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COM 302

INTRODUCTION TO DEMOGRAPHY AND VITAL STATISTICS

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Course title: Introduction to Demography and Vital Statistics

Course credit load: 2 Units

Series 1: Sources of Population Data

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Introduction

Every meaningful statement about population health rests on data. Whether a government is planning how many hospitals to build, where to deploy community health workers, or how to respond to an outbreak, it needs reliable information about how many people live where, how old they are, and how the population is changing. Demography is the science that provides this foundation, and the quality of demographic data determines the quality of the health decisions made from it.

The aim of this Series is to introduce you to the science of demography, to identify and evaluate the main sources from which population data are obtained, and to examine how the quality of that data affects its use in public health planning.

We shall commence by defining demography and its core concepts. Next, we will examine the national population census as the primary source of population data in Nigeria. Moving on, we will survey the other major sources including civil registration, surveys, and administrative records. Finally, we will close by examining how the quality and completeness of population data are assessed and how the data are used in health planning.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 1.1** define demography and explain its scope and importance in public health,
- **SLO 1.2** describe the basic demographic concepts of population, cohort, and demographic transition,
- **SLO 1.3** define a national population census and describe its purposes, methods, and history in Nigeria,
- **SLO 1.4** identify and describe the limitations and common errors in census data,
- **SLO 1.5** describe civil registration, sample surveys, and administrative records as sources of population data,
- **SLO 1.6** evaluate the completeness and accuracy of population data, and
- **SLO 1.7** explain how population data are used in health system planning and resource allocation.

1.1 Introduction to Demography

1.1.1 Definition and scope of demography

Demography is the scientific study of human populations, including their size, structure, distribution, and the processes that change them over time: **fertility** (births), **mortality** (deaths), and **migration**. The word derives from the Greek demos (people) and graphos (writing or description). Demography is both a descriptive and an analytical discipline: it describes the current state of a population and analyses the forces that drive change, generating the evidence base for policy and planning decisions at every level of government.

The scope of demography spans **formal demography**, which focuses on mathematical and statistical analysis of population data, and **social demography**, which examines the social, economic, and political determinants and consequences of demographic change. For health professionals, demography provides the population denominator for all health rates and indicators, identifies the groups at greatest risk of disease or death, and generates the projections on which health workforce planning, facility planning, and programme budgeting depend.

Fill in the blank: Demography is the scientific study of human populations, including their size, structure, distribution, and the three processes of fertility, _____ , and migration that drive change over time.

1.1.2 Importance of demography in public health

Public health cannot function without demographic data. Every epidemiological rate, from the infant mortality rate to the prevalence of hypertension, requires a population denominator. Without knowing how many people of what age and sex live in an area, it is impossible to calculate rates, set targets, or evaluate whether interventions are working. Demographic data also identify **at-risk groups**: knowing that a district has a rapidly growing adolescent population, for example, directs resources toward reproductive health and adolescent services.

Demographic projections are the basis of **health workforce planning** and **facility planning**. A district health plan based on the current population without accounting for projected growth may result in facilities that are inadequate within five years of opening. In Nigeria, where population growth rates have been among the highest in the world, demographic projections are critical for anticipating the health needs of a population that may double in size within a generation. Decision-makers who ignore demography plan for the population they imagine rather than the population that exists or will exist.

Fill in the blank: Every epidemiological rate requires a population _____ ; without knowing how many people of what age and sex live in an area, rates cannot be calculated and interventions cannot be evaluated.

1.1.3 Basic demographic concepts

Several fundamental concepts provide the vocabulary of demography. A **population** is a defined group of people sharing a geographic or other characteristic at a specified time. A **cohort** is a group of individuals who share a common experience in the same time period, such as all persons born in the same year (a **birth cohort**) or all persons who married in the same year. A **period** measure reflects the experience of the whole population at a given point in time, while a **cohort** measure follows a specific group over time.

The **demographic transition** describes the shift that occurs as countries develop, from high fertility and high mortality (stable but stagnant population) through a period of falling mortality with continued high fertility (rapid population growth) to low fertility and low mortality (stable but ageing population). Nigeria is in the middle phase: mortality, particularly child mortality, has fallen, but fertility remains high, producing rapid population growth. Understanding where a country sits in the demographic transition explains much about its current health challenges and future demographic trajectory.

Fill in the blank: The _____ transition describes the shift from high fertility and high mortality through rapid growth to low fertility and low mortality as countries develop; Nigeria currently sits in the phase of falling mortality with persistently high fertility.

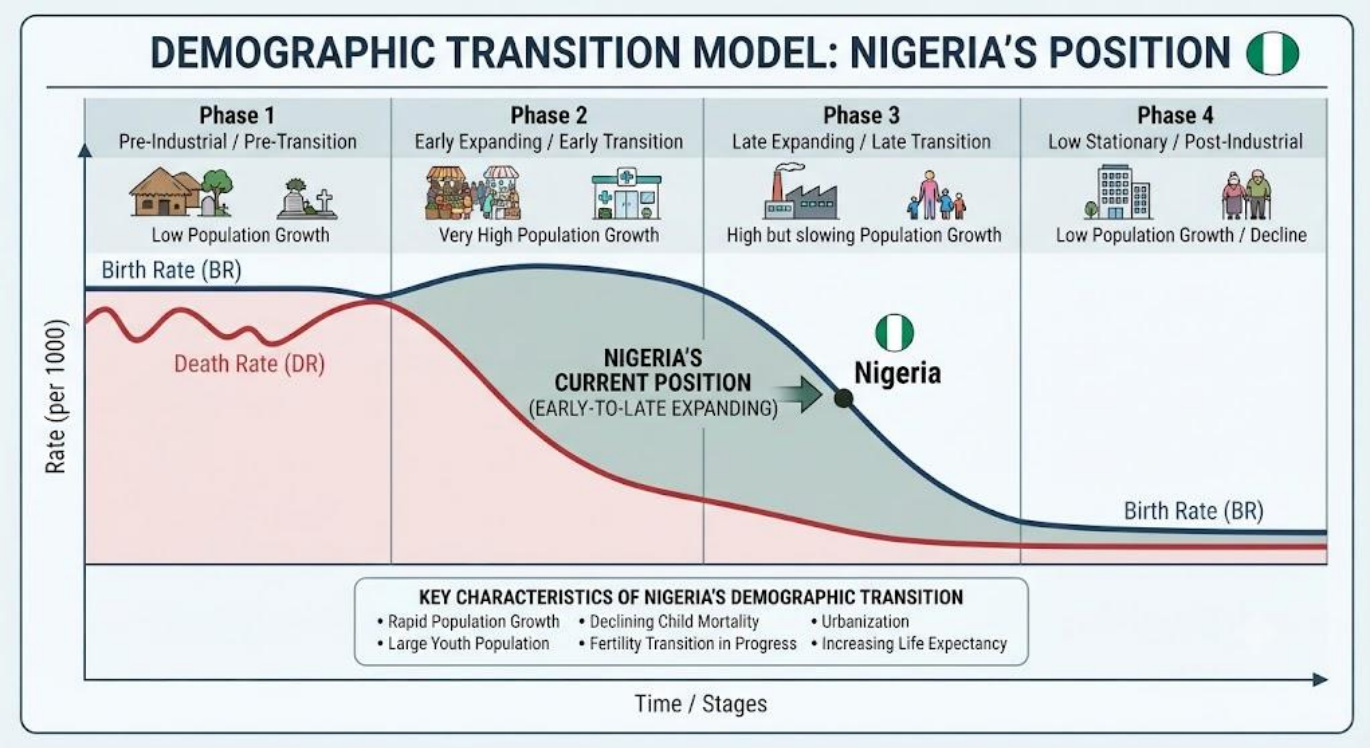

Figure 1.1: The demographic transition model

Pilot questions 1.1

1. Define demography.
2. Name the three processes that change population size.
3. Distinguish between formal demography and social demography.
4. Why does public health depend on demographic data?
5. Define the demographic transition and state which phase Nigeria currently occupies.

1.2 The National Population Census

1.2.1 Definition, purpose, and history of the census in Nigeria

A **national population census** is the total process of collecting, compiling, evaluating, analysing, and publishing demographic, economic, and social data pertaining to all persons in a country at a specified time. It is distinguished from a sample survey by its aim of universal coverage: every person present in the country on census night should be enumerated. The census serves multiple purposes: it provides the **population denominator** for all national statistics, determines the distribution of electoral seats and government revenue, guides infrastructure and social service planning, and provides baseline data for intercensal estimates and projections.

Nigeria has conducted several national censuses since independence, with counts in 1963, 1973 (annulled), 1991, and 2006; the most recent census was conducted in 2023 under the National Population Commission (NPC). Nigerian census history has been politically contentious because census results determine the allocation of federal revenues and political representation among states and ethnic groups. The 1973 census was annulled due to irregularities; the 1991 and 2006 censuses were also disputed. These political dimensions of the census are a uniquely Nigerian challenge that affects the reliability and acceptance of census data.

Fill in the blank: A national population _____ aims to enumerate every person present in a country at a specified time and provides the population denominator for all national statistics and the basis for revenue and political seat allocation.

1.2.2 Methods and organisation of a census

Two principal methods are used to conduct a census. The **de facto** method counts people where they are physically present on census night, regardless of their usual residence. The **de jure** method counts people at their usual place of residence, regardless of where they happen to be on census night. Nigeria has used the de facto method in recent censuses. Each method has advantages: de facto is simpler to administer since enumerators count whoever is present; de jure provides more useful information for planning since it reflects where people normally live.

A census is conducted in three phases: **preparatory** (mapping of enumeration areas, recruitment and training of enumerators, printing of questionnaires), **enumeration** (actual data collection in the field, typically over 7 to 14 days), and **post-enumeration** (data entry, processing, analysis, and publication). In Nigeria, the National Population Commission is responsible for census planning and execution. A **Post-Enumeration Survey (PES)** is typically conducted shortly after the census to estimate its coverage and accuracy by matching a sample of the population against the census records.

Fill in the blank: The _____ census method counts people where they are physically present on census night, regardless of their usual place of residence, and is the method used by Nigeria in recent censuses.

1.2.3 Limitations and errors in census data

Census data are subject to several types of error. **Coverage errors** occur when individuals are omitted from the count (undercount) or counted more than once (overcount). In Nigeria, undercounting is more common than overcounting and disproportionately affects remote rural communities, nomadic populations, slum dwellers, and young men. **Content errors** occur when recorded information is incorrect: age misreporting is particularly common, with many Nigerians rounding their age to a number ending in 0 or 5, producing a pattern called **age heaping**.

Political inflation of census counts, where communities or local officials exaggerate population figures to secure greater revenue allocation or political representation, is a documented problem in Nigerian census history. This, combined with geographic and infrastructural challenges (poor road access, security constraints in some regions), means that Nigerian census data should always be used alongside evaluation procedures to assess and adjust for known errors before application in health planning.

Fill in the blank: _____ heaping is a form of content error in census data where respondents round their age to a number ending in 0 or 5, distorting the reported age distribution of the population.

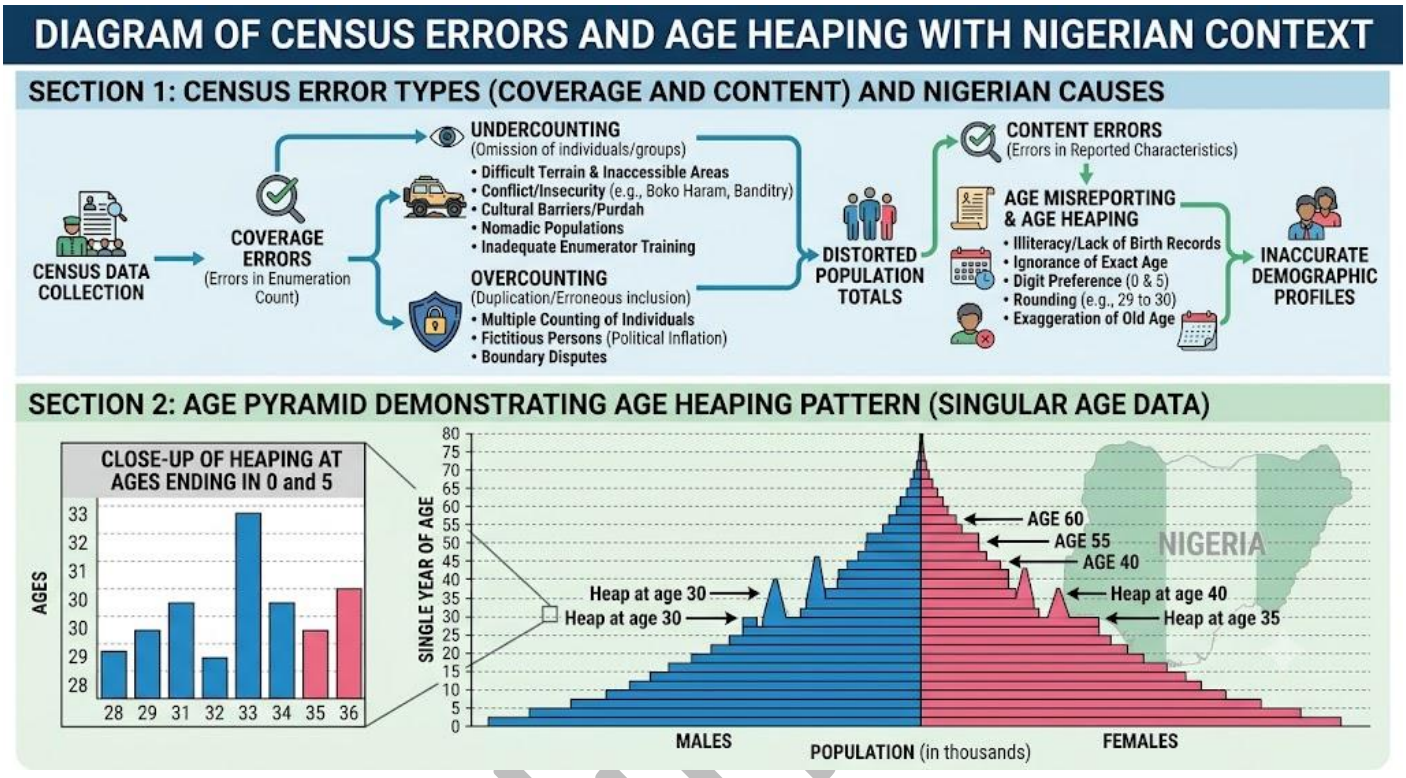

Figure 1.2: Sources of census errors and their effects on population data

Pilot questions 1.2

1. Define a national population census.
2. Distinguish between the de facto and de jure census methods.
3. Name the three phases of census organisation.
4. What is a Post-Enumeration Survey and what is its purpose?
5. Define age heaping and explain why it is a problem for demographic analysis.

1.3 Other Sources of Population Data

1.3.1 Civil registration systems

Civil registration is the continuous, permanent, compulsory, and universal recording of vital events (births, deaths, marriages, divorces, and stillbirths) as they occur, by a government authority. A functioning civil registration system produces the most timely and detailed population data available, generating continuous records of the vital events that change population size between censuses. In countries with complete civil registration, birth and death records provide the numerators for all vital rates without the need for surveys or estimation.

Nigeria does not have a complete civil registration system. The **National Population Commission** is responsible for vital events registration, but coverage remains far below universal. Estimates suggest that fewer than 30% of births and a much smaller proportion of deaths are registered in Nigeria. Low coverage reflects multiple barriers: limited awareness of the registration obligation, distance from registration offices, cost of the process, and limited consequences of non-registration. This gap in civil registration means that Nigeria must rely on alternative sources for vital statistics, with all the attendant estimation uncertainties.

Fill in the blank: Civil _____ is the continuous, permanent, compulsory recording of vital events such as births, deaths, and marriages by a government authority; Nigeria currently registers fewer than 30% of births.

1.3.2 Sample surveys and demographic surveys

Where civil registration is incomplete, **population-based sample surveys** provide the primary source of vital statistics. The **Nigeria Demographic and Health Survey (NDHS)** is conducted approximately every five years and provides nationally and regionally representative data on fertility, mortality, child health, nutrition, and HIV/AIDS. The **Multiple Indicator Cluster Survey (MICS)**, conducted by UNICEF, provides additional data on child welfare and maternal health indicators. These surveys use stratified cluster sampling to achieve national representativeness with manageable sample sizes.

Sample surveys have important advantages over the census for demographic analysis: they can collect more detailed information on behaviours and characteristics, they can be updated more frequently than the decennial census, and they can use standardised questionnaires that enable international comparisons. Their limitation is **sampling error**: estimates from a sample always carry uncertainty that must be quantified through confidence intervals. For small geographic areas (below the state level in Nigeria), surveys are often too small to provide reliable estimates, limiting their usefulness for subnational health planning.

Fill in the blank: The Nigeria Demographic and Health _____ is conducted approximately every five years and provides nationally representative data on fertility, mortality, child health, and nutrition.

1.3.3 Administrative records and population registers

Administrative records generated by government agencies and health facilities provide supplementary population data. Health facility records (outpatient registers, antenatal attendance registers, immunisation records) provide data on service utilisation and can serve as a proxy for health need. School enrolment records provide data on the child population. National identity databases, voter registration lists, and social protection beneficiary registers each provide partial coverage of the population, though each covers only those who have registered for a specific purpose and may not be representative.

A **population register** is a system in which every resident is continuously registered and updated, providing a real-time database of the population. True population registers are uncommon in Africa; they function best in small, highly administered countries with complete civil registration. Nigeria does not have a functioning population register, though the National Identity Management Commission (NIMC) **National Identity Database** is developing toward this function. When different administrative data sources are linked, a process called **data linkage**, the combined dataset can provide more comprehensive population information than any single source.

Fill in the blank: A population _____ is a continuously updated system recording every resident; most African countries, including Nigeria, lack this system and rely instead on censuses, surveys, and administrative records.

COMPARISON OF POPULATION DATA SOURCES IN NIGERIA

DATA SOURCE	COVERAGE	FREQUENCY	DATA TYPE	STRENGTHS	LIMITATIONS
CENSUS 	National, complete enumeration of all individuals and households. (e.g., The proposed 2023 Nigeria National Population and Housing Census).	Decennial (every 10 years), ideally. (e.g., Past censuses in 1991, 2006).	Detailed demographic, socio-economic, and housing data. (e.g., Age, sex, education, occupation, dwelling type).	Provides comprehensive, spatially disaggregated data; baseline for all demographic indicators.	High cost, logistical complexity; risk of undercounting or overcounting; data becomes outdated over time. Example: "National Population Commission (NPC) Census"
CIVIL REGISTRATION 	Continuous recording of vital events. (e.g., Births, deaths, marriages, divorces).	Continuous, real-time.	Individual-level records of specific events. (e.g., Birth registration, death certificate).	Provides real-time data; accurate for calculating fertility and mortality rates.	Under-registration in some areas; reliance on public compliance and functioning infrastructure. (e.g., Incomplete data in rural Nigeria), rural Nigeria). "National Population Commission (NPC) Birth & Death Registration"
SURVEYS 	Sample-based, representative of the population. (e.g., National or sub-national).	Periodic, ad-hoc (e.g., Every 3-5 years). (e.g., Nigeria Demographic and Health Survey - NDHS, General Household Survey - GHS).	Focused on specific topics, in-depth. (e.g., Health, income, employment, agriculture).	Flexible, cost-effective; provides high-quality, specialized data.	Sampling errors; data may not be as spatially detailed as a census. Example: "Nigeria Demographic and Health Survey (NDHS)"
ADMINISTRATIVE RECORDS 	Data collected for administrative purposes, often specific populations or areas. (e.g., Health, education, voters' register).	Continuous, as events occur.	Event-based, operational. (e.g., School enrollment, patient records, passport issuance).	Readily available, low additional cost; good for monitoring specific programs.	Not designed for demographic analysis; data quality varies; incomplete population coverage. (e.g., Inconsistent data across states). "Independent National Commission (INEC) Voter Register"

Figure 1.3: Sources of population data: a comparative overview

Pilot questions 1.3

1. Define civil registration.
2. What proportion of births are registered in Nigeria and what barriers explain this?
3. What is the NDHS and what data does it provide?
4. Name one advantage and one limitation of sample surveys compared to the census.
5. What is data linkage and why is it useful for population analysis?

1.4 Quality, Coverage, and Use of Population Data

1.4.1 Completeness and accuracy of population data

Two dimensions of data quality are most critical for demographic analysis. **Completeness** (also called **coverage**) refers to the proportion of the target population that is actually captured in the data source. A census with 90% coverage has missed 10% of the population; if the missed 10% are disproportionately young children or rural dwellers, the data will systematically misrepresent the population structure. **Accuracy** refers to whether the recorded values for captured individuals are correct: a census that counts every person but records their ages incorrectly has high coverage but low accuracy.

Standard demographic techniques are used to assess completeness and accuracy. **Age-sex ratios** compare the number of persons of each sex at each age against expected values; deviations signal either enumeration errors or content errors. **Whipple index** and **Myers blended index** quantify the degree of age heaping in a dataset. **Intercensal growth rates** are compared with expected values from mortality and fertility estimates; implausible growth rates signal census errors. These evaluation techniques allow users to identify the most problematic components of a dataset before using it for planning.

Fill in the blank: The _____ index and Myers blended index are demographic techniques used to quantify the degree of age heaping in a population dataset, identifying inaccuracy in reported ages.

1.4.2 Evaluating and adjusting population data

When population data are found to be incomplete or inaccurate, demographic techniques can be used to **adjust** them before use. **Smoothing** techniques replace irregular age distributions (produced by age heaping) with smoother distributions that more closely reflect the true underlying pattern. **Intercensal estimation** uses two successive census counts, combined with mortality and fertility assumptions, to produce population estimates for the years between censuses. **Population projections** extend estimates into the future using assumptions about future fertility, mortality, and migration trends.

The **Brass indirect estimation** techniques, developed for populations without complete vital registration, allow fertility and mortality rates to be estimated from census data on children ever born and children surviving. These methods have been widely applied in sub-Saharan Africa, including Nigeria, and provide the most reliable estimates of fertility and child mortality where direct registration data are absent. Understanding the assumptions and limitations of these techniques is important for critical use of demographic estimates in health planning.

Fill in the blank: _____ indirect estimation techniques allow fertility and mortality rates to be estimated from census questions about children ever born and children surviving, developed specifically for populations without complete vital registration.

1.4.3 Uses of population data in health planning

Population data underpin every major decision in health system planning. **Target population estimation** uses population data to determine how many people in a defined area need a specific service: how many pregnant women require antenatal care, how many children require immunisation, how many older adults require hypertension management. Without accurate population data, these targets are guesses rather than estimates, leading to either over-provision (wasted resources) or under-provision (unmet need) of services.

Health facility catchment area analysis uses population data to determine whether existing facilities are sufficient and appropriately distributed for the population they serve. **Epidemiological surveillance** uses denominator data to calculate disease incidence and prevalence. **Health workforce planning** uses population projections to estimate future service demand and required staffing levels. **Programme evaluation** uses population data to calculate coverage rates for interventions such as immunisation, skilled birth attendance, and HIV treatment. In each case, the quality of the population data directly determines the quality of the planning decision.

Fill in the blank: _____ population estimation uses population data to determine how many people in a defined area require a specific health service, providing the basis for resource allocation and target-setting in health planning.

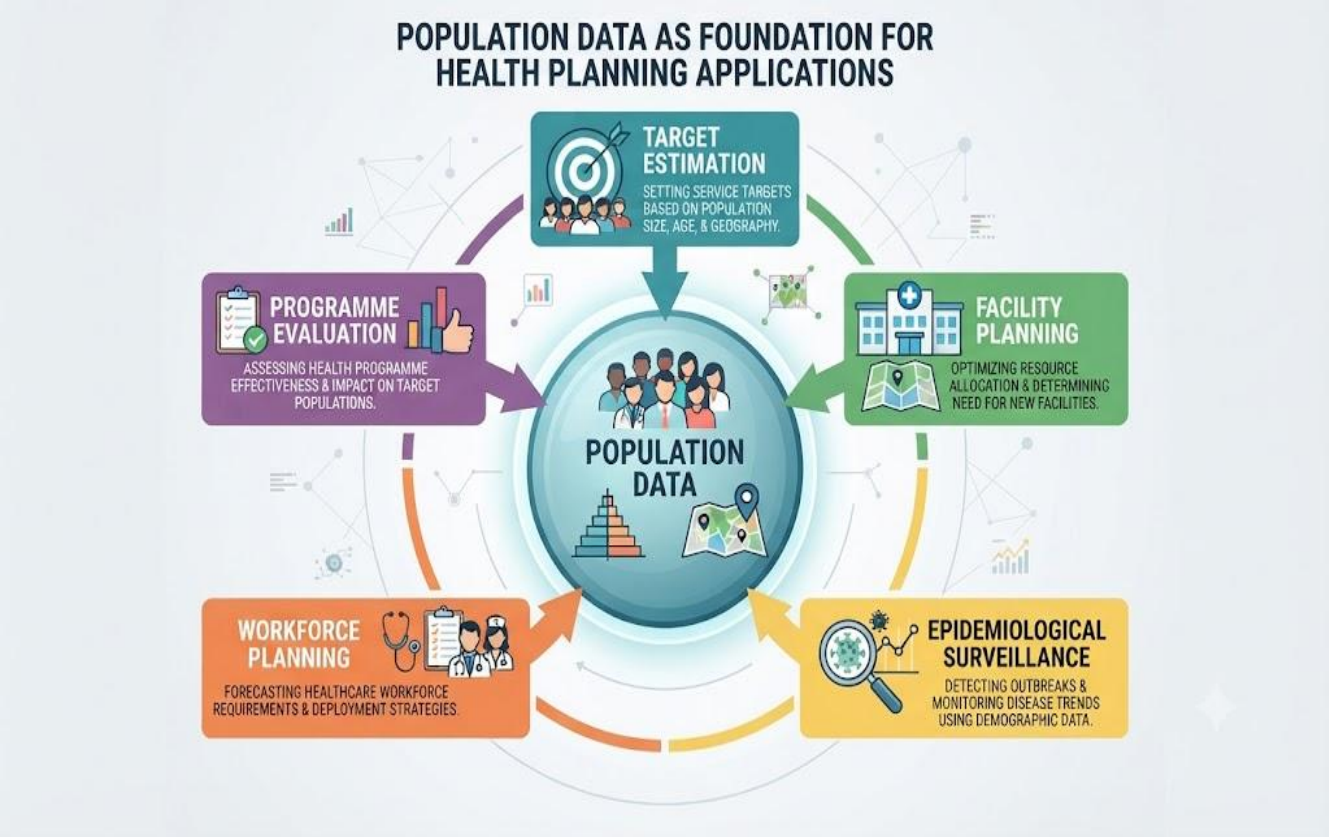

Figure 1.4: Uses of population data in health system planning

Pilot questions 1.4

1. Distinguish between completeness and accuracy as dimensions of data quality.
2. What does the Whipple index measure?
3. What is intercensal estimation and why is it needed?
4. What are Brass indirect estimation techniques?
5. Name three uses of population data in health system planning.

Series Summary

This Series introduced demography as the scientific foundation of population health and examined the major sources from which population data are obtained. Demography was defined through its core concepts: population, cohort, fertility, mortality, migration, and the demographic transition. The national population census was described as the primary source of population data in Nigeria, covering its purposes, methods (de facto versus de jure), organisational phases, and the characteristic errors, including age heaping and political inflation, that affect Nigerian census data.

Civil registration, sample surveys (particularly the NDHS and MICS), and administrative records were described as supplementary and alternative sources of population data, each with distinct strengths and limitations. The quality dimensions of completeness and accuracy were examined alongside the demographic techniques used to evaluate and adjust data. The Series concluded by establishing how population data support target estimation, facility planning, epidemiological surveillance, workforce planning, and programme evaluation in the health system, demonstrating that data quality is inseparable from planning quality (SLOs 1.1 to 1.7).

Glossary of Terms

- **Age heaping:** the tendency of survey or census respondents to report ages rounded to numbers ending in 0 or 5, distorting the age distribution.
- **Census:** the total process of collecting, compiling, and publishing demographic data on every person in a country at a specified time.
- **Civil registration:** the continuous, permanent, compulsory recording of vital events (births, deaths, marriages) as they occur.
- **Cohort:** a group of individuals who share a common experience in the same time period, such as birth in the same year.
- **De facto census:** a census that counts people where they are physically present on census night.

- **De jure census:** a census that counts people at their usual place of residence, regardless of where they are on census night.
- **Demographic transition:** the historical shift from high fertility and high mortality to low fertility and low mortality as countries develop.
- **Demography:** the scientific study of human populations, including their size, structure, distribution, and the processes of fertility, mortality, and migration.
- **NDHS (Nigeria Demographic and Health Survey):** a nationally representative sample survey conducted approximately every five years, providing data on fertility, mortality, and health indicators.
- **Post-Enumeration Survey:** a survey conducted after a census to estimate its coverage and accuracy by matching a sample against the census records.
- **Whipple index:** a demographic measure of age heaping, calculated from the proportion of the population reporting ages between 23 and 62 that end in 0 or 5.

Concept Check Questions [Series 1]

Objective questions

1. Demography is the scientific study of human populations, including their size, structure, distribution, and the processes of fertility, _____ , and migration. (Linked to SLO 1.1)
2. The _____ transition describes the historical shift from high fertility and high mortality to low fertility and low mortality as countries develop. (Linked to SLO 1.2)
3. A national population census that counts people where they are physically present on census night uses the _____ method. (Linked to SLO 1.3)
4. _____ heaping is a content error in census data where respondents report ages rounded to numbers ending in 0 or 5. (Linked to SLO 1.4)
5. The Nigeria Demographic and Health Survey (NDHS) is conducted approximately every _____ years and provides nationally representative health and demographic data. (Linked to SLO 1.5)
6. The _____ index and Myers blended index quantify the degree of age heaping in a population dataset. (Linked to SLO 1.6)

Short-answer questions

7. Explain why public health cannot function without demographic data, giving two specific examples. (Linked to SLOs 1.1, 1.7)
8. Distinguish between the de facto and de jure census methods, and describe two limitations of Nigerian census data. (Linked to SLOs 1.3, 1.4)
9. Compare civil registration and sample surveys as sources of population data in Nigeria. (Linked to SLO 1.5)

Long-answer questions

10. Define demography, explain the demographic transition, and discuss its implications for health planning in Nigeria. (Linked to SLOs 1.1, 1.2, 1.7)
11. Evaluate the national population census as a source of population data, covering its purpose, methods, limitations, and the techniques used to assess and adjust for its errors. (Linked to SLOs 1.3, 1.4, 1.6)

12. Discuss the alternative sources of population data available in Nigeria and assess their strengths and limitations for health planning purposes. (Linked to SLOs 1.5, 1.6, 1.7)

nswers to Concept Check Questions [Series 1]

Objective questions

1. Mortality.
2. Demographic.
3. De facto.
4. Age.
5. Five.
6. Whipple.

Short-answer questions

7. Public health requires demographic data because every epidemiological rate needs a population denominator: without knowing how many people of each age and sex live in an area, rates cannot be calculated. Example 1: calculating the infant mortality rate requires knowing both the number of infant deaths (numerator) and the number of live births (denominator) in the same population. Example 2: planning the number of immunisation doses needed in a district requires an estimate of the number of children under one year of age in that district.
8. De facto counts people where they are physically present on census night; de jure counts people at their usual place of residence. Two Nigerian census limitations: age heaping (respondents round ages to numbers ending in 0 or 5, distorting the age distribution); political inflation (communities or officials exaggerate counts to secure greater revenue allocation or political representation).
9. Civil registration is the continuous mandatory recording of vital events as they occur, providing real-time data without sampling error; in Nigeria, coverage is below 30% of births, making it an unreliable primary source. Sample surveys such as the NDHS provide nationally representative estimates of fertility, mortality, and health indicators at approximately five-year intervals; they have sampling error and cannot provide subnational estimates below the state level, but are currently the most reliable source of Nigerian vital statistics.

Long-answer questions

10. Demography is the scientific study of human populations, including size, structure, distribution, and the processes of fertility, mortality, and migration. The demographic transition describes the

historical shift from high fertility and high mortality (pre-transitional) through falling mortality with high fertility (rapid population growth) to low fertility and low mortality (post-transitional). Nigeria occupies the middle phase: mortality, especially child mortality, has fallen, but fertility remains high at approximately five children per woman, producing rapid population growth. Implications for health planning: Nigeria projected population of over 400 million by 2050 requires accelerated expansion of health facilities, workforce, and financing; the large and growing proportion of children and adolescents directs priority to reproductive health, immunisation, and nutrition; the eventual fertility decline will produce an ageing population requiring a shift toward chronic disease management.

11. The national population census aims to enumerate every person in a country at a specified time; it serves as the population denominator for all national statistics, determines revenue and seat allocation, and provides baseline data for projections. Methods: de facto (counts presence on census night, used in Nigeria) or de jure (counts usual residence). Three phases: preparatory (mapping, training), enumeration, post-enumeration. Limitations: coverage errors (undercounting of remote populations, nomads, slum dwellers); content errors (age heaping, sex misreporting); political inflation. Assessment techniques: age-sex ratio analysis, Whipple index (age heaping), intercensal growth rate comparison. Adjustment: age smoothing, intercensal estimation, Brass indirect estimation for mortality and fertility.
12. Civil registration: continuous mandatory recording of vital events; provides most timely data; Nigerian coverage below 30% of births, making it inadequate as a primary source; barriers include distance, cost, limited awareness. Sample surveys (NDHS, MICS): nationally representative, provide fertility, mortality, child health data; updated every 5 years; sampling error means estimates carry uncertainty; insufficient for subnational (below state level) planning. Administrative records: health facility registers, school enrolment, voter lists, NIMC database; partial coverage of specific subpopulations; useful as supplementary sources and for service utilisation data. Data linkage of multiple administrative sources improves coverage. Each source has specific strengths that make it appropriate for different planning purposes; using multiple sources together provides the most complete population picture.

Answers to Pilot Questions [Series 1]

Part 1.1

1. Demography is the scientific study of human populations, including their size, structure, distribution, and the processes of fertility, mortality, and migration that change them over time.
2. Fertility (births), mortality (deaths), and migration.
3. Formal demography focuses on the mathematical and statistical analysis of population data. Social demography examines the social, economic, and political determinants and consequences of demographic change.
4. Public health needs demographic data to calculate epidemiological rates (which require population denominators), identify at-risk groups, plan health services and workforce, and evaluate whether interventions are achieving their intended coverage.
5. The demographic transition is the historical shift from high fertility and high mortality to low fertility and low mortality as countries develop. Nigeria currently occupies the early-to-middle expanding phase: mortality has fallen but fertility remains high, producing rapid population growth.

Part 1.2

1. A national population census is the total process of collecting, compiling, evaluating, analysing, and publishing demographic, economic, and social data pertaining to all persons in a country at a specified time.
2. De facto counts people where they are physically present on census night, regardless of usual residence. De jure counts people at their usual place of residence, regardless of where they are on census night.
3. Preparatory phase (mapping, training, questionnaire preparation), enumeration phase (field data collection), and post-enumeration phase (data entry, processing, analysis, publication).
4. A Post-Enumeration Survey is a sample survey conducted shortly after a census to estimate its coverage and accuracy by matching a sample of the population against the census records; it quantifies the undercount and other errors.
5. Age heaping is the tendency of census or survey respondents to report ages rounded to numbers ending in 0 or 5. It is problematic because it distorts the age distribution, creating artificial peaks

at ages 20, 25, 30 and so on, making it impossible to accurately analyse age-specific rates or population structure without adjustment.

Part 1.3

1. Civil registration is the continuous, permanent, compulsory, and universal recording of vital events (births, deaths, marriages, divorces, stillbirths) as they occur, by a government authority.
2. Fewer than 30% of births are registered in Nigeria. Barriers include: limited awareness of the registration obligation; distance from registration offices; cost of the registration process; limited practical consequences of non-registration.
3. The Nigeria Demographic and Health Survey is a nationally representative population-based sample survey conducted approximately every five years; it provides data on fertility rates, infant and child mortality, maternal health, contraceptive use, nutrition, and HIV/AIDS indicators.
4. Advantage: surveys can collect more detailed information and can be updated more frequently than the decennial census. Limitation: estimates carry sampling error expressed as confidence intervals, and surveys are usually too small to provide reliable estimates below the state level.
5. Data linkage is the process of combining records from two or more administrative or data sources using a common identifier (such as name, date of birth, or national ID number). It is useful because it creates a more complete population dataset than any single source provides alone, improving coverage and enabling longitudinal tracking of individuals.

Part 1.4

1. Completeness (coverage) refers to the proportion of the target population captured in the data source. Accuracy refers to whether the recorded values for captured individuals are correct. A dataset can have high coverage but low accuracy (everyone counted but ages recorded incorrectly) or high accuracy but low coverage (correct data for those counted but many people missed).
2. The Whipple index quantifies the degree of age heaping by calculating the proportion of the population aged 23 to 62 that reports ages ending in 0 or 5; a score of 100 indicates no heaping, while higher values indicate increasing severity.

3. Intercensal estimation is the process of producing population estimates for years between two successive censuses, using the census counts as anchors and mortality and fertility assumptions to model the population in the intervening years. It is needed because censuses are only conducted every 10 years but planning requires annual population estimates.
4. Brass indirect estimation techniques allow fertility and mortality rates to be estimated from census questions about children ever born and children surviving, without requiring complete vital registration; developed by William Brass specifically for data-poor settings such as sub-Saharan Africa.
5. Any three of: target population estimation (how many people need a specific service), health facility catchment area analysis (are facilities sufficient and well distributed), epidemiological surveillance (disease incidence and prevalence calculation), health workforce planning (estimating future staffing needs), programme evaluation (calculating coverage rates for interventions).

References and Attributions [Series 1]

Textual references

- Pressat, R. (1985). The dictionary of demography. Blackwell.
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- National Population Commission Nigeria. (2010). Nigeria demographic and health survey 2008. NPC and ICF Macro.
- National Open University of Nigeria (NOUN). (2023). Introduction to demography and vital statistics course material. NOUN Press.

Figures, Plates, Tables, and Boxes

- Figure 1.1: The demographic transition model Attribution: AI generated using prompt "Generate a demographic transition model four-phase diagram showing birth rate and death rate curves with Nigeria positioned in the early-to-late expanding transition phase." Suggested OER search string: "demographic transition model birth rate death rate Nigeria population growth phases OER"
- Figure 1.2: Sources of census errors and their effects on population data Attribution: AI generated using prompt "Generate a diagram showing census error types (coverage and content) with Nigerian causes and an age pyramid demonstrating the age heaping pattern." Suggested OER search string: "census errors coverage content age heaping Nigeria population data quality OER"
- Figure 1.3: Sources of population data: a comparative overview Attribution: AI generated using prompt "Generate a comparison table of population data sources (census, civil registration, surveys, administrative records) with rows for coverage, frequency, data type, strengths, and limitations, with Nigerian examples." Suggested OER search string: "sources population data census civil registration survey administrative records Nigeria comparison OER"
- Figure 1.4: Uses of population data in health system planning Attribution: AI generated using prompt "Generate a hub-and-spoke diagram showing population data at the centre with five health planning applications as spokes: target estimation, facility planning, epidemiological surveillance, workforce planning, and programme evaluation." Suggested OER search string: "population data health planning uses target estimation epidemiological surveillance workforce Nigeria OER

Course code: COM 302

Course title: Introduction to Demography and Vital Statistics

Course credit load: 2 Units

Series 2: Population Dynamics and Growth

- **Part 2.1: Population Size, Distribution, and Density**
  - Sub Part 2.1.1: Measuring population size and distribution
  - Sub Part 2.1.2: Population density and its determinants
  - Sub Part 2.1.3: Urban-rural distribution in Nigeria
- **Part 2.2: Population Growth and Its Determinants**
  - Sub Part 2.2.1: Components of population change
  - Sub Part 2.2.2: Natural increase and net migration
  - Sub Part 2.2.3: Rates and measures of population growth
- **Part 2.3: Population Structure**
  - Sub Part 2.3.1: Age structure and the age-sex pyramid
  - Sub Part 2.3.2: Dependency ratios and their implications
  - Sub Part 2.3.3: Population momentum
- **Part 2.4: Population Projections and Policy**
  - Sub Part 2.4.1: Methods of population projection
  - Sub Part 2.4.2: Nigeria population projections and health implications
  - Sub Part 2.4.3: Population policy and its relationship to health

Introduction

A population is not static. It grows, shrinks, ages, urbanises, and shifts geographically in response to births, deaths, and migration. Understanding these dynamics is not merely an academic exercise: every health system response to population change, from building hospitals in rapidly urbanising areas to adapting services for an ageing population, depends on understanding how populations change and why. Nigeria offers one of the most striking examples of rapid population dynamics in the world, and the health implications of those dynamics are profound.

The aim of this Series is to examine the forces that drive population change, the measures used to quantify them, the age-sex structure that results, and the projections and policies that translate demographic knowledge into planning decisions.

We shall commence by examining population size, distribution, and density. Next, we will analyse the components of population growth: fertility, mortality, and migration. Moving on, we will examine population structure through the age-sex pyramid and dependency ratios. Finally, we will close by exploring population projections and the relationship between population policy and health.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 2.1** define and calculate measures of population size, distribution, and density,
- **SLO 2.2** describe the urban-rural distribution of the Nigerian population and its health implications,
- **SLO 2.3** explain the three components of population change and calculate rates of natural increase and growth,
- **SLO 2.4** interpret and construct an age-sex pyramid and calculate dependency ratios,

- **SLO 2.5** explain the concept of population momentum and its implications for future growth,
- **SLO 2.6** describe the main methods of population projection and their assumptions, and
- **SLO 2.7** explain the relationship between population policy and health outcomes in Nigeria.

2.1 Population Size, Distribution, and Density

2.1.1 Measuring population size and distribution

Population size is the total number of persons in a defined area at a specified time. It is most accurately measured by a census, with intercensal estimates produced by demographic methods for years between censuses. **Population distribution** describes how the population is spread across geographic space: which regions are densely settled, which are sparsely inhabited, and how this pattern changes over time. In Nigeria, the 2006 census recorded approximately 140 million people; by 2023 the estimated population exceeded 220 million, making Nigeria the most populous country in Africa and the sixth most populous in the world.

Distribution is measured through **population maps**, which display the geographic spread of the population, and through summary statistics such as the **coefficient of variation** of population density across administrative units. Uneven population distribution has direct health system implications: facilities must be located where the population is, and where population distribution is sparse or dispersed, the per-capita cost of health service delivery is higher. In Nigeria, the southwest and southeast are the most densely populated zones, while the northeast and northwest, though large in area, contain substantial populations with very different health needs and access profiles.

Fill in the blank: Nigeria is the most populous country in _____ , with an estimated population exceeding 220 million people by 2023, representing rapid growth from 140 million recorded in the 2006 census.

2.1.2 Population density and its determinants

Population density is the number of persons per unit area, typically expressed as persons per square kilometre. It is calculated as: density = population / area. High density does not automatically indicate urbanisation; some rural areas in Nigeria, particularly in the southeast, are very densely settled. Density is determined by a combination of historical settlement patterns, agricultural productivity of the land, proximity to water and transport routes, and economic opportunity. Areas of high density attract further in-migration, reinforcing their growth relative to less dense areas.

For health planning, density affects both **service accessibility** (dense populations can share facilities; sparse populations require dispersed provision) and **disease transmission** (communicable diseases spread more rapidly in dense settings). High-density urban slums in Lagos, Kano, and Port Harcourt combine dense settlement with poor sanitation and limited healthcare access, creating conditions for rapid transmission of waterborne and airborne diseases. Planning for these environments requires density-specific approaches rather than standardised national models.

Fill in the blank: Population _____ is expressed as persons per square kilometre and is calculated by dividing the total population by the total land area of the defined geographic unit.

2.1.3 Urban-rural distribution in Nigeria

Urbanisation is the process by which an increasing proportion of a population lives in urban areas. Nigeria is urbanising rapidly: the proportion of the population living in urban areas has grown from approximately 20% at independence in 1960 to over 52% by 2020, and urbanisation is projected to continue. **Urban areas** in Nigeria are defined by the National Population Commission as settlements with 20,000 or more inhabitants. Lagos is the largest city, with a population estimated at 15 to 20 million, and is one of the fastest-growing megacities in the world.

The health implications of urban-rural distribution are substantial. Urban areas offer better access to health facilities but face overcrowding, pollution, and health risks concentrated in informal settlements. Rural areas have more limited facility access, lower health worker availability, and different disease burdens (higher burden of tropical infectious diseases, complications of

pregnancy and childbirth, and injuries). The **urban health penalty** in Nigeria refers to the health disadvantages experienced by the urban poor, who combine the poor infrastructure of rural life with the social risks of urban environments. Health planning must address both urban and rural realities with context-specific strategies.

Fill in the blank: The urban health _____ describes the health disadvantages of the urban poor in Nigeria, who experience poor infrastructure and social risks of urban living without the health facility benefits enjoyed by higher-income urban residents.

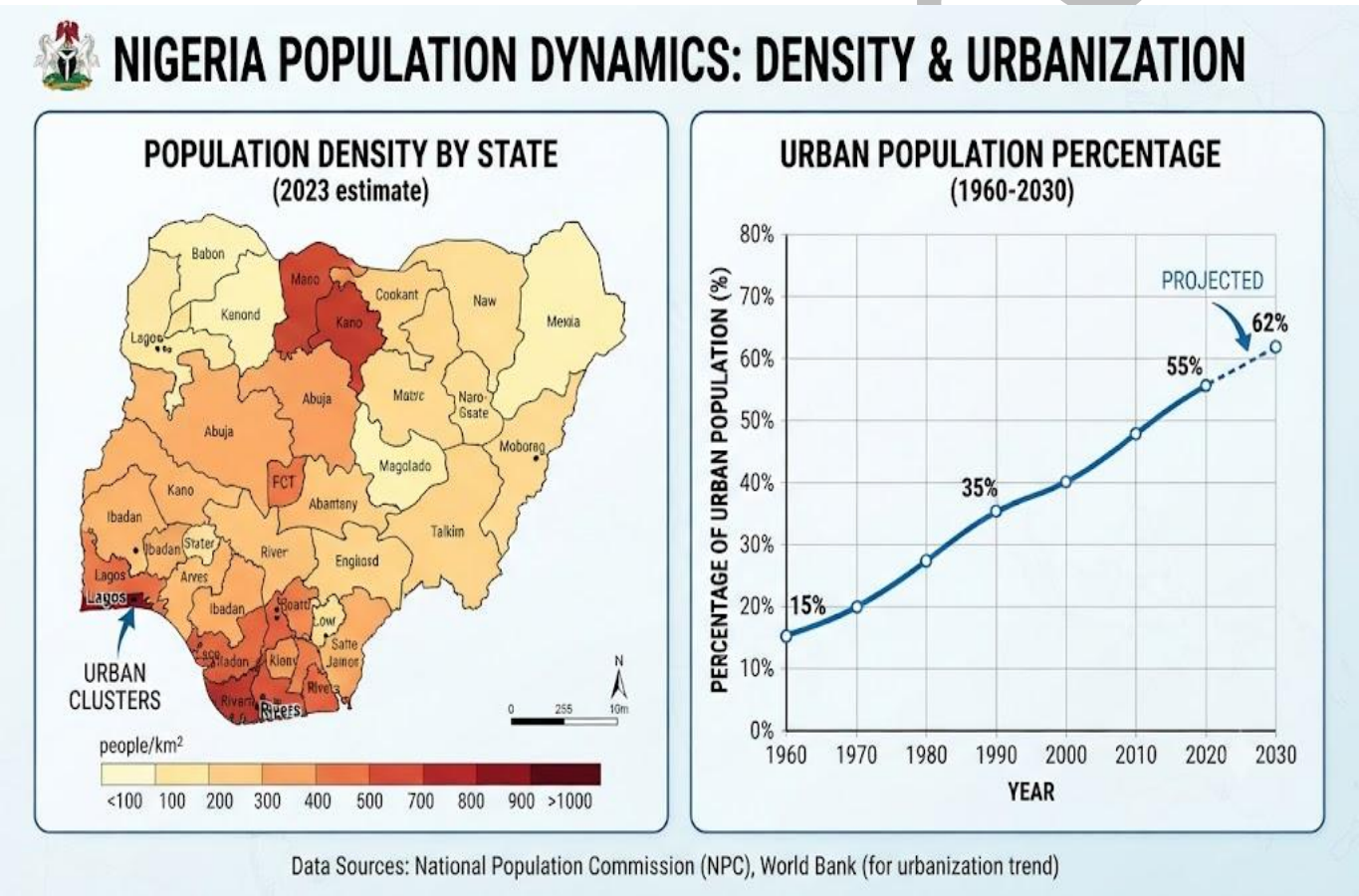

Figure 2.1: Population distribution and urbanisation in Nigeria

Pilot questions 2.1

1. How is population density calculated?
2. Which zones of Nigeria are most densely populated?
3. Define urbanisation and state the approximate proportion of Nigeria that is urban.

4. What is the urban health penalty?
5. Name two health implications of high population density in urban slums.

2.2 Population Growth and Its Determinants

2.2.1 Components of population change

Population size at any point in time is determined by three components of change: **fertility** (births adding to the population), **mortality** (deaths subtracting from the population), and **migration** (movement into and out of the defined area). These are expressed in the **demographic balancing equation**: P1 = P0 + B - D + I - E, where P1 is the population at the end of the period, P0 is the population at the start, B is births, D is deaths, I is in-migrants, and E is out-migrants. This simple equation is the foundation of all population accounting.

Each component is influenced by different factors and responds to different policy interventions. Fertility is influenced by contraceptive use, marriage patterns, education (especially female education), and economic development. Mortality is influenced by nutrition, sanitation, healthcare access, and disease burden. Migration is influenced by economic differentials between areas, conflict, climate, and land availability. Understanding which component is driving population change in a specific context is essential for designing appropriate health and population policy responses.

Fill in the blank: The demographic balancing equation is P1 = P0 + B - D + I - E, where B represents _____ , D represents deaths, I represents in-migrants, and E represents out-migrants.

2.2.2 Natural increase and net migration

Natural increase is the difference between births and deaths in a population over a specified period. When births exceed deaths, natural increase is positive and the population grows from within. Nigeria has one of the highest rates of natural increase in the world: with a total fertility

rate of approximately 5.3 children per woman and a relatively high but declining infant mortality rate, births substantially exceed deaths, producing a natural increase rate of approximately 2.6% per year. At this rate, the population doubles in approximately 27 years.

Net migration is the difference between in-migration and out-migration. For Nigeria as a whole, international net migration is modestly negative: more Nigerians emigrate than immigrate. However, internal migration, particularly rural-to-urban movement, substantially redistributes population within the country, with major implications for the distribution of health needs and services. Cities that receive large internal migrant flows face rapidly increasing demand for services, while source communities, particularly in rural areas, may experience population decline and loss of working-age adults.

Fill in the blank: _____ increase is the difference between births and deaths over a period; Nigeria rate of approximately 2.6% per year means the population doubles approximately every 27 years.

2.2.3 Rates and measures of population growth

The **crude birth rate (CBR)** is the number of live births per 1,000 population per year. The **crude death rate (CDR)** is the number of deaths per 1,000 population per year. The **rate of natural increase (RNI)** is calculated as (CBR - CDR) / 10, expressed as a percentage. The **population growth rate (r)** is the rate of natural increase adjusted for net migration. Nigeria CBR is approximately 37 per 1,000, CDR approximately 11 per 1,000, giving an RNI of approximately 2.6%, one of the highest in the world.

The **doubling time** is the number of years required for a population to double at its current growth rate, approximated by the formula: doubling time = 70 / r (where r is the annual growth rate as a percentage). At Nigeria growth rate of 2.6%, the doubling time is approximately 27 years. These measures collectively describe the pace of population growth and are used to project future population size, estimate health service demand, and evaluate the urgency of population policy responses.

Fill in the blank: The rate of natural increase is calculated as the crude birth rate minus the crude death rate, divided by _____ , and expressed as a percentage annual growth rate.

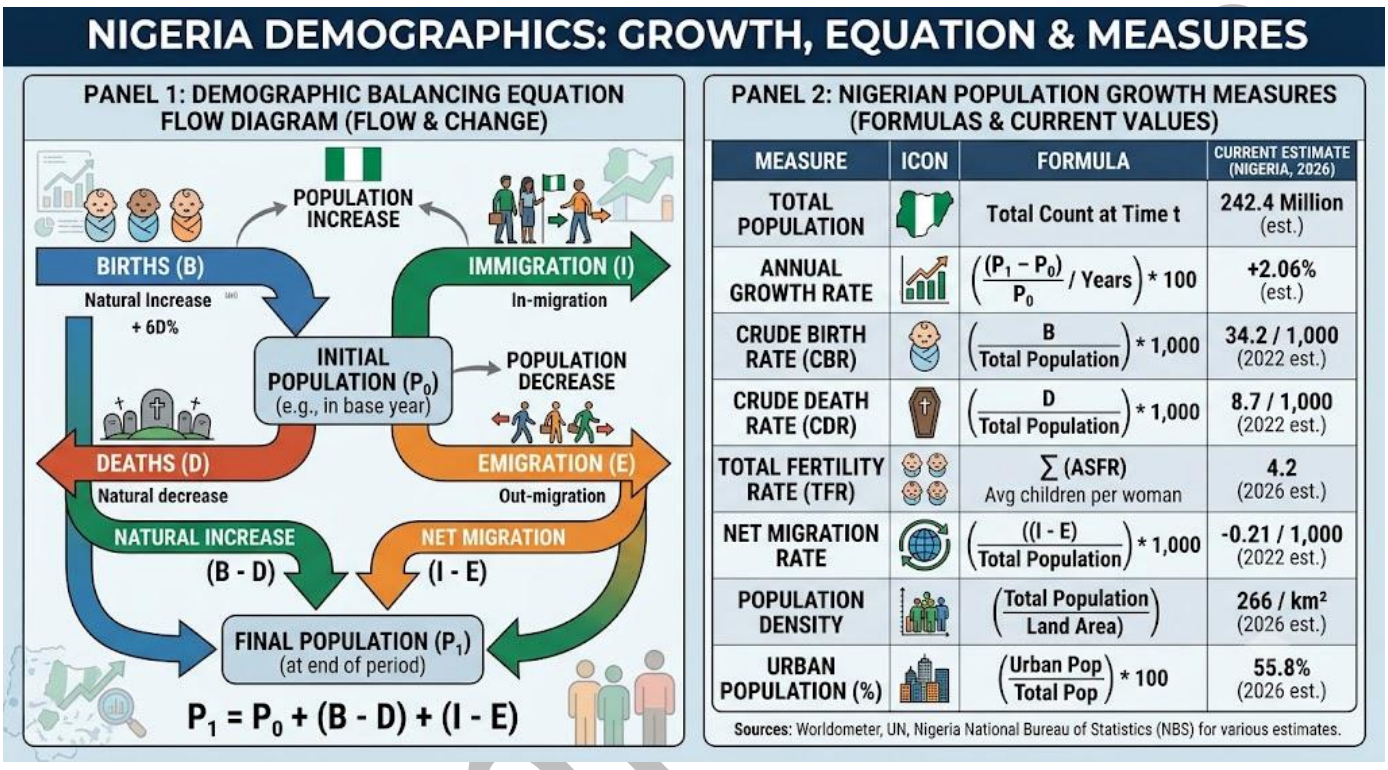

Figure 2.2: Components of population growth and Nigeria growth measures

Pilot questions 2.2

1. Write the demographic balancing equation and define each term.
2. Define natural increase and state Nigeria approximate rate.
3. Define the crude birth rate and crude death rate.
4. How is the rate of natural increase calculated?
5. What is the doubling time formula and what is Nigeria approximate doubling time?

2.3 Population Structure

2.3.1 Age structure and the age-sex pyramid

Population structure refers to the composition of a population by age and sex. It is represented visually by the **age-sex pyramid** (also called a population pyramid), which plots the number or percentage of males and females in each five-year age group as horizontal bars on either side of a central axis (males on the left, females on the right). The shape of the pyramid reflects the population demographic history: a broad base indicates high fertility; a narrowing base indicates falling fertility; a column-shaped pyramid indicates low fertility and low mortality; a top-heavy pyramid indicates an ageing population.

Nigeria pyramid has a characteristically broad base and rapidly narrowing apex, reflecting high fertility, high child survival due to improved immunisation and nutrition, and relatively high adult mortality. Children under 15 constitute approximately 44% of the Nigerian population, and youth (15 to 24) a further 19%, creating a **youthful population structure** with far-reaching implications for education, employment, and health services. Reproducing the age-sex pyramid for a specific population requires data on population by single year or five-year age group, disaggregated by sex, typically from a census or survey.

Fill in the blank: In a population pyramid, males are plotted on the _____ side of the central axis and females on the right, with the youngest age groups at the base and the oldest at the apex.

2.3.2 Dependency ratios and their implications

The **dependency ratio** is the ratio of the economically dependent population (children and elderly) to the economically active population (working-age adults). It is calculated as: dependency ratio = (population aged 0-14 + population aged 65+) / population aged 15-64, multiplied by 100. The **child dependency ratio** is calculated using only those aged 0-14 in the numerator; the **old-age dependency ratio** uses only those aged 65+. A high dependency ratio means that each working-age person must support more dependents, reducing savings, investment, and economic development.

Nigeria total dependency ratio is among the highest in the world, at approximately 85 per 100 working-age adults, driven almost entirely by the child component. This has direct health implications: a large dependent child population creates heavy demand for maternal and child health services, nutrition programmes, and immunisation. The **demographic dividend** is the economic growth potential that arises when fertility falls and the working-age population temporarily outweighs dependents, as occurred in East Asia in the 1980s and 1990s. Nigeria has not yet entered this transition; realising the demographic dividend requires accelerated fertility decline alongside investment in education and employment.

Fill in the blank: The dependency ratio is calculated as the population aged 0-14 plus aged 65 and over, divided by the population aged 15 to _____ , multiplied by 100.

2.3.3 Population momentum

Population momentum is the tendency of a population to continue growing even after fertility has fallen to replacement level (approximately 2.1 children per woman), because of the large cohorts of young people already in the population who have yet to reach their peak reproductive years. Even if Nigeria total fertility rate fell immediately to replacement level, the population would continue growing for several decades because of the large numbers of children and young adults already born. Momentum explains why population projections for high-fertility countries continue to show growth well beyond the point of fertility replacement.

Population momentum has important implications for health planning in Nigeria. Even optimistic scenarios of fertility decline project a Nigerian population of 400 million or more by 2050, driven significantly by momentum from current age structure. Health system planning must therefore account not only for current population needs but for the substantially larger population that demographic momentum makes inevitable regardless of short-term fertility change. This creates a planning imperative: investments in health system capacity made now will be needed for a much larger population within a generation.

Fill in the blank: Population _____ is the tendency of a population to continue growing after fertility falls to replacement level, due to the large numbers of young people already in the population who have yet to complete their reproductive years.

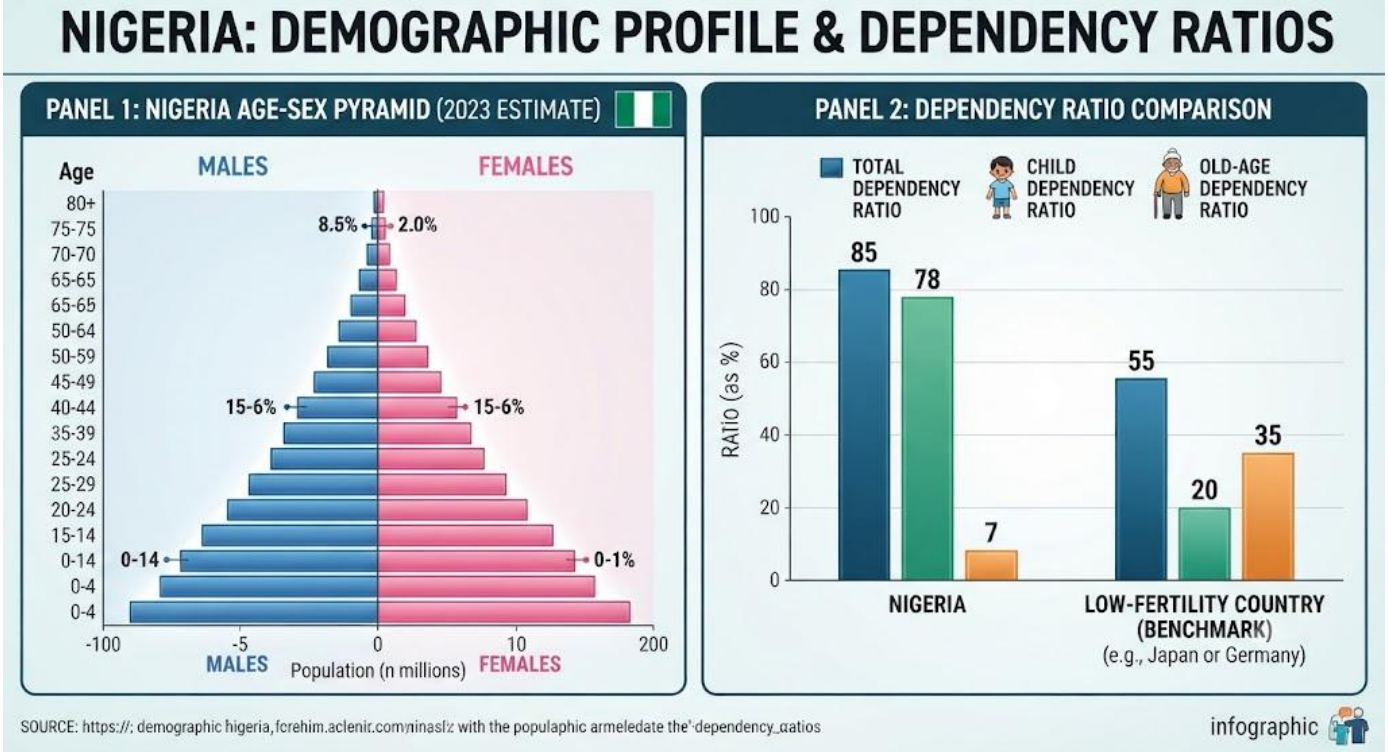

Figure 2.3: Nigeria age-sex pyramid and dependency ratio

Pilot questions 2.3

1. What shape does a high-fertility population pyramid have and why?
2. What percentage of the Nigerian population is under 15 years of age?
3. How is the total dependency ratio calculated?
4. Define the demographic dividend.
5. Explain population momentum and why it matters for Nigerian health planning.

2.4 Population Projections and Policy

2.4.1 Methods of population projection

Population projections are estimates of the future size and structure of a population based on assumptions about future fertility, mortality, and migration. The most common method is the **cohort-component method**, which projects each age-sex cohort forward using age-specific

survival rates (derived from life tables) and adds new births using age-specific fertility rates. Different scenarios (**high**, **medium**, and **low** variants) reflect different assumptions about how quickly fertility will fall, producing a range of projected population sizes rather than a single point estimate.

Simpler methods include **mathematical extrapolation** (fitting an arithmetic or geometric growth function to past census data and extending it forward) and **ratio methods** (projecting subnational populations as a proportion of a national total that is projected separately). Mathematical extrapolation is useful for short-term projections when age-specific data are unavailable, but it cannot account for changes in the age structure or for shifts in fertility or mortality trends. The cohort-component method is the standard for national and subnational projections used in health planning.

Fill in the blank: The _____ -component method projects each age-sex group forward using age-specific survival rates and fertility rates, and is the standard method for national population projections used in health planning.

2.4.2 Nigeria population projections and health implications

The United Nations medium-variant projection estimates Nigeria population will reach approximately 400 million by 2050 and over 700 million by 2100, making it one of the fastest-growing large populations in the world. These projections are based on the assumption that fertility will decline from its current level of approximately 5.3 to below 3 by mid-century, a trajectory that depends on continued investment in female education, family planning access, and economic development. If fertility remains high (the high variant), the 2050 population could approach 500 million.

The health implications are stark. At 400 million people, Nigeria would need to more than double its current health facility capacity, workforce, and financing simply to maintain current coverage levels, let alone improve them. **Maternal health** services will face growing demand from a large and growing cohort of women of reproductive age. **Immunisation programmes** will need to cover an expanding birth cohort. **Chronic disease management** capacity will need

to grow as the population ages. Planning for these demands begins now with projections that make the scale of the challenge explicit.

Fill in the blank: The UN medium-variant projection estimates Nigeria population will reach approximately _____ million by 2050, based on the assumption that fertility will decline from 5.3 to below 3 by mid-century.

2.4.3 Population policy and its relationship to health

Population policy refers to deliberate government actions aimed at influencing population size, growth, distribution, or structure. Policies may be **pro-natalist** (encouraging more births), **anti-natalist** (encouraging fewer births), or **redistributive** (encouraging migration to relieve pressure in dense areas). Nigeria National Population Policy (2004, revised 2018) sets a target of reducing the total fertility rate to 4 children per woman by 2030, through investment in female education, promotion of family planning, and delay of marriage.

Population policy and health are mutually reinforcing: lower fertility improves maternal and child health by reducing high-parity and closely spaced births; better health reduces the child mortality that motivates high fertility; female education simultaneously reduces fertility and improves child health. The **unmet need for family planning** in Nigeria (the proportion of women who want to avoid pregnancy but are not using contraception) is estimated at approximately 16%, representing both a health need and a population policy opportunity. Addressing unmet need through improved access to contraception is among the highest-impact interventions for both maternal health and fertility reduction.

Fill in the blank: _____ need for family planning refers to the proportion of women who want to avoid pregnancy but are not currently using any method of contraception; in Nigeria this is estimated at approximately 16%.

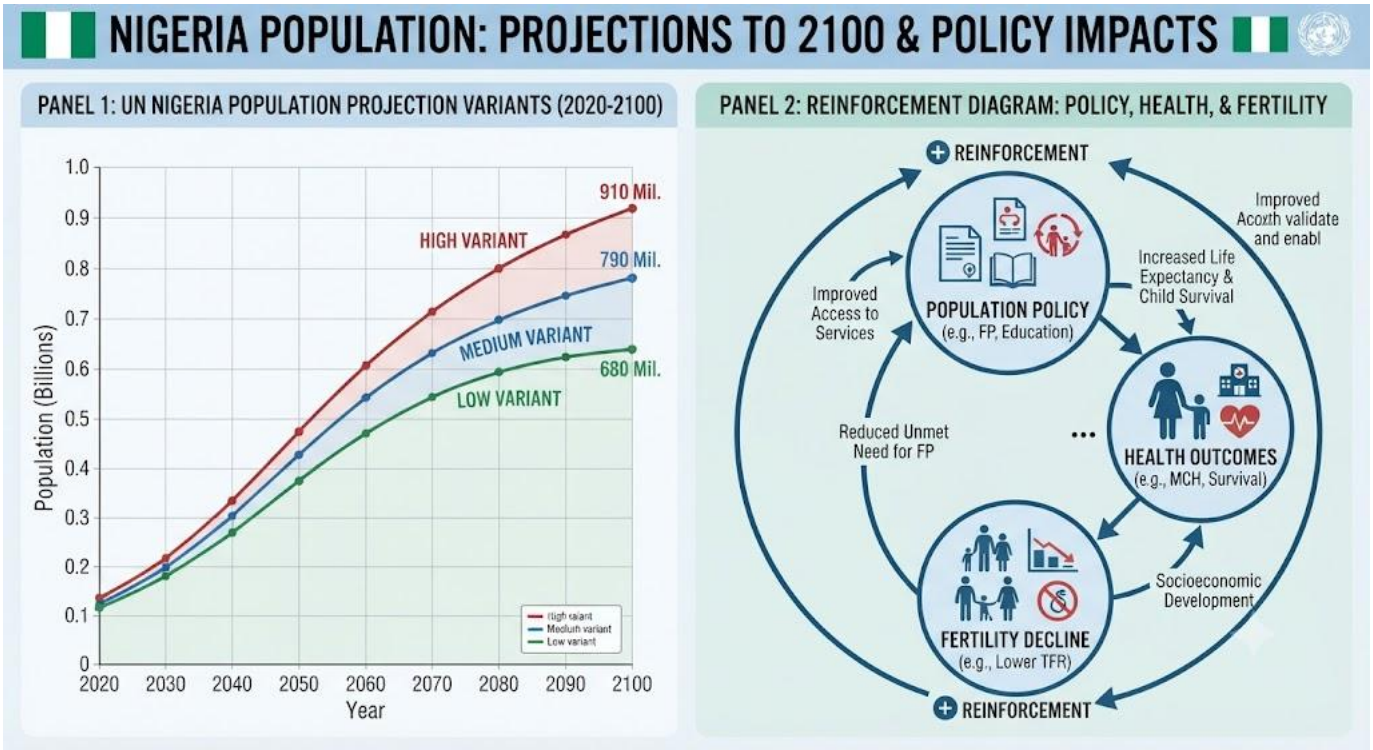

Figure 2.4: Nigeria population projections and policy context

Pilot questions 2.4

1. Define population projection.
2. What is the cohort-component method of population projection?
3. What does the UN medium-variant project as Nigeria 2050 population?
4. What is unmet need for family planning and what is Nigeria estimate?
5. Explain why population policy and health policy are mutually reinforcing.

Series Summary

This Series examined the dynamics of population change through size, distribution, growth, structure, and projections. Population density and the rapid urbanisation of Nigeria were described alongside their implications for disease transmission and health service planning. The three components of population change, fertility, mortality, and migration, were analysed through the demographic balancing equation and the rates derived from it, establishing Nigeria as one of the world fastest-growing populations with a doubling time of approximately 27 years.

Population structure was examined through the age-sex pyramid, the dependency ratio, and population momentum, demonstrating why Nigeria demographic trajectory is locked into continued growth for decades regardless of near-term fertility change. Population projections using the cohort-component method were described, and the UN variants were applied to Nigeria to illustrate the scale of health system expansion required. The Series concluded by examining the mutual reinforcement between population policy, including family planning and female education, and health outcomes, establishing that demography and health are inseparable in the Nigerian planning context (SLOs 2.1 to 2.7).

Glossary of Terms

- **Age-sex pyramid:** a graphical display of population structure showing the number or percentage of males and females in each age group as horizontal bars.
- **Cohort-component method:** a population projection method that projects each age-sex cohort forward using age-specific survival and fertility rates.
- **Crude birth rate:** the number of live births per 1,000 population per year.
- **Crude death rate:** the number of deaths per 1,000 population per year.
- **Demographic balancing equation:** $P1 = P0 + B - D + I - E$; the equation expressing population change as the sum of births minus deaths plus net migration.

- **Demographic dividend:** the economic growth potential arising when fertility falls and the working-age population temporarily outweighs dependents.
- **Dependency ratio:** the ratio of the economically dependent population (under 15 and over 65) to the working-age population (15-64), multiplied by 100.
- **Doubling time:** the number of years for a population to double at its current growth rate; approximated as 70 divided by the annual growth rate percentage.
- **Natural increase:** the difference between births and deaths in a population over a specified period.
- **Population momentum:** the tendency of a population to continue growing after fertility reaches replacement level due to the large numbers of young people already in the population.
- **Unmet need for family planning:** the proportion of women who want to avoid pregnancy but are not using any method of contraception.
- **Urbanisation:** the process by which an increasing proportion of a population lives in urban areas.

Concept Check Questions [Series 2]

Objective questions

1. Population density is calculated by dividing the total _____ by the total land area of the geographic unit. (Linked to SLO 2.1)
2. The urban health _____ describes the health disadvantages of the urban poor who lack health facility access despite living in cities. (Linked to SLO 2.2)
3. In the demographic balancing equation, the letter B represents _____ . (Linked to SLO 2.3)
4. The rate of natural increase is calculated as the crude birth rate minus the crude death rate, divided by _____. (Linked to SLO 2.3)

5. In a population pyramid, males are plotted on the _____ side of the central axis. (Linked to SLO 2.4)
6. Population _____ is the tendency of a population to continue growing after fertility reaches replacement level. (Linked to SLO 2.5)

Short-answer questions

7. Explain the demographic balancing equation and describe the three components of population change. (Linked to SLO 2.3)
8. Define the dependency ratio, calculate Nigeria approximate ratio, and explain the concept of the demographic dividend. (Linked to SLOs 2.4, 2.7)
9. Describe the cohort-component method of population projection and explain why projections use high, medium, and low variants. (Linked to SLO 2.6)

Long-answer questions

10. Discuss population structure in Nigeria, covering the age-sex pyramid, dependency ratio, and population momentum, and analyse their implications for health service planning. (Linked to SLOs 2.4, 2.5, 2.7)
11. Evaluate Nigeria population growth dynamics, covering the components of change, growth rates, projections, and the relationship between population policy and health. (Linked to SLOs 2.3, 2.6, 2.7)

Answers to Concept Check Questions [Series 2]

Objective questions

6. Population.
7. Penalty.
8. Births.
9. 10.
10. Left.
11. Momentum.

Short-answer questions

12. P1 = P0 + B - D + I - E: the population at the end of the period equals the starting population plus births minus deaths plus in-migrants minus out-migrants. The three components are fertility (births, which add to the population), mortality (deaths, which subtract), and migration (movement in and out of the area, which may add or subtract depending on net direction).
13. Dependency ratio = (population 0-14 + population 65+) / population 15-64 x 100. Nigeria ratio is approximately 85 per 100 working-age adults, one of the highest in the world, driven mainly by the child component. The demographic dividend is the economic growth potential that arises when fertility falls and the working-age population temporarily outweighs dependents; it has not yet occurred in Nigeria but is achievable with accelerated fertility decline and investment in education and employment.
14. The cohort-component method projects each age-sex cohort forward using age-specific survival rates from life tables, adding new births using age-specific fertility rates applied to women in reproductive age groups. Three variants are used because projections depend on assumptions about future fertility and mortality trends that are uncertain: the high variant assumes slower fertility decline, the medium variant assumes the most likely trajectory, and the low variant assumes faster decline; the range illustrates planning uncertainty.

Long-answer questions

15. **Basic response:** Nigeria age-sex pyramid has a broad base (high fertility producing many children) that narrows rapidly upward, with children under 15 constituting approximately 44% of the population. The total dependency ratio of approximately 85 per 100 working-age adults, driven almost entirely by the child component, means each working-age person supports many dependents. Population momentum means the population will continue growing for decades even if fertility falls immediately to replacement level, because of the large cohorts already born. **Value-added response:** These structural features have compounding health implications. The large child population creates irreducible demand for immunisation, nutrition, and child health services for decades ahead. High dependency ratios constrain household savings and government fiscal space for health investment. Momentum makes population stabilisation a multi-generational project, so health system expansion planning must assume a population of 400 million or more by 2050 even in optimistic scenarios, requiring radical scale-up of facilities, workforce, and financing that begins with decisions made now.
16. **Basic response:** Nigeria population grows through high natural increase (CBR approximately 37, CDR approximately 11, RNI approximately 2.6% per year) with a doubling time of 27 years. Internal migration redistributes population from rural to urban areas. UN medium-variant projections estimate 400 million by 2050, dependent on fertility declining to below 3. Nigeria National Population Policy targets a TFR of 4 by 2030 through family planning, female education, and delayed marriage. **Value-added response:** Population policy and health are mutually reinforcing: lower fertility reduces maternal deaths from high-parity births, improves child nutrition, and expands the resource available per child. Better health, particularly reduced child mortality, reduces the fertility motivation of high-parity childbearing. Addressing unmet need for family planning (approximately 16%) is among the highest-impact intersectoral actions available, simultaneously improving maternal health and accelerating the fertility decline that would allow Nigeria to approach the demographic dividend.

Answers to Pilot Questions [Series 2]

Part 2.1

11. Density = population / area (expressed as persons per square kilometre).
12. The southwest (Lagos, Ogun, Osun) and southeast (Anambra, Imo, Abia) are most densely populated.
13. Urbanisation is the process by which an increasing proportion of a population lives in urban areas. Approximately 52% of Nigeria population was urban as of 2020.
14. The urban health penalty describes the health disadvantages experienced by the urban poor, who combine poor infrastructure (inadequate water, sanitation, and housing) with the social risks of urban environments, without accessing the health facilities that make urban living beneficial for higher-income groups.
15. Any two of: rapid spread of communicable diseases (waterborne, airborne) due to overcrowding and poor sanitation; overcrowded health facilities with inadequate capacity to serve the dense population.

Part 2.2

1. P1 = P0 + B - D + I - E. P1 = population at end of period; P0 = population at start; B = births; D = deaths; I = in-migrants; E = out-migrants.
2. Natural increase is the difference between births and deaths in a population. Nigeria rate of natural increase is approximately 2.6% per year.
3. Crude birth rate: number of live births per 1,000 population per year. Crude death rate: number of deaths per 1,000 population per year.
4. RNI = (CBR - CDR) / 10, expressed as a percentage. For Nigeria: (37 - 11) / 10 = 2.6%.
5. Doubling time = 70 / r (where r is the annual growth rate as a percentage). At Nigeria rate of 2.6%, doubling time = 70 / 2.6 = approximately 27 years.

Part 2.3

6. A broad base tapering rapidly to a narrow apex, reflecting high fertility producing large numbers of young children, with progressively fewer people surviving to older ages due to mortality.
7. Approximately 44%.
8. (Population 0-14 + population 65+) / population 15-64, multiplied by 100.
9. The demographic dividend is the economic growth potential that arises when fertility falls and the working-age population temporarily outweighs dependents, freeing resources for savings, investment, and economic development, as occurred in East Asia in the 1980s and 1990s.
10. Population momentum is the tendency of a population to continue growing even after fertility falls to replacement level, because of the large cohorts of young people already in the population who have yet to complete their reproductive years. For Nigeria health planning it means that even rapid fertility decline will not prevent the population from reaching 400 million or more by 2050, making large-scale health system expansion inevitable and creating a planning imperative to invest in capacity now.

Part 2.4

11. A population projection is an estimate of the future size and structure of a population based on stated assumptions about future fertility, mortality, and migration.
12. The cohort-component method projects each age-sex cohort forward over successive time periods using age-specific survival rates derived from life tables, and adds new births by applying age-specific fertility rates to women in each reproductive age group.
13. Approximately 400 million by 2050.
14. Unmet need for family planning is the proportion of women who want to avoid pregnancy but are not currently using any method of contraception. Nigeria estimate is approximately 16%.

15. Lower fertility reduces maternal deaths from high-parity births and improves child health by allowing longer birth intervals and more resources per child. Better health, particularly lower child mortality, reduces the perceived need for high fertility as parents no longer need many births to achieve a desired number of surviving children. Female education simultaneously reduces fertility and improves child health outcomes, making education investment a point of maximum intersection between population and health policy.

References and Attributions [Series 2]

Textual references

1. United Nations, Department of Economic and Social Affairs. (2022). World population prospects 2022. UN DESA.
2. Bongaarts, J. (2009). Human population growth and the demographic transition. Philosophical Transactions of the Royal Society B, 364(1532), 2985-2990.
3. National Population Commission Nigeria and ICF. (2019). Nigeria demographic and health survey 2018. NPC and ICF.
4. National Open University of Nigeria (NOUN). (2023). Introduction to demography and vital statistics course material. NOUN Press.

Figures, Plates, Tables, and Boxes

1. Figure 2.1: Population distribution and urbanisation in Nigeria Attribution: AI generated using prompt "Generate a two-panel diagram showing a Nigerian population density map by state and a line graph of urban population percentage from 1960 to 2030." Suggested OER search string: "Nigeria population density urbanisation map urban rural distribution OER"
2. Figure 2.2: Components of population growth and Nigeria growth measures Attribution: AI generated using prompt "Generate a two-panel diagram showing the demographic balancing equation as a flow diagram and a table of Nigerian population growth measures with formulas and current values." Suggested OER search string: "demographic balancing equation natural increase crude birth rate crude death rate Nigeria population growth OER"
3. Figure 2.3: Nigeria age-sex pyramid and dependency ratio Attribution: AI generated using prompt "Generate a two-panel diagram showing a Nigeria age-sex pyramid with broad base and a bar chart comparing Nigeria dependency ratios (total, child, old-age) against a low-fertility country benchmark." Suggested OER search string: "Nigeria age-sex pyramid dependency ratio population structure high fertility OER"

4. Figure 2.4: Nigeria population projections and policy context Attribution: AI generated using prompt "Generate a two-panel diagram showing UN high-medium-low projection variants for Nigeria population to 2100 and a reinforcement diagram linking population policy, health outcomes, and fertility decline." Suggested OER search string: "Nigeria population projection UN variants 2050 2100 family planning fertility policy OER

Course code: COM 302

Course title: Introduction to Demography and Vital Statistics

Course credit load: 2 Units

Series 3: Demographic Characteristics

- **Part 3.1: Fertility: Concepts and Measures**
    - Sub Part 3.1.1: Definition and determinants of fertility
    - Sub Part 3.1.2: Measures of fertility
    - Sub Part 3.1.3: Fertility trends in Nigeria
- **Part 3.2: Mortality: Concepts and Measures**
    - Sub Part 3.2.1: Definition and determinants of mortality
    - Sub Part 3.2.2: Measures of mortality
    - Sub Part 3.2.3: Mortality trends and the life table
- **Part 3.3: Migration: Concepts and Measures**
    - Sub Part 3.3.1: Definition, types, and determinants of migration
    - Sub Part 3.3.2: Measures of migration
    - Sub Part 3.3.3: Migration and health in Nigeria
- **Part 3.4: Morbidity and Disability**
    - Sub Part 3.4.1: Measuring morbidity: incidence and prevalence
    - Sub Part 3.4.2: Disability and its measurement
    - Sub Part 3.4.3: The burden of disease: DALYs and YLLs

Introduction

The three demographic processes of fertility, mortality, and migration are not abstractions. They determine whether a population grows or shrinks, ages or stays young, and faces infectious or chronic disease as its primary health challenge. Behind every statistic is a woman who gave birth, a person who died, or a family that moved. Understanding how these processes are defined and measured is the foundation of all quantitative health and population analysis.

The aim of this Series is to define and calculate the key measures of fertility, mortality, and migration, and to extend that measurement framework to morbidity and disability as dimensions of population health.

We shall commence with fertility: its determinants and the range of measures from the crude birth rate to the total fertility rate. Next, we will examine mortality and its measures, culminating in the life table. We will then address migration, its types and measures, and its health implications for Nigeria. Finally, we will close by examining morbidity and disability, including the global burden of disease framework.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 3.1** define fertility and calculate the crude birth rate, general fertility rate, and total fertility rate,
- **SLO 3.2** explain the proximate determinants of fertility and describe fertility trends in Nigeria,
- **SLO 3.3** define mortality and calculate crude death rates, age-specific death rates, and infant mortality rates,
- **SLO 3.4** construct and interpret a life table and explain its applications in health planning,
- **SLO 3.5** define migration and describe its types, determinants, and measures,

- **SLO 3.6** define incidence and prevalence and explain their relationship, and
- **SLO 3.7** explain DALYs and YLLs as measures of the burden of disease.

3.1 Fertility: Concepts and Measures

3.1.1 Definition and determinants of fertility

Fertility is the actual reproductive performance of an individual, couple, or population, measured by the number of live births. It is distinct from **fecundity**, which is the biological capacity to reproduce. A woman may be fecund (biologically capable of bearing children) but have low fertility if she uses contraception or delays childbearing. Fertility is determined by a set of **proximate determinants** identified by Bongaarts (1978): marriage or sexual exposure, contraceptive use, postpartum infecundability (period of infertility after birth, prolonged by breastfeeding), and induced abortion.

These proximate determinants mediate the effect of socioeconomic factors: female education, economic development, urbanisation, and cultural norms influence fertility primarily by changing the proximate determinants. For example, female education delays marriage, increases contraceptive use, and reduces desired family size, all of which reduce fertility. In Nigeria, fertility remains high (total fertility rate approximately 5.3) because all four proximate determinants operate at levels that favour high fertility: marriage is nearly universal and early, contraceptive prevalence is low, breastfeeding is common, and induced abortion is restricted.

Fill in the blank: The four proximate determinants of fertility identified by Bongaarts are marriage or sexual exposure, contraceptive use, postpartum _____ , and induced abortion.

3.1.2 Measures of fertility

Several measures capture different aspects of fertility. The **crude birth rate (CBR)** = (live births / mid-year population) × 1,000. It is easy to calculate but affected by the age-sex structure of the population. The **general fertility rate (GFR)** = (live births / mid-year population of women aged 15–49) × 1,000; this restricts the denominator to women of reproductive age, making it a more

precise measure. The **age-specific fertility rate (ASFR)** = (births to women aged x to x+n / mid-year population of women aged x to x+n) × 1,000; it measures fertility within each five-year age group.

The **total fertility rate (TFR)** is the sum of all age-specific fertility rates multiplied by 5 (for five-year age groups), representing the average number of children a woman would bear if she experienced current age-specific rates throughout her reproductive life. It is the most widely used summary fertility measure. **Replacement-level fertility** is approximately 2.1 children per woman in low-mortality populations (slightly higher where mortality is elevated). Nigeria TFR of approximately 5.3 is more than twice replacement level, indicating continued rapid population growth.

Fill in the blank: The total fertility rate equals the sum of all age-specific fertility rates multiplied by _____ (for five-year age groups) and represents the average number of children a woman would bear if current rates applied throughout her reproductive life.

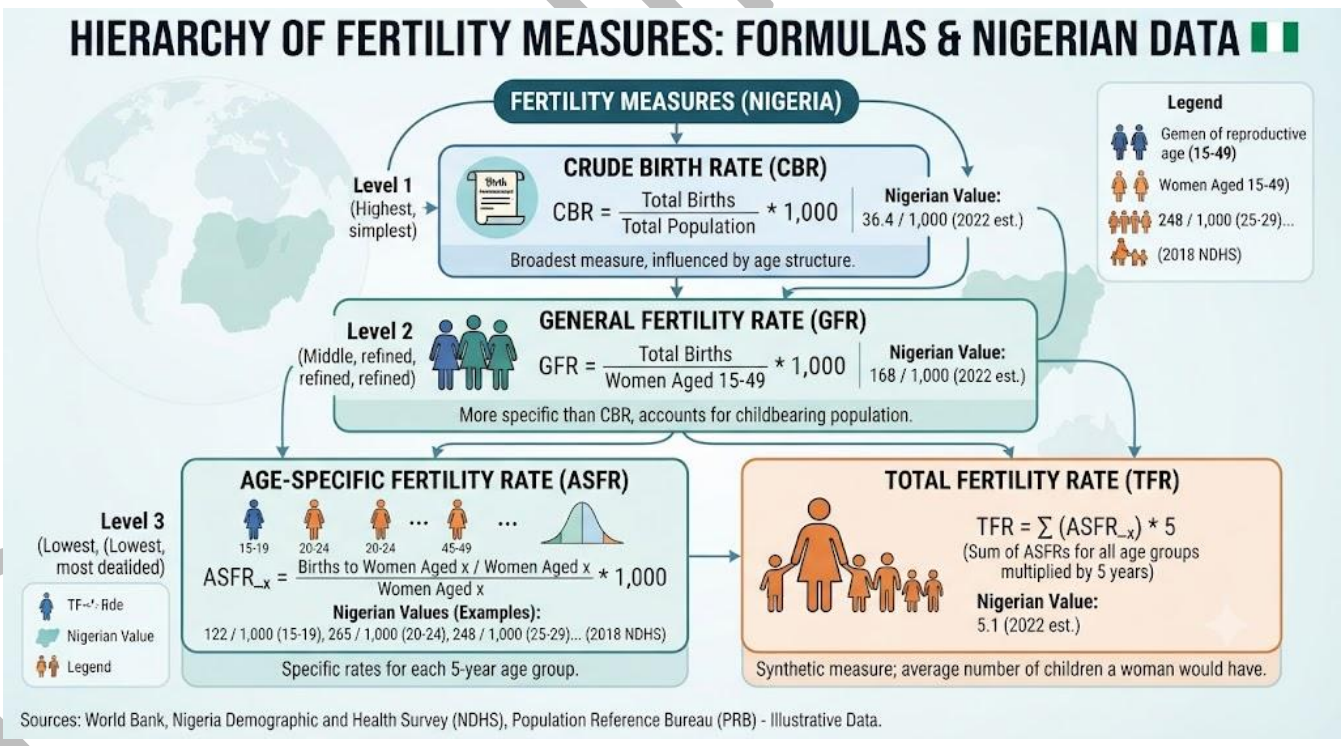

Figure 3.1: Fertility measures and their relationships

3.1.3 Fertility trends in Nigeria

Nigeria total fertility rate has declined only modestly from approximately 6.9 in the 1980s to 5.3 in 2018, one of the slowest fertility transitions in sub-Saharan Africa. Contraceptive prevalence remains low at approximately 17% of married women using any method. There is marked regional variation: the northern zones have TFRs above 7, while the south-south and southeast have TFRs closer to 4. This regional variation reflects differences in female education, age at marriage, and contraceptive access, with the north lagging in all three.

The health implications of high fertility are significant. Women with four or more pregnancies (**grand multiparity**) face higher risks of anaemia, uterine rupture, postpartum haemorrhage, and obstetric fistula. Closely spaced births (less than 24 months apart) increase the risk of low birth weight, preterm birth, and child malnutrition. High fertility perpetuates rapid population growth, stretching health system capacity. Accelerating Nigeria fertility transition through investment in female education, family planning access, and economic empowerment is among the highest-impact health and development interventions available.

Fill in the blank: Nigeria total fertility rate of approximately 5.3 remains more than twice _____ -level fertility of 2.1, indicating continued rapid population growth and persistent high demand for maternal and child health services.

Pilot questions 3.1

1. Distinguish between fertility and fecundity.
2. Name the four proximate determinants of fertility.
3. Write the formula for the crude birth rate.
4. Define the total fertility rate and state Nigeria approximate value.
5. Name two health consequences of high fertility for Nigerian women.

3.2 Mortality: Concepts and Measures

3.2.1 Definition and determinants of mortality

Mortality refers to deaths occurring in a population over a specified period. Its study is **thanatology** within demography. Mortality is determined by the interplay of biological factors (genetic susceptibility, immune status, age), environmental factors (sanitation, air quality, disease vectors), socioeconomic factors (income, education, occupation), and healthcare factors (access to prevention and treatment). In Nigeria, the leading causes of mortality include malaria, lower respiratory infections, neonatal disorders, HIV/AIDS, diarrhoeal diseases, and cardiovascular disease, reflecting the double burden of infectious and non-communicable disease.

Mortality varies systematically by **age** (highest in infants and the very old, lowest in older children and young adults), **sex** (males have higher mortality than females at most ages), **geographic location** (higher in rural areas and northern Nigeria), and **socioeconomic status** (higher in lower-income households). These differentials identify the populations at greatest mortality risk and point to the interventions most likely to reduce it: improved neonatal care, malaria prevention, nutrition, and equitable health service access.

Fill in the blank: Mortality is highest among _____ and the very old, lowest in older children and young adults, reflecting the characteristic U-shaped age pattern of death rates.

3.2.2 Measures of mortality

The **crude death rate (CDR)** = (deaths / mid-year population) × 1,000. The **age-specific death rate (ASDR)** = (deaths in age group x / mid-year population in age group x) × 1,000. The **infant mortality rate (IMR)** = (deaths under 1 year of age / live births) × 1,000; this is one of the most widely used indicators of population health and development. The **under-five mortality rate (U5MR)** = (deaths under 5 years / live births) × 1,000. The **maternal mortality ratio (MMR)** = (maternal deaths / live births) × 100,000.

Nigeria IMR was approximately 72 per 1,000 live births in 2018, and U5MR approximately 120 per 1,000, among the highest in the world and reflecting high neonatal, infant, and child mortality from preventable causes. The MMR was approximately 512 per 100,000 live births, meaning roughly 1 in 200 births results in a maternal death. These indicators collectively define Nigeria high premature mortality burden and the urgency of investments in reproductive, maternal, neonatal, and child health services.

Fill in the blank: The infant mortality rate is calculated as deaths under _____ year of age divided by live births, multiplied by 1,000, and is one of the most widely used indicators of population health.

REFERENCE TABLE: KEY MORTALITY MEASURES (NIGERIA)

MORTALITY MEASURE	DEFINITION / DESCRIPTION	FORMULA	UNIT	CURRENT ESTIMATE (NIGERIA, LATEST AVAILABLE)
CRUDE DEATH RATE (CDR)	Number of deaths per 1,000 population in a given year.	$\frac{\text{Total Deaths}}{\text{Total Mid-year Population}} * 1{,}000$	per 1,000 people	**Approx. 11.5 - 12.5** (varies by source, 2022 est.)
INFANT MORTALITY RATE (IMR)	Number of deaths of infants under age 1 per 1,000 live births.	$\frac{\text{Deaths under age 1}}{\text{Total Live Births}} * 1{,}000$	per 1,000 live births	**Approx. 55 - 65** (varies, 2023 est.)
MATERNAL MORTALITY RATIO (MMR)	Number of maternal deaths per 100,000 live births.	$\frac{\text{Number of Maternal Deaths}}{\text{Total Live Births}} * 100{,}000$	per 100,000 live births	**Approx. 800 - 1,050** (high, varies significantly, 2020-2023 est.)
UNDER-5 MORTALITY RATE (U5MR)	Number of deaths of children under age 5 per 1,000 live births.	$\frac{\text{Deaths under age 5}}{\text{Total Live Births}} * 1{,}000$	per 1,000 live births	**Approx. 100 - 120** (varies, 2022 est.)
LIFE EXPECTANCY AT BIRTH (e_0)	Average number of years a newborn is expected to live if mortality patterns remain constant.	Based on a life table calculation.	Years	**Approx. 53 - 55** (varies, lower end, 2023 est.)
NEONATAL MORTALITY RATE (NMR)	Number of deaths during the first 28 days of life per 1,000 live births.	$\frac{\text{Deaths in first 28 days}}{\text{Total Live Births}} * 1{,}000$	per 1,000 live births	**Approx. 30 - 35** (varies, 2022 est.)

***Note:** All values are estimates and vary by source (e.g., World Bank, UN, WHO, National Bureau of Statistics). Please refer to the specific year and source for precise data.*

Figure 3.2: Mortality measures and Nigeria current values

3.2.3 Mortality trends and the life table

A **life table** is a demographic model that describes the mortality experience of a cohort from birth to death. It begins with a hypothetical cohort of 100,000 births (the radix) and applies age-

specific death rates to calculate, for each age interval, the number surviving, the number dying, the probability of dying, and the number of life years lived. The **life expectancy at birth (e_0)** derived from the life table is the average number of years a newborn would live if subjected to current age-specific mortality rates throughout life. Nigeria life expectancy at birth is approximately 55 years.

Life tables are used in health planning to estimate the years of life lost to premature death, to compare mortality between populations after controlling for age structure, and to project future mortality. The **standardised mortality ratio (SMR)** compares observed deaths in a population to expected deaths based on a standard population age-specific rates, allowing mortality comparisons between populations with different age structures. Declining IMR and U5MR in Nigeria over recent decades, while still high, reflect improvements in immunisation coverage, nutrition, and malaria control that have increased life expectancy from approximately 44 years in 1980 to approximately 55 years today.

Fill in the blank: Life expectancy at birth (e_0) is derived from the life table and represents the average years of life a newborn would live if subjected to current _____ -specific mortality rates throughout their life.

Pilot questions 3.2

1. Write the formula for the infant mortality rate.
2. Define the maternal mortality ratio and state Nigeria approximate value.
3. What is a life table and what is its radix?
4. Define life expectancy at birth.
5. What is the standardised mortality ratio and why is it used?

3.3 Migration: Concepts and Measures

3.3.1 Definition, types, and determinants of migration

Migration is the permanent or semi-permanent change of residence by an individual or group. It is classified by **direction** (internal: within a country; international: between countries), **distance** (short-distance: within a region; long-distance: inter-regional or international), **duration** (permanent, seasonal, or circular), and **voluntariness** (voluntary: driven by economic or personal reasons; forced: driven by conflict, disaster, or persecution). **Rural-to-urban migration** is the dominant internal migration pattern in Nigeria, driven by economic differentials between urban and rural areas.

The determinants of migration are described by the **push-pull model**: push factors (conditions in the origin area that drive people to leave, such as poverty, unemployment, drought, or conflict) and pull factors (conditions in the destination area that attract migrants, such as employment opportunities, better services, or social networks). In Nigeria, the high rates of rural-to-urban migration are driven by push factors of limited rural economic opportunity and inadequate services, and pull factors of urban employment and higher incomes. International emigration is driven by brain drain: skilled professionals, particularly nurses and doctors, emigrating to high-income countries for better pay and working conditions.

Fill in the blank: The push-pull model describes migration determinants as push factors (conditions driving people _____ the origin area) and pull factors (conditions attracting people to the destination area).

3.3.2 Measures of migration

Migration is the most difficult demographic component to measure because it involves a process (movement) rather than an event (birth or death) and is not universally registered. Key measures include the **in-migration rate** = (in-migrants / mid-year population) × 1,000; the **out-migration rate** = (out-migrants / mid-year population) × 1,000; and the **net migration rate** = (in-migrants − out-migrants / mid-year population) × 1,000, which may be positive (population gain from

migration) or negative (population loss). The **gross migration rate** is the sum of in-migration and out-migration rates and measures total population turnover.

Migration data are collected from census questions on place of birth and place of residence five years before the census, from household surveys, from border crossing records, and from administrative databases. Each source has limitations: census questions miss short-term or return migrants; surveys have small samples; border records are incomplete for undocumented migrants. In Nigeria, internal migration estimates rely primarily on census comparison of birthplace and current residence. The **lifetime migration rate** compares birthplace to current residence in the census, while the **period migration rate** compares residence at two time points.

Fill in the blank: The net migration rate is calculated as in-migrants minus out-migrants, divided by the _____ -year population, multiplied by 1,000, and may be positive or negative.

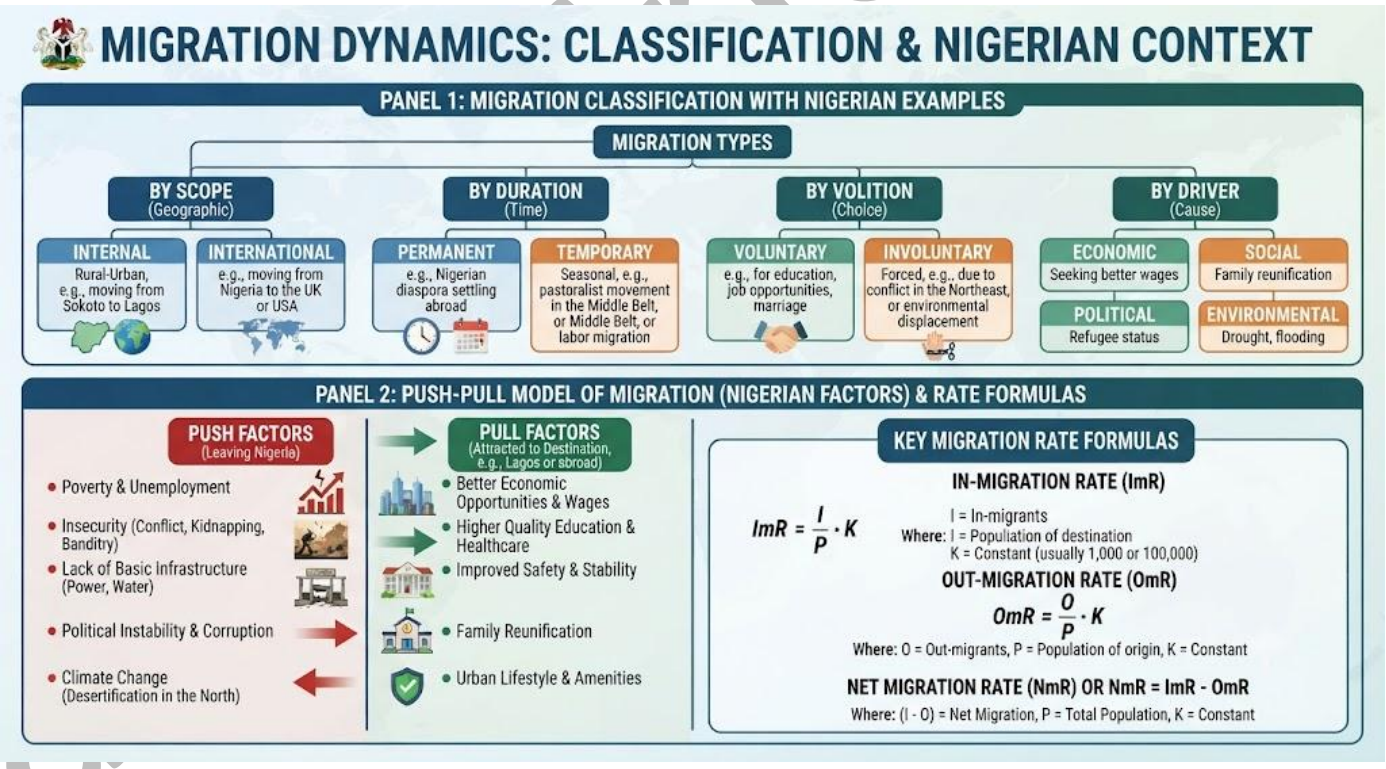

Figure 3.3: Migration types, determinants, and measures

3.3.3 Migration and health in Nigeria

Migration affects health through multiple pathways. **Migrants** face health risks during the migration process itself (physical hazards of journey, violence, exposure) and in the destination area (poor housing, food insecurity, social isolation, discrimination, and limited access to health services). The **healthy migrant effect** refers to the observation that migrants are often healthier than the resident population at their destination at the time of arrival, because migration selects for those who are physically and economically capable of moving; this health advantage tends to erode over time as migrants adopt the lifestyle and exposures of the destination population.

For Nigeria, the most significant migration-health interaction is **brain drain**: the emigration of trained health professionals to the United Kingdom, United States, Canada, and Gulf states. Nigeria trains doctors and nurses at substantial public cost, only to lose a disproportionate share to emigration. This reduces the health worker-to-population ratio in Nigeria, increasing the burden on remaining staff and reducing access to care. Internal rural-to-urban migration concentrates health need in cities whose infrastructure and services have not kept pace with population growth, producing urban health penalties particularly in informal settlements.

Fill in the blank: The healthy _____ effect describes the observation that migrants are often healthier than the resident population at their destination at time of arrival, because migration selects for those who are physically and economically capable of moving.

Pilot questions 3.3

1. Classify migration by direction and voluntariness, giving a Nigerian example of each.
2. What is the push-pull model of migration?
3. Write the formula for the net migration rate.
4. What is the healthy migrant effect?
5. How does brain drain affect the Nigerian health system?

3.4 Morbidity and Disability

3.4.1 Measuring morbidity: incidence and prevalence

Morbidity refers to illness, disease, or injury in a population. It is measured primarily through **incidence** and **prevalence**. **Incidence** is the number of new cases of a disease occurring in a population at risk over a defined time period. The **incidence rate** = (new cases during period / population at risk at start of period) × multiplier (10^n), where n is chosen to give a convenient number. **Prevalence** is the number of existing cases (new and old) at a specific point in time (**point prevalence**) or during a period (**period prevalence**).

The relationship between incidence and prevalence is: Prevalence ≈ Incidence × Duration of disease. A disease with high incidence but short duration (such as seasonal influenza) may have low prevalence at any given time; a disease with moderate incidence but long duration (such as diabetes) accumulates a high prevalence. This relationship is important in health planning: **incidence** measures the rate at which a disease is occurring and reflects prevention success, while **prevalence** measures the burden of existing cases and reflects the demand for treatment services.

Fill in the blank: The relationship between incidence, prevalence, and disease duration is expressed as: Prevalence ≈ Incidence × _____ of disease.

3.4.2 Disability and its measurement

Disability is an umbrella term for impairments, activity limitations, and participation restrictions resulting from the interaction between a person health condition and contextual factors (environmental and personal). The **International Classification of Functioning, Disability and Health (ICF)** provides a standard framework for measuring and classifying disability. Disability is measured through census questions, population surveys (such as the WHO model disability survey), and clinical assessments. In Nigeria, disability prevalence estimates vary widely between surveys depending on the questions used and the definition applied.

Disability has important health planning implications: disabled persons often have higher healthcare utilisation needs, face barriers to accessing services, and are at elevated risk of poverty. The **Washington Group Short Set** of six disability questions is the international standard for census and survey measurement of disability, covering difficulty in seeing, hearing, walking, self-care, communication, and cognition. These questions identify functional limitations in a comparable, cross-nationally validated format. Nigeria use of standardised disability questions in population surveys would substantially improve the evidence base for disability-inclusive health planning.

Fill in the blank: The Washington Group Short _____ of disability questions covers difficulty in seeing, hearing, walking, self-care, communication, and cognition, and is the international standard for census-based disability measurement.

3.4.3 The burden of disease: DALYs and YLLs

Disability-adjusted life years (DALYs) measure the total burden of disease as the sum of years of life lost to premature death (**YLL**) and years lived with disability (**YLD**): DALY = YLL + YLD. One DALY represents one year of healthy life lost. **YLL** = number of deaths × standard life expectancy at age of death. **YLD** = number of cases × disability weight (0 to 1, where 0 = perfect health and 1 = death) × duration. DALYs allow comparison of the burden of different diseases regardless of whether they kill or merely disable, and are used to prioritise health interventions by the burden they address.

Nigeria and sub-Saharan Africa carry a disproportionate share of the global burden of disease measured in DALYs. Communicable, neonatal, and nutritional diseases account for the majority of DALYs in Nigeria, driven by malaria, neonatal disorders, diarrhoeal diseases, and HIV/AIDS. Non-communicable diseases (cardiovascular disease, diabetes, mental disorders) are a growing contributor. The **Global Burden of Disease (GBD)** study, produced by the Institute for Health Metrics and Evaluation (IHME), provides annual country-level DALY estimates and is the primary global resource for burden of disease analysis and health priority-setting.

Fill in the blank: A disability-adjusted life year (DALY) is the sum of years of life lost to premature death (YLL) and years lived with _____ (YLD), representing one year of healthy life lost.

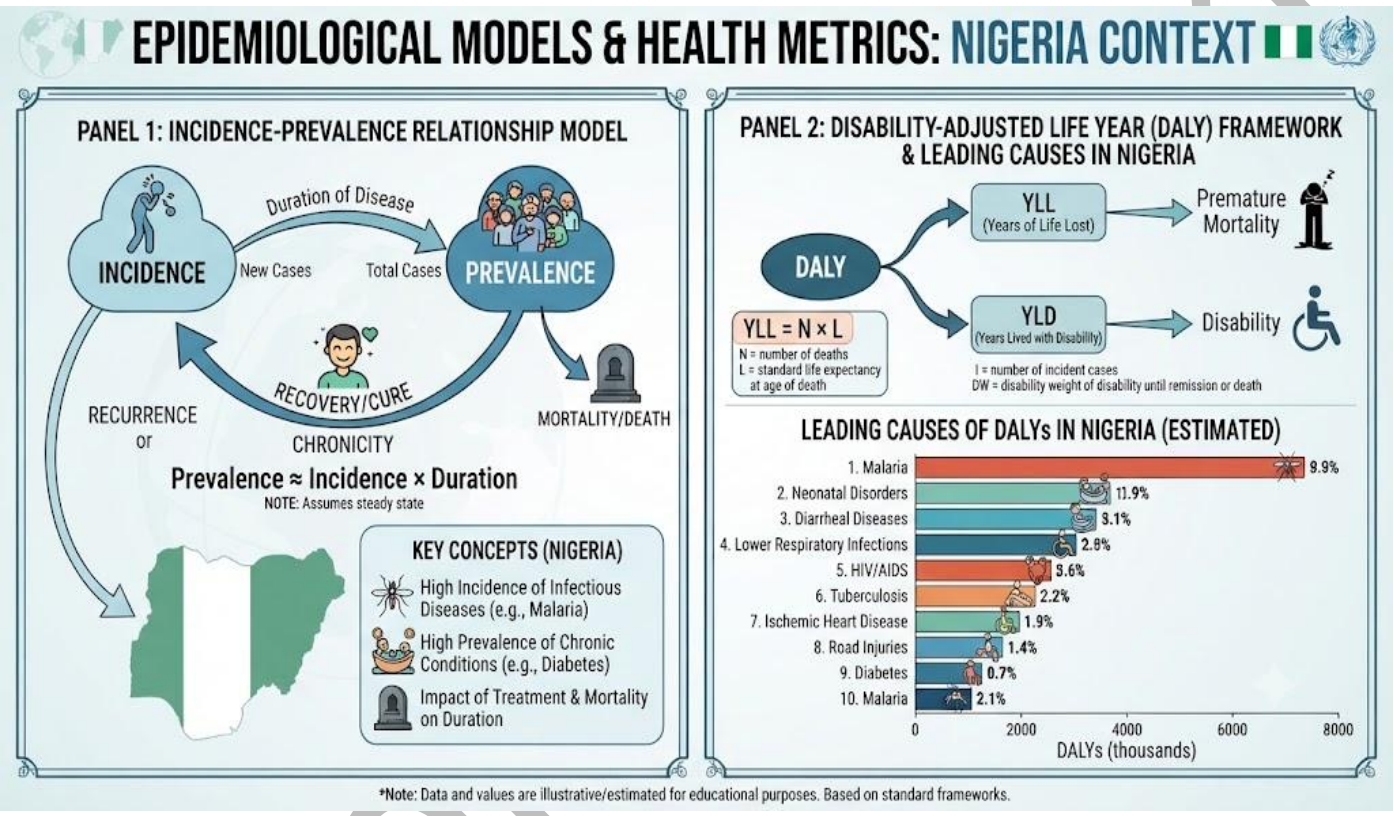

Figure 3.4: Morbidity measures and the burden of disease framework

Pilot questions 3.4

1. Distinguish between incidence and prevalence.
2. Write the relationship between prevalence, incidence, and duration.
3. What does DALY stand for and what does one DALY represent?
4. Write the formula for DALY.
5. Name the two leading communicable disease contributors to the burden of disease in Nigeria.

Series Summary

This Series examined the measurement of the three demographic processes and extended that measurement framework to morbidity and disability. Fertility was measured through the CBR, GFR, ASFR, and TFR, with the TFR established as the primary summary measure; Nigeria high TFR of 5.3 and the health consequences of high fertility and grand multiparity were described. Mortality was measured through CDRs, age-specific rates, IMR, U5MR, and MMR, and the life table was introduced as the instrument that synthesises age-specific mortality into life expectancy and other summary measures.

Migration was classified by direction, distance, duration, and voluntariness, with rural-to-urban migration and brain drain identified as the most health-relevant migration phenomena in Nigeria. Morbidity was measured through incidence and prevalence and their relationship via disease duration. Disability was framed through the ICF and the Washington Group Short Set. The Series concluded with the DALY framework, establishing YLL + YLD as the comprehensive measure of health burden that supports evidence-based priority-setting in health planning (SLOs 3.1 to 3.7).

Glossary of Terms

- **Age-specific death rate (ASDR):** deaths in a specific age group per 1,000 mid-year population in that age group.
- **Age-specific fertility rate (ASFR):** live births to women in a specific age group per 1,000 mid-year women in that age group.
- **Crude birth rate (CBR):** live births per 1,000 mid-year population per year.
- **Crude death rate (CDR):** deaths per 1,000 mid-year population per year.
- **DALY:** disability-adjusted life year; one year of healthy life lost, equal to YLL + YLD.
- **Fecundity:** the biological capacity to reproduce, distinct from fertility, which is actual reproductive performance.

- **Incidence:** the number of new cases of a disease in a population at risk over a defined period.
- **Infant mortality rate (IMR):** deaths under one year of age per 1,000 live births.
- **Life expectancy at birth:** the average years of life a newborn would live if subjected to current age-specific mortality rates throughout life.
- **Maternal mortality ratio (MMR):** maternal deaths per 100,000 live births.
- **Net migration rate:** in-migrants minus out-migrants per 1,000 mid-year population.
- **Prevalence:** the number of existing cases of a disease in a population at a point in time or during a period.
- **Total fertility rate (TFR):** the average number of children a woman would bear if current age-specific fertility rates applied throughout her reproductive life.
- **YLL:** years of life lost to premature death; a component of DALYs.
- **YLD:** years lived with disability; a component of DALYs, calculated as cases multiplied by disability weight multiplied by duration.

Concept Check Questions [Series 3]

Objective questions

1. The four proximate determinants of fertility are marriage, contraceptive use, postpartum _____ , and induced abortion. (Linked to SLO 3.1)
2. The total fertility rate equals the sum of all age-specific fertility rates multiplied by _____ for five-year age groups. (Linked to SLO 3.1)
3. The infant mortality rate is deaths under _____ year of age per 1,000 live births. (Linked to SLO 3.3)
4. The life table begins with a hypothetical cohort of _____ births, called the radix. (Linked to SLO 3.4)
5. Net migration rate = (in-migrants − out-migrants) / mid-year population × _____. (Linked to SLO 3.5)
6. A DALY equals years of life lost (YLL) plus years lived with _____ (YLD). (Linked to SLO 3.7)

Short-answer questions

7. Distinguish between the crude birth rate, general fertility rate, and total fertility rate, and state which is the most useful summary measure. (Linked to SLO 3.1)
8. Define the infant mortality rate and maternal mortality ratio, write their formulas, and state Nigeria approximate current values. (Linked to SLO 3.3)
9. Distinguish between incidence and prevalence and explain their relationship via disease duration, giving a clinical example. (Linked to SLO 3.6)

Long-answer questions

10. Discuss fertility measurement in Nigeria, covering the proximate determinants, major fertility measures, current TFR, and health consequences of high fertility. (Linked to SLOs 3.1–3.2)
11. Explain the life table, describe how it is constructed, and discuss its applications in health planning and mortality analysis. (Linked to SLOs 3.3–3.4)

12. Define DALYs and their components, explain how they are calculated, and assess their value for health priority-setting in Nigeria. (Linked to SLO 3.7)

Answers to Concept Check Questions [Series 3]

Objective questions

6. Infecundability.
7. 5.
8. 1.
9. 100,000.
10. 1,000.
11. Disability.

Short-answer questions

12. CBR = live births / mid-year population × 1,000; denominator includes all ages and both sexes, so it is affected by age-sex structure. GFR = live births / mid-year women aged 15–49 × 1,000; restricts denominator to women of reproductive age, making it more precise. TFR = sum of all ASFRs × 5; represents the average children a woman would bear under current rates and is not affected by age structure, making it the most useful summary measure for comparison across populations and over time.
13. IMR = (deaths under 1 year / live births) × 1,000; Nigeria approximately 72 per 1,000 live births (2018 NDHS). MMR = (maternal deaths / live births) × 100,000; Nigeria approximately 512 per 100,000 live births, meaning roughly 1 in every 200 deliveries results in a maternal death, among the highest ratios in the world and reflecting inadequate skilled birth attendance, emergency obstetric care, and antenatal services.
14. Incidence is the number of new cases of a disease occurring in a population at risk over a defined period. Prevalence is the number of existing cases at a point in time. Relationship: Prevalence ≈ Incidence × Duration. Example: type 2 diabetes has moderate incidence but long duration (lifelong), producing high prevalence; in contrast, a

respiratory infection (influenza) has high incidence but short duration (days to weeks), producing low point prevalence despite many new cases occurring.

Long-answer questions

15. **Basic response:** Fertility is actual reproductive performance (live births), distinct from fecundity (biological capacity). Proximate determinants: marriage/sexual exposure, contraceptive use, postpartum infecundability, induced abortion. CBR = births/population × 1,000. GFR = births/women 15–49 × 1,000. TFR = sum of ASFRs × 5; Nigeria TFR approximately 5.3, more than twice replacement level. Health consequences: grand multiparity raises risk of haemorrhage, uterine rupture, anaemia, obstetric fistula; closely spaced births increase low birth weight and child malnutrition.

Value-added response: Nigeria slow fertility transition (TFR fell from 6.9 to 5.3 over 30 years) reflects low contraceptive prevalence (17%), early and universal marriage especially in the north, and limited female education. The northern TFR above 7 compared to southern TFRs near 4 shows that sub-national variation requires targeted regional strategies rather than a uniform national approach.

16. **Basic response:** A life table is a model describing the mortality experience of a hypothetical birth cohort of 100,000 (the radix) subjected to current age-specific death rates. Columns include: l_x (survivors at age x), d_x (deaths in interval x to x+n), ${}_xq_x$ (probability of dying), L_x (person-years lived), T_x (total person-years from age x onward), and e_x (life expectancy at age x). Nigeria e_0 approximately 55 years. Applications: calculating years of life lost, comparing mortality between populations (SMR), health workforce planning, and evaluating intervention impact.

Value-added response: The life table converts age-specific death rates into a coherent summary of the mortality experience, allowing planners to identify at which ages preventable deaths are concentrated. If U5MR falls from 120 to 60 per 1,000, the gain in life expectancy at birth can be quantified from the life table, providing a measurable return on investment in child health programmes that supports advocacy for continued funding.

17. **Basic response:** DALY = YLL + YLD. YLL = deaths × standard life expectancy at age of death. YLD = cases × disability weight (0–1) × duration. One DALY = one year of healthy life lost. Nigeria top DALY causes include malaria, neonatal disorders, lower respiratory infections, HIV/AIDS, and diarrhoeal diseases among communicable causes, alongside growing non-communicable disease burden.

Value-added response: DALYs are valuable for priority-setting because they capture both fatal and non-fatal disease burden in a single metric, preventing the undervaluation of disabling conditions with low mortality (such as mental disorders, musculoskeletal disease). In Nigeria, where mental disorders receive less than 1% of the health budget despite accounting for a significant share of DALYs, the GBD framework provides objective evidence to advocate for resource reallocation toward neglected high-burden conditions.

Answers to Pilot Questions [Series 3]

Part 3.1

11. Fertility is the actual reproductive performance of an individual or population, measured by live births. Fecundity is the biological capacity to bear children. A woman may be fecund but have low fertility if she uses contraception or delays childbearing.
12. Marriage or sexual exposure, contraceptive use, postpartum infecundability, and induced abortion.
13. CBR = (live births / mid-year population) × 1,000.
14. The total fertility rate is the average number of children a woman would bear if she experienced current age-specific fertility rates throughout her reproductive life (ages 15–49). Nigeria TFR is approximately 5.3 children per woman.
15. Any two of: anaemia from repeated pregnancies; uterine rupture (grand multiparity); postpartum haemorrhage; obstetric fistula; closely spaced births increasing child malnutrition and low birth weight.

Part 3.2

1. IMR = (deaths under 1 year of age / live births) × 1,000.
2. Maternal mortality ratio = (maternal deaths / live births) × 100,000. Nigeria approximate value: 512 per 100,000 live births.
3. A life table is a demographic model that describes the mortality experience of a hypothetical cohort of 100,000 births (the radix) as they age and die under current age-specific mortality rates, generating columns for survivors, deaths, probability of dying, and life expectancy at each age.
4. Life expectancy at birth (e_0) is the average number of years a newborn would live if subjected to current age-specific mortality rates throughout their life. It is derived from the life table and is approximately 55 years in Nigeria.
5. The standardised mortality ratio (SMR) compares observed deaths in a study population to the expected deaths if the standard population age-specific rates applied; it is used to compare mortality between populations with different age structures while controlling for the confounding effect of age.

Part 3.3

6. By direction: internal (within Nigeria, e.g. rural-to-urban migration from Kebbi to Lagos) and international (between countries, e.g. Nigerian nurses emigrating to the UK). By voluntariness: voluntary (e.g. economic migrants moving to Lagos for employment) and forced (e.g. internally displaced persons fleeing Boko Haram insurgency in the northeast).
7. The push-pull model describes migration as driven by push factors (conditions at the origin area motivating departure, such as poverty, unemployment, drought, or conflict) and pull factors (conditions at the destination that attract migrants, such as employment opportunities, higher wages, better services, or existing social networks).
8. Net migration rate = (in-migrants − out-migrants) / mid-year population × 1,000.

9. The healthy migrant effect is the observation that migrants are often healthier than the resident population at their destination at the time of arrival, because migration selects for individuals who are physically capable and economically motivated to move; this advantage tends to erode over time as migrants adopt destination-area behaviours and exposures.
10. Brain drain reduces Nigeria health worker-to-population ratio, increases workload on remaining staff, reduces access to specialist care, and represents a loss of the public investment made in training emigrating professionals. Rural areas and secondary facilities are most severely affected.

Part 3.4

11. Incidence is the number of new cases of a disease occurring in a population at risk over a defined period; it measures the rate at which disease is occurring. Prevalence is the number of existing cases (new and old) at a specific point or during a period; it measures the burden of disease at a given time.
12. Prevalence ≈ Incidence × Duration of disease.
13. DALY stands for disability-adjusted life year. One DALY represents one year of healthy life lost, either through premature death or through living with disability or illness.
14. DALY = YLL + YLD, where YLL = deaths × standard life expectancy at age of death, and YLD = cases × disability weight (0 to 1) × duration.
15. Malaria and neonatal disorders.

References and Attributions [Series 3]

Textual references

1. Bongaarts, J. (1978). A framework for analysing the proximate determinants of fertility. Population and Development Review, 4(1), 105-132.
2. GBD 2019 Diseases and Injuries Collaborators. (2020). Global burden of 369 diseases and injuries in 204 countries and territories. The Lancet, 396(10258), 1204-1222.
3. World Health Organization. (2001). International classification of functioning, disability and health (ICF). WHO Press.
4. National Open University of Nigeria (NOUN). (2023). Introduction to demography and vital statistics course material. NOUN Press.

Figures, Plates, Tables, and Boxes

1. Figure 3.1: Fertility measures and their relationships Attribution: AI generated using prompt "Generate a diagram showing the hierarchy of fertility measures (CBR, GFR, ASFR, TFR) with formulas and Nigerian current values for each." Suggested OER search string: "fertility measures crude birth rate general fertility rate total fertility rate Nigeria OER"
2. Figure 3.2: Mortality measures and Nigeria current values Attribution: AI generated using prompt "Generate a reference table of six mortality measures with formulas, units, and Nigeria current values." Suggested OER search string: "mortality measures crude death rate infant mortality rate maternal mortality ratio Nigeria OER"
3. Figure 3.3: Migration types, determinants, and measures Attribution: AI generated using prompt "Generate a two-panel diagram showing migration classification with Nigerian examples and a push-pull model with Nigerian factors and migration rate formulas." Suggested OER search string: "migration types push pull model internal international Nigeria measures in-migration out-migration OER"
4. Figure 3.4: Morbidity measures and the burden of disease framework Attribution: AI generated using prompt "Generate a two-panel diagram showing the incidence-

prevalence relationship model and the DALY framework with YLL and YLD formulas and a bar chart of leading DALY causes in Nigeria." Suggested OER search string: "incidence prevalence relationship DALY YLL YLD disability adjusted life years Nigeria burden of disease OER"

Course code: COM 302

Course title: Introduction to Demography and Vital Statistics

Course credit load: 2 Units

Series 4: Health Data and Vital Statistics

- **Part 4.1: Health Data: Definition and Sources**
  - Sub Part 4.1.1: Definition and importance of health data
  - Sub Part 4.1.2: Routine health information systems
  - Sub Part 4.1.3: Health surveys and surveillance systems
- **Part 4.2: Vital Statistics**
  - Sub Part 4.2.1: Definition and scope of vital statistics
  - Sub Part 4.2.2: Registration of vital events in Nigeria
  - Sub Part 4.2.3: Uses of vital statistics in health planning
- **Part 4.3: Measurement of Health and Disease**
  - Sub Part 4.3.1: Rates, ratios, and proportions
  - Sub Part 4.3.2: Measures of disease frequency
  - Sub Part 4.3.3: Measures of association
- **Part 4.4: Collection, Organisation, and Presentation of Health Data**
  - Sub Part 4.4.1: Data collection methods in health research
  - Sub Part 4.4.2: Data organisation and management
  - Sub Part 4.4.3: Presentation of health data: tables, charts, and graphs

Introduction

Every health system decision, from where to build a clinic to which disease to prioritise for control, rests on data. The quality of those decisions depends entirely on the quality of the data that supports them. Health data and vital statistics are the raw material of epidemiology, health planning, and evidence-based policy. Understanding where this data comes from, how it is collected and organised, and how it is best presented for analysis and communication is an essential competency for anyone working in health.

The aim of this Series is to define health data and vital statistics, describe the systems through which they are collected in Nigeria, explain the statistical measures used to describe disease frequency and association, and introduce the principles of health data collection, organisation, and presentation.

We shall commence by examining the definition, sources, and systems that generate health data. Next, we will explore vital statistics in depth. Moving on, we will examine the statistical measures used in health measurement. Finally, we will close by addressing the practical aspects of data collection, organisation, and presentation.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 4.1** define health data and describe the major sources from which health data are obtained in Nigeria,
- **SLO 4.2** explain the structure and functions of routine health information systems and surveillance systems,
- **SLO 4.3** define vital statistics and describe the vital events registration system in Nigeria,
- **SLO 4.4** distinguish between rates, ratios, and proportions and calculate selected measures of disease frequency,

- **SLO 4.5** explain and calculate measures of association including relative risk and odds ratio, and
- **SLO 4.6** describe the principles of health data collection, organisation, and presentation using appropriate tables and graphs.

4.1 Health Data: Definition and Sources

4.1.1 Definition and importance of health data

Health data is any information that describes the health status of individuals or populations, the determinants of health, or the performance of health systems. It encompasses clinical data from patient encounters, laboratory results, vital events records, population survey findings, facility utilisation statistics, and environmental health measurements. Health data is the foundation of **evidence-based health policy**: without reliable data, decision-makers cannot identify which populations are most at risk, which interventions are working, or where resources should be directed.

The importance of health data is captured in the principle: **"what gets measured gets managed."** Countries with strong health data systems respond to outbreaks faster, allocate resources more equitably, and achieve better health outcomes than those with weak systems. Nigeria has made significant investments in health data through the District Health Information System 2 (DHIS2) platform, the Nigeria Demographic and Health Survey, and the Integrated Disease Surveillance and Response system; however, data quality, completeness, and timeliness remain challenges across much of the health system.

Fill in the blank: Health _____ is any information describing the health status of individuals or populations, the determinants of health, or the performance of health systems, and forms the foundation of evidence-based policy.

4.1.2 Routine health information systems

A **routine health information system (RHIS)** collects data continuously from health facilities as part of their normal service delivery operations, without the need for a special survey. In Nigeria, the primary RHIS is the **Health Management Information System (HMIS)**, implemented through the **District Health Information System 2 (DHIS2)** platform. Facilities report monthly on outpatient attendance, inpatient admissions, antenatal care visits, deliveries, immunisation doses, laboratory tests, and disease notifications. These data are aggregated at the local government, state, and national levels for planning and monitoring.

The quality of RHIS data depends on **completeness** (all facilities reporting), **timeliness** (data submitted within the required period), and **accuracy** (data correctly recorded and entered). In Nigeria, RHIS data quality is variable: urban facilities and higher-level facilities tend to report more completely and accurately than rural and primary facilities. Data quality improvement requires investment in staff training, supervision, data validation processes, and feedback to facilities so that staff understand how their data are used and are motivated to improve reporting.

Fill in the blank: The District Health Information System 2 (DHIS2) is the platform used in Nigeria to implement the Health Management Information _____ , through which facilities report monthly health service data for aggregation and analysis.

4.1.3 Health surveys and surveillance systems

Population-based health surveys generate data that the RHIS cannot provide: information on the population not accessing health services, on behaviours and risk factors, and on health outcomes not recorded in clinical registers. The **Nigeria Demographic and Health Survey (NDHS)** and the **Multiple Indicator Cluster Survey (MICS)** are the primary national health surveys. Disease-specific surveys include the Nigeria HIV/AIDS Indicator and Impact Survey (NAIIS) and the National Nutrition and Health Survey (NNHS). Each uses a nationally representative sample to produce population-level estimates with defined confidence intervals.

Disease surveillance systems monitor the occurrence of specific diseases or conditions continuously or periodically, with the aim of detecting outbreaks and guiding control responses. The **Integrated Disease Surveillance and Response (IDSR)** system, coordinated by the Nigeria Centre for Disease Control (NCDC), requires health facilities to report specified notifiable

conditions weekly. **Sentinel surveillance** uses a subset of sites to monitor disease trends continuously; it is less comprehensive than universal reporting but more sensitive to trend changes. Event-based surveillance uses informal sources (media, community reports, rumours) to detect potential health threats early.

Fill in the blank: The Integrated Disease Surveillance and Response (IDSR) system requires health facilities to report specified notifiable conditions on a _____ basis to the NCDC for outbreak detection and response.

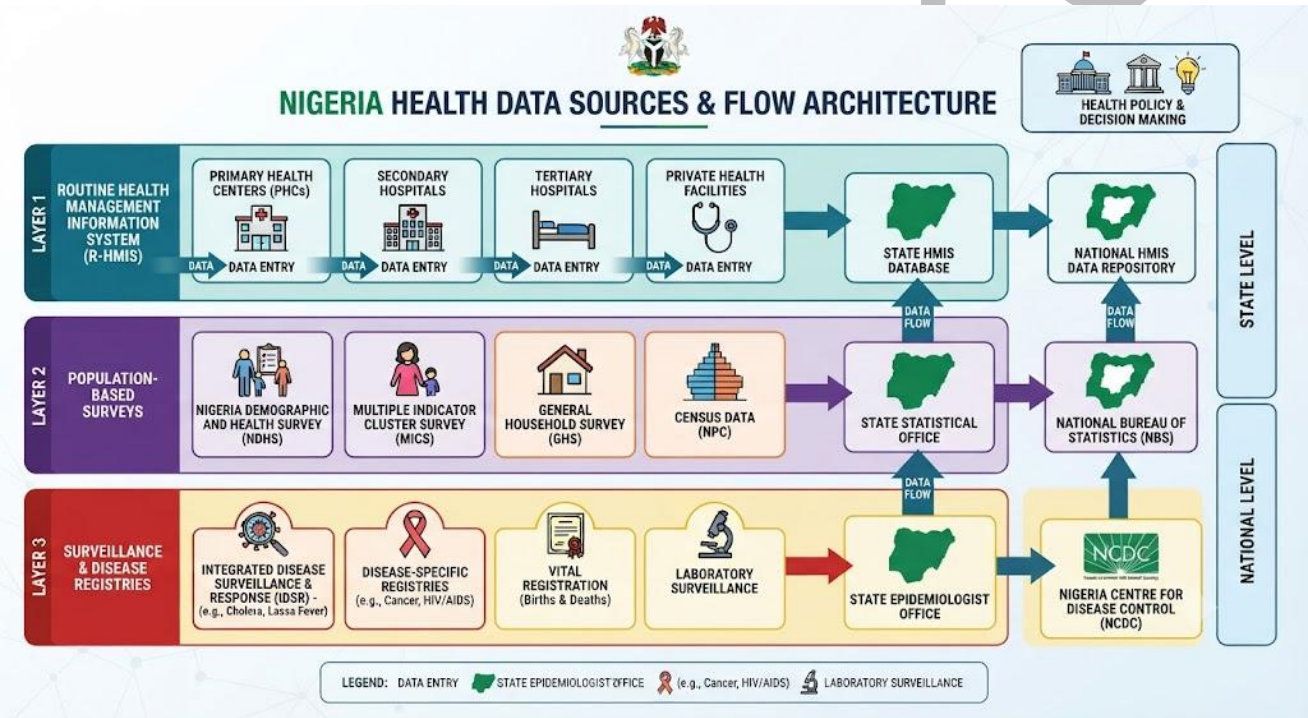

Figure 4.1: Health data sources in Nigeria

Pilot questions 4.1

1. Define health data and give two examples.
2. What is a routine health information system?
3. Name the RHIS platform used in Nigeria.
4. Name two national health surveys conducted in Nigeria.
5. What is the IDSR and what is its purpose?

4.2 Vital Statistics

4.2.1 Definition and scope of vital statistics

Vital statistics are statistics derived from the registration of vital events: births, deaths, marriages, divorces, and foetal deaths (stillbirths). They are the most fundamental demographic and health data because they record the events that change population size and structure. Vital statistics provide the numerators for the most critical health indicators: birth rates, death rates, infant mortality rates, and maternal mortality ratios all require counts of births and deaths that can only be obtained reliably through complete vital registration or, where registration is incomplete, through population surveys and indirect estimation.

Vital statistics serve multiple purposes beyond health planning. Birth registration establishes legal identity: a person without a birth certificate cannot access education, healthcare, financial services, or formal employment in most countries. Death registration is the legal basis for inheritance and estate settlement. Marriage and divorce registration governs family law. The **civil registration and vital statistics (CRVS)** system that generates vital statistics is therefore both a public health infrastructure and a legal and social infrastructure, and its strengthening benefits individuals as well as the health system.

Fill in the blank: Vital _____ are derived from the registration of vital events including births, deaths, marriages, divorces, and foetal deaths, and provide the numerators for key health indicators.

4.2.2 Registration of vital events in Nigeria

Vital events registration in Nigeria is the responsibility of the **National Population Commission (NPC)**, established under the National Population Commission Act. Registration is legally compulsory: births must be registered within 60 days and deaths within 3 days of the event. In practice, enforcement is minimal and coverage remains far below universal. The 2018 NDHS estimated that only 43% of children under 5 had their births registered, with wide regional variation: registration is higher in the south (over 70%) than in the north (below 30%).

The gaps in vital registration have several consequences. Death registration is even less complete than birth registration, making cause-of-death statistics unreliable: Nigeria national cause-of-death data are primarily estimated from surveys and modelling rather than from registered deaths with medical certification. Strengthening the CRVS system requires investment in registration infrastructure, community awareness, and the integration of registration into maternal and child health service delivery (registering births at the time of delivery and deaths at the time of a health facility encounter).

Fill in the blank: In Nigeria, births must be registered within _____ days and deaths within 3 days of the event, though enforcement is minimal and actual registration coverage falls far below these legal requirements.

4.2.3 Uses of vital statistics in health planning

Vital statistics support health planning through several pathways. **Numerator data** for health rates: birth counts provide the denominator for child health indicators (immunisation coverage, stunting prevalence) and the numerator for fertility rates; death counts by age and cause provide the data for mortality analysis and cause-of-death statistics. **Population estimation**: in the absence of a recent census, birth and death registration data can be used to update population estimates through the balancing equation. **Priority-setting**: cause-of-death data identify which conditions are killing the most people and guide decisions about where to invest in prevention and treatment.

Programme monitoring: trends in vital statistics indicators (IMR, U5MR, MMR) are the primary outcome measures for maternal and child health programmes. **International comparison**: standardised vital statistics indicators allow Nigeria performance to be compared with other countries and against global targets such as the Sustainable Development Goals (SDG 3). Because Nigeria vital registration is incomplete, most of these uses depend on vital statistics estimated from surveys and demographic models rather than from the registration system directly. Improving registration coverage would substantially improve the timeliness, granularity, and reliability of these data for all planning purposes.

Fill in the blank: Cause-of-death data from vital statistics support health _____ -setting by identifying which conditions are responsible for the most deaths and directing investment toward prevention and treatment of those conditions.

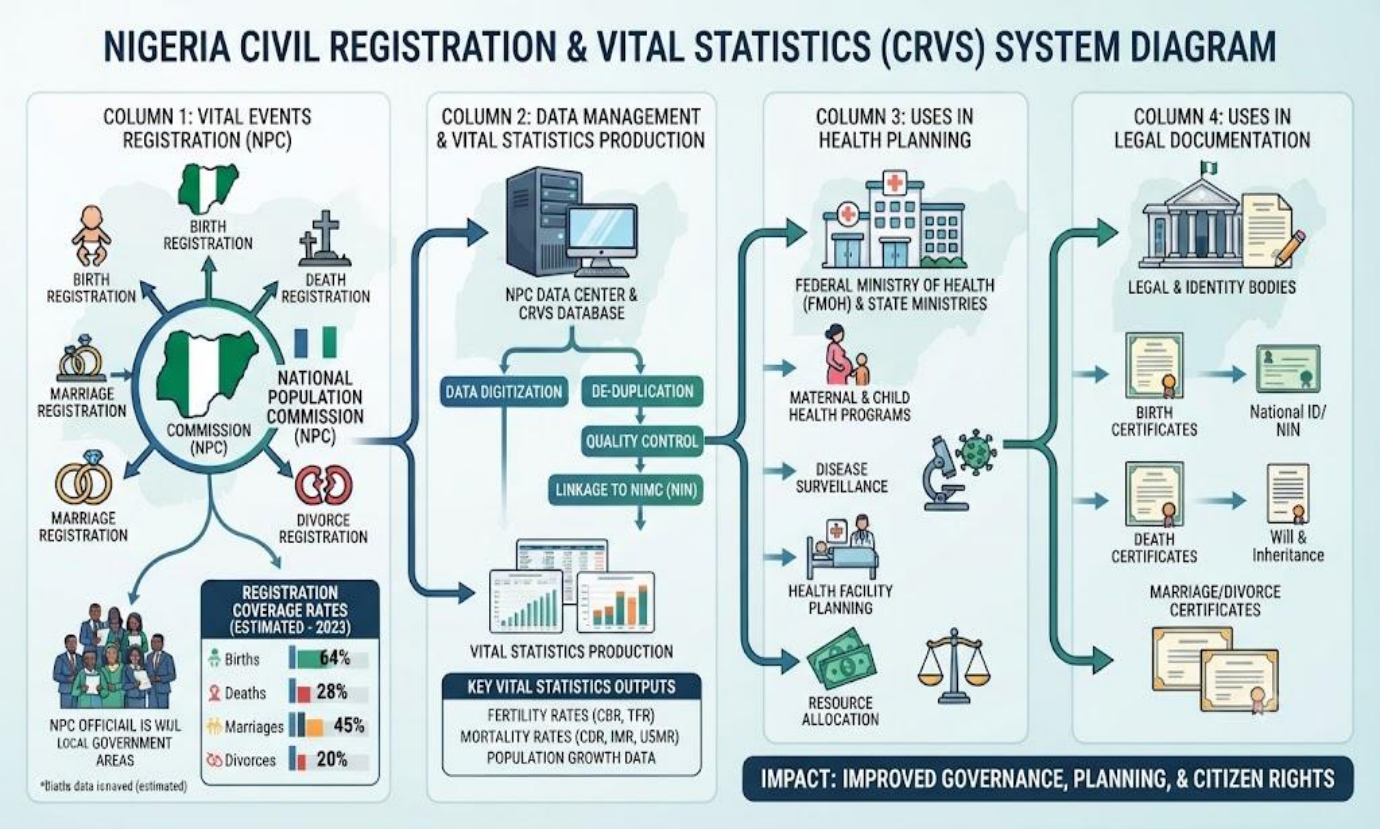

Figure 4.2: The civil registration and vital statistics system in Nigeria

Pilot questions 4.2

1. Define vital statistics and name the vital events from which they are derived.
2. Which body is responsible for vital events registration in Nigeria?
3. What proportion of children under 5 have their births registered in Nigeria?
4. Name two non-health uses of birth registration.
5. Name three uses of vital statistics in health planning.

4.3 Measurement of Health and Disease

4.3.1 Rates, ratios, and proportions

Three types of measures are used to quantify health and disease. A **proportion** is a fraction in which the numerator is included in the denominator, expressing a part as a fraction of the whole; it ranges from 0 to 1 (or 0% to 100%). A **ratio** is the quotient of two quantities where the numerator may or may not be included in the denominator; it has no fixed range. A **rate** is a measure of the frequency of a health event in a defined population over a defined time period; it includes a time dimension and is expressed per a standard population size (per 1,000, per 10,000, or per 100,000). The distinction matters because rates, ratios, and proportions have different mathematical properties and different interpretations.

Examples: the proportion of deliveries occurring in a health facility = facility deliveries / total deliveries. The sex ratio = males / females (a ratio, not a proportion, because males are not included in the female denominator). The crude birth rate = live births / mid-year population × 1,000 (a rate because it includes a time dimension and a standard multiplier). Misidentifying a proportion as a rate or vice versa leads to errors in interpretation and comparison. The **case fatality rate (CFR)** = deaths from a disease / cases of that disease × 100; despite its name, it is technically a proportion, not a rate, because it has no time dimension.

Fill in the blank: A _____ is a fraction in which the numerator is included in the denominator, ranging from 0 to 1; a rate differs by including a time dimension, expressed per a standard population multiplier.

4.3.2 Measures of disease frequency

The two fundamental measures of disease frequency are **incidence** and **prevalence** (defined in Series 3). Beyond these, several derived measures are important. The **attack rate** = cases during an outbreak / population at risk × 100; used in outbreak investigation to measure the proportion of the exposed population that becomes ill. The **secondary attack rate (SAR)** = secondary cases in household contacts / susceptible household contacts × 100; measures the transmissibility of an

infection within households. The **case fatality rate (CFR)** = deaths from a disease / confirmed cases of that disease × 100; measures the lethality of a disease.

The **notification rate** = notified cases / population × 10^5; used for notifiable diseases reported to the IDSR. The **proportional mortality ratio (PMR)** = deaths from a specific cause / total deaths × 100; expresses the proportion of all deaths attributable to a specific cause. It is used when cause-specific death rates cannot be calculated (as in Nigeria, where population denominators may be unavailable at the facility level). Each measure serves a specific analytical purpose, and choosing the correct measure for a given question is a core epidemiological skill.

Fill in the blank: The attack rate during an outbreak is calculated as the number of cases divided by the population at _____ , multiplied by 100, expressing the proportion of exposed persons who became ill.

REFERENCE TABLE: KEY DISEASE FREQUENCY MEASURES

MEASURE	TYPE	FORMULA	UNITS	APPLICATION EXAMPLE
CUMULATIVE INCIDENCE (CI) or INCIDENCE PROPORTION	Measure of Risk	(Number of new cases / Total population at risk) over a time period	Proportion (0-1 or %)	Proportion of a cohort developing influenza during a flu season (e.g., 15%).
INCIDENCE RATE (IR) or INCIDENCE DENSITY	Type: Measure of Force of Morbidity	(Number of new cases / Total person-time of observation)	per person-time (e.g., per 1,000 person-years)	Rate of tuberculosis diagnosis in a community per 1,000 person-years of follow-up.
POINT PREVALENCE	Type: Measure of Burden (Snapshot)	(Number of existing cases at a specific time / Total population at that time)	Proportion (0-1 or %)	Percentage of the population with diagnosed diabetes on January 1st, 2023.
PERIOD PREVALENCE	Type: Measure of Burden (Duration)	(Number of existing cases + Number of new cases during a period / Average population during that period)	Proportion (0-1 or %)	Proportion of hospital patients experiencing a hospital-acquired infection during their stay (e.g., in one month).
ATTRIBUTABLE RISK (AR) or RISK DIFFERENCE	Type: Measure of Impact	(Incidence in exposed - Incidence in unexposed)	Rate/Risk Difference	Excess lung cancer risk in smokers compared to non-smokers (e.g., 50 additional cases per 1,000).
ATTRIBUTABLE RISK PERCENT (AR%)	Type: Measure of Preventable Burden	((Incidence in exposed - Incidence in unexposed) / Incidence in exposed) * 100	Percentage (%)	90% of lung cancer in smokers could be prevented if they did not smoke.
POPULATION ATTRIBUTABLE RISK (PAR) or POPULATION RISK DIFFERENCE	Type: Measure of Public Health Impact	(Incidence in total population - Incidence in unexposed)	Rate/Risk Difference	Number of cases of heart disease in a whole population attributable to high cholesterol levels.

*Note: All formulas and units are illustrative/standard in epidemiology.

Figure 4.3: Measures of disease frequency: formulas and applications

4.3.3 Measures of association

Measures of association quantify the strength of the relationship between an exposure and a health outcome. The **relative risk (RR)** (also called the risk ratio) = incidence in exposed / incidence in unexposed; it measures how many times more likely exposed persons are to develop the outcome compared with unexposed persons. An RR of 1 indicates no association; RR > 1 indicates increased risk; RR < 1 indicates protective effect. RR is used in cohort studies where incidence can be directly calculated.

The **odds ratio (OR)** = (cases exposed / cases unexposed) / (controls exposed / controls unexposed); used in case-control studies where incidence cannot be directly measured. When the disease is rare (< 10% in the population), the OR approximates the RR. The **attributable risk (AR)** = incidence in exposed − incidence in unexposed; it measures the absolute excess risk attributable to the exposure, useful for estimating the number of cases preventable by removing the exposure. The **population attributable risk (PAR)** extends this to estimate the cases preventable at the population level if the exposure were eliminated.

Fill in the blank: The relative risk is calculated as incidence in the _____ group divided by incidence in the unexposed group; a value greater than 1 indicates that exposure increases the risk of the outcome.

Pilot questions 4.3

1. Distinguish between a rate, a ratio, and a proportion, giving one health example of each.
2. Why is the case fatality rate technically a proportion rather than a rate?
3. Write the formula for the attack rate and state when it is used.
4. Define relative risk and state what an RR of 2.5 means.
5. When is the odds ratio a good approximation of the relative risk?

4.4 Collection, Organisation, and Presentation of Health Data

4.4.1 Data collection methods in health research

Health data are collected through four main methods. **Observation** involves the systematic recording of events or behaviours as they occur, without intervention; used in clinical audit, facility surveys, and field epidemiology. **Interview** (structured or unstructured) gathers information directly from respondents through face-to-face, telephone, or computer-assisted methods; used in surveys and qualitative research. **Questionnaire** (self-administered) allows respondents to complete instruments independently; used in large surveys and community studies. **Documentary review** (abstraction of existing records) extracts data from clinical registers, patient files, laboratory records, and administrative databases.

The choice of collection method depends on the research question, the type of data needed, the resources available, and the population being studied. In Nigeria, the most common methods for national health data are structured household interviews (NDHS, MICS) and facility record abstraction (HMIS). **Data quality** is a function of instrument design (clear, unambiguous questions), interviewer training, field supervision, and data entry validation. The use of **electronic data capture (EDC)** through tablet-based or mobile phone-based tools (such as Open Data Kit, KoBoToolbox, or REDCap) has improved data quality and timeliness in Nigerian research and health information settings.

Fill in the blank: Electronic data _____ (EDC) tools such as KoBoToolbox and REDCap have improved data quality and timeliness in Nigerian health research by enabling real-time validation during data entry.

4.4.2 Data organisation and management

Raw health data must be organised before analysis. **Data entry** is the transcription of data from collection instruments into a digital format; it should be followed by **range and consistency checks** to identify impossible or implausible values (a blood pressure of 0/0, or a delivery date before the estimated conception date). **Coding** converts categorical responses into numeric or alphanumeric values for analysis (e.g. ICD-10 codes for diagnoses, WHO disability codes for

functional limitations). **Data cleaning** identifies and resolves errors, duplicates, and missing values before analysis begins.

Databases (such as Microsoft Excel for simple datasets, SPSS, Stata, R, or SQL-based systems for complex datasets) organise health data into structured formats with defined variables (columns) and records (rows). Good database design follows the principle that each cell contains one value, each column one variable, and each row one observation. **Metadata** (data about data: variable definitions, coding schemes, collection dates, and data source documentation) must be maintained alongside the dataset so that others can understand and use the data correctly. Data management plans submitted with research proposals are now required by most ethics committees and funding bodies.

Fill in the blank: _____ cleaning is the process of identifying and resolving errors, duplicates, and missing values in a dataset before analysis begins, ensuring that results are not distorted by data quality problems.

4.4.3 Presentation of health data: tables, charts, and graphs

Health data are communicated through tables and visual displays. A **frequency table** presents the number and percentage of observations in each category of a variable. A **contingency table (cross-tabulation)** presents the joint distribution of two categorical variables (e.g. disease status by exposure status in a 2×2 table). A **histogram** displays the distribution of a continuous variable by plotting frequency against value intervals; unlike a bar chart, the bars are adjacent (no gaps) because the variable is continuous. A **bar chart** compares values across discrete categories with gaps between bars.

A **pie chart** shows the composition of a whole as proportional segments; it is appropriate only when the categories sum to 100% and there are few categories (no more than five or six). A **line graph** displays trends over time and is appropriate when both axes are continuous or ordered. A **scatter plot** shows the relationship between two continuous variables, one on each axis. For health data, the **epidemic curve** (a histogram of case counts over time during an outbreak) is a specialised display that helps identify the source and mode of transmission. Every table and graph should have a clear title, labelled axes, units of measurement, and a data source.

Fill in the blank: A _____ displays the distribution of a continuous variable by plotting frequency against value intervals, with adjacent bars (no gaps), distinguishing it from a bar chart which uses gaps between categories.

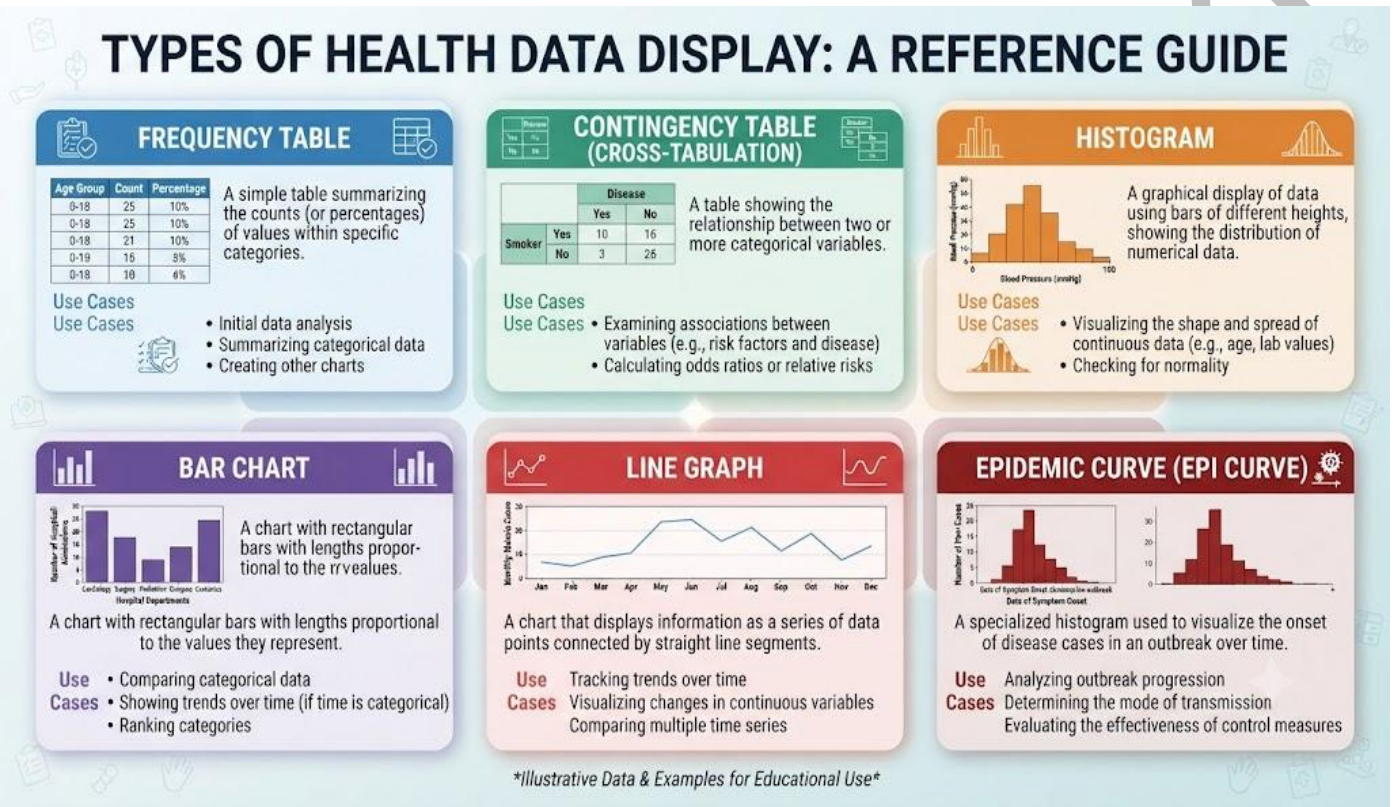

Figure 4.4: Types of health data presentation

Pilot questions 4.4

1. Name four methods of health data collection.
2. What is electronic data capture and name one tool used in Nigeria.
3. What is data cleaning and why is it necessary?
4. Distinguish between a histogram and a bar chart.
5. When is a pie chart appropriate for presenting health data?

Series Summary

This Series examined health data and vital statistics as the informational foundation of public health practice. Health data was defined and its major sources described: routine health information systems (DHIS2/HMIS), population surveys (NDHS, MICS), and surveillance systems (IDSR). Vital statistics were examined as data derived from civil registration of births, deaths, and other vital events; the low registration coverage in Nigeria and its consequences for health data quality were analysed. The three building blocks of health measurement, rates, ratios, and proportions, were defined and distinguished, and key measures of disease frequency and association were introduced.

The practical aspects of health data work were addressed through the four data collection methods (observation, interview, questionnaire, documentary review), the principles of data organisation and cleaning, and the selection of appropriate tables and charts for communicating health data. The Series establishes that good health data practice encompasses the full cycle from collection through organisation to presentation, and that the quality of each step determines the reliability of the evidence that supports health decisions (SLOs 4.1 to 4.6).

Glossary of Terms

- **Attack rate:** cases during an outbreak divided by population at risk, multiplied by 100; measures the proportion of exposed persons who became ill.
- **Case fatality rate (CFR):** deaths from a disease divided by confirmed cases, multiplied by 100; a proportion measuring disease lethality.
- **Civil registration and vital statistics (CRVS):** the integrated system for registering vital events and generating vital statistics from those records.
- **DHIS2:** District Health Information System 2; the software platform used to implement Nigeria HMIS for facility-level health data reporting.

- **Health data:** any information describing the health status of individuals or populations, the determinants of health, or the performance of health systems.
- **IDSR:** Integrated Disease Surveillance and Response; the system coordinated by the NCDC for notifiable disease reporting and outbreak response in Nigeria.
- **Odds ratio (OR):** the ratio of the odds of exposure among cases to the odds of exposure among controls; used in case-control studies.
- **Proportion:** a fraction in which the numerator is included in the denominator, ranging from 0 to 1.
- **Rate:** a measure of the frequency of a health event in a population over a defined time period, expressed per a standard multiplier.
- **Ratio:** the quotient of two quantities where the numerator may or may not be included in the denominator.
- **Relative risk (RR):** incidence in exposed divided by incidence in unexposed; measures how many times more likely the exposed are to develop the outcome.
- **Vital statistics:** statistics derived from the registration of vital events including births, deaths, marriages, divorces, and foetal deaths.

Concept Check Questions [Series 4]

Objective questions

1. The District Health Information System 2 (DHIS2) is the platform used in Nigeria to implement the Health Management Information _____ . (Linked to SLO 4.2)
2. The Integrated Disease Surveillance and Response (IDSR) system requires health facilities to report notifiable conditions on a _____ basis. (Linked to SLO 4.2)
3. Vital _____ are derived from the registration of births, deaths, marriages, divorces, and foetal deaths. (Linked to SLO 4.3)
4. A _____ is a fraction in which the numerator is included in the denominator, ranging from 0 to 1, while a rate includes a time dimension. (Linked to SLO 4.4)
5. The relative risk (RR) is calculated as incidence in the _____ group divided by incidence in the unexposed group. (Linked to SLO 4.5)
6. A _____ displays the distribution of a continuous variable with adjacent bars (no gaps), unlike a bar chart which compares discrete categories. (Linked to SLO 4.6)

Short-answer questions

7. Define a routine health information system, describe its structure in Nigeria, and identify two data quality challenges. (Linked to SLO 4.2)
8. Distinguish between a rate, a ratio, and a proportion, and give one health example of each. (Linked to SLO 4.4)
9. Define relative risk and odds ratio, write the formula for each, and state when each is used. (Linked to SLO 4.5)

Long-answer questions

10. Discuss vital statistics in Nigeria: define them, describe the registration system, assess coverage, and explain their uses in health planning. (Linked to SLOs 4.3, 4.4)
11. Explain the principles of health data collection, organisation, and presentation, illustrating with examples relevant to Nigerian health practice. (Linked to SLO 4.6)

12. Evaluate the measures of disease frequency and association used in epidemiology, covering their formulas, applications, and appropriate use in health research. (Linked to SLOs 4.4, 4.5)

Answers to Concept Check Questions [Series 4]

Objective questions

6. System.
7. Weekly.
8. Statistics.
9. Proportion.
10. Exposed.
11. Histogram.

Short-answer questions

12. A routine health information system collects data continuously from health facilities as part of normal service delivery. In Nigeria, it operates through the HMIS on the DHIS2 platform; facilities report monthly on outpatient attendance, immunisation, deliveries, and disease notifications, aggregated at LGA, state, and national levels. Two data quality challenges: incomplete reporting (not all facilities submit data on time) and inaccurate data entry (recording errors not detected without validation).
13. Rate: frequency of a health event in a population over a defined time, expressed per a standard multiplier; example: CBR = live births / mid-year population × 1,000 per year. Ratio: quotient of two quantities where the numerator may not be in the denominator; example: sex ratio = males / females. Proportion: fraction in which numerator is included in denominator; example: proportion of deliveries in facilities = facility births / total births (ranges 0–1).
14. Relative risk (RR) = incidence in exposed / incidence in unexposed; used in cohort studies where incidence can be directly measured. Odds ratio (OR) = (cases exposed /

cases unexposed) ÷ (controls exposed / controls unexposed); used in case-control studies where incidence cannot be directly measured. When disease prevalence is below 10%, OR ≈ RR.

Long-answer questions

15. **Basic response:** Vital statistics are derived from civil registration of births, deaths, marriages, divorces, and foetal deaths. In Nigeria, the NPC is responsible; births must be registered within 60 days, deaths within 3 days. Coverage: approximately 43% of births registered nationally, lower in the north (below 30%) than the south (above 70%); death registration is even less complete. Uses: numerator data for IMR, MMR, and fertility rates; population estimation via the balancing equation; cause-of-death analysis for priority-setting; monitoring SDG health targets.

Value-added response: The gaps in Nigeria vital registration mean that most health indicators rely on survey estimates and demographic modelling rather than registered events. Strengthening the CRVS system by integrating birth registration into maternal health services (registering at delivery) and death registration into health facility discharge processes would improve both registration coverage and the timeliness of data for health planning, reducing dependence on five-yearly surveys.

16. **Basic response:** Data collection methods: observation (systematic recording of events, e.g. facility audit), interview (face-to-face or telephone, e.g. NDHS household survey), questionnaire (self-administered, e.g. clinic exit interviews), documentary review (e.g. HMIS register abstraction). Organisation: data entry with range and consistency checks; coding using ICD-10 or other standard schemes; data cleaning to resolve errors, duplicates, and missing values; database design with one variable per column and one record per row. Presentation: frequency tables for categorical data, histograms for continuous distributions, line graphs for trends over time, epidemic curves for outbreak analysis.

Value-added response: Electronic data capture (EDC) tools such as KoBoToolbox and REDCap have transformed data quality in Nigerian health research by enabling real-time

validation at point of entry, automatic date and range checks, and direct digital transfer to analysis platforms. The shift from paper-based to electronic data capture reduces transcription errors, accelerates data availability, and supports real-time data quality monitoring, but requires reliable power, device availability, and staff digital literacy.

17. **Basic response:** Incidence rate = new cases / population at risk × 10^n (measures rate of disease occurrence). Prevalence = existing cases / population at a point in time (measures disease burden). Attack rate = cases / population at risk × 100 (used in outbreak investigation). Secondary attack rate = secondary cases / susceptible contacts × 100 (measures within-household transmissibility). Case fatality rate = deaths / cases × 100 (measures lethality). Notification rate = notified cases / population × 100,000 (used for notifiable diseases). Proportional mortality ratio = cause-specific deaths / total deaths × 100 (used when population denominators unavailable). Relative risk and odds ratio measure association between exposure and outcome.

Value-added response: The choice between measures depends on study design and data availability. Incidence requires follow-up of an at-risk population; prevalence is measurable in a cross-sectional survey. Attack rate is specific to outbreak investigation. Case fatality rate measures lethality but is inflated when mild cases are not diagnosed. The PMR is a useful proxy for cause-specific mortality in settings like Nigeria where population denominators are unavailable for facility-level death data, but it cannot distinguish whether high PMR for a cause reflects high mortality or low total mortality from other causes.

Answers to Pilot Questions [Series 4]

Part 4.1

11. Health data is any information describing the health status of individuals or populations, the determinants of health, or the performance of health systems. Examples: laboratory test results; DHIS2 outpatient attendance figures.

12. A routine health information system continuously collects health data from facilities as part of normal service delivery, without a special survey.
13. District Health Information System 2 (DHIS2).
14. Any two of: Nigeria Demographic and Health Survey (NDHS), Multiple Indicator Cluster Survey (MICS), Nigeria HIV/AIDS Indicator and Impact Survey (NAIIS), National Nutrition and Health Survey (NNHS).
15. The Integrated Disease Surveillance and Response (IDSR) system is coordinated by the NCDC and requires health facilities to report specified notifiable diseases weekly; its purpose is to detect outbreaks early and coordinate public health response.

Part 4.2

1. Vital statistics are statistics derived from the registration of vital events: births, deaths, marriages, divorces, and foetal deaths (stillbirths).
2. The National Population Commission (NPC).
3. Approximately 43% of children under 5 have their births registered nationally (2018 NDHS).
4. Any two of: establishing legal identity (access to education, financial services, formal employment); enabling inheritance and estate settlement; enabling passport and national identity document application.
5. Any three of: providing numerator data for IMR, MMR, and fertility rates; supporting population estimation via the demographic balancing equation; providing cause-of-death data for health priority-setting; monitoring SDG health targets; enabling legal documentation of identity.

Part 4.3

6. Rate: includes a time dimension, expressed per standard multiplier; example: IMR = deaths under 1 year / live births × 1,000. Ratio: numerator may not be in denominator;

example: sex ratio = males / females. Proportion: numerator is a subset of denominator; example: proportion of maternal deaths = obstetric deaths / all female deaths of reproductive age.

7. The case fatality rate has no time dimension in its formula (deaths / cases); it does not express how fast the event occurs per unit time, which is the defining characteristic of a rate. It is therefore correctly classified as a proportion.
8. Attack rate = cases during outbreak / population at risk × 100. Used in outbreak investigation to measure the proportion of the exposed population that becomes ill during the outbreak period.
9. Relative risk (RR) = incidence in exposed / incidence in unexposed. An RR of 2.5 means that exposed persons are 2.5 times more likely to develop the outcome than unexposed persons.
10. When the disease is rare (prevalence below 10% in the study population), the odds ratio approximates the relative risk.

Part 4.4

11. Observation, interview, questionnaire (self-administered), and documentary review (record abstraction).
12. Electronic data capture (EDC) is the use of digital tools to collect data directly into electronic form at the point of collection, enabling real-time validation. One tool used in Nigeria: KoBoToolbox (also acceptable: REDCap, Open Data Kit).
13. Data cleaning is the process of identifying and resolving errors, duplicates, and missing values in a dataset before analysis. It is necessary because uncorrected errors distort analysis results and lead to incorrect conclusions.
14. A histogram displays the distribution of a continuous variable by plotting frequency against value intervals with adjacent bars (no gaps), reflecting the continuous nature of the variable. A bar chart compares values across discrete categories with gaps between bars.

15. A pie chart is appropriate when: the data categories are mutually exclusive and exhaustive (sum to 100%); there are few categories (no more than five or six); the purpose is to show the composition of a whole rather than compare values across groups.

References and Attributions [Series 4]

Textual references

1. Bonita, R., Beaglehole, R., & Kjellstrom, T. (2006). Basic epidemiology (2nd ed.). World Health Organization.
2. World Health Organization. (2018). Strengthening civil registration and vital statistics for births, deaths and causes of death. WHO Press.
3. National Population Commission Nigeria and ICF. (2019). Nigeria demographic and health survey 2018. NPC and ICF.
4. National Open University of Nigeria (NOUN). (2023). Introduction to demography and vital statistics course material. NOUN Press.

Figures, Plates, Tables, and Boxes

1. Figure 4.1: Health data sources in Nigeria Attribution: AI generated using prompt "Generate a three-layer diagram of Nigerian health data sources showing routine HMIS, population surveys, and surveillance systems with data flow arrows to state and national levels." Suggested OER search string: "health data sources Nigeria DHIS2 HMIS NDHS IDSR surveillance routine information system OER"

2. Figure 4.2: The civil registration and vital statistics system in Nigeria Attribution: AI generated using prompt "Generate a CRVS system diagram for Nigeria showing vital events registration by NPC, generation of vital statistics, and their uses in health planning and legal documentation with registration coverage rates." Suggested OER search string: "civil registration vital statistics Nigeria NPC birth registration death registration CRVS OER"
3. Figure 4.3: Measures of disease frequency: formulas and applications Attribution: AI generated using prompt "Generate a reference table of seven disease frequency measures with formulas, units, and application examples." Suggested OER search string: "disease frequency measures incidence prevalence attack rate case fatality rate notification rate OER"
4. Figure 4.4: Types of health data presentation Attribution: AI generated using prompt "Generate a reference diagram showing six types of health data display (frequency table, contingency table, histogram, bar chart, line graph, epidemic curve) with examples and appropriate use cases." Suggested OER search string: "health data presentation tables histogram bar chart line graph epidemic curve contingency table OER"

Course code: COM 302

Course title: Introduction to Demography and Vital Statistics

Course credit load: 2 Units

Series 5: Measurement and Standardisation of Vital Rates

- **Part 5.1: Measurement of Fertility Rates**
  - Sub Part 5.1.1: Gross reproduction rate and net reproduction rate
  - Sub Part 5.1.2: Cohort versus period fertility measures
  - Sub Part 5.1.3: Calculation of total fertility rate: worked examples
- **Part 5.2: Measurement of Mortality Rates**
  - Sub Part 5.2.1: Cause-specific and age-standardised death rates
  - Sub Part 5.2.2: The life table: construction and interpretation
  - Sub Part 5.2.3: Standardised mortality ratio
- **Part 5.3: Standardisation of Vital Rates**
  - Sub Part 5.3.1: The need for standardisation
  - Sub Part 5.3.2: Direct standardisation
  - Sub Part 5.3.3: Indirect standardisation
- **Part 5.4: Population-Health Interaction**
  - Sub Part 5.4.1: Interaction between medical action and population health
  - Sub Part 5.4.2: Health transition and epidemiological transition

- Sub Part 5.4.3: Implications for health policy in Nigeria

Introduction

The basic measures of fertility and mortality introduced in earlier Series of this course take on full analytical power only when they are refined, compared, and standardised. A crude death rate of 15 per 1,000 in one population and 10 per 1,000 in another tells us little if the first population is older than the second: the higher crude rate may simply reflect an older age structure rather than worse health conditions. Standardisation solves this problem by allowing fair comparison across populations with different structures.

The aim of this Series is to extend and deepen the measurement of fertility and mortality rates, to introduce the techniques of direct and indirect standardisation, and to examine the interaction between population dynamics and health outcomes in the Nigerian context.

We shall commence by extending fertility measurement to the gross and net reproduction rates and worked TFR calculations. Next, we will deepen mortality measurement through cause-specific rates, the life table, and the standardised mortality ratio. Moving on, we will address standardisation directly, covering both direct and indirect methods with worked examples. Finally, we will close by examining the population-health interaction through the health and epidemiological transitions and their implications for Nigerian health policy.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **SLO 5.1** define and calculate the gross reproduction rate and net reproduction rate,
- **SLO 5.2** distinguish between cohort and period fertility measures and calculate the TFR from age-specific data,
- **SLO 5.3** calculate cause-specific death rates and age-standardised death rates,

- **SLO 5.4** construct a life table from age-specific mortality data and derive life expectancy,
- **SLO 5.5** explain why standardisation is necessary and apply direct and indirect standardisation to compare populations,
- **SLO 5.6** calculate and interpret the standardised mortality ratio, and
- **SLO 5.7** explain the health and epidemiological transitions and discuss their implications for health policy in Nigeria.

5.1 Measurement of Fertility Rates

5.1.1 Gross reproduction rate and net reproduction rate

The **gross reproduction rate (GRR)** is the average number of daughters a woman would bear if she survived through her entire reproductive life (aged 15–49) and experienced current age-specific fertility rates. It equals the TFR multiplied by the proportion of births that are female (approximately 0.4878, the female birth fraction):

GRR = TFR × (female births / total births) ≈ TFR × 0.4878

The GRR assumes no mortality among women of reproductive age. The **net reproduction rate (NRR)** corrects for this by incorporating the probability that a woman survives to each age of childbearing. It is the average number of daughters a woman would bear, accounting for mortality:

NRR = Σ ($ASFR_x \times L_x / l_0 \times 0.4878$)

where L_x is the life table person-years lived at age x and l_0 is the radix (100,000). An NRR of 1.0 means each generation exactly replaces itself (replacement-level fertility adjusted for mortality). NRR > 1 indicates a growing population; NRR < 1 indicates a declining population. Nigeria NRR is substantially above 1, confirming rapid population growth.

Fill in the blank: The gross reproduction rate equals the TFR multiplied by the female birth fraction (approximately 0.4878); the _____ reproduction rate refines this by also accounting for female mortality across the reproductive age span.

5.1.2 Cohort versus period fertility measures

A **period fertility measure** describes the fertility experience of the entire population at a specific point in time, using age-specific rates observed during a defined calendar period. The TFR is a period measure: it asks what would happen if a hypothetical woman experienced today rates throughout her reproductive life. A **cohort fertility measure** follows a specific group of women (a birth cohort) from the start to the end of their reproductive lives, recording all births they actually experience. The **completed cohort fertility rate** is the actual average number of children born to women who have finished childbearing.

Period and cohort measures may differ substantially when fertility is changing. In a population where fertility is falling, the period TFR will understate completed cohort fertility for older cohorts (who experienced higher rates earlier in life) and may overstate it for younger cohorts (who will experience lower rates in the future). Period measures are more commonly used in practice because they do not require waiting for a cohort to complete childbearing; cohort measures are more appropriate for analysing completed reproductive histories in retrospective surveys.

Fill in the blank: A _____ fertility measure follows a specific group of women from the start to the end of their reproductive lives and records all births they actually experience, while a period measure uses rates observed across all age groups at a single point in time.

5.1.3 Calculation of total fertility rate: worked examples

The TFR is calculated by summing the age-specific fertility rates (ASFRs) across all five-year reproductive age groups (15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49) and multiplying by 5 (the width of each age interval). The ASFRs are expressed as live births per 1,000 women in each age group per year.

Example: Suppose a population has the following ASFRs (per 1,000 women):

Age 15–19: 80; Age 20–24: 220; Age 25–29: 200; Age 30–34: 150; Age 35–39: 90; Age 40–44: 40; Age 45–49: 10

Sum of ASFRs = 80 + 220 + 200 + 150 + 90 + 40 + 10 = 790 per 1,000

TFR = (790 / 1,000) × 5 = 3.95 children per woman

To calculate the GRR from this TFR:

GRR = 3.95 × 0.4878 = 1.93 daughters per woman

This indicates the population is growing (GRR > 1). If the NRR (accounting for female mortality) were calculated to be 1.75, this confirms that each generation is producing more than enough daughters to replace itself even after accounting for deaths before the end of reproductive life.

Fill in the blank: To calculate the TFR, the sum of all age-specific fertility rates (expressed per 1,000 women) is divided by 1,000 and multiplied by _____ , the width of each five-year age group.

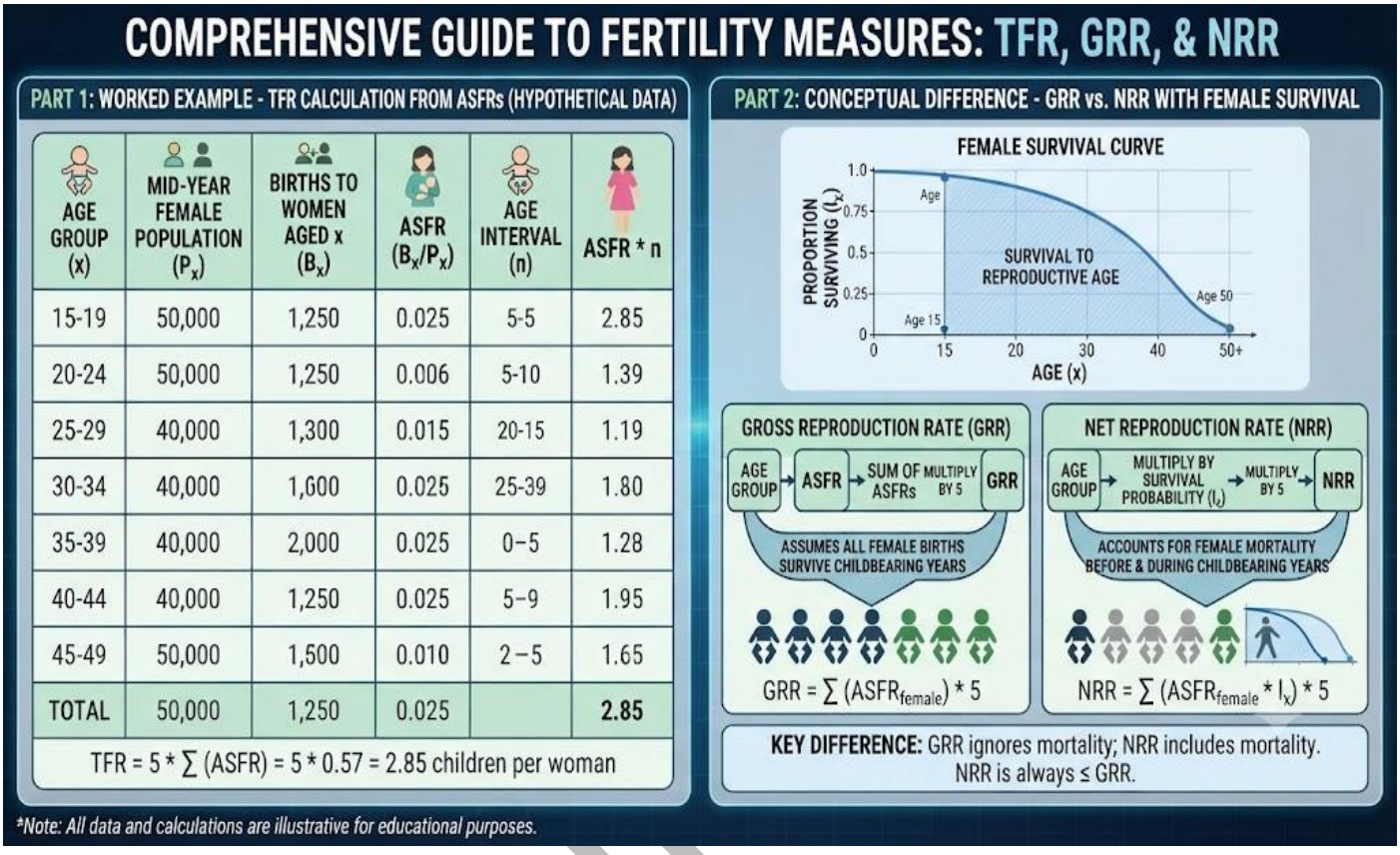

Figure 5.1: Fertility rate calculations: TFR, GRR, and NRR

Pilot questions 5.1

1. Write the formula for the gross reproduction rate.
2. How does the net reproduction rate differ from the gross reproduction rate?
3. What does an NRR of exactly 1.0 indicate?
4. Distinguish between a period fertility measure and a cohort fertility measure.
5. Calculate the TFR if the sum of ASFRs (per 1,000) across seven age groups is 850.

5.2 Measurement of Mortality Rates

5.2.1 Cause-specific and age-standardised death rates

The **cause-specific death rate (CSDR)** measures mortality from a specific cause in a defined population:

CSDR = (deaths from cause C / mid-year population) × 100,000

It is expressed per 100,000 population. For example, if there are 5,000 malaria deaths in a population of 10 million: CSDR = (5,000 / 10,000,000) × 100,000 = 50 per 100,000. Cause-specific rates allow comparison of the relative importance of different causes of death within a population and tracking of trends in specific causes over time.

The **age-standardised death rate (ASDR)** adjusts for differences in age structure between populations before comparison, using either direct or indirect standardisation (covered in Part 5.3). Without age standardisation, comparing crude death rates between a young Nigerian population and an older European population would be misleading: the higher crude rate in Europe may simply reflect its older age structure rather than worse health conditions. Age-standardised rates provide a fair basis for comparison by applying a common standard age structure to both populations.

Fill in the blank: The cause-specific death rate is calculated as deaths from a specific cause divided by mid-year population, multiplied by _____ , and allows comparison of the relative importance of different causes of death.

5.2.2 The life table: construction and interpretation

A life table is constructed from a set of **age-specific death rates ($_nm_x$)** observed in a population during a defined period. The principal columns are:

$_nq_x$: probability of dying between age x and x + n, derived from **$_nm_x$** using the relationship: **$_nq_x$** ≈ (n × **$_nm_x$**) / (1 + n/2 × **$_nm_x$**)

$\mathbf{l}_x$: number surviving to exact age x, beginning with $l_0 = 100{,}000$ (the radix): $l_{x+n} = l_x \times (1 - \mathbf{nq}_x)$

$\mathbf{nd}_x$: number dying in the interval x to x + n: $\mathbf{nd}_x = l_x - l_{x+n}$

$\mathbf{nL}_x$: person-years lived in the interval: $\mathbf{nL}_x \approx n/2 \times (l_x + l_{x+n})$

$\mathbf{T}_x$: total person-years lived from age x onward: $T_x = \Sigma\ \mathbf{nL}_x$

$\mathbf{e_0}$ (life expectancy at birth): $e_0 = T_0 / l_0 = T_0 / 100{,}000$

The life table converts observed age-specific mortality into a coherent summary of mortality experience, enabling calculation of life expectancy at any age, survival probabilities, and years of life lost to premature death.

Fill in the blank: In a life table, l_x represents the number surviving to exact age x, beginning with l2080 = _____ (the radix), and declining as deaths accumulate across successive age intervals.

5.2.3 Standardised mortality ratio

The **standardised mortality ratio (SMR)** is the ratio of observed deaths in a study population to the number of deaths that would be expected if the standard population age-specific death rates applied to the study population. It is used in indirect standardisation (see Part 5.3):

SMR = Observed deaths / Expected deaths × 100

An SMR of 100 indicates mortality equal to the standard. SMR > 100 indicates excess mortality; SMR < 100 indicates lower mortality than the standard. For example, if 450 deaths are observed in a study population but only 350 would be expected based on standard rates applied to that population age structure: SMR = (450 / 350) × 100 = 128.6, indicating 28.6% excess mortality relative to the standard population.

Fill in the blank: An SMR greater than _____ indicates that the study population has higher mortality than the standard population; an SMR less than 100 indicates lower mortality.

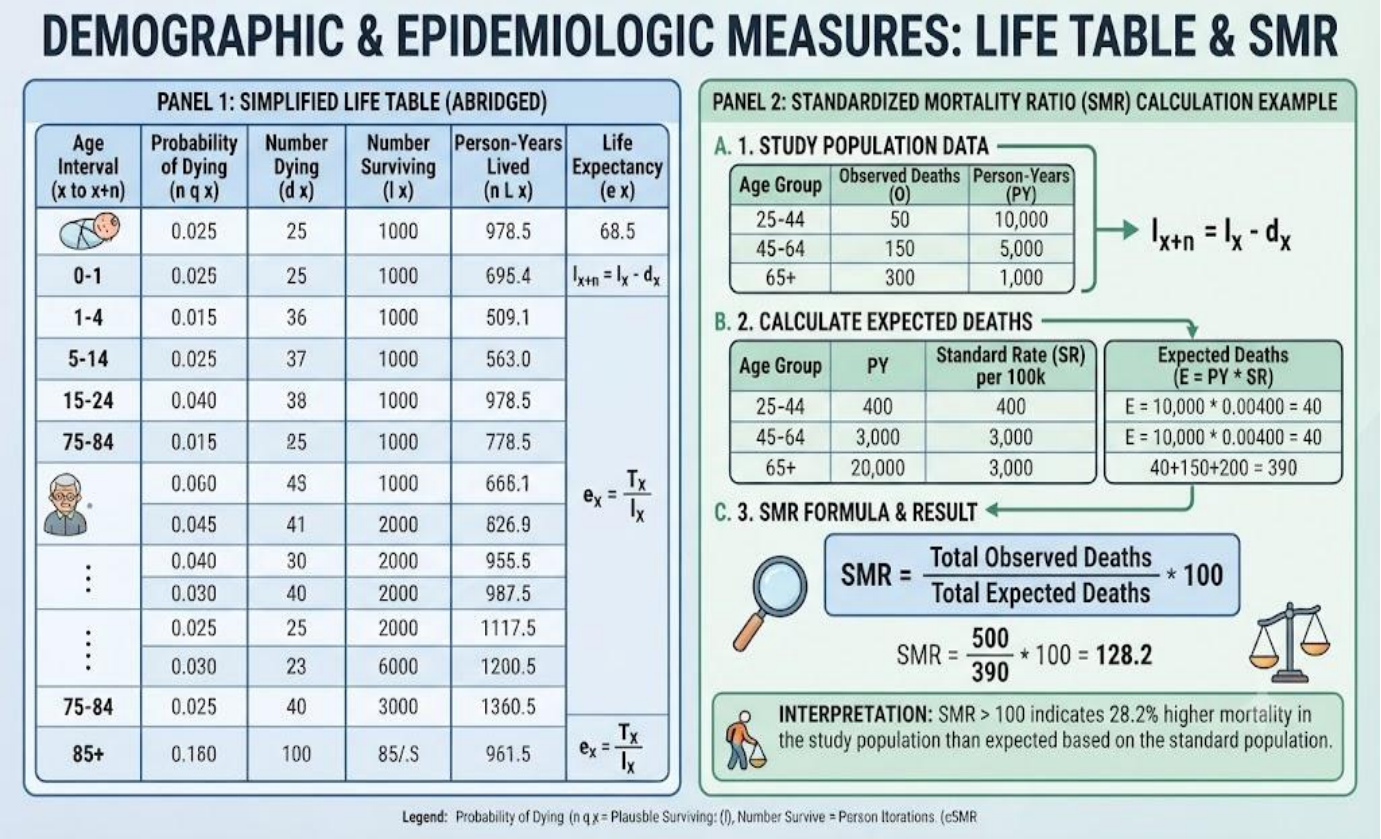

Figure 5.2: Life table construction and SMR calculation

Pilot questions 5.2

1. Write the formula for the cause-specific death rate.
2. Why is age standardisation necessary when comparing death rates between populations?
3. Name the six principal columns of a life table.
4. Write the formula for life expectancy at birth from the life table.
5. Calculate the SMR if observed deaths are 300 and expected deaths are 240.

5.3 Standardisation of Vital Rates

5.3.1 The need for standardisation

When comparing vital rates between two populations or over time within the same population, differences in **age structure** can confound the comparison. A crude death rate reflects both the underlying mortality risk at each age and the proportion of the population in each age group. If

two populations have the same age-specific death rates but different age structures, their crude death rates will differ: the population with a larger proportion of elderly persons will have a higher crude death rate even though it is no less healthy. Standardisation removes this confounding effect by controlling for age structure.

Age structure is the most important confounder in mortality comparisons, but standardisation can also be applied for sex, socioeconomic status, or any other compositional variable. Two methods are available: **direct standardisation** applies the observed age-specific rates of each study population to a common standard age structure, producing an age-standardised rate. **Indirect standardisation** applies the standard population age-specific rates to the study population age structure, producing an expected number of deaths that is compared with the observed number via the SMR. Direct standardisation is preferred when age-specific rates are available and reliable; indirect standardisation is used when age-specific rates are unreliable or unavailable in the study population.

Fill in the blank: Standardisation is necessary because differences in _____ structure between populations can confound comparisons of crude vital rates, making one population appear healthier or sicker than it truly is.

5.3.2 Direct standardisation

In **direct standardisation**, the age-specific rates of each study population are applied to the age distribution of a chosen **standard population** to produce a **directly standardised (age-adjusted) rate**. The steps are:

1. Obtain the age-specific death rates (ASDRs) for each population being compared.

2. Choose a standard population (e.g. the WHO World Standard Population, or the total of the populations being compared).

3. For each age group, multiply the study population ASDR by the standard population size in that age group to obtain the expected deaths.

4. Sum the expected deaths across all age groups.

5. Divide total expected deaths by total standard population to obtain the directly standardised rate.

Example: Population A has an ASDR of 5 per 1,000 for age group 0–4, and the standard population has 10,000 in that age group; expected deaths from that age group = 5/1,000 × 10,000 = 50. Repeat for all age groups, sum expected deaths, and divide by total standard population to obtain the standardised rate for Population A. Repeat for Population B. The two standardised rates can then be compared directly.

Fill in the blank: In direct standardisation, the age-specific rates of each study population are applied to the age distribution of a common _____ population to produce an age-adjusted rate that removes the confounding effect of age structure.

5.3.3 Indirect standardisation

In **indirect standardisation**, the age-specific rates of a **standard population** are applied to the age structure of each study population to calculate the **expected** number of deaths. The expected deaths represent how many deaths would have occurred if the study population had experienced the standard mortality rates. The observed deaths in the study population are then compared with the expected deaths via the SMR:

SMR = (Observed deaths / Expected deaths) × 100

Indirect standardisation is preferred when: (1) age-specific death rates in the study population are unreliable due to small numbers; (2) only total deaths and population age structure (not age-specific deaths) are available in the study population. The **indirectly standardised death rate** can then be derived by multiplying the crude death rate of the standard population by the SMR divided by 100. Indirect standardisation is commonly used in occupational health (comparing mortality in a specific occupational group to that of the general population) and in small-area health analysis.

Fill in the blank: Indirect standardisation is preferred when age-specific rates in the study population are unreliable due to _____ numbers in individual age cells, making direct standardisation statistically unstable.

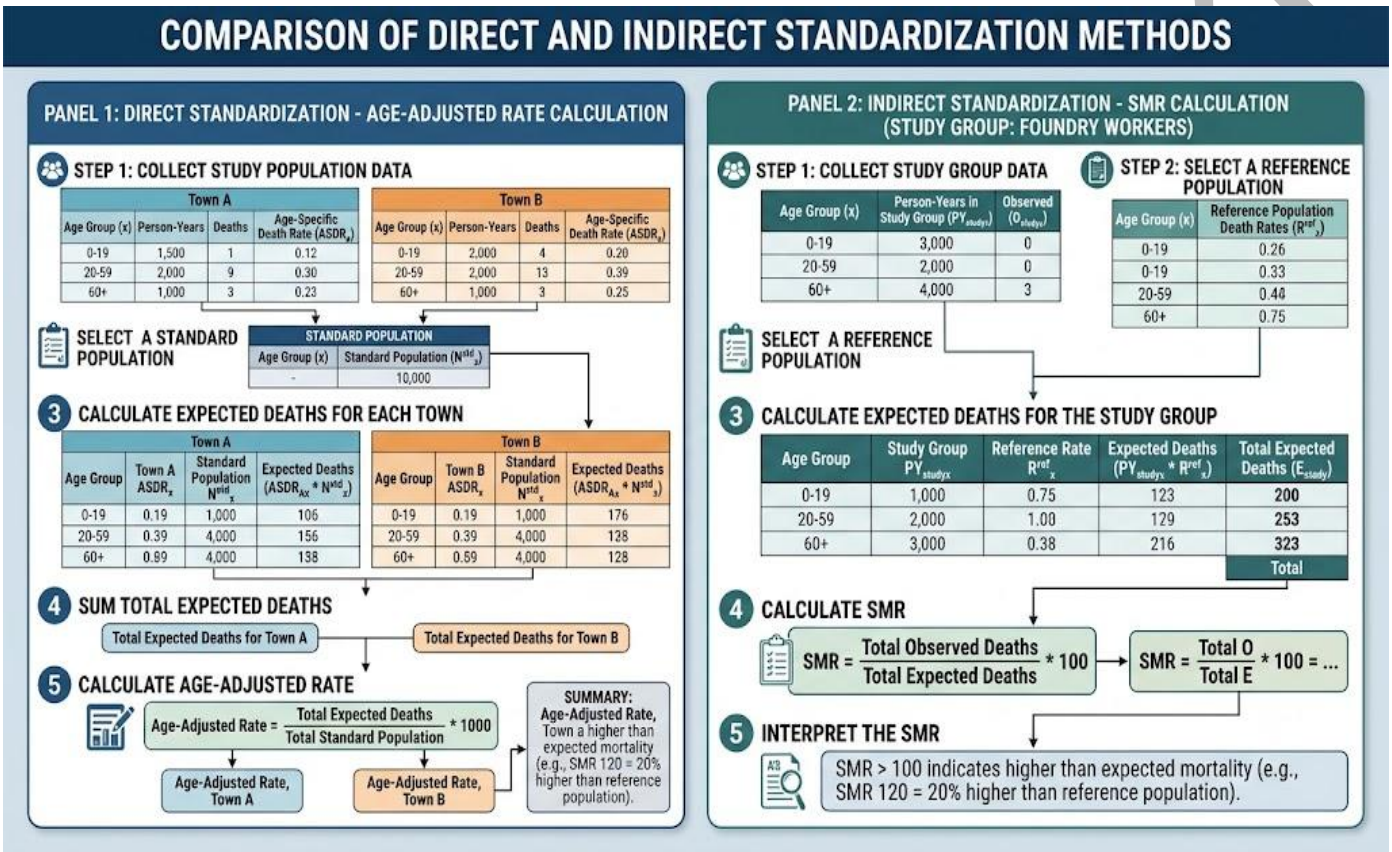

Figure 5.3: Direct and indirect standardisation: worked comparison

Pilot questions 5.3

1. Why is standardisation of vital rates necessary?
2. What is a standard population and how is it chosen?
3. List the five steps of direct standardisation.
4. When is indirect standardisation preferred over direct standardisation?
5. Write the SMR formula and interpret an SMR of 85.

5.4 Population-Health Interaction

5.4.1 Interaction between medical action and population health

Medical interventions interact with demographic processes in ways that shape both population dynamics and health outcomes. Reductions in **child mortality** through immunisation, oral rehydration therapy, malaria control, and improved nutrition reduce the number of childhood deaths without immediately reducing fertility, producing a period of rapid population growth. As child survival improves and parents become confident that their children will survive, fertility typically begins to decline: this lag between mortality decline and fertility decline is the engine of rapid population growth in the demographic transition.

Conversely, high fertility perpetuates conditions that drive mortality: closely spaced births reduce child nutrition; high parity increases maternal mortality; rapid population growth strains the health system capacity to deliver preventive and curative services. These feedback loops mean that medical action and population dynamics are not separate domains: investments in child survival, maternal health, and family planning all influence population growth rates, age structure, and future health service demand. A health ministry that plans its clinical services without considering demographic dynamics will consistently underestimate demand and under-resource services.

Fill in the blank: Reductions in child _____ through immunisation and nutrition improve survival without immediately reducing fertility, producing a period of rapid population growth that is the engine of the demographic transition.

5.4.2 Health transition and epidemiological transition

The **health transition** is the broad shift in population health accompanying development, encompassing the epidemiological transition, the risk factor transition (from nutritional deficiency and infectious disease risks toward tobacco, alcohol, physical inactivity, and unhealthy diet), and the healthcare transition (from traditional healing to biomedical care). The **epidemiological transition**, first described by Omran (1971), describes a shift in the dominant causes of death from **infectious and parasitic diseases** (high mortality, especially in children) to

chronic non-communicable diseases (cardiovascular disease, cancer, diabetes) as populations develop and age.

Nigeria is in an early and incomplete epidemiological transition. Infectious diseases, including malaria, tuberculosis, and diarrhoeal diseases, continue to account for the majority of deaths, particularly in children. Simultaneously, non-communicable diseases are rising rapidly, driven by urbanisation, dietary transition, and reduced physical activity. This **double burden of disease** places Nigeria health system under dual pressure: it must maintain infectious disease control programmes while developing the chronic disease management infrastructure needed to address the growing NCD epidemic. Countries that manage this transition through integrated health systems avoid the inefficiency of building two parallel systems; those that do not face compounding burdens.

Fill in the blank: The _____ transition, described by Omran, refers to the shift from infectious and parasitic diseases as the dominant causes of death to chronic non-communicable diseases as countries develop and their populations age.

5.4.3 Implications for health policy in Nigeria

Nigeria demographic and epidemiological profile generates specific health policy imperatives. The large and growing child population requires sustained investment in immunisation, nutrition, malaria prevention, and neonatal care: Nigeria accounts for approximately 13% of global under-five deaths. The persistently high fertility rate and maternal mortality ratio require accelerated investment in family planning access, skilled birth attendance, and emergency obstetric care. The rapid urbanisation requires urban health strategies that address both the infectious disease risks of informal settlements and the growing NCD burden of urban dietary and lifestyle transition.

The growing working-age population represents both a **demographic dividend opportunity** (if productive employment and health are maintained) and a health challenge (as NCDs including hypertension, diabetes, and mental disorders emerge in this age group). The slow but real ageing of the population in the south requires anticipatory investment in geriatric care and long-term care services that do not yet exist at scale. Health policy in Nigeria must simultaneously address the unfinished agenda of infectious disease control, the emerging NCD epidemic, and the

structural health system investments needed to serve a population that will more than double within a generation.

Fill in the blank: Nigeria accounts for approximately _____ % of global under-five deaths, reflecting persistent high child mortality that requires sustained investment in immunisation, nutrition, malaria prevention, and neonatal care.

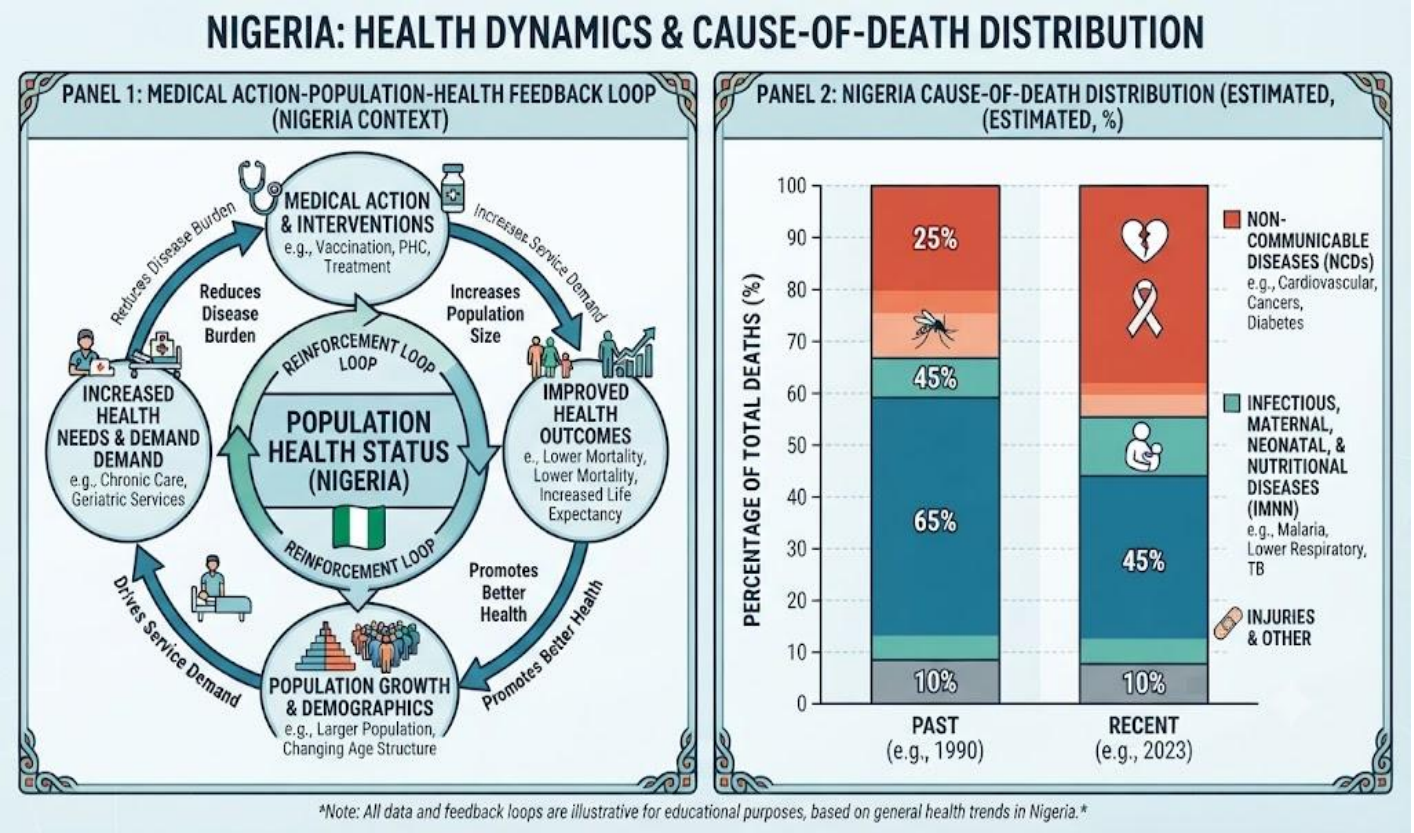

Figure 5.4: Population-health interaction and the epidemiological transition in Nigeria

Pilot questions 5.4

1. Explain the lag between mortality decline and fertility decline during the demographic transition.
2. Define the epidemiological transition.
3. What is the double burden of disease and why does it challenge the Nigerian health system?
4. Name three health policy priorities generated by Nigeria demographic profile.

5. What is the demographic dividend and what conditions are required to realise it?

Series Summary

This Series extended and deepened the measurement of vital rates through more refined fertility and mortality measures, standardisation techniques, and their integration with population-health theory. Fertility measurement was extended to the GRR and NRR, the distinction between period and cohort measures was clarified, and TFR calculation from ASFRs was demonstrated with worked examples. Mortality measurement was extended to cause-specific rates, the full construction of a life table, and the derivation of life expectancy, completed by the standardised mortality ratio as the key output of indirect standardisation.

Standardisation was introduced as the solution to the age-structure confounding problem in vital rate comparisons, with direct and indirect methods described and applied through worked examples. The Series concluded with the population-health interaction, examining how medical action influences demographic dynamics, how the epidemiological transition shapes the disease burden, and how Nigeria current position in an incomplete transition generates the specific health policy imperatives of simultaneous infectious disease control, NCD prevention, and health system expansion for a rapidly growing population. Together, the five Series of this course provide a comprehensive foundation in demography and vital statistics for health practice and planning in Nigeria (SLOs 5.1 to 5.7).

Glossary of Terms

- **Age-standardised death rate:** a death rate adjusted for differences in age structure by applying study population rates to a standard population, enabling fair comparison.
- **Cause-specific death rate:** deaths from a specific cause per 100,000 mid-year population.
- **Cohort fertility measure:** a fertility measure that follows a specific group of women through their entire reproductive lives, recording all births they actually experience.

- **Direct standardisation:** applying the age-specific rates of study populations to a common standard age structure to produce comparable age-adjusted rates.
- **Double burden of disease:** the simultaneous presence of high infectious disease mortality and rising non-communicable disease burden in a single population.
- **Epidemiological transition:** the shift from infectious and parasitic diseases to chronic non-communicable diseases as dominant causes of death during development.
- **Gross reproduction rate (GRR):** the average number of daughters a woman would bear if she survived through her entire reproductive life under current ASFRs; equals TFR × 0.4878.
- **Indirect standardisation:** applying standard population age-specific rates to the study population age structure to calculate expected deaths, compared with observed deaths via the SMR.
- **Net reproduction rate (NRR):** the average number of daughters a woman would bear accounting for female mortality across the reproductive age span; NRR = 1.0 indicates replacement-level fertility.
- **Period fertility measure:** a fertility measure using age-specific rates observed in a defined calendar period applied to a hypothetical woman.
- **Standardised mortality ratio (SMR):** observed deaths divided by expected deaths, multiplied by 100; SMR > 100 indicates excess mortality relative to the standard.

Concept Check Questions [Series 5]

Objective questions

1. The gross reproduction rate equals the TFR multiplied by approximately _____ , the female birth fraction. (Linked to SLO 5.1)
2. An NRR of exactly 1.0 indicates that the population is at _____ -level fertility, with each generation exactly replacing itself. (Linked to SLO 5.1)
3. The TFR is calculated by summing all ASFRs and multiplying by _____ for five-year age groups. (Linked to SLO 5.2)
4. The cause-specific death rate is expressed per _____ population. (Linked to SLO 5.3)
5. In a life table, life expectancy at birth (e_0) equals T_0 divided by _____ (the radix). (Linked to SLO 5.4)
6. An SMR of _____ indicates that the study population has mortality equal to the standard population. (Linked to SLO 5.6)

Short-answer questions

7. Distinguish between the GRR and NRR and explain what each indicates about population replacement. (Linked to SLO 5.1)
8. Explain why age standardisation is necessary and describe when direct versus indirect standardisation is preferred. (Linked to SLO 5.5)
9. Define the epidemiological transition and explain what is meant by the double burden of disease in Nigeria. (Linked to SLO 5.7)

Long-answer questions

10. Calculate the TFR, GRR, and NRR using provided ASFR data, and interpret the results in the context of Nigerian population dynamics. (Linked to SLOs 5.1–5.2)
11. Explain the steps of direct standardisation and apply them to compare mortality between two hypothetical populations, interpreting the results. (Linked to SLOs 5.3–5.5)

12. Discuss the interaction between population dynamics and health outcomes in Nigeria, covering the demographic and epidemiological transitions and their health policy implications. (Linked to SLOs 5.6–5.7)

Answers to Concept Check Questions [Series 5]

Objective questions

6. 0.4878.
7. Replacement.
8. 5.
9. 100,000.
10. 100,000.
11. 100.

Short-answer questions

12. GRR = TFR × 0.4878; it assumes no female mortality across the reproductive age span. NRR incorporates female survival from birth through the reproductive years; it equals GRR adjusted downward by female mortality. GRR > 1 indicates above-replacement fertility ignoring mortality; NRR > 1 confirms population growth even after accounting for female deaths; NRR = 1.0 is exact replacement; NRR < 1 indicates eventual population decline.
13. Standardisation removes the confounding effect of age structure, allowing fair comparison of vital rates between populations with different age compositions. Direct standardisation is preferred when age-specific rates are available and reliable in both study populations; indirect standardisation is preferred when age-specific rates are unreliable (small numbers in age cells) or unavailable, with only total deaths and age structure known.
14. The epidemiological transition is the shift from infectious and parasitic diseases as dominant causes of death to chronic non-communicable diseases (cardiovascular disease, cancer, diabetes) as populations develop and age. Nigeria double burden describes the simultaneous persistence of high infectious disease mortality (malaria, tuberculosis, diarrhoea) alongside a rapidly rising NCD burden, placing dual demands on a health system with limited resources.

Long-answer questions

15. **Basic response:** Given ASFRs (per 1,000): 15–19: 80, 20–24: 220, 25–29: 200, 30–34: 150, 35–39: 90, 40–44: 40, 45–49: 10. Sum = 790. TFR = (790 / 1,000) × 5 = 3.95. GRR = 3.95 × 0.4878 = 1.93. If female survival factor = 0.88 (illustrative), NRR = 1.93 × 0.88 = 1.70. TFR 3.95 indicates rapid growth; GRR 1.93 confirms each woman replaces herself with nearly two daughters; NRR 1.70 confirms population growth even after female mortality, consistent with a high-growth developing population.

Value-added response: A TFR of 3.95, while lower than Nigeria national TFR of 5.3, still represents substantially above-replacement fertility. The NRR of 1.70 means each generation is 70% larger than the preceding one: if this persists, the population will approximately double every 30–40 years. The health system implication is that every current investment in maternal and child health services must be scaled up proportionally to serve this growing population, making demographic projections an indispensable input to health facility and workforce planning.

16. **Basic response:** Direct standardisation applies study population ASFRs (or ASDRs) to a common standard age structure. Steps: (1) Obtain ASDRs for both populations A and B. (2) Choose a standard population (e.g. total of A and B combined). (3) For each age group: multiply study population ASDR by standard population size to obtain expected deaths. (4) Sum expected deaths across all age groups for each population. (5) Divide total expected deaths by total standard population to get age-standardised rate. Example: if Population A yields a standardised rate of 12 per 1,000 and B yields 10 per 1,000, A has higher mortality after removing the confounding effect of age structure.

Value-added response: The power of direct standardisation lies in attributing observed rate differences to mortality risk rather than to compositional differences. In Nigeria, comparing state-level mortality without standardisation would mislead: a state with a younger age structure (e.g. Kano with higher fertility) would show lower crude rates than Lagos, not because its residents are healthier but because there are fewer elderly residents. Standardised rates reveal the underlying mortality risk, informing more equitable resource allocation across states.

17. **Basic response:** Medical action reduces child mortality through immunisation and nutrition without immediately reducing fertility, producing rapid population growth (demographic transition middle phase). The epidemiological transition shifts dominant mortality from infectious diseases to NCDs as populations develop and age. Nigeria occupies an incomplete transition: infectious diseases persist (malaria, TB, neonatal disorders account for the majority of deaths) alongside rising NCDs. Health policy must address both: child survival programmes, maternal health services, family planning, and simultaneously NCD prevention (hypertension, diabetes) and management.

Value-added response: The most underappreciated interaction is between fertility decline and health system capacity. Each woman in Nigeria will bear an average of 5.3 children; if the TFR were to fall to 3.0, approximately 40% fewer births would occur annually within a generation, reducing the demand on maternal and child health services and freeing fiscal space for NCD management. Family planning is therefore not only a reproductive health intervention but a health system capacity strategy: accelerating fertility decline is one of the most powerful investments available to create a sustainable health system for Nigeria growing but eventually stabilising population.

Answers to Pilot Questions [Series 5]

Part 5.1

11. GRR = TFR × (female births / total births) ≈ TFR × 0.4878.
12. The NRR incorporates the probability that a woman survives through each age of her reproductive life; GRR assumes all women survive. NRR is always lower than or equal to GRR because some women die before completing their reproductive years.
13. An NRR of exactly 1.0 indicates replacement-level fertility: each generation produces exactly enough daughters to replace itself, accounting for female mortality.
14. A period measure uses rates observed across all age groups at a single point in time, applied to a hypothetical woman. A cohort measure follows a specific group of women through their actual reproductive lives, recording births they experience.

15. TFR = (850 / 1,000) × 5 = 4.25 children per woman.

Part 5.2

1. CSDR = (deaths from cause C / mid-year population) × 100,000.
2. Age standardisation is necessary because populations with older age structures have higher crude death rates even if their age-specific mortality is identical to a younger population. Without standardisation, the comparison is confounded by age structure differences rather than reflecting true differences in health.
3. The six principal columns are: $\mathbf{nm}_x$ (age-specific death rate), $\mathbf{nq}_x$ (probability of dying in interval), l_x (survivors at age x), $\mathbf{nd}_x$ (deaths in interval), $\mathbf{nL}_x$ (person-years lived in interval), T_x (total person-years from age x), e_x (life expectancy at age x).
4. $e_0 = T_0 / l_0 = T_0 / 100{,}000$.
5. SMR = (300 / 240) × 100 = 125.0. This indicates 25% excess mortality in the study population relative to the standard.

Part 5.3

6. Standardisation is necessary because differences in age structure between populations confound comparisons of crude vital rates, making a population with a larger elderly proportion appear sicker even if its age-specific mortality is identical to a younger population.
7. A standard population is a reference age distribution used as the common base for standardisation. It is chosen as the WHO World Standard Population, the combined total of the populations being compared, or a national reference population; the choice affects the magnitude but not the direction of standardised rate differences.
8. (1) Obtain ASDRs for each study population. (2) Choose a standard population. (3) Multiply each study population ASDR by the standard population size in that age group

to obtain expected deaths. (4) Sum expected deaths across all age groups. (5) Divide total expected deaths by total standard population to get the age-standardised rate.

9. Indirect standardisation is preferred when: age-specific rates in the study population are unreliable due to small numbers; or only total deaths and population age structure (not age-specific deaths) are available for the study population.
10. SMR = (Observed / Expected) × 100. An SMR of 85 means the study population has mortality 15% lower than the standard population.

Part 5.4

11. Child mortality falls first through medical interventions (immunisation, nutrition, rehydration), reducing deaths without changing reproductive behaviour. Fertility remains high because parents perceive higher child mortality risk (based on historical experience) and because the cultural, economic, and social norms supporting high fertility change slowly. This lag produces rapid population growth until fertility adjusts downward in response to confident child survival.
12. The epidemiological transition is the historical shift in the dominant causes of death from infectious and parasitic diseases (with high child mortality) to chronic non-communicable diseases (cardiovascular disease, cancer, diabetes) as populations develop economically and their age structures age.
13. The double burden of disease describes the simultaneous presence of high infectious disease mortality and a rapidly rising NCD burden. It challenges the Nigerian health system because both require different infrastructure, workforce skills, and service delivery models: infectious disease control requires community-level prevention and primary care; NCD management requires chronic disease management, specialist referral, and long-term medication supply. Resources must be allocated across both simultaneously.
14. Any three of: sustained investment in immunisation, nutrition, malaria prevention, and neonatal care for the large child population; accelerated investment in family planning and skilled birth attendance for the high fertility rate and MMR; urban health strategies

addressing both infectious disease risks in informal settlements and emerging NCDs; NCD prevention (hypertension, diabetes) for the growing working-age population; anticipatory geriatric care investment for the slowly ageing southern population.

15. The demographic dividend is the economic growth potential that arises when fertility falls, the working-age population temporarily exceeds dependents, and savings, investment, and labour supply increase. Conditions required: fertility must decline; the large working-age cohort must have access to productive employment; investment in education and health must enable the cohort to be economically productive; governance must channel savings into productive investment.

References and Attributions [Series 5]

Textual references

1. Omran, A. R. (1971). The epidemiologic transition: A theory of the epidemiology of population change. Milbank Memorial Fund Quarterly, 49(4), 509-538.
2. Preston, S., Heuveline, P., & Guillot, M. (2001). Demography: Measuring and modelling population processes. Blackwell.
3. World Health Organization. (2013). WHO methods and data sources for country-level causes of death 2000-2012. WHO Press.
4. National Open University of Nigeria (NOUN). (2023). Introduction to demography and vital statistics course material. NOUN Press.

Figures, Plates, Tables, and Boxes

1. Figure 5.1: Fertility rate calculations: TFR, GRR, and NRR Attribution: AI generated using prompt "Generate a worked example table for TFR calculation from ASFRs and a diagram showing the conceptual difference between GRR and NRR with a female survival curve." Suggested OER search string: "total fertility rate TFR calculation ASFR gross net reproduction rate NRR GRR worked example OER"
2. Figure 5.2: Life table construction and SMR calculation Attribution: AI generated using prompt "Generate a two-panel diagram showing a simplified life table with all columns and values, and an SMR calculation example showing observed versus expected deaths." Suggested OER search string: "life table construction columns lx dx Lx Tx ex standardised mortality ratio SMR OER"
3. Figure 5.3: Direct and indirect standardisation: worked comparison Attribution: AI generated using prompt "Generate a two-panel diagram showing a worked direct standardisation table and a worked indirect standardisation SMR calculation with labelled steps." Suggested OER search string: "direct standardisation indirect standardisation SMR age-adjusted death rate worked example OER"

4. Figure 5.4: Population-health interaction and the epidemiological transition in Nigeria
   Attribution: AI generated using prompt "Generate a two-panel diagram showing the medical action-population-health feedback loop and a stacked bar chart of Nigeria cause-of-death distribution showing the double burden of infectious disease and rising NCDs."
   Suggested OER search string: "epidemiological transition health transition Nigeria double burden disease NCD infectious OER"