COURSE CODE: STS 478

COURSE TITLE: DEMOGRAPHY

NUMBER OF UNIT: 3 UNITS

COURSE DURATION: THREE HOURS PER WEEK.

COURSE DETAILS:

COURSE COORDINATOR: Mrs. F.S. Apantaku

LECTURER OFFICE LOCATION: A101

COURSE CONTENT:

Sources of population data, Errors in demographic data, Vital rates and ratios, Migration and distribution of population, Techniques of population projections, The life table and associated problems, Manpower statistical interpolation and graduation in demographic analysis.

COURSE REQUIREMENTS:

This is a compulsory course for all statistics students. Students are expected to have a minimum of 75% attendance to be able to write the final examination.

READING LIST:

1.) **Brass, W. et al (1968). The Demography of Tropical Africa. New Jersey: Princeton University.**
2.) **Iwunor, C. (1993). Techniques for Integrated Projections. UN Development Programme NIR / 91 / 001 – Population and Development.**
3.) **Kpedekpo, G.M.K. (1982). Essentials of Demographic Analysis for Africa. London. Heineman.**
4.) **Nsowah – Nuamah, N.N.N. (2007). Demographic statistics. A Handbook of Methods and Measures in Demography. Accra. Academic Press.**
5.) **Shryock, H.S. & Siegel, J.S. (1976). The Meyhods and Materials of Demography. Washington DC. US Bureau of the Census.**

LECTURE NOTES

INTRODUCTION

Demography is the statistical analysis of population data. The term **Demography**, was coined from two Greek words (**demos** meaning people, and **graphein** meaning to write or describe). Its subject – matter includes: (a) examination of the total size of population (b) examination of population distribution i.e. rural/urban (c) examination of the structure of population i.e. age and sex composition (d) examination of changes in population over time i.e. growth or decline (e) examination of the causes and effects of population change.

As a distinct branch of scientific knowledge, demography may be defined as ″the study of size, territorial distribution and composition of population, changes there – in, and the components of such changes, which may be identified as natality, mortality, territorial movement (migration), and social mobility (change of status) ″. This definition, however relates only to one aspect of modern demography. Modern demography is divided into two parts, namely

Demographic Analysis – this deals with the study of the components of change in the population. These components are also called **population dynamics**, i.e. fertility, mortality, and migration.

Population Studies – this deals with addressing demographic events and phenomenon in the socio – economic context. It relates population dynamics to socio – economic, biological, and political or other environmental factors.

Ideally, the study of demography requires extensive and accurate population statistics. The **demographer** subsists by calculating rates, assuming implicitly a decision – making process regarding when, how many and how far in – between to have babies; by explaining birth intervals by postpartum amenorrhea, voluntary abstinence, contraceptive use – effectiveness, period of Infecundability and related fertility – inhibiting indicators; by constructing elegant life tables; by measuring activity rates and migration rates and by periodically projecting the size of the total population by its components; by validating and updating the results usually presented in three variants – high, medium and low, using census figures where available and vital registration where these exist.

SOURCES OF POPULATION DATA

Demographic data usually consist of data on age, occupation, religion, marital status, e. t. c

The collection and analysis of demographic data is usually to attain administrative, planning or research purposes. Demographic data are derived mainly from two sources, namely national and international sources.

National Sources of Demographic Data

Population census

A census of population may be defined as the total process of collecting, compiling and publishing demographic, economic and social data pertaining, at a specified time or times, to all persons in a country or delimited territory.

Essential Features of the Census

Some of the essential features of an official national census are;

1. Sponsorship - an official national census is sponsored and carried out by the national government.
2. Defined Territory - the coverage of a census operation should relate to a precisely defined territory.
3. Universality – the enumeration should include every member of the community within the scope of the census without omission or duplication.
4. Simultaneity - the total population enumerated should refer to one well defined point of time.
5. Individual unity – a census implies that separate data are recorded for each individual by direct enumeration and not by registration.
6. Compilation and publication – the compilation and publication of data by geographic areas and by basic demographic variables is an integral part of a census.

Census Periodicity

Census data are of greater value if censuses are taken at regular intervals. A series of periodic censuses is of great importance in assessing trends - the past can be appraised, the present accurately described, and the future estimated. The UN recommended that every country develop a census programme which will provide that a population census be taken every ten years.

Uses of census statistics

1. Planning for national development, i.e. educational, housing, manpower, health planning, and e.t.c.
2. Investigating the adequate of the relationship between demographic and socio-economic processes.
3. Measuring the levels and trends in the standard of living of the population.
4. The allocation of parliamentary seats.
5. The allocation of resources.

Censuses Taken in Nigeria, 1911-2006

Year	Reported population
1911	15,969,320
1921	18,624,690
1931	19,928,171
1950/53	30,417,000
1962/63	55.7m
1973	79.8m (cancelled)
1991	88,992,220
2006	140,003,542

Vital Registration

The vital registration is the continuous, permanent and compulsory registration of the occurrence and characteristics of vital events – births, deaths, marriages, change of name, nationalisation, e.t.c The statistics generated from the exercise is referred to as **vital statistics** because they have to do with the individuals entry into, and departure out of life, with the changes in the civil status of the individual in his/her life time.

In many developing countries, vital statistics are inadequate and defective to the extent that they can hardly serve to measure demographic levels and trends. In Nigeria, the vital registration is one of the major responsibilities of the National Population Commission of Nigeria.

Statistical Uses of Vital Statistics

1. Vital statistics provide additional data independent of census on measures of fertility and mortality both for small and large areas.

2. The sex ratio at birth computed from records of births provides a very important piece of information for use in population projections.

3. The data from vital registration gives information on the seasonality of births and deaths. This has relevance for the planning of related services.

4. The system is used as a check on census enumeration, particularly at the infant and childhood range where under - enumeration is common.

5. In a longitudinal – type survey about fertility and mortality, records of birth, death, marriage and divorce can be very useful.

6. They are useful in formulating population control programmes, and for evaluating the effectiveness of such programmes.

Sample surveys

Sample survey seeks to collect information only from a fraction of the population. It is employed to arrive at estimates of demographic characteristics, size, distribution, mortality, fertility and migration. In Nigeria, the efforts to generate reliable demographic data has included the conduct of numerous national sample surveys such as-

1965/66 Demographic Sample Survey (DSS)

1981/82 Nigerian Fertility Survey (NFS)

1982 National Integrated Survey of Households (NISH)

1990, 1999, 2003, 2008 Nigeria Demographic and Health Survey (NDHS).

Population Register

This source of demographic data is usually employed by the developed/industrialised countries who maintain a regular update list of people resident in a country with details of sex, date of birth, marital status, place of residences, e.t.c. The population register can only be effectively maintained where education is reasonably high with an accurate address system.

Administrative Sources - i.e. public records, private records (such as records of religions bodies).

International sources

1. United Nations Demographic Year book
2. Demographic Handbook for Africa - Economic Commission for Africa
3. Yearbook on Epidemiological and Vital Statistics - World Health Organisation.

Importance and quality of Demographic data

National plans for the provision of such need as housing, food, education, health, e.t.c depend on the relevant socio – demographic statistics classified by age and sex. Most population processes like fertility and mortality are either age - sex dependent or age-sex selective.

Many demographic and socio economic attributes are sex specific, this is understandable because of the biological differences between the gender. It follows therefore that the importance of accurate age-sex data in demographic analysis cannot be over emphasised. However, age data tend to be more inaccurate than sex data.

ERRORS IN DEMOGRAPHIC DATA

The accuracy of demographic statistics varies from one country to another. The deficiencies are most in the developing countries because among other problems of lack of administrative machinery, individual ignorance about certain personal details and sometimes open hostility to some types of inquiry, due to ignorance. Errors in the demographic data are mainly of two types, namely, coverage and content errors.

Coverage Errors – are due to persons being missed or counted more than once. They are of two types. Individual of a given age may have been missed by the census officials or erroneously included in it (i.e. counted twice). The first type is called ***under enumeration*** at this age, while the second type represents ***over enumeration***, the balance of the two types of errors represents ***net under enumeration*** at this age.

Content Errors - refers to instances where the characteristics of a person counted in a census enumeration or in the registration of a vital event are incorrectly reported or tabulated. The five principal sources of errors of content are:

1. The respondent - when he/she intentionally or unintentionally fail to give the appropriate information required. A classic example is misstatement of age or the case where widows or divorces report themselves as single.
2. The enumerator - where he/she classifies a person incorrectly even though give the correct information.
3. The coding process - errors caused from the failure to allocate information on the census or survey schedule to the proper code.
4. The editing process.
5. Errors may arise at all stage of the compiling process or during tabulations.

ERRORS IN AGE DATA

Demographic data are usually classified by age and sex. Errors in age reporting are more frequent than errors in sex reporting. With reference to Nigeria, in census/survey reporting of age, there are five major forms irregularities -

1. Under reporting of children aged less than one year.
2. A tendency to give an exact age of some legal significance e.g. voting at election or marriage.
3. Distinct over statement of age at very advanced ages.
4. The reporting of some individuals as being of an unknown age.

5. Age heaping.

These irregularities must be detected, adjusted or corrected before demographic data could be used for any meaningful analysis. Hence, the following methods of evaluating demographic data or of detecting age irregularities.

Whipple's Index of Digit Preference

This give the relative preference for digit 'O' and '5' while reporting age in the interval 23 to 62 years. It is computed as;

$$WI = \frac{P_{25}+P_{30}+P_{35}+P_{40}+P_{45}+P_{50}+P_{55}+P_{60}}{\frac{1}{5}\sum_{x=23}^{62} Px} \times 100$$

Where

P_x = the number of persons reporting their age as x years.

If there is no heaping at '0' and '5' the index will have a value of **100**. If there is complete heaping, the index will have a value of **500**. To test for heaping at ages 30, 40, 50, and 60 i.e. ages ending in '0' the index is computed as;

$$WI = \frac{P_{30}+P_{40}+P_{50}+P_{60}}{\frac{1}{10}\sum_{x=23}^{62} Px} X\ 100$$

To test for heaping at ages ending in '5' i.e. 25, 35, 45, and 55, the index is computed as;

$$WI = \frac{P_{25}+P_{35}+P_{45}+P_{55}}{\frac{1}{10}\sum_{x=23}^{62} Px} X\ 100$$

Example

Using age distribution data for a West African country (1960), determine the extent of heaping on

(a) Digit '0' and '5'.

(b) Digit '0' only

(c) Digit '5' only.

Age	population	Age	population
23	38687	25	77141
24	51289	30	110379
26 - 29	201450	35	64091
31 - 34	132136	40	81515
36 - 39	134140	45	44654
41 - 44	84422	50	52024
46 - 49	77102	55	14024
51 – 54	44751	60	38377
56 – 59	45283		482205
60	38377		
61	4779		

62 7866
1304110

(a) Digit 0 and 5 = 482205 X 100 = 185.1

1(1304110)
5

(b) Digit 0 only = 282295 X 100 = 216.5
1 (1304110)
10

(c) Digit 5 only = 199910 X 100 = 153.3
1 (1304110)
10

Limitations of Whipple's index

1. It does not measure preference for digits other than '0' and '5'
2. It considers only the arbitrary interval 23 to 62 years and not the entire life span of 0 to 80 or 100 years.
3. It does not take into consideration the decreasing nature of the age distribution due to depletion by death.
4. It's applicable only to single year's data.

Myer's Blended Index of Digit Preference

This index is used for evaluating single - year age – sex data. It can give the extent of digit preference for all the digits 0, 1, 2, 3... 9. It can be used to report errors for all ages 10 – 99 years.

Assumption

The underlying assumption of the method is that in the absence of systematic irregularities in the reporting of age, the blended sum at each terminal digit should be approximately equal to 10% of the total blended population.

If the sum at any given digit exceeds 10% of the total blended population, it indicates over selection of ages ending in that digit (i.e. digit preference).

On the other hand, a negative deviation or sum that is less than 10% of the total blended population indicates an under selection of the ages ending in that digit (i.e. digit avoidances).

If age heaping is non-existent, the index would be approximately zero.

Example

Use the Myer's blended index to assess the quality of age data gin below-

Digit	10 – 19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
0	386	417	307	190	89	80	50	40	10
1	133	93	90	89	41	35	33	10	2
2	341	227	100	40	30	25	15	6	4
3	223	160	90	46	28	22	8	5	1

4	201	138	50	38	25	10	8	5	3
5	298	238	201	154	148	65	25	2	3
6	198	105	70	49	31	18	12	6	4
7	166	86	50	45	25	9	5	4	2
8	255	100	90	40	28	10	5	5	2
9	132	85	40	20	8	6	2	2	2

Procedure for computations

1. Sum all the populations ending in each digit over the whole range i.e. 10-99
2. Sum figures between ages 20-99.
3. Multiply the sums in (1) by coefficients; 1, 2, 3,4,5,6,7,8,9 and 10.
4. Multiply the sums in (2) by coefficients from 9 descending to 0 i.e. 9 ,8 ,7, 6 , 5 ,4 ,3 ,2 ,1 ,0.
5. Add the product of (3) and (4) , to obtain the blended sum
6. Add up the blended sum in (5).
7. Find the percent (%) of the total blended sum at different digit ends.
8. Take the deviations of each % in (7) from 10.0. This result indicates the extent of concentration or avoidance of a particular digit.

Terminal digit	Sum (10 – 99)	Coefficient	Product	Sum (20 – 99)	Coefficient	Product	Blended Sum	Percent Dist	Dev From 10%	Remarks
0	1569	1	1569	1183	9	10647	12216	21.7	11.7	Preference
1	526	2	1052	393	8	3144	4196	7.5	-2.5	Avoidance
2	788	3	2364	447	7	3129	5493	9.8	-.2	Avoidance
3	583	4	2332	360	6	2160	4492	8.0	-2.0	Avoidance
4	478	5	2390	277	5	1385	3775	6.7	-3.3	Avoidance
5	1134	6	6804	836	4	3344	10148	18.0	8.0	Preference
6	493	7	3451	295	3	885	4336	7.7	-2.3	Avoidance
7	392	8	3136	226	2	452	3588	6.4	-3.6	Avoidance
8	535	9	4815	280	1	280	5095	9.0	-1.0	Avoidance
9	297	10	2970	165	0	0	2970	5.3	-4.7	Avoidance
							56309			

Limitations of Myer's Blended Index

(1) It has no sound theoretical basis
(2) It does not capture other forms of age bias
(3) It is not suitable for grouped data.

United Nations Age Sex Accuracy Index

This index which was proposed by the United Nation is used for evaluation of five-year age-sex data. The index is also referred to as **Joint Score**. It has three components;

(a) Average sex ratio score (S)

This score is obtained by fist calculating the sex ratio at each age group. Successive differences irrespective of sign are added and averaged.

Age – specific sex ratio = $\frac{{}_5Px^m}{{}_5PX^f}$ X 100

${}_5Px^m$ =males aged x to x + 5

${}_5px^f$ = females aged x to x + 5

(b) Average male age ratio score (M)

For each age group for males, calculate the age ratios computed as

Age ratio = $\frac{{}_5P_x}{½ ({}_5P_{x-5} + {}_5P_{x+5})}$ X 100

The deviations from unity irrespective of sign are added and averaged (M).

(c) Average female age ratio score (F)

For each age group for females, the age ratios are calculated using the same formulae as for males. The deviations from unity irrespective of sign are added and averaged (F).

The index is then computed as: **UNAI = 3(S) + M + F.**

The reported age-sex data for a given population is presumed to be **accurate** if the age-sex accuracy index is between **0 and 19.9, inaccurate** if the index is between **20 and 39.9**, and **highly inaccurate** if the index is **above 40**.

Example

Use the United Nation age-sex accuracy index to assess the age – sex reporting of the data shown in the table below-

Age Group	Male Population	Female Population	Sex Ratio	First Difference	Male Age Ratio	Dev from 100	Female Age Ratio	Dev from 100
0-4	2376	2350	101.1	5	-	-	-	-
5-9	1983	1972	100.6	-.3	99.1	-.9	99.5	-.5
10-14	1628	1614	100.9	-.1	99.9	-.1	99.7	-.3
15-19	1277	1265	101.0	-.1	97.3	-2.7	97.3	-2.7
20-24	997	986	101.1	-2.5	95.7	-4.3	96.5	-3.5
25-29	807	779	103.6	1	97.4	-2.6	95.6	-4.4
30-34	661	644	102.6	-.8	97.4	-2.6	98.2	-1.8
35-39	551	533	103.4	-.8	95.4	-4.6	104.3	4.3
40-44	394	378	104.2	8.2	96.3	-3.7	93.2	-6.8
45-49	267	278	96.0	10.9	90.8	-9.2	91.8	-8.2
50-54	194	228	85.1	4.6	90.7	-9.3	95.4	-4.6
55-59	161	200	80.5	-2.9	97.6	-2.4	102.3	2.3
60-64	136	163	83.4	-.3	103.0	3	100.9	0.9
65-69	103	123	83.7	-11.2	97.6	-2.4	101.7	1.7
70-74	75	79	94.9	-10.2	90.9	-9.1	86.8	13.2
75-79	62	59	105.1	-	-	-	-	-
				54.4		56.9		55.2
				S=3.63		M=4.06		F=3.94

UNAI = 3(S) + M + F

=3 (3.63) + 4.06 + 3.94
= 10.89 + 4.06 + 3. 94
= 18.89
Comment : Age – sex reporting is accurate.

VITAL RATES AND RATIOS

Demography is an interdisciplinary subject which is strongly embedded in sociology, geography, economics, ecology, biology, statistics and genetics. Therefore, in demographic analysis, extensive use is made of several concepts. Of particular importance are the mathematical concepts of ratios and rates. These concepts are very useful in demographic analysis; however, caution is needed in their interpretation.

VITAL RATIOS

A ratio is a general term given to any numerator - denominator relationship between two numbers. Prominent ratios in demographic analysis are.

(1) Sex ratio

Sex ratio is the ratio of males to females in a given population, usually expressed as number of males for every 100 females i.e.

$$SR = \frac{\text{No of males}}{\text{No of females}} \times 100$$

Sex ratio is affected by

(a) sex ratio at birth (always more than 100 with a range from 102 - 105).
(b) differential patterns of mortality for males and females
(c) differential patterns of migration for males and females in population.

Sex ratio for Uganda 2000 population.

Age group	Males	Females	SR
0-4	2376	2350	101
5-9	1983	1972	101
10-14	1628	1614	101
15-19	1277	1265	101
20-24	997	980	102
25-29	807	779	104
30-34	661	644	103
35-39	551	533	103
40-44	394	378	104

45-49	267	278	96
50-54	194	228	85
55-59	161	200	81
60-64	136	163	83
65-69	103	123	84
70-74	75	79	95
75-79	62	59	106
total	11,671	11,646	100

2. Age Dependency Ratio

This is the ratio of persons in the 'dependent ages' (under 15 and 65+) to those in the 'economically productive' ages i.e.

$$\frac{P_{0-14} + P65}{P_{15-64}} \times 100$$

The age dependency ratio indicates the relative predominance of person in the 'dependent' ages in relation those in the productive ages.

3. Child Woman Ratio

The child woman ratio is a fertility measure computed or based on census data. It is defined as the number of children under age 5 per 1000 women of child bearing age in a given year.

$$CWR = \frac{\text{No of children under 5yrs}}{\text{No of women ages 15 - 49}} \times 1000$$

4. Maternal Mortality Ratio

Maternal death is death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration or site of the pregnancy from any cause related to,or aggravated by the pregnancy or its management, but, not from accidental causes. Maternal mortality ratio is the number of women who die as a result of complications of pregnancy or child bearing in a given year per 100,000 live births in that year i.e.

Region	live births	Deaths due to causes			
		abortion	lack of ANC	lack of Eoc	MMR
A	56403	67	32	10	193
B	97166	81	14	6	104
C	93415	72	18	10	107

Why measure maternal mortality?

1. To establish levels and trends of maternal mortality.
2. To identify characteristics and determinants of maternal deaths
3. To monitor and evaluate effectiveness of activities designed to reduce maternal mortality
4. To monitor progress towards MDG 5.

Factors contributing to high maternal mortality in developing countries

1. Pregnancies in the youngest and oldest ages of the reproductive period
2. Maternal depletion through pregnancies that are too closely spaced

3. High parity births
4. Lack of access to adequate health services
5. Lack of skilled birth attendants
6. Inadequate nutrition in childhood and adolescence
7. Complications from poorly performed abortion

VITAL RATES

Rates are special case of ratios. They measure the likelihood of the occurrence of a phenomenon within a given population, defined by the spatial and temporal characteristics. In demographic analysis, there are crude rates and specific rates

Crude rates are obtained by relating the number of events of a specified type occurring within an interval usually one year, to the size of the population within which the events occurs e.g. CBR & CDR.

Specific rates are obtained on the basis of events occurring in or to particular sub - populations' e.g. ASFR and ASFR.

(1) Crude Birth Rates (CBR)

Number of live births per 1000 population in a given year i.e.

$$CBR = \frac{B}{P} \times 1000$$

Limitations

(a) Only a crude estimate of fertility, all the population included in the denominator is not 'exposed' to the risk of pregnancy.

(b) Not good for comparing fertility across populations, as variations in age distribution of the populations being compared will affect the birth rate.

(2) General Fertility Rate (GFR)

Number of live births per 1000 women aged 15-49 in a given year i.e.

$$GFR = \frac{Births}{P^f_{15-49}} \times 1000$$

The GFR is a more refined measure than CBR to compare fertility across populations.

(3) Age Specific Fertility Rate (ASFR)

Number of births per year per 1000 women of a specific age group i.e.

$$ASFR = \frac{Ba}{P^f_a} \times 1000$$

Useful for

(a) Comparisons in fertility behaviour at different ages.

(b) For comparison of fertility at different ages over time.

(c) for comparison of fertility across countries/populations.

Example

Age	popn of female	live births	ASFR
15-19	1611090	463631	288

20-24	1558276	427298	274
25-29	1425242	412878	290
30-34	1381174	380778	276
35-39	1632695	308671	189
40-44	1581373	281161	178
45-49	140055	239701	171
	10590405	2514118	1666

$$GFR = \frac{2514118}{10590405} \times 1000$$

= 237 per 1000 women

(4) Total Fertility Rate (TFR)

The average number of children that would be born to a woman by the time she ended childbearing if she were to pass through all her childbearing years conforming to the age-specific fertility rates of a given year.

TFR =5 x ∑ ASFR per woman
= 5[1666/1000]
= 5 x 1.666
= 8 Per woman

The TFR is the best single measure to compare fertility across populations.

(5) Gross Reproduction Rate (GRR)

The GRR is the average number of daughters that would be born to a woman during her life-time if she passed through her child-bearing years conforming to the age-specific fertility rates of a given year.

The GRR is exactly like TFR, except that it counts only daughters and literally measures 'reproduction' - a woman reproducing herself in the next generation by having a daughter.

GRR = TFR x [proportion of female births to total births].

Example

Age Group	Female Popn	Female birth	Total birth	ASFR
15-19	79865	4293	8813	110.3
20-24	63315	8582	17620	278.3
25-29	51860	7104	14585	281.2
30-34	44440	4986	10235	230.3
35-39	38795	3686	7569	195.1
40-44	32250	1344	2760	85.6
45-49	26720	186	381	14.3
		30181	61963	1195.1

TFR = 5 X 1.1951
= 6 per woman

$$GRR = 6 \times \frac{30181}{61963}$$

= 3 daughters

(6) Crude Death Rate (CDR)

The CDR is the number of deaths in a given year per 1000 mid - year population i.e.

$$CDR = \frac{D}{P} \times 1000$$

(7) Age Specific Death Rate (ASDR)

The ASDR is the number or deaths per year in a specific age (group) per 1000 persons in the age group.

$$ASDR = \frac{D_a}{P_a} \times 1000$$

Why ASDRS?

(a) can compare mortality at different ages.
(b) can compare mortality in the same age groups over time and /or between countries and areas.
(c) can be used to calculate life tables to create an age-independent measure of mortality /life expectancy.

(8) Cause Specific Death Rates (CSDR)

The CSDR is the number of deaths attributable to a particular cause (C) divided by population at risk, usually expressed in deaths per 100,000.

i.e. $$CSDR = \frac{Dc}{P} \times 100,000$$

Example

Community	Population at risk	Deaths by causes: TB	Malaria	Diabetes
A	304848	278	252	188
B	211075	170	170	154
C	416418	193	180	228

CSDR	TB	Malaria	Diabetes
A	91.2	82.7	61.7
B	80.6	81.0	73.0
C	46.4	43.2	54.7

(9) Infant Mortality Rate (IMR)

The IMR is the number of deaths of infants under age 1 per year per 1000 live births in the same year, i.e.

$$IMR = \frac{D_{infants}}{\text{Total live births}} \times 1000$$

Why IMR?

(a) The IMR is a good indicator of the overall health status of a population.
(b) It is a major determinant of life expectancy at birth.
(c) The IMR is sensitive to levels and changes in socio economic conditions of a population.

The IMR can be divided into -

Neo Natal Mortality Rate – which is defined as the number of deaths of infants under 4 weeks or under 1 month of age during a year per 1000 live births during the year i.e.

Post Neo Natal Mortality Rate – which is defined as the number of infant deaths at 4 through 51 weeks of age or 1 through 11 months of age during the year, i.e.

(10) Maternal Mortality Rate (MMR)

The MMR is the number of women who dies as a result of complications of pregnancy or child bearing in a given year per 100, 000 woman of childbearing age in the population.

$$MMR = \frac{\text{No of Maternal deaths}}{\text{No of women age 15-49}} \times 1000,000$$

TECHNIQUES OF POPULATION PROJECTION

Population projection is an exercise at calculating the future values of a population. To arrive at the future values, it may be necessary to use several techniques and inter relationships in arriving at projections. The reliability of the projected values will depend upon the validity of the assumptions regarding the future trajectory of a population as well as of the vital rates (fertility, mortality and migration) that would determine its growth and change. It also depends on the accuracy with which these assumptions are translated into quantitative terms.

When projections refers to an indication as to the most likely population at a given date, they are described as 'forecast' where as projections could lead to unlikely future values of the population, forecasts are expected to produce very likely future values . Thus, all forecasts are projections but not all projections are forecasts. Usually, exercises in projections are not attempted for periods less than 15 or 25 years.

Population projections are essentially concerned with future growth. They may be obtained or prepared for:

a. Total population of the country
b. Principal geographical sub divisions or specific localities within them.
c. Different types of place of residence e.g. rural-urban.
d. Other socio economic sub groups of the population e.g. economically active population.

The principal characteristics for which projections are needed are – total population, age-sex structure, fertility, mortality, migration and other demographic aggregates. Aside from population projections, other projections required for socio economic planning include:

a. educational characteristics e.g. school enrolment, educational attainment, e.tc.
b. economic characteristics e.g. economically active population, employment by occupation and industry, e.tc.
c. social aggregate like household, families, e. t c.

Uses of population projections

1. Population projections constitute one of the essential inputs in developing long term and short-term national development plans.
2. Monitoring and evaluation of plans and plan implementation are better performed keeping in view the population for which they are meant e.g. plans to achieve Vision 20/2020 should be viewed vis – a - vis the target or projected population for the year 2020.
3. Population projections are also very important for marketing planning.
4. Population projections are particularly useful in demographic analysis.
5. Sectoral plans and programmes as well as sectoral allocation of funds depend on the availability of accurate and reliable population projections.

Techniques

Population projection techniques refer to the various procedures for arriving at the future size and the age-sex composition of the population at specific points in time. The various methods of population projections could be broadly classified into;

(a) Mathematical projections method
(b) cohort- component method

The distinction between the two methods of population projections lies on the nature of assumptions made about the pattern of change in the different elements of population dynamics.

Mathematical methods

The use of the mathematical methods involves application of a plausible mathematical equation to derive projections of the total population on the basis of total population data available from one or more censuses. The mathematical methods are:

(a) Arithmetic growth
(b) Geometric growth
(c) Discrete time exponential growth
(d) Continuous time exponential growth

Arithmetic growth model

This method assumes that population growth is linear or follows an arithmetic progression i.e. that there is a constant amount of increase per unit of time.

Projection equation: $P_t = P_o\ (1 + r\,t)$, where

P_t = size of the population in year t

P_o = size of the population in the base year

r = average annual rate of growth

t = length of the time interval, and

$$r = \frac{P_t - P_o}{t.\ P_o}$$

Example

Nigeria

1963	1991
55670055	88514501

t = 1991 – 1963 = 28

$$r = \frac{88514501 - 5567055}{28(55670055)}$$

$$= \frac{3284444600}{1558761540}$$

= 0.211(2.11%).

2000 – 1991 = 9

P_{2000} = 88514501 [1 + (.0211x 9)]

= 88514501(1.1899)

=105,323,405

Geometric Growth Model

Under this method, it is assumed that population growth follows a geometric progression i.e. The population in succeeding years increase or decreases at a constant proportion or percentage of the population in the previous year.

Projection equation: $P_t = P_o(1 + r)^t$,where

$$r = \left(\left(\frac{Pt}{P_o}\right)^{1/t} - 1\right) \times 100$$

Example

State	1963 census	1991census	r	P_{2005}
Anambra	3596618	5929198	.01801	7,612452
Bauchi	2431296	4294413	.02053	5,707746
Kaduna	1553302	3969252	.03417	6,344652
Lagos	1443568	5685781	.05018	11,284505

i.e. Lagos = $\left(\frac{5685781}{1443568}\right)^{1/28} - 1$

= 0.05018

Cohort- Component method

The component method involves the separate projection of mortality, fertility and net migration. The method which used indicators of population change employed a variety of procedure. Some of them estimate total population directly, other estimate just net migration, and then combined with a separate estimate of a natural increase.

The indicators could be used to make projections of population by regression or ratio method. Usually, the method is applied by age-sex groups yielding direct projections of age-sex structure, total population can be derived from combination of projection from age-sex groups.

Explicit assumptions on fertility, mortality and migration are made; hence, one can get an insight into the ways population change.

MIGRATION AND POPULATION DISTRIBUTION

Definitions

Migration – geographic movement of people across a specified boundary for the purpose of establishing a new permanent or semi - permanent residence. Refugees and Internally Displaced Persons are not considered as migrants.
Circular migration - regular pattern of short term migration i.e. home to office/school
International migration - moves between countries

(a) Immigration - move into a new country

(b) Immigrant - an international migrant who enters the area from a place outside the country.

(c) Emigration - move out of home country

(d) Emigrant - an international migrant departing to another country by crossing the
international boundary.

Internal migration - moves within a country.

(a) In – migration - movement into a new political/geographically/administratively defined area within the same country.
(b) In – migration - a person who moves into a new area within the same country.
(c) Out – migration - movement out a geographically/administratively defined area within the same country.
(d) Out migrant - a person who moves out of an area within the same country.

Net migration - the net effect of immigration and emigration (or in - migration and out-migration) on an area's population increase or decrease.

Sources of Data

1. Population censuses (birth place, residence at some earlier time, duration of residence).
2. Administrative data such as arrival and departure statistics and visa statistics
3. Special surveys such as population based surveys and survey of passengers
4. International organizations such as ILO, UNHCR, UN, EU, PRB, OECD, etc.

Uses of Data on Internal Migration

1. To ascertain the amount of migratory movement into and out of an area that has occurred over a specified period of time.
2. To ascertain the characteristics of the persons who have migrated.
3. Statistics on internal migration are needed for appraising the nature and magnitude of any problems involved in migratory movements.
4. For planning programmes intended to cope with problems arising from migratory movement.

5. Statistics on internal migration are also needed for the scientific basis of the nature and causes of migration and its consequences.

ESTIMATION OF INTERNAL MIGRATION

Internal migrations in several countries are not usually recorded as they occur; hence actual migration rates are rarely calculated. However, on the basis of available statistics from censuses and surveys, estimates of basic migration measures are obtained. The basic measures include:

(a) Crude Immigration Rate

CIR =I/P x 1000, where I = number of in-migrants

(b) Crude Out Migration Rate

COR=O/p x1000, where O = out migrants

(c) Crude Gross Migration Rate

CGR = I + 0/p x 1000

Internal migration can be estimated using three key methods - namely,

1. Place of origin by place of Enumeration statistics
2. Demographic Balancing Equation
3. Cohort - component method

PLACE OF ORIGIN BY PLACE OF ENUMERATION STATISTICS

Procedure

(a) Data obtained from census and contains number of people enumerated in their place of

Origin as well as those enumerated elsewhere.

(b) Numbers of immigrants and out migrants are obtained from the cross - tabulation table

(c) Total residence is used as the mid - year population

(d) Basic rates are computed

Example: Nigeria, 1991Census - Population classified by Home State and State of Enumeration State of Origin

State of Origin	Adamawa	Bauchi	Borno	Jigawa	Kano	Plateau	Taraba	Yobe
Adamawa	102281	3172	1515	317	1073	206	2489	582
Bauchi	562	234420	351	1045	1521	1633	298	630
Borno	680	685	109810	929	977	98	50	2041
Jigawa	1	90	6	168619	409	11	0	141
Kano	188	435	403	3345	336535	226	22	169

Plateau	430	3726	719	585	3036	133536	180	247
Taraba	1217	842	84	107	153	638	41110	144
Yobe	43	351	349	594	573	31	21	70278

State	In - Migrants I	Out-Migrants O	Residence P
Adamawa	9351	3121	111632
Bauchi	6040	9301	240460
Borno	5460	3427	115270
Jigawa	658	6922	169277
Kano	4788	7742	341323
Plateau	8923	2843	142459
Taraba	3185	3060	44295
Yobe	1962	3954	72240

MIGRATION RATES PER '000

State	CIR	COR	CGR	CNR
Adamawa	83.8	28.0	111.7	55.8
Bauchi	25.1	38.7	63.8	- 13.6
Borno	47.4	29.7	77.1	17.6
Jigawa	3.9	40.9	44.8	- 37.0
Kano	14.0	22.7	36.7	- 8.6
Plateau	62.6	20.0	82.6	42.7
Taraba	71.9	69.1	141.0	2.8
Yobe	27.2	54.7	81.9	- 27.6

THE LIFE TABLE

The life table may be defined as the life history of a hypothetical cohort of people born in a certain period and subjected to gradual losses by mortality at each age, Life tables provides a description of the most prominent aspect of the state of human mortality. They can be specifically applied to the following aspects of population analysis:

1 The preparation of population projection and estimates
2 The study of reproduction, replacement, marriage, birth intervals and contraceptive use
3 In the summarisation of the age specific risks of death in a population by providing us with the chance of dying and survival as a function of age and in the comparison of these risks in different
4 In the analysis of data from developing countries, life table models or reference sets can be used for the graduation and defective data.

ASSUMPTIONS

1 The cohort is "closed" against migration in or out. Hence, there are no changes in Membership except the losses due to death
2. People die at each age according to a schedule that is fixed in advance and dues not Change
3. At each age (excepting the first few years of life) death are evenly distributed between one birthday and the next

4. The cohort also originate from some standard number of birth called the radix of life table
5 the cohort normally contains members of only one sex

TYPES OF LIFE TABLE

1. *Generation of life table*
   The cohort or generation life table is usually constructed for groups still living and stops at the present age.
2. *Conventional life table*
   The period or cross sectional or conventional life table express the mortality experience that a hypothetical cohort would have if it experienced the mortality rates observed in a given time.

CONSTRUCTION OF LIFE TABLE

There are two major types of life table which can be constructed:

Complete life table

A complete life table is a table in which the mortality experience is considered in single years of age throughout the life span. All the columns of the life table are given for single years and it is extremely detailed.

Abridged life table

An abridge life table is one in which the measures are given not for every single year of age, but for age groups.

THE SPECIAL MEANING OF AGE AND SOME CONVENTIONS OF NOTATION

Age as would be used for each individual is the exact numbers of completed years that have elapsed since birth. When we use the phrase exact age 20 in a life table, we tend to mean when a person reaches exact age x, when he reaches his x^{th} birthday. For a year afterwards, he remain in the interval x to x +1 until he reaches the next birthday when x + 1 becomes his exact age, he is x plus some function of a year of age.

Hence, life table functions can be classified into two categories - those referring to exact age and those referring to an interval of age. Functions referring to an interval of age carry two subscripts e.g. nq_x the first subscripts, n, indicates the number of completed years over which the interval extends and the second subscript, x, indicates the exact age at which the interval commence, thus, the interval extends from age x to x + n.

In the complete life table, all intervals are equal to 1. The subscripts n preceding the interval functions is often dropped; qx rather than nqx. The functions referring to exact years of age attained. This subscript is usually indicated. This subscripts is usually indicated as x and is placed after the symbol defining the function e.g. e_x.

FUNCTION OF THE LIFE TABLE AND RELATIONSHIP BETWEEN THE LIFE TABLE COLUMNS

Life table functions can be classified into two categories - those referring to an exact age those referring to an interval of age -

1 nmx

The age-specific death rate(nmx) is defined as the number of death in a given calendar year between exact ages x and x + n divided by the mid-year population in an actual population, i.e.

nmx = nDx/nPx where

nDx = deaths in the interval x to x + n

nPx = mid - year population in the interval x to x + n.

2 1_x

The function 1_x denotes the survivors of a cohort of life born babies to the exact age x. The initial values of the survivors' column are 1o. It is known as the radix. It can be conveniently taken as 100000; 10000, or 1000.

3 nd_x

The function ndx denotes deaths experienced by the life table cohort within the interval x to x + n, i .e

ndx = 1x - 1x + n

Similarly, dx = 1xqx

4 nq_x

The function nqx defines the probability of a person aged x dying within the interval x to x + n ie

Nqx = ndx/lx

The nqx differs from the ordinary age specific death rate nmx in the sense that nqx is based on the life table population at the beginning of the age span x to x + n interval to which it refers. The nmx is a central rate based on the actual population at the mid point of that period

5 nPx

The function npx defines the probability of a person aged x surviving through the interval x to x + n years it is the complement of nqx i.e.

nPx = lx + n/lx = 1 - nqx

6 nMx

The function nMx is the life table central death rate. It is defined as the number of deaths in the life table (ndx) divided by the number of persons nLx in the stationary population of the life table between ages x and x + n, i.e.

nMx = ndx/nlx

7 nLx

The function nLx shows the number of person-years lived by the cohort during the interval between specified birthdays ie between x and x + n years. The nLx is defined as follows-
nLx = n/2 (lx + lx + n)
However, for 75+ = lx + n/2(ndx)
For age 0, Lo = .3lo + .7l_1,
For age 1 – 4,
4L_1, = 1.3l_1, + 2.7l_5

8 T_x
The function Tx is derived directly from the nLx column. This function is simply the summation of the nLx column, the summation commencing with the beginning or the terminal of the stationary population.

9 e_x
The function ex is the expectation of life remaining to persons who attain the exact age x i.e e_x = Tx/lx
At age x = o, 1/eo = lo/To => eo = To/lo

Example-

Age	|x	dx	qx	Px	Lx	Tx
0	10000	1632	.1632	.8368	8858	370366
1	8368	1557	.1861	.8139	29268	361508
5	6811	316	.0464	.9536	33265	332240
10	6495	179	.0276	.9724	32028	298975
15	6316	199	.0315	.9685	31083	266947
20	6117	207	.0339	.9661	30068	235864
25	5910	192	.325	.9675	29070	205796
30	5718	241	.0421	.9579	27988	176726
35	5477	260	.0747	.9526	26735	148738
40	5217	390	.0747	9253	25110	122003
45	4827	542	.1123	.8877	22780	96893
50	4285	525	.1225	.8775	20113	74113
55	3760	543	.1443	.8557	17443	54000
60	3217	686	.2131	.7869	14370	36557
65	2531	690	.2725	.7275	10930	22187
70	1841	732	.3974	.6026	7375	11257
75+	1109	1109	1.0000	.0000	3882	3882

Age	ex(yrs)	nMx
0	37.0	.1843
1	43.2	.0532
5	48.8	.0095
10	46.0	.0056
15	42.3	.0064
20	38.6	.0069
25	34.8	.0066
30	30.9	.0086
35	27.2	.0097
40	23.4	.0155
45	20.1	.0238
50	17.3	.0261
55	14.4	.0311
60	11.4	.0471
65	8.8	.0631
70	6.1	.992
75+	3.5	.01299

$nMx = ndx/nLx \Rightarrow nM_5 = 316/33265 = .0095$
$Lo = .3lo + .7l_1 = .3(10000) + .7(8368) = 8858$
$L_5 = 5/2(l_5 + l_{10}) = 5/2\ (6811 + 6495) = 33265$

DEM0GRAPGHIC MODELS

Demographic models are generalisations about a demographic phenomenon or process, and are used as tools of estimation. In this role, the use of models becomes particularly important when available data are limited and defective, when relevant demographic data are easily available, there is little justification for using such models, but they are indispensable in checking and adjusting data, in filling gaps in the available records and in deriving reliable estimate from fragmentary pieces of evidence, each of which may be defective if taken in isolation.

The three types of models that are widely used and applied in demographic estimation are -

1. Models stable population
2. Quasi stable population model
3. Model life Tables e.g.
   - UN models life tables
   - Reed -Merell model life table
   - Regional (Coale and Demeny) model life table
   - Brass model life tables
   - Carrier and Hobcraft system

STATISTICAL INTERPOLATION AND GRADUATION

Meaning of interpolation

Interpolation is defined as the art of inferring intermediate values in a given series of data by use of mathematical formulae or a graphic procedure. Many of the techniques used for extrapolation; hence the term interpolation is often used to refer to both types of inference.

Broadly speaking interpolation encompasses not only mathematical and graphic devises for estimating intermediate or external values in a series (e.g. animal population figures from decennial figures, survivors in a life table for single ages from survivors at every fifth age), but also mathematical and graphic devices for subdividing grouped data into component parts (e.g figures for single years of age from data for 5 year age groups),and for inferring rates for subgroups from rates for broad groups (e.g. birth rates by duration of marriage).

Interpolation is essentially a form of estimation that involves direct application of mathematical formulae cannot be obtained, some external series of data suggestive also a means of making population estimates. Interpolation of this type is a way of prorating the series in order to obtain more exact calibration.

The interpolation formulae or method produces a good fit if it exactly reproduces the given values. The fit is approximate if the result does not pass through the original values or maintain the original totals

USES OF INTERPOLATION

1. They may be used in making population estimates ie Brass p/f and Brass p1|p2 methods

2.They may bee used in smoothening a given series of data in order toensure regularity by removing undesired fluctuations

3. They are useful for the purpose of adjusting defective data
4. They help to estimate abnormalities from a series, such as those due to war, epidemics, refugees movements, population transfers etc

METHODS OF INTERPOLATION OF POINT DATA

1 Graphic interpolation
2 Polynomial interpolation
3 Osculatory interpolation
4 Use of spline functions

METHODS OF INTERPOLATING GROUPED DATA

1 Prorating
2 Osculatory interpolation

GRADUATION OF DATA ON AGE DISTRIBUTION

Age data usually contain irregularities these errors must be detected and corrected before such age data is used for any meaningful demographic purpose. Upon detection of irregularities, most age distributions are usually corrected by methods of graduation or smoothing which includes

a graphic methods

b moving average method
c curve-fitting formulae

A number of graduation methods use mathematical approaches to derive data for 5-years age groups that are corrected primarily for net reporting errors. The mathematical methods are grouped into two namely mathematical methods proposed by united Nation and other mathematical methods.

MATHEMATICAL METHODS PROPOSED BY UN

The UN proposed different methods for adjusting the errors in the age groups
0 – 4, 5 – 9, 10 - 74, and 75+.

OTHER MATHEMATICALS METHODS

These techniques include the carrier-farrag ratio method, Newtons Quadratic formular and the Spragues osculatory graduation method. To smooth a population distribution of 5-years age groups using and of these three methods, the procedure is to group the age groups into 10 = years age groups before applying the techniques.

CARRIER - FARRAG GRADUATION METHOD

This methods consists essentially of splitting the total numbers reported in two adjacent five-years age groups (quinary age groups) by first grouping the quinary age groups into 10-years age groups (denary age groups). The graduated population is then obtain by the manipulation of simple algebraic formulae ie

$U_2 = 1/2U_2 + 1/16(U_0 - U_4)$

$U_3 = 1/2U_2 - 1/16(U_0 - U_4)$

NEWTONS QUADRATIC METHOD

The graduation formula is given as $5P_X = 1/210Px + 1/16\ (10P_{x-10} - 10P_{x+10})$

This formula is applied after re-grouping the data from quinary to denary

Example: Carrier - Farrag method

Age group	Enumerated population Quinary	Denary population Ui=ui+ui+1	Graduated population, Ui
5---9	736169		
10-14	573723	1309892	
15-19	425970		417881.3
20-24	338311	754281	336399.7
25-29	352284		347490.9
30-34	305756	658040	310549.1
35-39	259617		250516.1
40-44	199129	458746	208229.7
45-49	170264		176200.1
50-54	149483	319747	143546.9
55-59	98073		111425.5
60-64	99448	197521	86095.5
65-69	62115		67476.1
70-74	54992	117107	49630.9

75-79	28013		
80-84	26746	54759	
85+	34041		

Uo = 1309892
I.e. 15-19 => U2 = 754281
U4 = 658040
U2= ½ 754281 +1/16 (1309892-658040)
= 417881.3
U3 =1/2 754281 -1/6 (1309892-658040)
= 336399.75

Example: Newton's Quadratic Method

Age group	Reported population (quinary)	Denary population	Graduated population
0-4	18.1		
5-9	17.5	35.6	
10-14	12.0		12.1
15-19	9.4	21.4	9.3
20-24	7.2		7.6
25-29	6.8	14.0	6.4
30-34	6.2		6.1
35-39	5.2	11.4	5.3
40-49	4.1		4.2
45-49	3.4	7.5	3.3
50-54	2.8		2.6
55-59	1.8	4.6	

i.e
10-14 =1/2 21.4+1/6 (35.6-14) =12.1
15-19 =21.4-12.1 =9.3
20-24 =1/2 14.0 +1/16(21.4-11.4) =7.6
25-29 =14-7.6=6.4

Limitations of the mathematical methods

1. They assume that the types and magnitude of errors are the same or similar from age group to the next or between the two sex groups or even over a period of time.
2. Although these techniques tends to smoothen the data vertically (age ratios),they do not guarantee horizontal smoothness (sex ratios) and diagonal smoothness (survival ratios).