Overview of Demographic Concepts and Methods

United Nations Statistics Division

Outline

1. What is demography
2. Meaning of “population”
3. Population change and components of population growth
4. Demographic transition
5. Data sources
6. Demographic measurements
7. Direct and indirect techniques

What is demography?

Literally translated from the Greek, *'demography'* means *'description of the people'*

One definition among many:

"Demography is the study of the size, territorial distribution, and composition of population, changes therein, and the components of such changes, which may be identified as natality, mortality, territorial movement (migration), and social mobility (change of status)."
(Duncan & Hauser 1972)

>>*The study of population processes*

Meaning of “population”

1. Collection of persons alive at a specified point in time who meet certain criteria

Examples:

- The “population of India on April 1, 1995,"
- The "population of American black females in the Northeast on June 1, 1900”

2. Kind of collectivity that persists through time even though its members are continuously changing through attrition and accession. Thus, "the population of India" may refer to the aggregate of persons who have ever been alive in the area we define as India and possibly even to those yet to be born there. The collectivity persists even though a virtually complete turnover of its members occurs at least once each century.

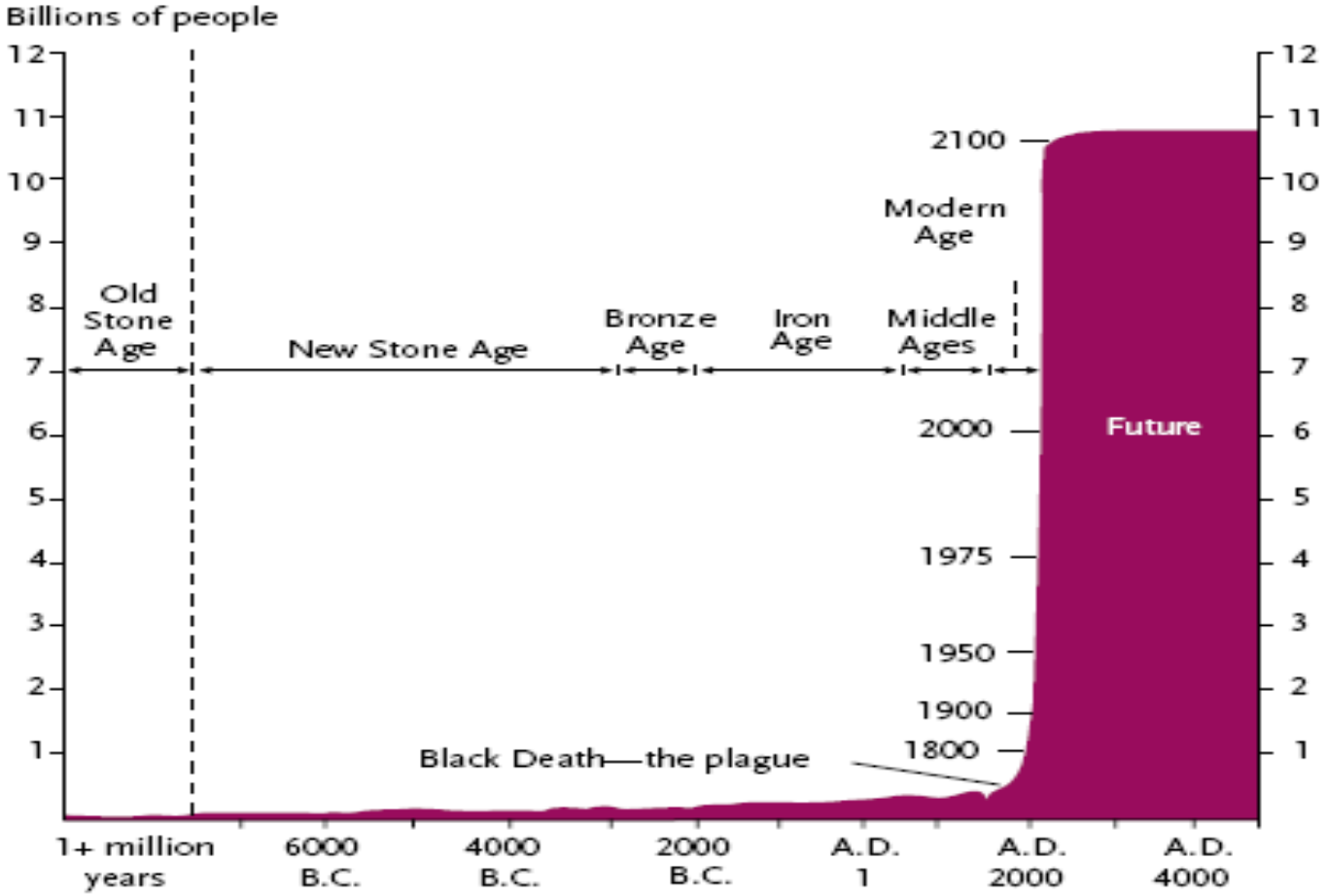
Source: Preston et al. (2001)

Demographic analysis

- Focuses on this enduring collectivity **>>** studying changes in its size, growth rates, and composition
- Emphasis is on understanding aggregate processes, but demography is also attentive to the implications of those processes for individuals
- Many of the indexes used in demography (life expectancy at birth, total fertility rate) translate aggregate-level processes into statements about the demographic circumstances faced by an average or randomly-chosen individual

Source: Preston et al. (2001: 1-2)

World population growth through history



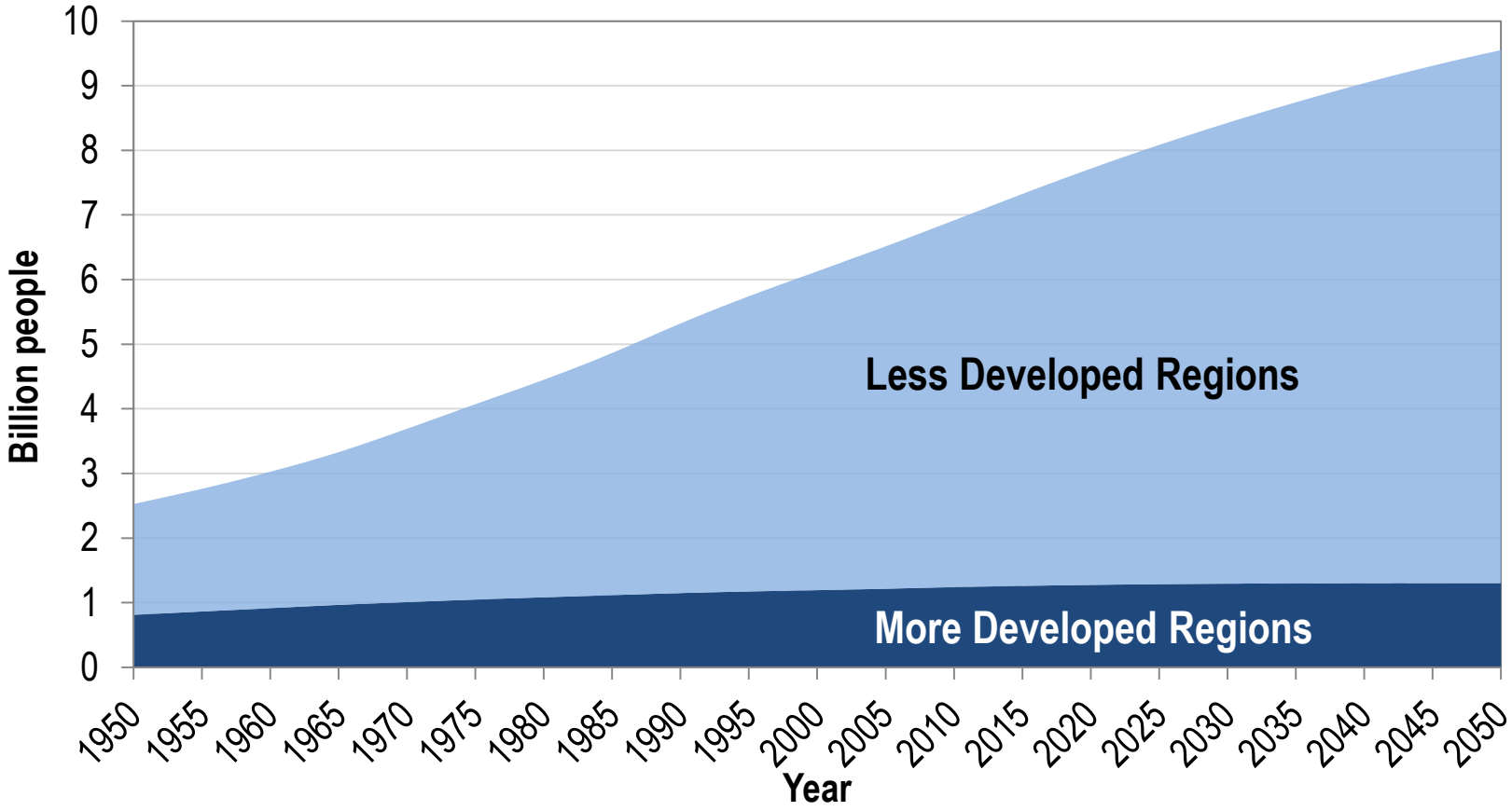
Source: McFalls 2007: 25

World population growth through history

World population	When?	How long?
1 billion	1800	All of human history
2 billion	1930	130 years
3 billion	1960	30 years
4 billion	1975	15 years
5 billion	1987	12 years
6 billion	1999	12 years
7 billion	2013	14 years
…	…	…

Source: McFalls 2007: 25

World population growth 1950-2050



Source: UNPD (2013)

World population clock, 2014

	World	More developed countries	Less developed countries
Population	7,238,184,000	1,248,958,000	5,989,225,000
Natural increase per			
Year	86,582,000	1,466,000	85,115,000
Month	7,215,167	122,167	7,092,917
Week	1,665,038	28,192	1,636,827
Day	237,211	4,016	233,192
Hour	9,884	167	9,716
Minute	165	3	162
Second	2.7	0.0	2.7

Source: Haub & Kaneda (2014)

How to understand these changes?

What are the components of population growth?

Components of population growth

$$P_t = P_0 + (B - D) + (I - E)$$

Population at time *t*

Population at time *0*

Natural increase
(Births – Deaths)

Net migration
(Immigration – Emigration)
(arrivals – departures)

Components of population growth

Population growth can occur only if:

1. Natural increase is positive

$B > D \Rightarrow B$ increases or D declines

and/or

2. Net migration is positive

$I > E \Rightarrow I$ increases or E declines

In history, the first case is more important to understand the impressive population growth

>> Demographic transition

Demographic Transition

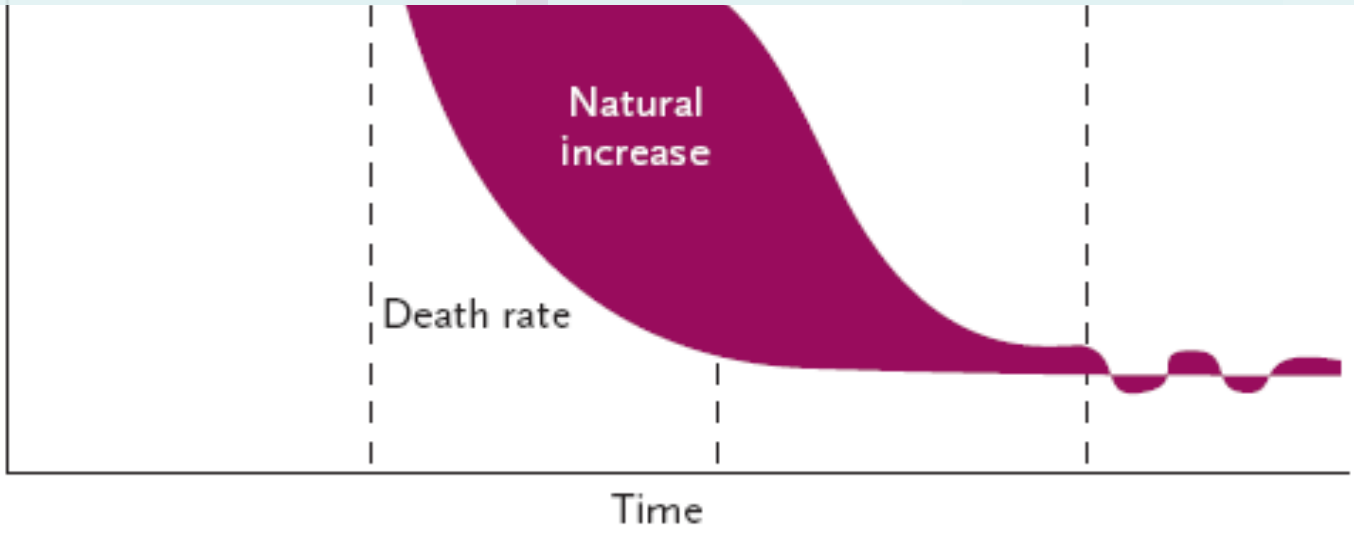
- One of demography's main theoretical preoccupation in 20th century
- More a generalization from observed trends than a theory
- Descriptive and pedagogic value
- Many patterns of transition, with different timing and explanations

>> Movement of death and birth rates in a society, from a situation where both are high (in the pre-transition stage) to one where both are low (in the post-transition stage).

>> Transition is the interval between these two stages during which the population increases oftentimes rapidly, as births exceed deaths.

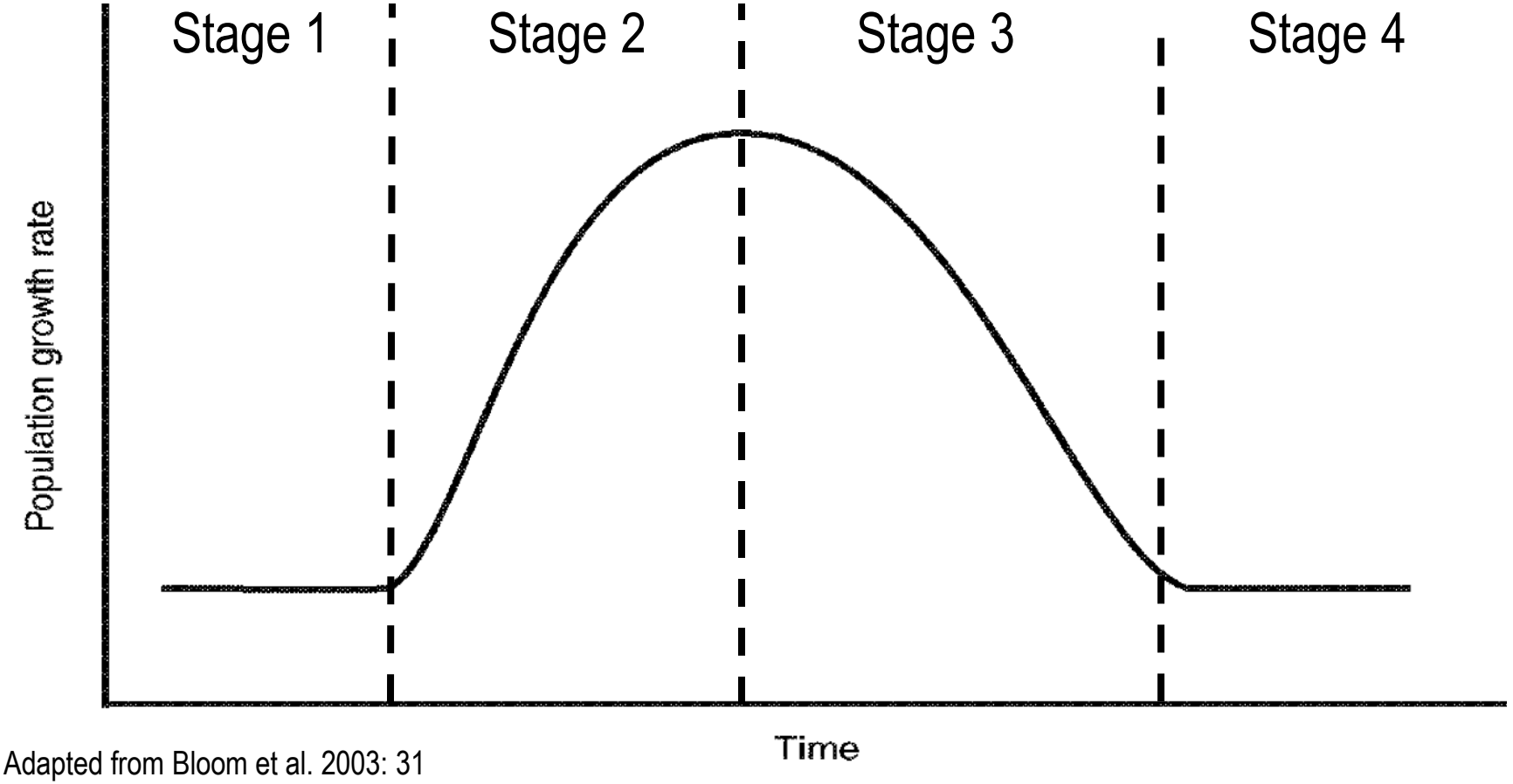
Classic stages of demographic transition

Before the star	Mortality decli	Fertility decline	At the end of the DT
life was short, b many, growth w population was	Improved living health practice ⇒ population	Population growt at the beginning at the end of the	Birth and death rates are close again. Low population growth with fluctuations



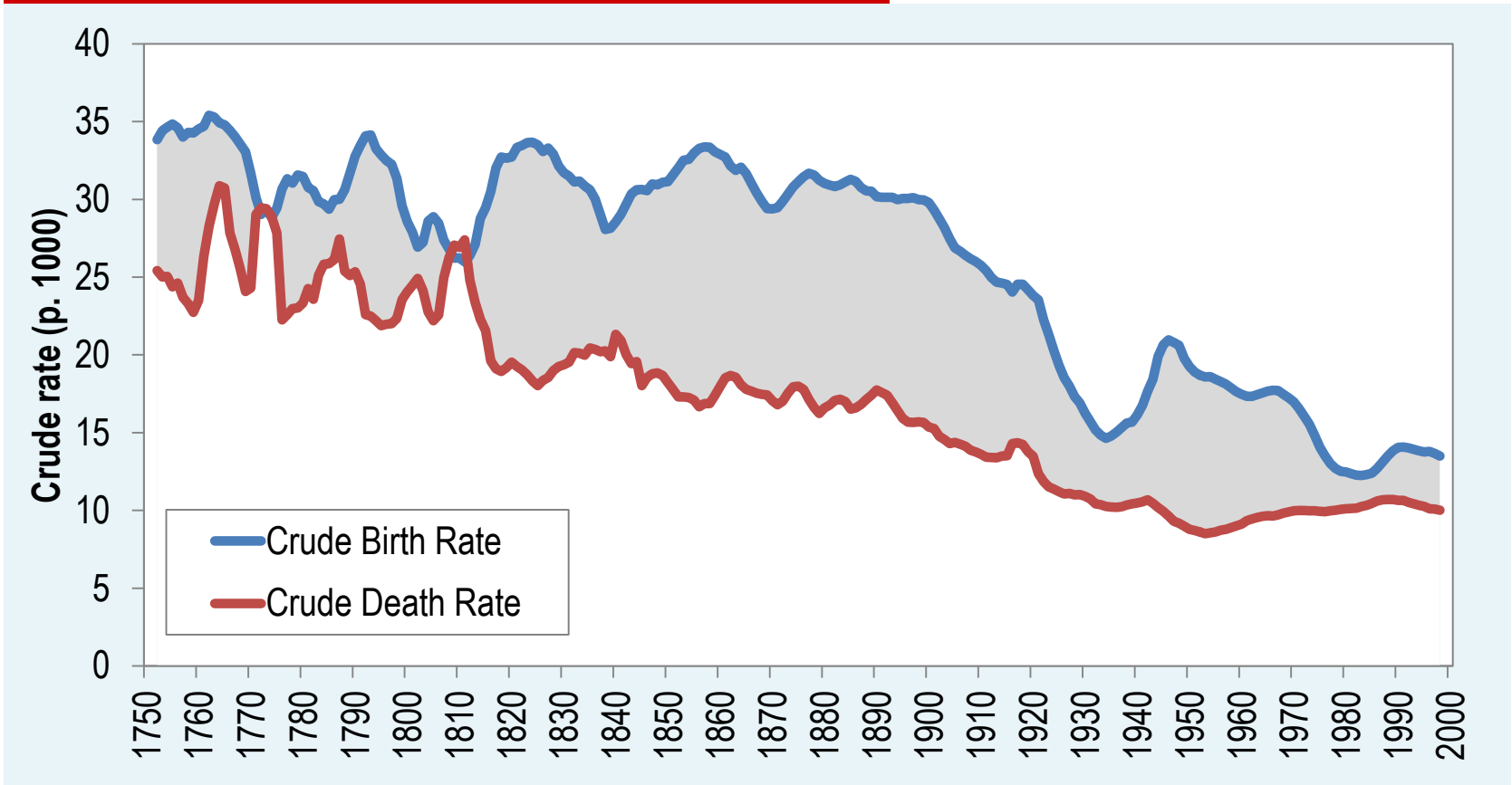
Source: McFalls 2007: 27

Growth rate over the demographic transition



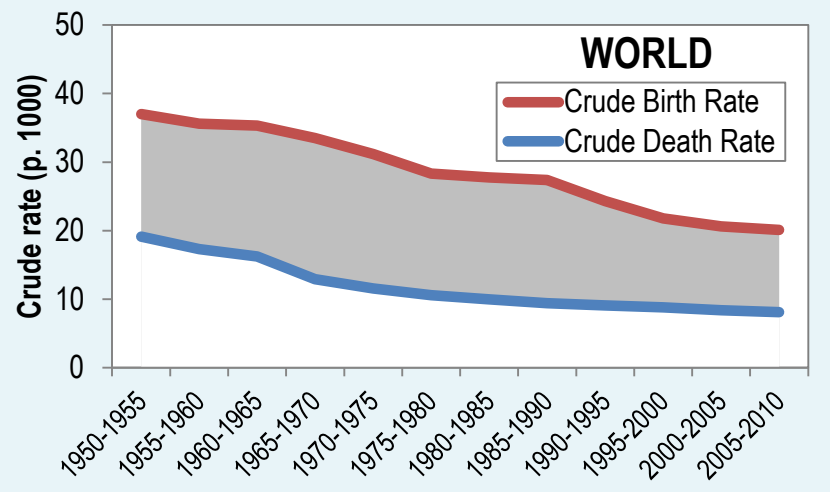
Adapted from Bloom et al. 2003: 31

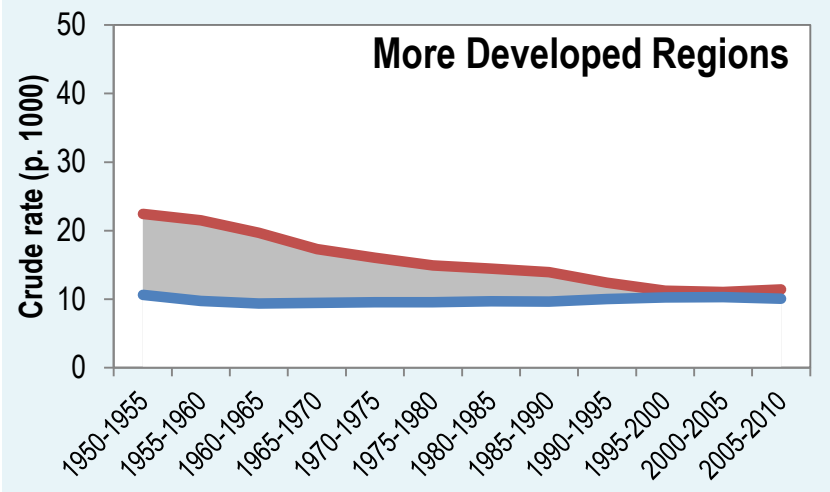
250 years of demographic transition in Norway

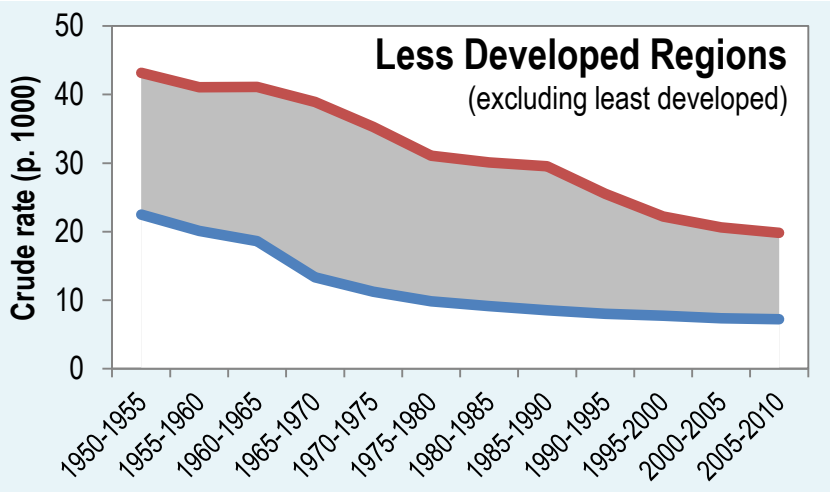


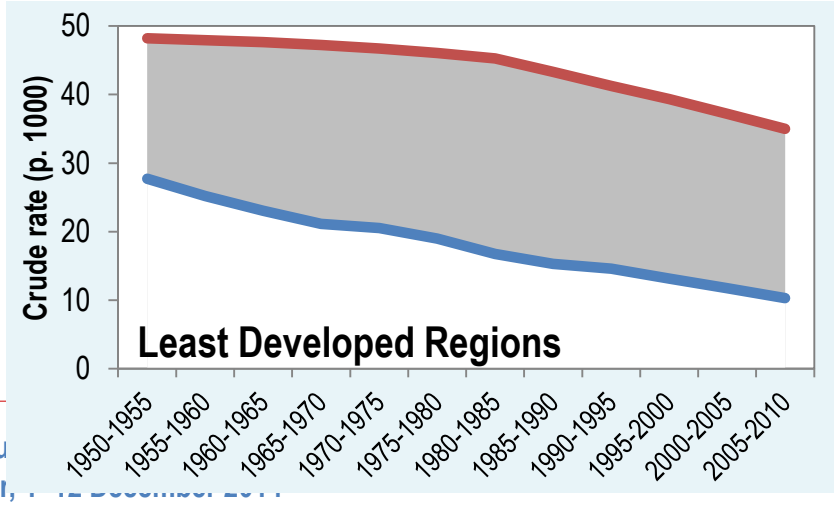
Data source: Moving average computed from Rowland (2003)

Demographic transition across the globe (*Data source*: UNPD 2013)

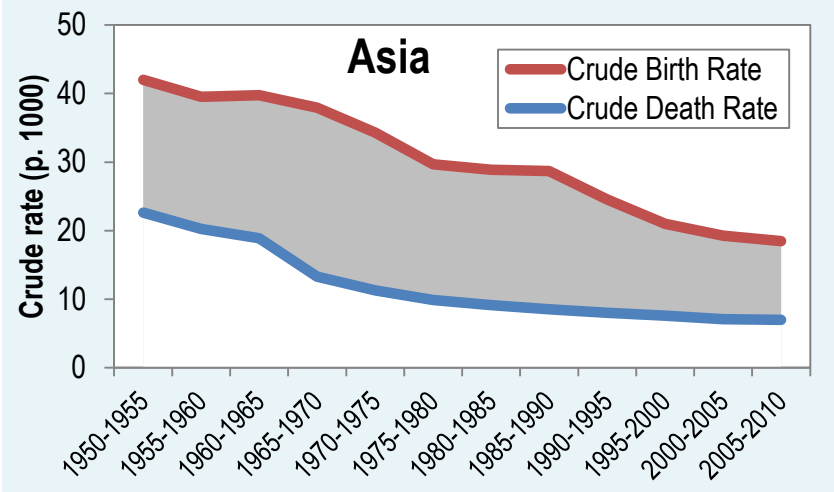


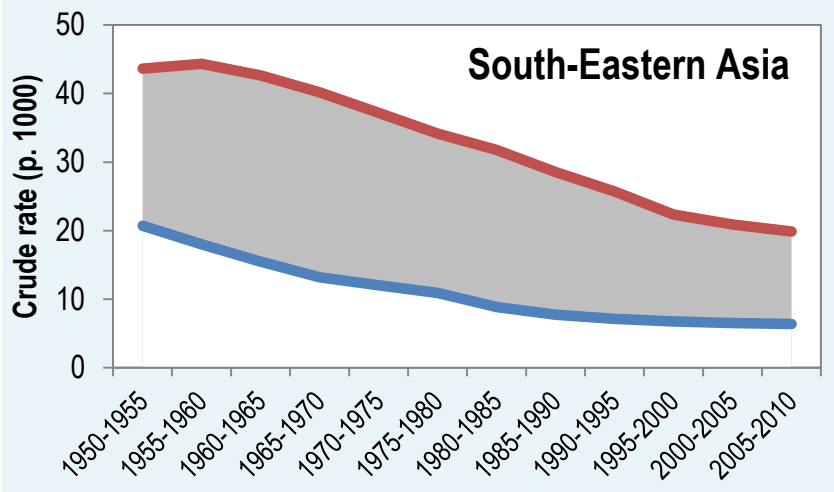


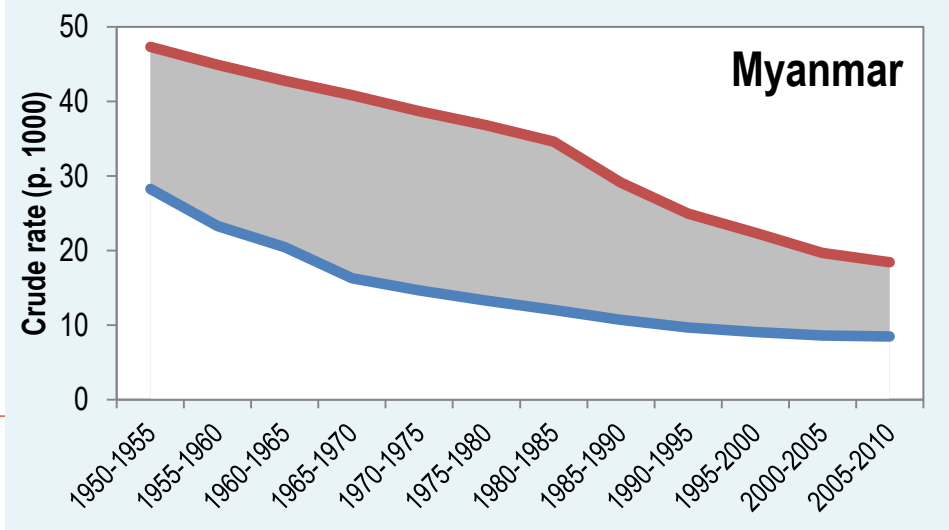




Demographic transition in Asia (*Data source*: UNPD 2013)

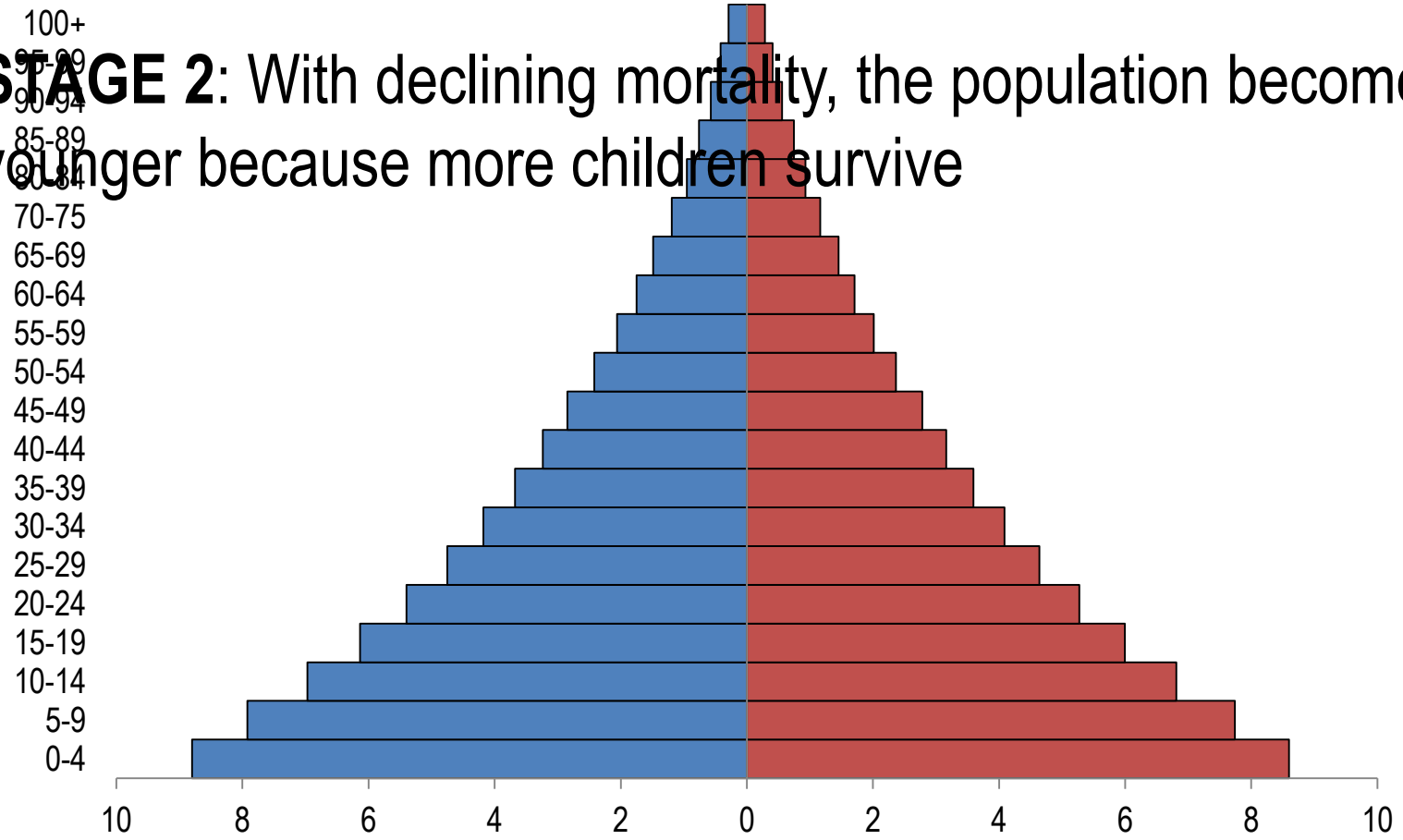






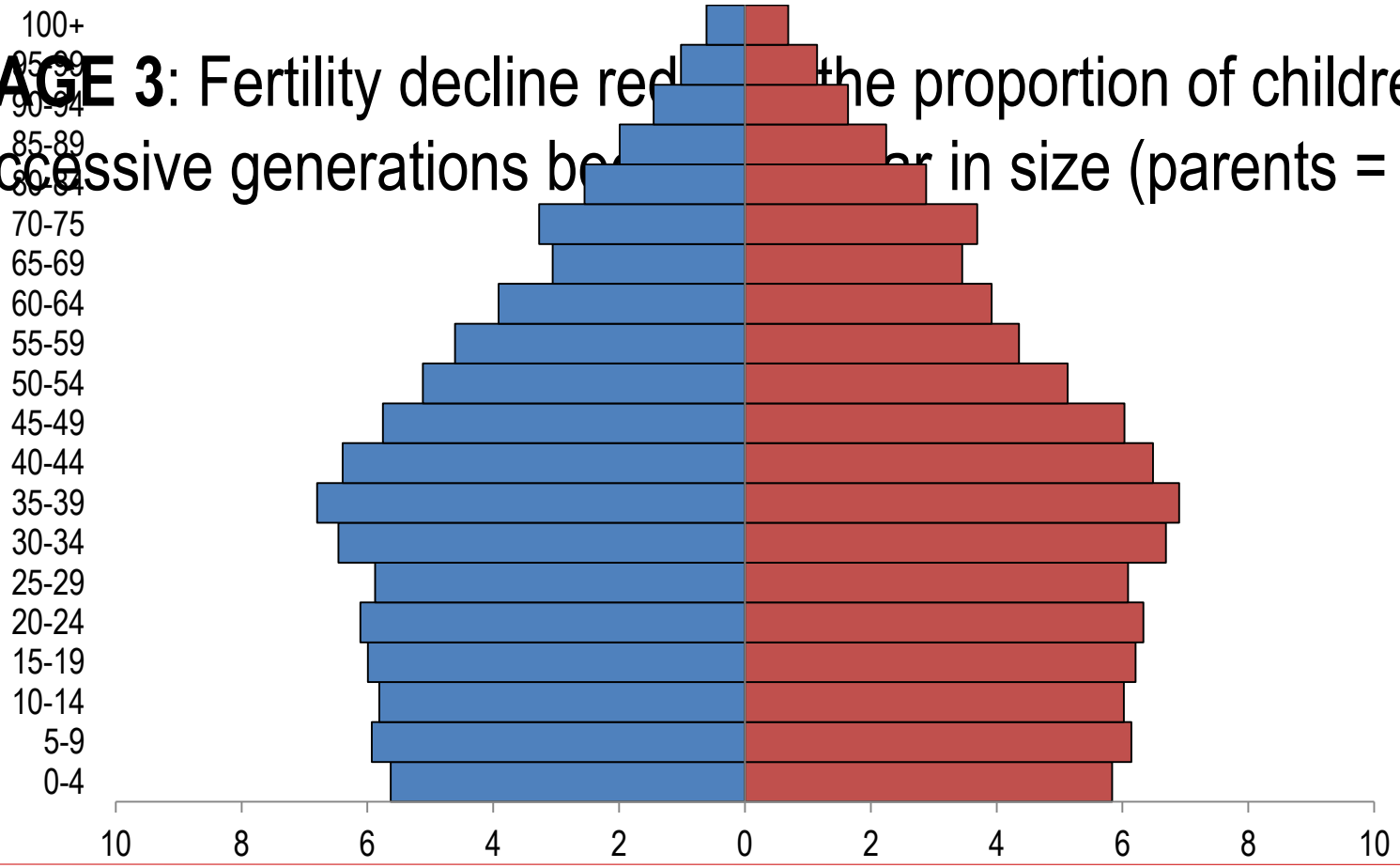
Changes in age structure through the demographic transition (DT)

STAGE 2: With declining mortality, the population becomes younger because more children survive



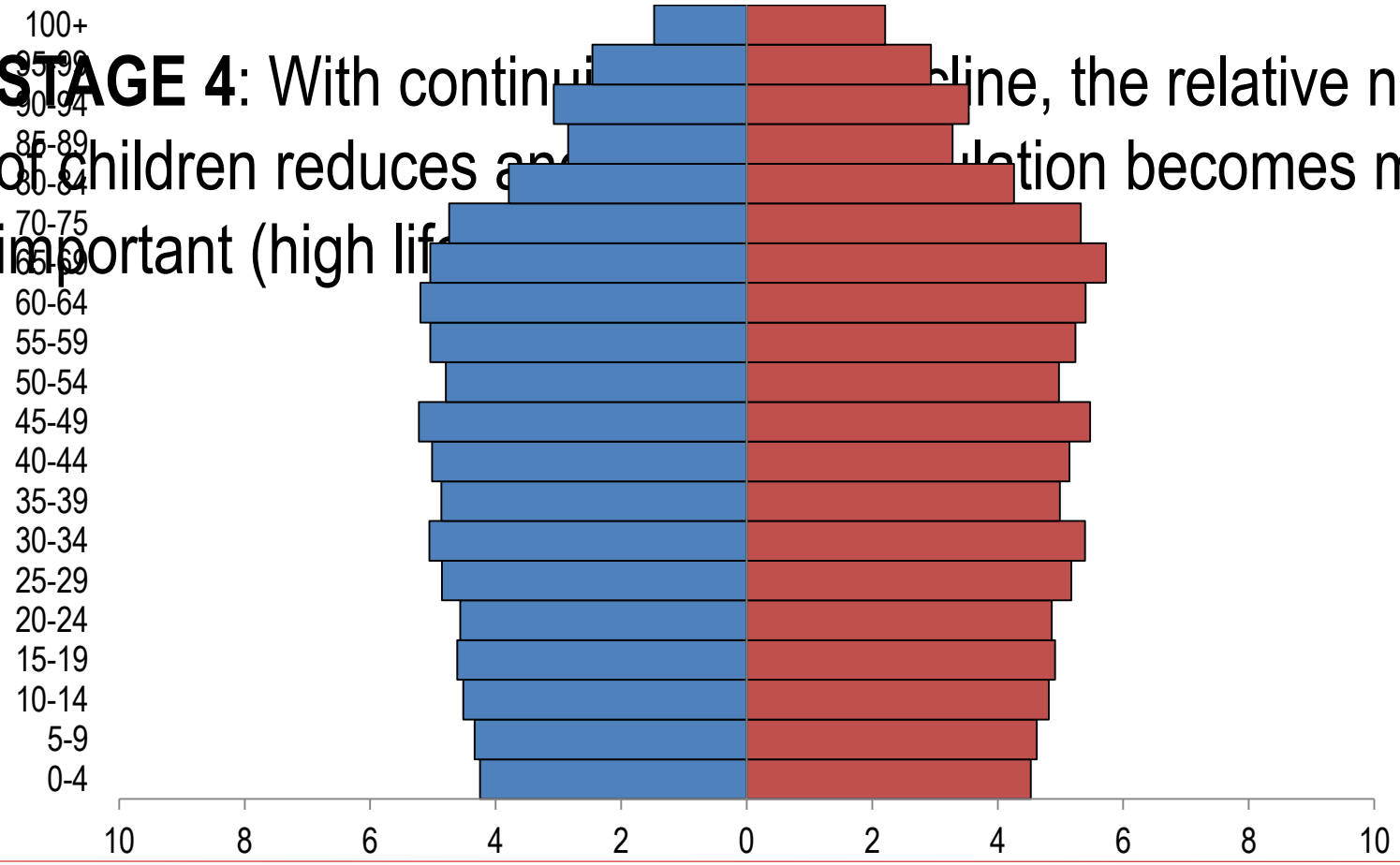
Changes in age structure through the demographic transition (DT)

STAGE 3: Fertility decline red[illegible]he proportion of children.
Successive generations be[illegible]r in size (parents = children).

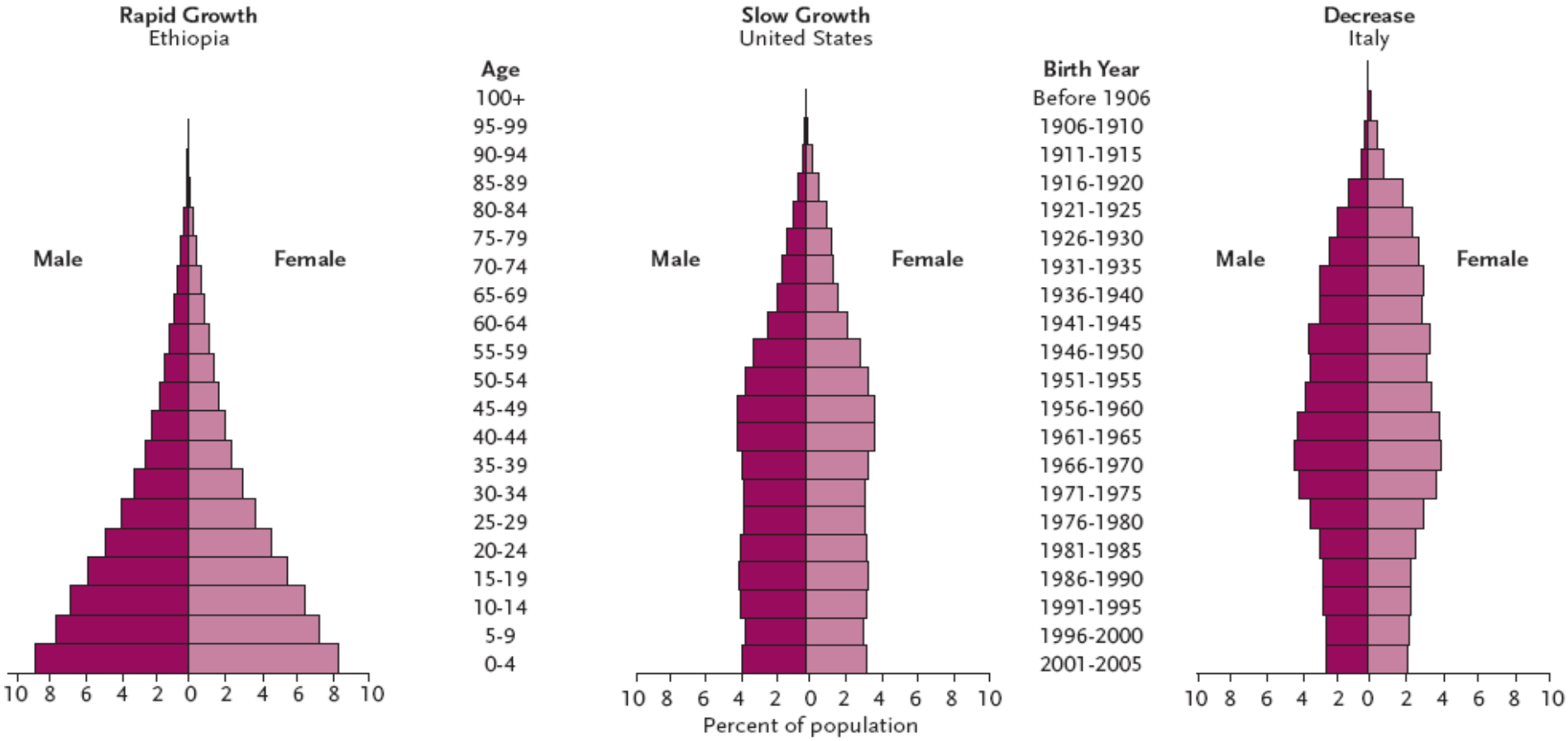


Changes in age structure through the demographic transition (DT)

STAGE 4: With continui[illegible]cline, the relative number of children reduces a[illegible]lation becomes more important (high lif[illegible]



Diversity of population pyramids, 3 different stages



Source: McFalls 2007: 19

Components of population growth

$$P_t = P_0 + (B - D) + (I - E)$$

Each component of population growth (population, births, deaths, migration) need to be estimated from empirical data

>> Data sources

Data sources

Main sources

- Census
- Vital registration
- Sample surveys

Some other sources

- Population register
- Demographic Surveillance System (DSS)

Data sources – Census

"The total process of collecting, compiling, evaluating, analysing, and publishing or otherwise disseminating demographic, economic and social data pertaining to all persons in a country or in a well-delineated part of a country at a specified time." (United Nations 2008)

- **Total process**
  Not sufficient to simply collect and collate information in a census, but also analyze, publish and disseminate the data.
- **Demographic, economic and social data**
  To collect more than just a simple headcount of the population
- **Universality**
  To enumerate all people in a population
- **Simultaneity**
  To produce a snapshot of the population at a point in time

Data sources – Census

- The oldest, most demanding, and most important source of demographic information **>>** many demographic methods developed for census data
- Among the most complex and massive peacetime exercises a nation undertakes
- Requires the mapping the entire country, mobilizing and training an army of enumerators, conducting a massive public campaign, canvassing all households, collecting individual information, compiling vast amounts of completed questionnaires, and analysing and disseminating the data

Data sources – Census

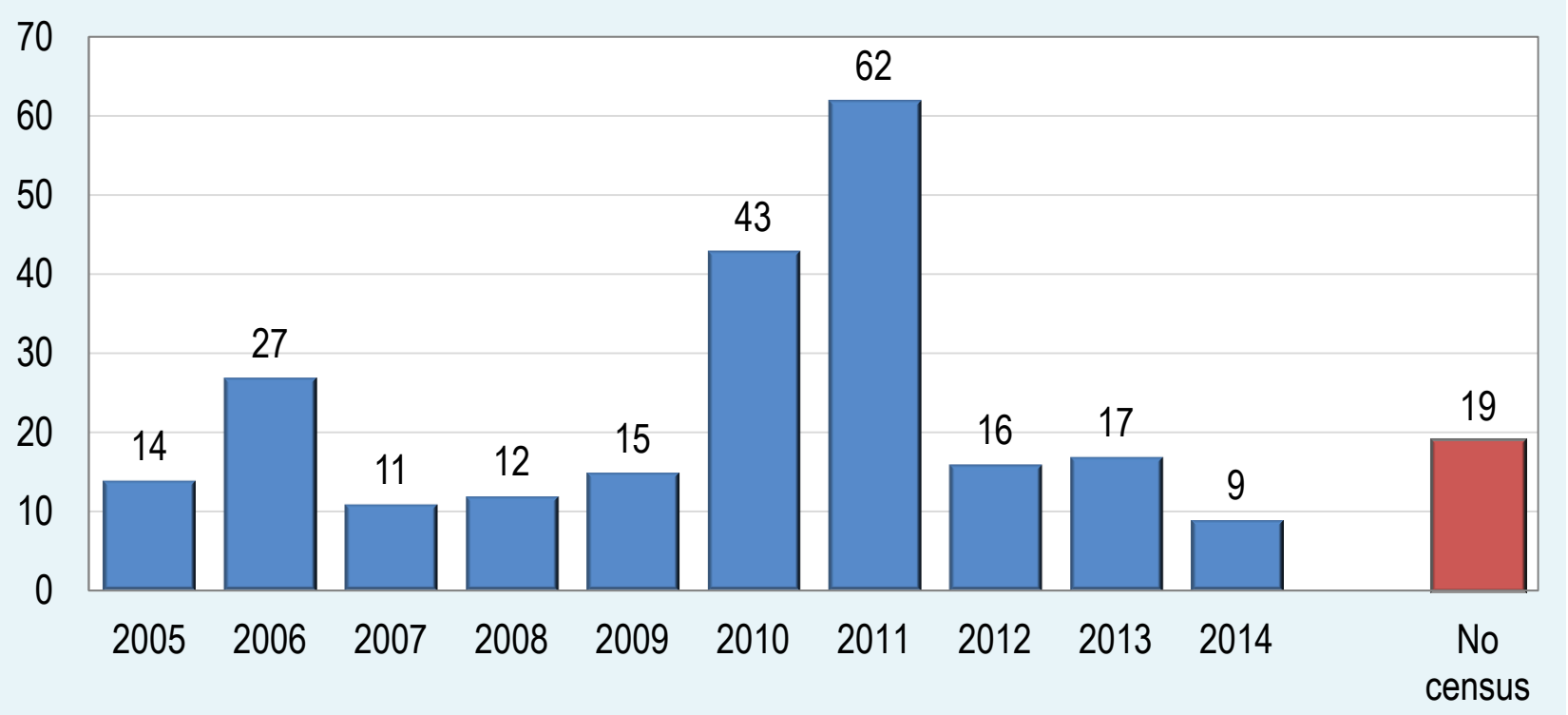
- (Recommended) to be conducted once per decade
- UN Principles and Recommendations (**>>** 3rd revision forthcoming)
- 2010 World Population and Housing Census Programme (UNSD)
  - 19 countries have not conducted a census (slight improvement compared to 26 during the 2000-round)

> UNSD Population Census Datasets: http://unstats.un.org/unsd/demographic/products/dyb/dybcensusdata.htm

> Micro samples available for 79 countries (258 censuses) at IPUMS International (Integrated Public Use Microdata Series): https://international.ipums.org/international/

General overview – 2010 round of censuses

Number of countries/areas that conducted, plan to conduct and did not schedule a population and housing census in the 2010 round, by year



Enumeration used in 2010 round of censuses

	Total countries	*Percent*
Total	126	*100*
Face-to-face interview, paper questionnaire	94	*75*
Face-to-face interview, electronic questionnaire	14	*11*
Telephone	14	*11*
Self-enumeration, paper questionnaire, collected by enumerators	30	*24*
Self-enumeration, paper questionnaire, return by mail	18	*14*
Self-enumeration, internet	33	*26*
Register-based enumeration	18	*14*
Pre-existing administrative records	8	*6*
Other	2	*2*

* The sum of the categories exceeds 100% as countries were asked to provide answers as to all the methods they applied.

Data sources – Census (De facto vs. De jure)

De facto (Latin, for 'in actual fact')
The population is enumerated where it is found, regardless of the respondent's usual place of residence.

De jure (Latin for 'in law')
The respondent is enumerated at their usual place of residence, regardless of where they stayed on the census date.

In highly mobile populations, or populations subject to extensive seasonal migration (e.g. crop-pickers), De facto and De jure data may give widely divergent results

Source: IUSSP & UNFPA (n.d.)

Data sources – Census

Advantages	Disadvantages
The coverage aims to be universal	The size and complexity of the exercise means that the content and quality control efforts may be limited
Census provides sampling frame for subsequent surveys and studies	Due to high costs, census is conducted only every ten years
The census can serve as a useful tool for 'nation-building', by involving the entire population	Some delay between data collection and release of results (typically, between 18 months to two years) meaning that the census only offers a snapshot of the population at some point in the past
Census data avoids the sampling errors that can occur with sample data	Risks that census being politicised – either by groups who feel that they might be systematically undercounted by the exercise, or by parties with a vested interest in seeking to ensure that their group's population is found to be larger than that of other groups
Censuses provide data for small areas, such as districts and counties, which is vital for the planning of services	

Source: IUSSP & UNFPA (n.d.)

Data sources – Vital registration system

- The second main source for demographers
- Collect information on individuals when (or shortly) after they experience the vital events (birth, marriage, death, (sometimes) migration)
- In almost all developed countries, registration of births, deaths, and marriages is compulsory
- Vital data collected are tabulated totals from individual records
- Sometimes more extensive information collected (e.g. statistics for birth could include sex, birth weight, place of birth…)
- Despite progress, civil registration systems still deficient in many countries

  >> For example, only 60% of the 230 countries and areas register at least 90% of births occurred in the country. While for death registration, only 47% of the countries and areas have at least 90% coverage. (UNSD 2012)

Data sources – Sample surveys

- More and more important as statistical science has developed
- Collect vital statistics where the official registration system is inadequate or nonexistent and for intercensal period
- Collect supplementary demographic and other data, where it is not feasible to collect the same from the population census
- Since the 1970s, coordinated demographic surveys have been taken around the world through the World Fertility Survey (WFS), the Demographic and Health Surveys (DHS), the Multiple Indicator Cluster Surveys (MICS), or other national types of survey

> DHS micro datasets available online at: www.dhsprogram.com
> MICS micro datasets available online at: http://www.childinfo.org/mics.html

Data sources – Some other sources

Population register

>> If country has a system of continuous registration it is possible to maintain a separate card for each individual from the time of his birth (or immigration) to his death (or emigration) and to continually update the record by recording such additional registration data as marriage, divorce, birth of children, etc.

Demographic Surveillance System (DSS)

>> DSS monitors demographic and health characteristics of a population living in a well-defined geographic area. A baseline census is followed by regular update of key demographic events (birth, death, migration, marriage…) and heath events

Demographic measurements (rate, ratio, proportion)

Rate

The most widely used comparative measures of population change
Ideally, demographic rates show ideally the relationship between the number of demographic events (numerator) and the population at risk of experiencing them (denominator) in a specific period of time.

$$Rate = \frac{Number\ of\ Demographic\ Events}{Population\ at\ Risk\ during\ specific\ period\ of\ time}$$

$$Rate = \frac{Number\ of\ Occurrences}{Number\ of\ Person\text{-}years\ Lived}$$

Demographic measurements (rate, ratio, proportion)

Rate

- When studying the relative incidence of births, deaths, marriages, migration and other vital events, it is apparent that the number of these events depends on the interval of time chosen (usually one year).
- A common method of comparing the incidence of births in several countries is to calculate for each country the number of births during one year per 1,000 persons in the population of that country *at the middle of the year*. The result is called a rate, in this case a rate per 1,000 per year.

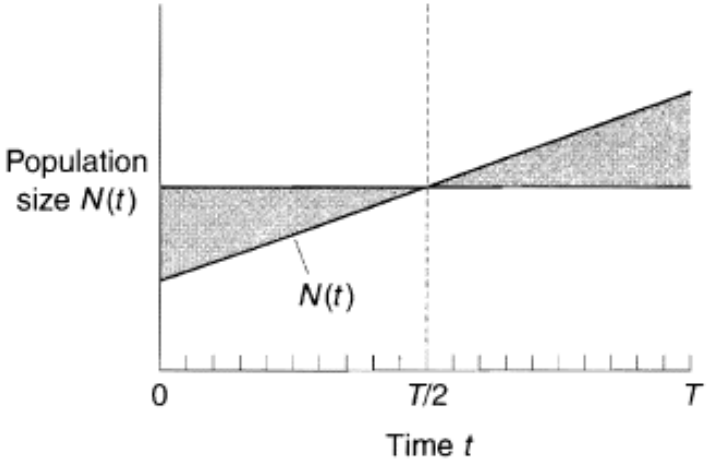
  >> Mid-year population calculated as the mean or average of the population at the start and end of the year

Demographic measurements – Rate, examples

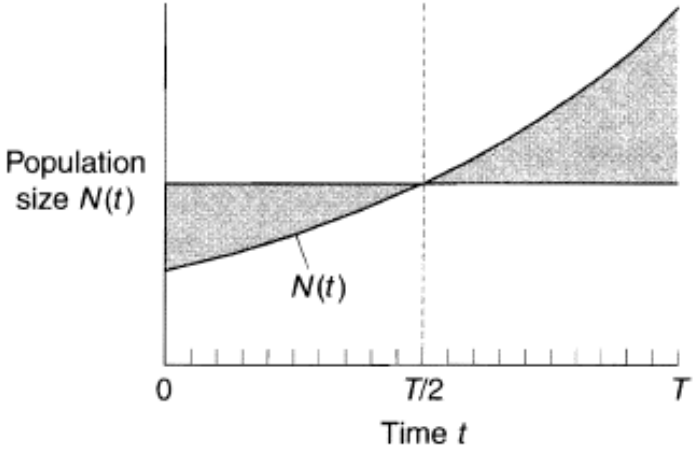
Crude Birth Rate and Crude Death Rate

>> Example in Excel

A note on approximation of person-years



When population increase linearly, the estimate of person-years lived using the mid-period population times period length will be accurate because the overestimate for the first half-period is exactly offset by the underestimate for the second half- period, i.e., the two triangles have equal areas



When population follows an exponential growth pattern, the two shaded surfaces have different areas and the mid-year approximation *will underestimate* person-years lived during the period.

Source: Preston et al. (2001: 16)

Demographic measurements (rate, ratio, proportion)

Ratio

- The size of a number relative to another convenient number
- When the population at risk is unavailable **>>** Ratio
- Denominators for ratios selected depending on the available data and ease of understanding
- Example: sex ratio **>>** the number of men per hundred women (men/women $*$ 100)

Demographic measurements (rate, ratio, proportion)

Proportion

- A ratio in which the denominator includes the numerator
- Decimal fraction (between 0 and 1)

Percentage

- A proportion mutliplied by 100
- Easier to read/interpret

Demographic measurements – Example

	Number (in thous.)	?	?
Sinhalese	11,053	0.744	74.4
Tamil	2,652	0.179	17.9
Ceylon Moor	1,026	0.069	6.9
Others	117	0.008	0.8
Total	**14,848**	**1.000**	**100.0**

Source: Pollard et al. (1990)

Demographic measurements – Example

	Number (in thous.)	Proportion	Percentage
Sinhalese	11,053	0.744	74.4
Tamil	2,652	0.179	17.9
Ceylon Moor	1,026	0.069	6.9
Others	117	0.008	0.8
Total	**14,848**	**1.000**	**100.0**

In 1984, 15.5 births per 1,000 population per year were observed in Australia >> ???? **Rate**

Source: Pollard et al. (1990)

Demographic measurements - Probability

- The ratio of the number of demographic events to the *initial population at risk* of experiencing them in a fixed period of time
- In demography, probabilities are always based on the *initial population*
- For example, probability of dying at age 100 is based on the number of people who celebrated their 100th birthdays (initial population)

$$Probability = \frac{Number\ of\ Occurrences}{Number\ of\ Preceding\ Events\ or\ Trials}$$

- Since each occurrence in the numerator (e.g., divorce) must be preceded by an event in the denominator (marriage), the number of occurrences cannot exceed the number of preceding events

>> a probability cannot exceed one and, since we are only dealing with positive quantities, probabilities cannot be negative

Source: Preston et al. (2001: 19)

Demographic measurements - Probability

- Populations do not have probabilities except insofar as they pertain to **cohorts** that are included in the population.
- Although we could count the number of marriages in a population during some calendar year and the number of divorces during that year, the two numbers combined do not give a sensible estimate of the probability of divorce because they don't apply to the same cohort. If we happened to choose a year in a small population where no one married but there was a divorce, our population's probability of divorce q^D *would be* $1/0 = \infty$ (infinity), *an obviously* absurd outcome.
- Only when we count the events pertaining to the **cohort** at risk of the event we can properly define a probability

Source: Preston et al. (2001: 19)

Demographic measurements - Cohort

- Cohort is the aggregate of all units that experience a particular demographic event during a specific time interval
- As for a population, a cohort always has some specific geographic referent whether it is explicit or implicit
- A cohort usually consists of people, but it may also consist of entities (e.g., marriages) formed by a demographic event.
- The cohort is usually identified verbally both by the event itself and by the time period in which it is experienced
- Birth cohort = most used **>>** Persons born during the same period will pass through life together
- Examples:
  - "US birth cohort of 1942" = all persons born as US citizens in calendar year 1942
  - "French marriage cohort of 1990'' = all marriages contracted in France during the calendar year 1990

Source: Preston et al. (2001)

Demographic measurements – Cohort

Main limitation of working with cohort is that for computing cohort rates and probabilities requires complete information on each individual until he or she has died (or at least has ceased to be "at risk" of the event of interest)

For mortality, need to wait until the last person of a birth cohort passes away in order to compute mortality indicators

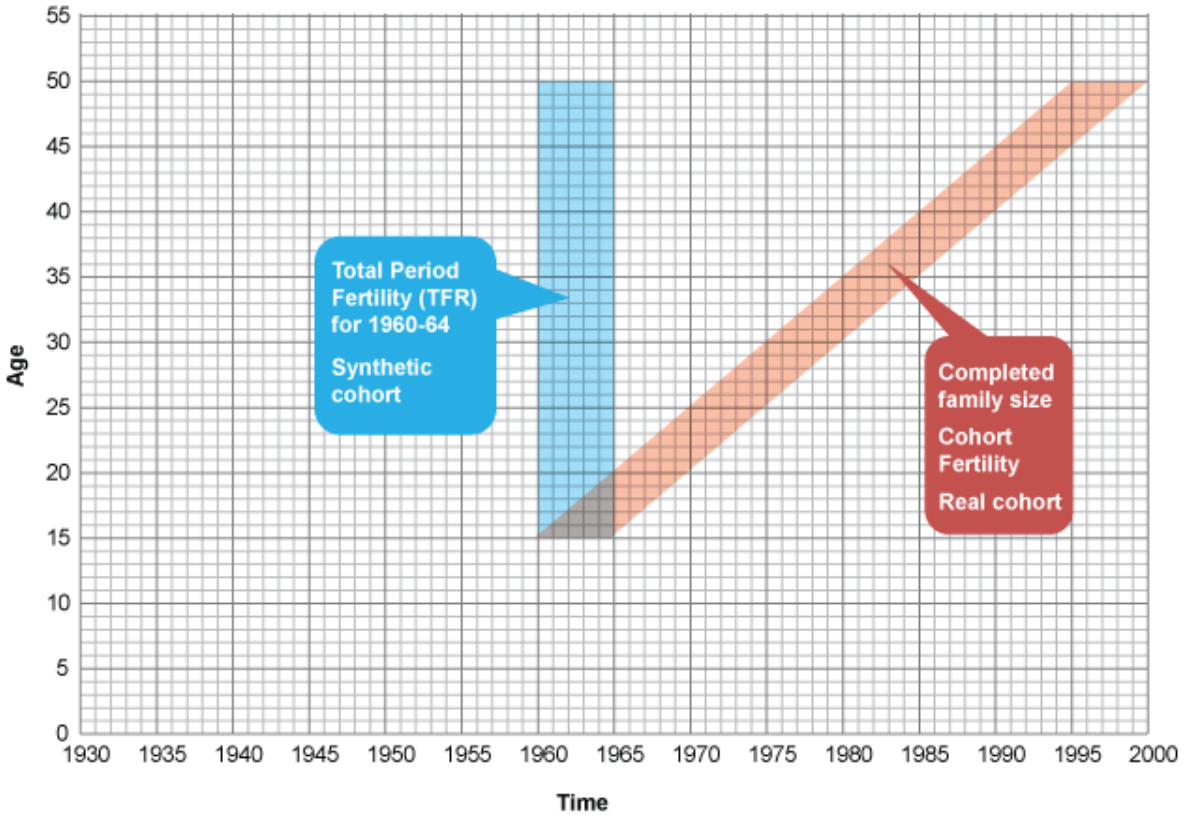
For fertility, need to wait until the last woman of a birth cohort reaches the end of her childbearing ages

>> Demographers have developed the artifact of the **synthetic cohort**

- Synthetic cohort mixes the experiences of persons from different (birth) cohorts in order to compute demographic indicators

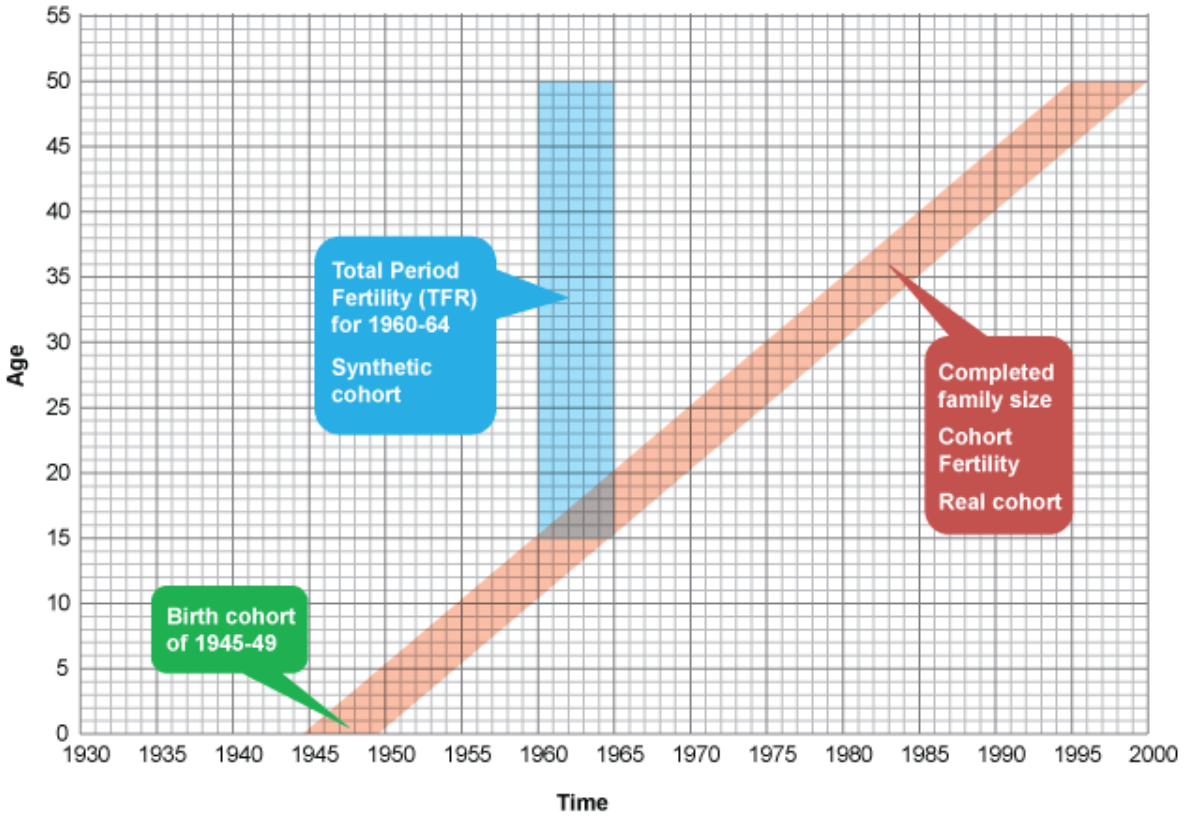
Source: Preston et al. (2001)

Example: Period Fertility vs. Cohort Fertility



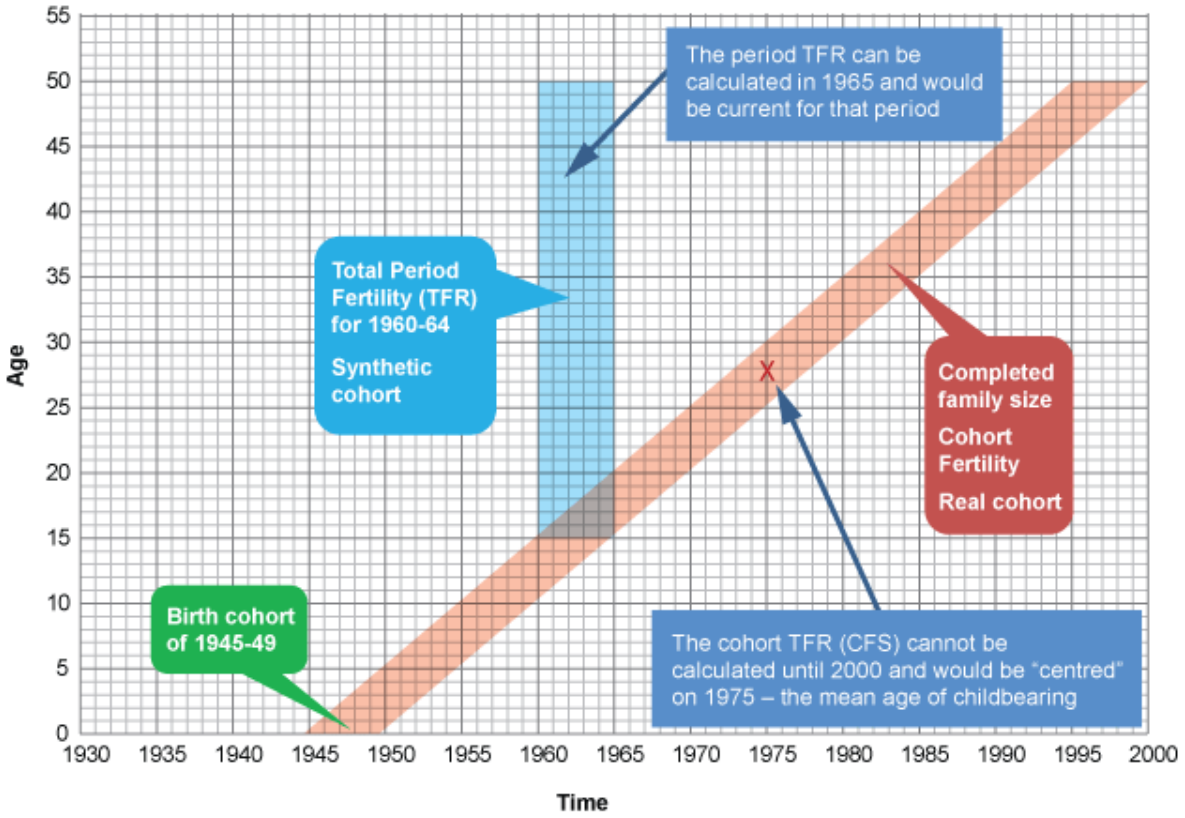
Source: IUSSP & UNFPA (n.d.)

Example: Period Fertility vs. Cohort Fertility



Source: IUSSP & UNFPA (n.d.)

Example: Period Fertility vs. Cohort Fertility



Source: IUSSP & UNFPA (n.d.)

Direct and indirect techniques

"In a perfect world, data would always be complete, accurate, current, pertinent, and unambiguous. In the real world, data are generally flawed on some or all of these dimensions"

(Feeney 2003: 190)

Direct and indirect techniques

Direct techniques require reliable and comprehensive information on population, births, deaths… usually from censuses and registration systems

But, in most parts of the world, vital registration is incomplete and censuses usually suffer from underenumeration and other defects

Many of the standard direct methods of demographic estimation that can be used in a “perfect world” cannot be applied successfully to the majority of the world population

Starting in the 1960s, development of estimation methods for use with deficient and incomplete demographic data (William Brass (1921-1999) and associates)

>> Indirect demographic estimation

Direct and indirect techniques

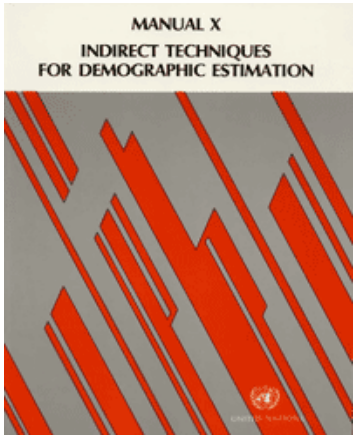
Indirect techniques

Use available information and/or assumption (through the use of models) to infer the levels and trends of demographic change

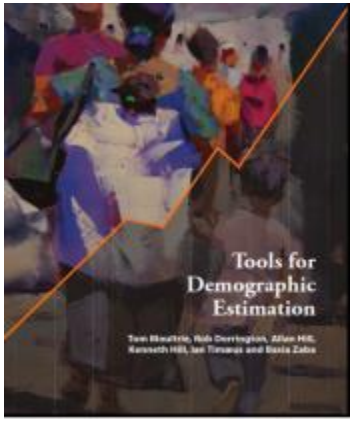
Example:

- Levels and trends in child mortality can be estimated by answers to the question on the number of children ever born and children surviving by age of women
- Adult mortality can be estimated using answers on the question on parental survival or on siblings survival
- Fertility can be estimated using the population structure by single age and sex

Indirect techniques – Main references



United Nations (1983), *Manual X: Indirect Techniques for Demographic Estimation*, New York: United Nations, available online at: http://www.un.org/en/development/desa/population/publications/manual/estimate/demographic-estimation.shtml



Moultrie T.A., R.E. Dorrington, A.G. Hill, K. Hill, I.M. Timæus & B. Zaba (eds) (2013), *Tools for Demographic Estimation*. Paris: International Union for the Scientific Study of Population. available online at: http://demographicestimation.iussp.org/

Available in PDF: http://demographicestimation.iussp.org/content/get-pdf-book-website

Indirect techniques – Main packages

MORTPAK – The United Nations software package for demographic measurement, available online: http://www.un.org/en/development/desa/population/publications/mortality/mortpak.shtml

Excel templates provided with each chapter of Moultrie et al. (2013), available online: http://demographicestimation.iussp.org/

Direct and indirect techniques

"The problem of estimating demographic measures from incomplete data is a challenging one, one for which there is no universal answer and one which therefore requires in the demographer the qualities of resourcefulness and imagination."

(Pollard et al. 1990: 164)

References

Brass, W. (1985), *Advances in Methods for Estimating Fertility and Mortality from Limited and Defective Data,* London: Centre for Population Studies, London School of Hygiene and Tropical Medicine.

Feeney G. (2003), "Data assessment", in Demeny, P & G McNicoll (eds). *Encyclopaedia of Population*. Vol. 1. New York: Macmillan Reference USA, pp. 190-193.

IUSSP & UNFPA (n.d.), *Population Analysis for Policies and Programmes*, Paris: IUSSP and UNFPA, available online at: http://papp.iussp.org/ (last accessed 1 December 2014).

McFalls, J.A. Jr. (2007), *Population: A Lively Introduction*, 5th edition, Washington D.C., Population Reference Bureau.

Pollard, A.H., Y. Farhat & G.N. Pollard (1990), *Demographic Techniques*, 3rd edition, Sydney: Pergamon Press.

Preston, S., P. Heuveline & M. Guillot (2001), *Demography: Measuring and Modeling Population Processes*, Oxford: Blackwell Publishers Ltd.

United Nations (2008). *Principles and Recommendations for Population and Housing Censuses, Revision 2.* New York: United Nations, DESA.

UNPD (United Nations Population Division) (2013), *World Population Prospects: The 2012 Revision*, New York, DESA, Population Division, available online at: http://esa.un.org/unpd/wpp/index.htm (last accessed 1 December 2014).

UNSD (United Nations Statistics Division) (2012), *Coverage of Birth and Death Registration* [electronic resource], New York: United Nations, DESA, Statistics Division, available online at: http://unstats.un.org/unsd/demographic/CRVS/CR_coverage.htm (last accessed 2 December 2014)

Thank you

ကျေးဇူးတင်ပါတယ်။

Questions/comments?

>> until 12 December:

>> After 12 December: **spoorenberg@un.org**