

P25 LAT3072-1 Demography

Actuarial Sciences

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2. Age and sex structure

P25 13/01 - 09/05

1 Age and sex structure

- The interdependence of population structure and vital events
- The measurement of age
- Population pyramids
- Sex ratio
- Dependency ratios
- Factors Shaping Age and Sex Structure in Populations

Introduction

Exploring Age and Sex Structure in Demography

In demography, understanding the connection between age and sex is essential for analyzing population dynamics.

- 1 **Population Structure:** This refers to how people are distributed by age and sex (male and female) within a population.
- 2 **Vital Events:** Events such as births, deaths, and migration that directly influence the population's size and composition.

Key Point: The interaction between age, sex, and vital events helps explain changes in population size and structure over time.

Introduction

Dynamic Relationship Between Population Structure and Vital Events

From Structure to Vital Events: The age and sex distribution influences vital events. Examples:

- Birth rates depend on the number of women in reproductive age.
- Mortality rates are higher among older age groups.

Vital events shape the population structure over time. Examples:

- Births increase the younger population.
- Migration can alter age and sex composition.

Key Insight: Understanding this continuous feedback between structure and events is essential for analyzing population dynamics.

Outline

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Structure and vital events

Understanding the Likelihood of Demographic Events

Births, deaths, and migrations do not occur uniformly across all individuals. The probability of these events is influenced by two primary factors: Age and Sex.

- For example, it is nearly impossible for individuals beyond a certain age to give birth.
- Furthermore, the likelihood of these events differs based on whether the individual is male or female.
- Mortality rates are closely tied to age: Generally, older individuals have a higher likelihood of dying compared to younger individuals.

Structure and vital events

Vital events and their likelihood to occur

Mortality risk also varies by sex

- Generally, males have a higher likelihood of dying than females across nearly all age groups.

Also, Migration patterns shift throughout life!

- People are more likely to migrate between the ages of 20 and 40, often influenced by life cycle stages^a.
- Migration may also be influenced, to some extent, by whether an individual is male or female.

^aPeople at this age is more free to move while having no kids and looking for better professional, academic or job opportunities. However, old people (65+) often emigrate for health reasons (e.g., to go to warmer climates or to sea level). In any case, political or war situations can drive massive or constant migratory movements of all ages.

Structure and vital events

Vital events and their likelihood to occur

It becomes evident that the number of births, deaths, and migrations in a population depends not only on its size but also on its age and sex structure.

- A key goal of formal demography is to develop measures that account for these factors, removing the effects of population size and age structure.
- In other words, we aim to create "pure" measures of mortality, fertility, and migration.

Structure and vital events

Vital events and their likelihood to occur

For example, according to the CDC (Centers for Disease Control and Prevention), in 2019, there were 2,854,838 deaths in the United States, compared to 418,703 in Spain. Can we conclude from these numbers that mortality is more severe in the U.S. than in Spain?

Structure and vital events

Vital events and their likelihood to occur

The answer is 'no'.

- At that time, the U.S. population exceeded 328 million, while Spain's population was around 47 million, making it **natural to expect more deaths in the larger population!**
- To accurately assess mortality, we need to account for population size and **eliminate the effects of size differences.**

Any ideas on how we might do this?...

Structure and vital events

Shots to the future

Also, the **current structure** of a population is shaped by its **history**, meaning it reflects past patterns of fertility, mortality, and migration.

- For instance, **high fertility rates** during a period will result in a generation later having a **comparatively large number of women of childbearing age**.
 - This, in turn, could lead to a **higher number of births than before**.
- Similarly, **significant migration or high mortality**—such as that caused by war—**tends to reduce the population of young adult males**.
 - As a result, this will lead to a **relatively small number of elderly men in the future**, perhaps 50 years later.

Structure and vital events

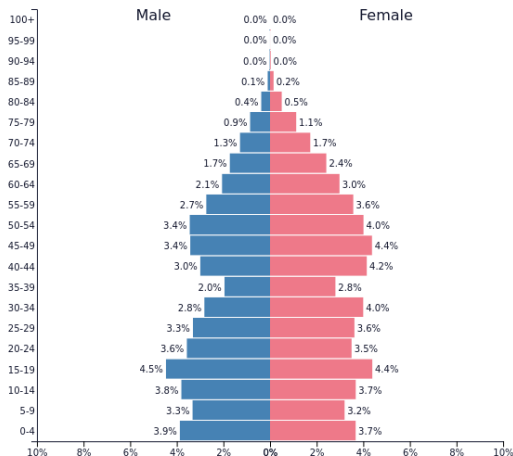


Figure: Population pyramid of Germany, 1955. Population: 70,334,152. Source: *populationpyramid.net*.

Structure and vital events

Shots to the future

- **World War I (1914-1918):** There was a notable decrease in births during the conflict, **as many men were at war and the economic situation was unstable**. This created a "gap" in the base of the pyramid for those born during those years.
- **World War II (1939-1945):** A significant decline in births is seen during this conflict. Additionally, the high mortality rates among young men in combat created an "imbalance" in the pyramid, with fewer men than women in those cohorts.
- **Postwar Effect:** After both wars, especially after World War II, there was a visible "baby boom", marked by **an expansion of the base of the pyramid in the 1950s^a**.

^aThis surge in births, which lasted until 1964, was driven by the **economic recovery and social stability** that followed the war, creating an environment that encouraged family growth and higher birth rates.

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Measuring age

Age last birthday

Understanding Age Measurement in Demography

When someone says, "I'm 25," they mean they've already celebrated their 25th birthday but haven't yet reached their 26th. **This way of measuring is what demographers refer to as 'age last birthday'.**

- If you think about it, this method is somewhat unusual when compared to how we measure other quantities like height, weight, or distance.
- Typically, these measurements are rounded to the nearest integer.
 - e.g, when someone says "25 meters", they mean the actual length is somewhere between 24.5 and 25.5 meters.

Measuring age

Exact age

The Uniqueness of Age Measurement

- In contrast to other measurements, **age is always rounded down**.
 - When someone says, "I'm 25" it means **his age is somewhere between 25 and 26 years**.

To avoid confusion, demographers use the term '**exact age**' to differentiate it from '**age last birthday**'.

Age misreporting

Distortions in Age Distribution

Distortions in age distribution can arise from several factors, including:

- Real factors such as historical levels of mortality, fertility, or migration.
- Misreporting of age, which can occur for two main reasons:
 - **Unintentional Misreporting**: People may genuinely not know their exact age.
 - **Intentional Misreporting**: Individuals might deliberately provide incorrect age information for various reasons.
- While age misreporting **is less problematic in developed societies**, it can be **a significant issue in less literate communities**.

Such misreporting often leads to **implausible or surreal age distributions** that do not accurately reflect the true population structure.

Age misreporting

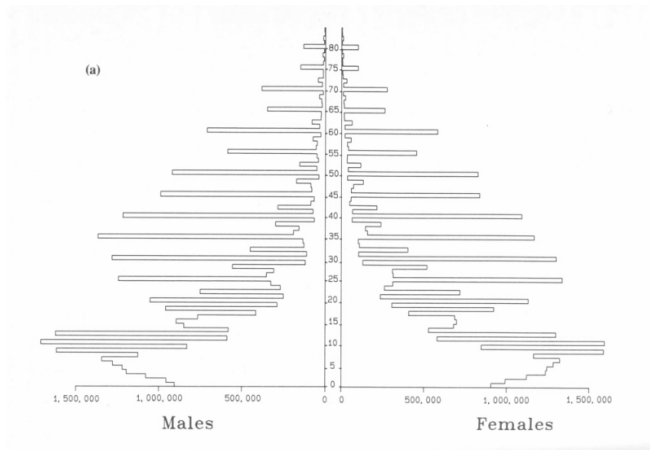


Figure: 1. (Uncorrected) population pyramid of Bangladesh, 1974.

Age misreporting

Age Structure Distortions: Bangladesh, 1974

The last figure displays the uncorrected age structure of Bangladesh in 1974, revealing **an unusual pattern caused by digit preference and shifting**. Reasons for Digit Preference and Shifting:

- **Exaggeration by Older Individuals:** In societies where age confers status or perceived merit, **older people may inflate their age**.
- **Young Men:** To avoid military service, **young men might understate or overstate their age**.
- **Young Mothers:** In certain societies, it is common for **young mothers to exaggerate their age**.
- **Unmarried Older Women:** In certain societies, **older, unmarried women may understate their age**.
- **Lack of Age Knowledge:** In the past or in very remote and underdeveloped areas, **people may not know their exact age, leading interviewers to estimate**.

Whipple's Index

Whipple's Index: Measuring Age Preference

One straightforward method to assess preference for ages ending in 0 and 5 is **Whipple's Index**. Here's how it works:

- 1. Count the number of individuals aged 23 to 62 who report ages ending in 0 or 5.
- 2. Divide this count by the total number of people aged 23 to 62.
- 3. Adjust the Result: Multiply the result by 5. For easier interpretation, it is often multiplied by 100.

Purpose: Whipple's Index helps to quantify how much more common certain ages (ending in 0 or 5) are reported compared to other ages, **revealing any preference for these "round" ages.**

Estimating reliability of age data

Quality	Whipple's Index	Deviation from perfect
Highly accurate	< 105	< 5
Fairly accurate	$105 - 110$	$5 - 9.99$
Approximate	$110 - 125$	$10 - 24.99\%$
Rough	$125 - 175$	$25 - 74.99\%$
Very rough	> 175	$\geq 75\%$

Table: 1. UN scores for estimating and interpreting reliability of age data

Bangladesh's Whipples's Index

Whipple's index for Bangladesh, 1974

For the population of Bangladesh, 1974, the Whipple's Index is

$$\frac{\text{Pop. } \{25, 30, 35, \dots, 60\}}{\text{Pop } \{23 - 62\}} = \frac{15,911,386}{25,175,563} = 0.632.$$

Multiplying that number by 5 and by 100:

$$0.632 * 5 * 100 = 316.0$$

Bangladesh's Whipples's Index

Whipple's index for Bangladesh, 1974

The data for Bangladesh in 1974, as shown in the previous table, **is extremely rough!**

- More sophisticated measures for age heaping include the **Myers' Blended Index**.
- Myers' Blended Index is notably more complex than Whipple's Index, offering a preference score for each terminal digit as well as an overall measure (see, e.g., Shyrock and Siegel, 1976:116-18).

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Population pyramids

Population Pyramids

Population pyramids are graphical tools used to illustrate the distribution of a population by age and sex.

- They are termed "pyramids" due to their shape, which, in the past, typically resembled a pyramid.
- The base of the pyramid represents the younger segments of the population, while the top indicates the older segments.

Population pyramids

Population Pyramids

When constructing population pyramids, certain conventions are followed:

- 1. Males are represented on the left, and females on the right.
- 2. The younger age groups are shown at the bottom, while the older age groups are at the top.
- 3. Age groups are typically organized in single-year or **five-year intervals**, **although other groupings are possible** but less common.
- 4. The bottom scale can represent either absolute numbers (actual amounts) or relative numbers (percentages).
- 5. When using percentages, **they should be based on the total population of both sexes combined** to avoid distorting the pyramid's representation.

To effectively compare the age structures of **two populations with significantly different sizes**, a **percentage pyramid** is most appropriate.

Bangladesh population pyramids

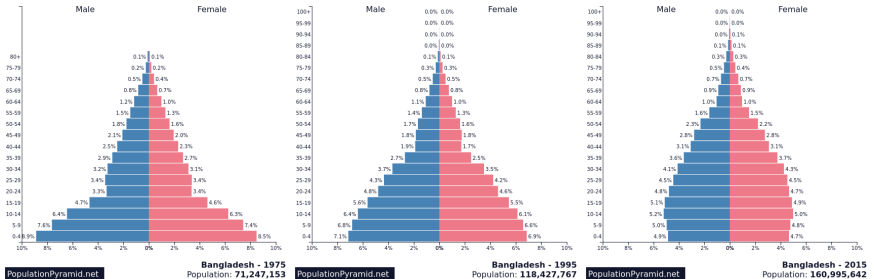


Figure: 2. Bangladesh population pyramids:1975, 1995, 2015. Source: populationpyramid.net

Single and five year grouping

A one-year or five-year grouping?

When should you use single-year or five-year age groupings? This choice is important as it affects the pyramid's pattern.

- Notice that a population pyramid is essentially two histograms, so interval choices can significantly alter the observed structure.
 - Too many intervals (e.g., single-year groups) can create excessive noise, while too few (e.g., more than five years) can result in a flat, uninformative structure.
 - In some actuarial contexts, one-year brackets are essential.

Typically, five-year groupings strike a balance, offering a clear view without excessive noise or flattening.

Single and five year grouping

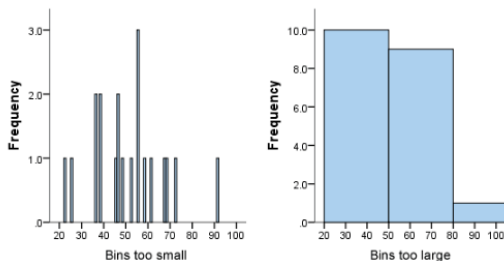


Figure: 3. Histogram constructed on the same data, but (left) with too many bins (small bin width) or too few beins (large bin width).

Single and five year grouping

A one-year or five-year grouping?

The pattern of a population pyramid reveals the age and sex distribution of a population.

- A youthful age structure, like that of Bangladesh in 1975, produces a pyramid with a broad base and a roughly triangular shape.
- An older age structure results in a more rectangular pyramid with a relatively narrow base.

Analysis of the pyramids from 1975 and 1995 suggests that Bangladesh was moving towards a more rectangular shape in the years that followed.

Angola and Japan nowadays

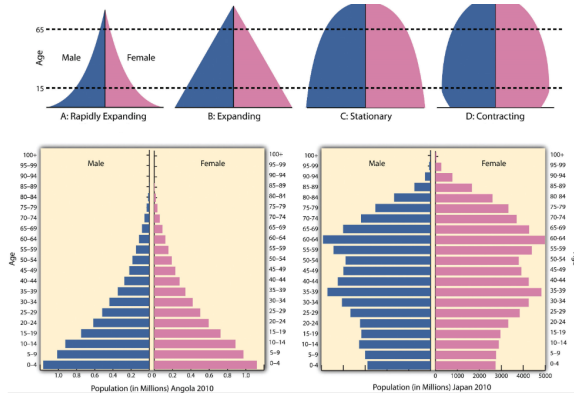


Figure: 4. Comparison of Angola and Japan pyramids, 2010. Left: Angola, *rapidly expanding*. Right: Japan, *contracting*. Middle stages are *expanding* and *stationary*.