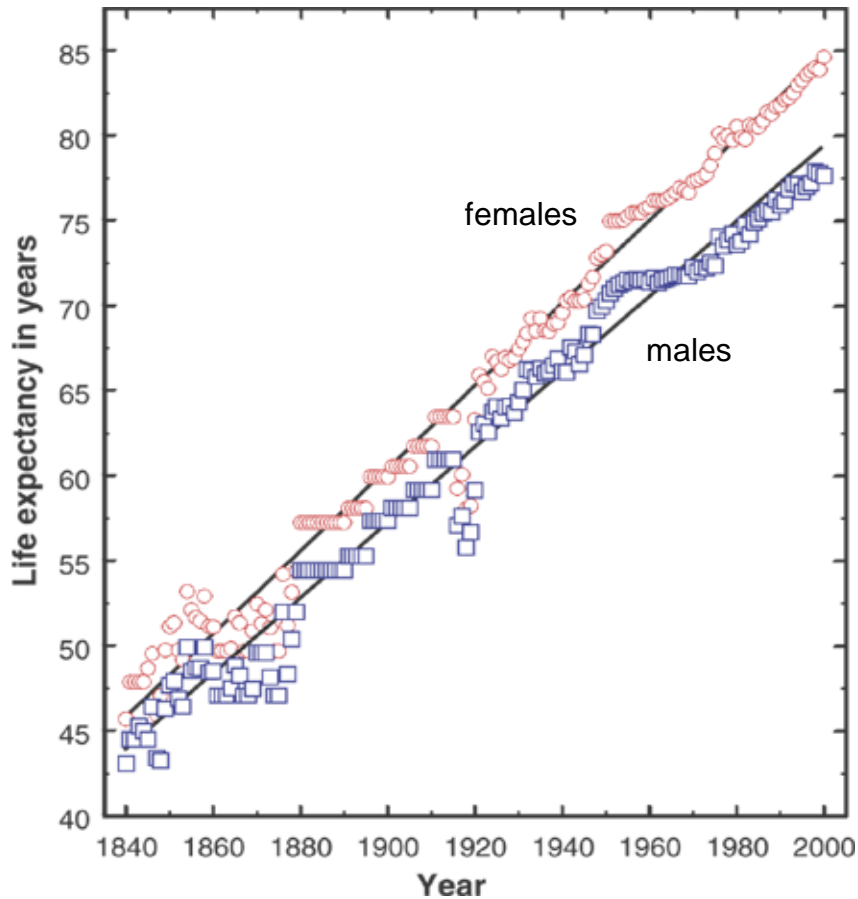
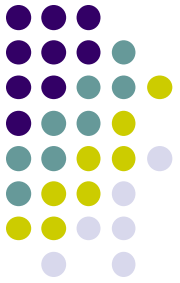
Nico's current (that is, based on data from 2013) remaining life expectancy (e_{65}) is 18.4 years: he can expect to become $65+18.4 = 83.4$ years old (with today's mortality)

But we «know» that mortality will decrease the next 20 years

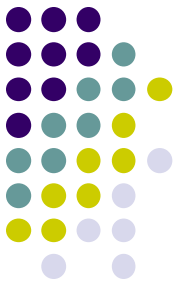
Nico can expect to be older than 83.4 years – an e_{65} equal to 18.4 years is an underestimation of the «real» e_{65} (that is, the e_{65} for birth cohort 1949, which we cannot compute before all born in 1949 have died)

Record life expectancy

has increased linearly in 160 years (~3 mnths. pr. year / ~2.5 years pr. decade)



Source: Oeppen and Vaupel (2002) *Science*



Crude Birth Rate too crude

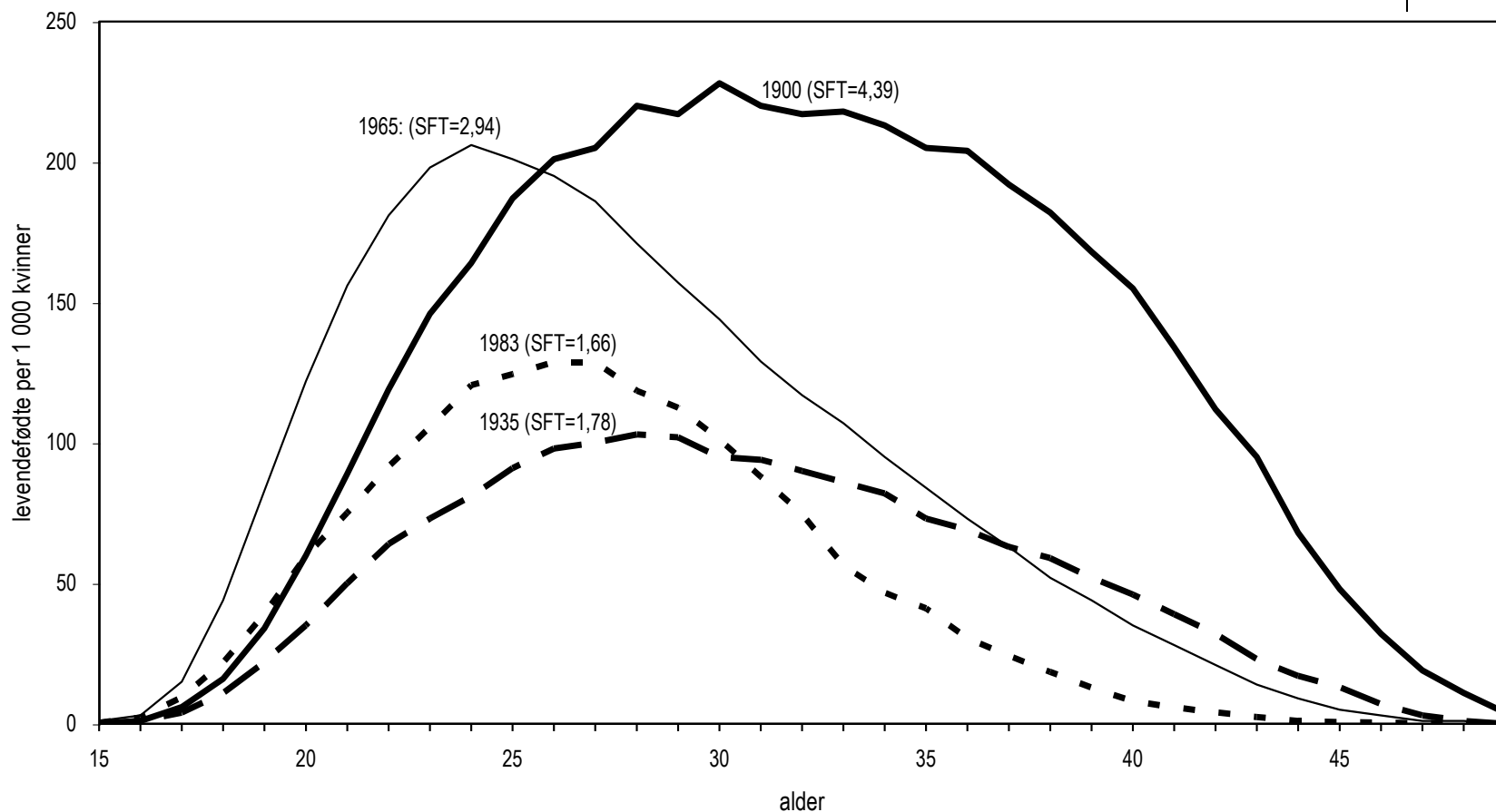
Age specific fertility rate ASFR

- one-year age groups (x,x+1) 15, 16, 17, ..., 49
- five-year age groups (x,x+5) 15-19, 20-24, ... 45-49

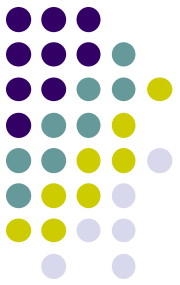
$$\text{ASFR} = \frac{\text{\# births to women in age group}}{\text{mid-year population of women in age group}} \cdot 1000$$

See example Russian Federation in Table 7.1

Age specific fertility rates, Norway, selected years



NB SFT = Total Fertility Rate ("Samlet fruktbarhetstall")
Horizontal scale: age. Vertical scale: live births per 1000 women.



Total Fertility Rate (TFR)

TFR = sum, over all ages, of ASFR/1000

Average number of children a young girl eventually will have, provided that current ASFR's remain constant, no mortality

When ASFR's are given for five-year intervals:

TFR = 5 x (sum, over all ages, of ASFR/1000)

Total Fertility Rate (TFR)



Period TFR : based on ASFR's observed in one particular year/period for women born in different years → synthetic measure

Cohort TFR: based on ASFR's for women born in one particular year/period, observed in different years → actual # children

Cohort TFR also called Completed Cohort Fertility (CCF)

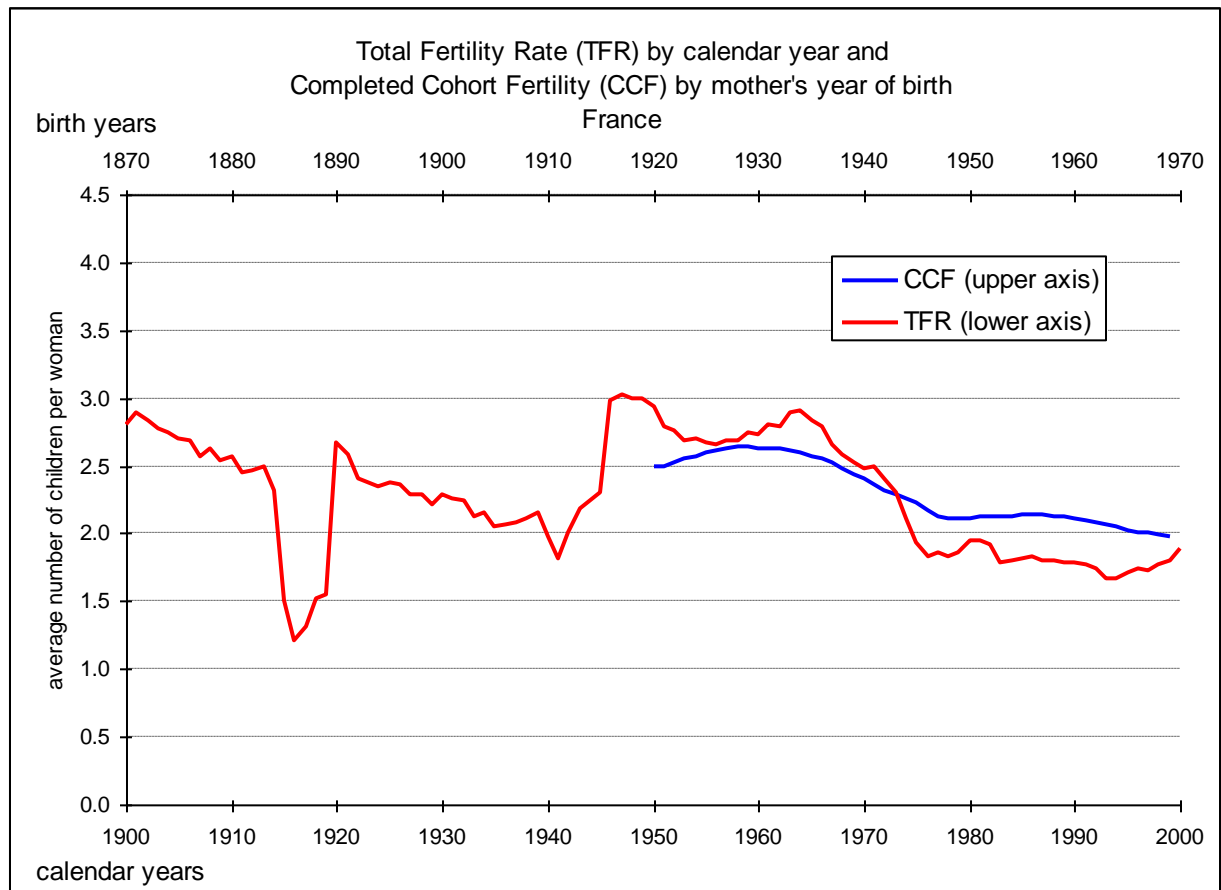
Period TFR synthetic measure



Period TFR's are poor predictors of the number of children a woman ultimately will have

Based on unrealistic assumption that ASFR's will remain constant over time

Period TFR influenced by postponement and catching up effects in the timing of births



Gross Reproduction Rate (GRR)



$GRR = TFR \times (\text{proportion girls among live births})$

Average number of daughters a woman will have when she experiences childbearing as given by the set of ASFR's that underly the TFR – ignoring mortality

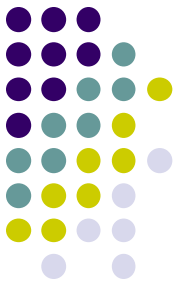
Extent to which a group of women reproduces themselves by daughters

Proportion girls among live births



Usually around 0.485 in Western countries

Lower in some developing countries



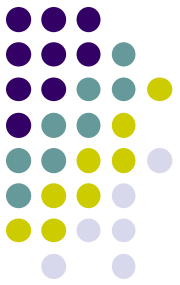
Net Reproduction Rate (NRR)

Takes mortality into account

Given: ASFR's for one year – fertility rates

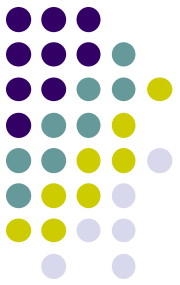
ASDR's for women for one year – mortality rates

NRR = Average number of daughters a woman will have when she experiences childbearing and mortality as given by the set of ASFR's and ASDR's



Western countries: little difference between GRR and NRR
Developing countries: big differences

	GRR 1993	NRR 1993
Burkina Faso	3.50	2.41
United Kingdom	0.86	0.85



$NRR = 1$

Fertility is at replacement level

When $NRR = 1$ for a long time, then population size will become constant eventually (ignoring migration)

$NRR > 1$ (< 1)

Fertility is over (under) replacement level

Long run: increasing (falling) population