Biostatistics

By

Prof. Khalil Mohamed Abbas Ayad

Professor of Public Health & Community Medicine

Faculty of Medicine – Tanta University

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توصيف مقرر دراسى

1- بيانات المقرر		
الرزمز الكودى :	اسم المقرر : الإحصاء الحيوي	الفرقة / المستوى : (
التخصص :	عدد الوحدات الدراسية : نظرى 2 عملى	

2- هدف المقرر:	**Provide the students with theoretical and practical contents on statistics to be able to handle efficiently and interpret different types of data relevant to their future career on medical records and disease registries.**
3- المستهدف من تدريس المقرر :	
ا. المعلومات والمفاهيم :	**By the end of the course, the student should be able to :** - Define the basic concept of biostatistics and their relevance to biomedical field. - Define data sources, collection techniques, and measurement scales. - Describe types of variables. - Identify different methods of data summarization, organization and presentation.
ب- المهارات الذهنية :	**By the end of the course, the student should be able to :** - Differentiate between methods of data presentation.
ج- المهارات المهنية :	**By the end of the course, the student should be able to :** - Use computer tools to make relevant library search and be familiar with some statistical packages. - Handle raw data performing calculations on numerical summarization, designing tables and making graphs. - Handle different types of hospital statistics.

By the end of the course, the student should be able to : - Develop skills needed for data presentation and making reports. - Work independently or as a part of team demonstrating creativity. - Enhancing team work sprit.	د- المهارات العامة :
Definitions and importance of statistics. **Sources and techniques of data collection.** **Types and measurements of variables :** - Classifications of variables. - Scales of measurements of variables. - Errors of measurements. **Demography and vital statistics :** - Census - Population pyramid. - Population growth - Vital indices (morbidity - mortality - fertility) **Hospital statistics :** - Inpatient census. - Measures of efficiency of bed utilization.	4- محتوى المقرر :
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• Individual guidance • Individual feedback • Remedial programs	6- أساليب التعليم والتعلم للطلاب ذوى القدرات المحدودة :
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8- قائمة الكتب الدراسية والمراجع :	
أ- مذكرات	Handouts by the nominated lecturer.
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ج- كتب مقترحة	Text book of Biostatstic e.g Encyclopedia of Biostatistics (2010), Peter Armitage 2nd edition.
د- دوريات علمية أو نشرات .... الخ	Not recommended at this level.

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1- Overall Course Aims :

Provide the students with theoretical and practical contents on statistics to make them able to handle efficiently and interpret different types of data relevant to their future career on medical records and disease registries.

2- Intended learning outcomes (ILOs) :

A. Knowledge and Understanding :

By the end of the course, the student should be able to :

a1 : Define the basic concept of biostatistics and their relevance to biomedical field.

a2 : Define data sources, collection techniques, and measurement scales.

a3 : Describe types of variables.

A4 : Define hospital statistics and how to measure the efficiency of bed utilization.

B. Intellectual Skills:

By the end of the course, the student should be able to :

b1 : Construct frequency distribution table for individual and grouped data.

C. Professional and Practical Skills :

By the end of the course, the student should be able to :

c1 : Use computer tools to make relevant library search and be familiar with some statistical packages.

c3 : Interpret areas under normal curve (AUC).

c5 : Handle different types of hospital statistics.

D. General and Transferable Skills :

By the end of the course, the student should be able to :

d1 : Develop skills needed for data presentation and making reports.

d2 : Work independently or as a part of team demonstrating creativity.

d3 : Enhancing team work sprit.

Chapter (1)

Uncertainty, Research, and Statistics

By the end of this chapter, the student should be able to :

- Define statistics, biostatistics.
- Be oriented with the importance of statistics in medical field.
- Recognize the different types of statistical analysis techniques.
- Understand the different sources of data and types of data collection techniques.

How do we go to uncover the truth about things?

We have two tools to pursue scientific inquiry :

1- We have our *senses*, through which we experience the world and make *observations*.

2- We have the *ability to reason*, which enables us to make *logical inferences*.

Clearly, we need both tools ;

- All the individual observations in the world would not in themselves create a theory, and ;
- All the logic in the world is not going to create an observation.

Background :

Prior to the twentieth century, medical research was primarily based on *trial* and *empirical evidence* ;

- *Diseases* and the *risk factors* associated with it were not well understood.
- *Drugs* and *treatments* for diseases were generally untested.

As medicine has moved to become more *evidence based*, biostatistics has become more important and relevant to its practice. It has also become increasingly evident that the interpretation of much of the research in health sciences depends, to a large extent, on biostatistical principles and methods.

What is Biostatistics ?

Biostatistics is a branch of applied statistics that is concerned with the application of statistical methods to *medicine and other biological fields*. It deals with development and application of the most appropriate statistical methods for :

- *Collection* of data.
- *Organiztion* and *Summarization* of collected data.
- *Presentation* and *Analysis* of the summarized data.
- *Interpretation* and **Decision Making** on the basis of analyzed data.

Statistics is the science of :

Gaining **information** from numerical and categorical **data**

Statistical Methods :

They are objective methods by which *group trends* are abstracted from measurements or observations on many *separate individuals*. Statistical methods help us make *scientific* and *intelligent* decisions. Statistical methods can be used to find answers to the questions like :

- What kind and how much data need to be collected?
- How can we organize and summarize the data?
- How can we analyse the data and draw conclusions from it?
- How can we assess the strength of the conclusions and evaluate their uncertainty?

Statistical Analysis :

Statistical analysis is concerned specifically with ***making sense of data*** and permitting valid conclusions or inferences to be drawn from them. So that, we can obtain *valid* and *defensible* answers to the questions that prompted the research. Statistical analysis enables us *making wise decisions in the face of uncertainty*.

There are two distinct phases of the statistical analysis, the *descriptive* and the *inferential* (analytic) phases.

❑ The Descriptive Phase of Statistics :

After we have run a study, we usually get masses of *raw data*. Usually, we are unable to make any sense of the data in such rough and crude form. A data set in its crude original form is usually very large, consequently, such a data set is not very helpful in drawing conclusions or making decisions.

It is easier to draw conclusions from summary tables and graphs than from the original version of a data set. So, we reduce data size by constructing tables, drawing graphs, or calculating summary measures. The portion of statistics that helps us do this type of statistical analysis is called descriptive statistics, which make up a *small part* of the field of statistics. It provides procedures for organizing, summarizing, and presenting the data in ways that can *easily be communicated* to others.

- **The Inferential (Analytic) Phase of Statistics :**

In statistics, the collection of all elements of interest is called a *population*. The selection of a subset of elements from this population is called a *sample*. A major part of statistics deals with making decisions, inferences and predictions about populations based on results obtained from samples. The area of statistics that deals with such decision-making procedures is referred to as inferential statistics.

Because it is often impractical to survey the *entire population*, we rarely know population values. In inferential statistics, we try to estimate various population values on the basis of the corresponding sample values (i.e generalizing beyond the data).

The population values, such as the population mean and standard deviation, and population range, are referred to as parameters. For every statistic we calculate from sample data, there is a corresponding parameter. We use the known (*statistics derived from a sample*) to reveal the secrets of the unknown (*population parameters*).

Probability, which gives a measurement of the likelihood that a certain outcome will occur, acts as a link between descriptive and inferential statistics. As inferential statistics is based on the probability theory, this should alert us to the fact that inferential statistics never really *proves* anything.

Statistics cannot prove anything, it just put limits to uncertainty.

Estimating parameters from statistics is no more mysterious than judging the state of a person's health from a collection of vital signs. Both <u>reduce uncertainty</u> but both also have the <u>possibility of error</u>. The beauty of statistics is that, it offers procedures for putting known boundaries on the expected error.

- ***A Parameter*** is a value or characteristic associated with a population. Parameters are denoted using Greek letters e.g the population mean (μ) and population standard deviation (δ).
- ***A Statistic*** is a summary numerical value or characteristic associated with a sample. Statistics are denoted using Roman letters e.g the sample mean ($\bar{x}$) and sample standard deviation (s).

Sample statistics are estimates of the corresponding population parameters (e.g $\bar{x}$ is an estimate of μ)

Collection of Data

(Sources – Types - Techniques)

Sources of data :

1- Routinely kept records : *Hospital medical records* for example contain a large amount of data on patients.

2- Surveys : If the data needed to answer a question are not available from routinely kept records, the logical alternative source may be a *survey* or *a census*.

3- Experiments : Frequently the data needed to answer a question are available only as a result of an *experiment* or *clinical trials*.

4- External sources : The data needed to answer a question may already exist in the form of *published reports*, commercially available *data banks* or the *research literature*.

Types of data :

a- Primary data : gathered by the researcher and usually through a survey or research experiment or clinical trial.

b- Secondary data : the data that have been already collected and recorded by somebody else and readily available for others.

Advantages and disadvantages of secondary data :

Advantages

- Faster.
- Less expensive.
- Less activities and efforts (Field trip, Survey etc.).

Disadvantages

- May be not adequate.
- May not meet the specific needs of the researcher.
- Outdated information.
- Variation in definitions.
- Inaccurate or biased.

Data collection techniques :

Data-collection techniques allow us to *systematically* collect data about our elements of a study (people, objects, events) and about the settings in which they occur. We have the following data collection techniques :

(1) Using available records :

Usually there is a large amount of data that has already been collected by others, although it may not necessarily have been analyzed or published.

(2) Observing :

Observation is a technique that involves systematically selecting, watching and recording behavior of the target elements in a study.

(3) Interviewing (face-to-face) :

An interview is a data-collection technique that involves oral questioning of respondents, either individually or as a group. Answers to the questions posed during an interview can be recorded by writing them down or by tape-recording the responses, or by a combination of both. *Checklist* or *questionnaires* are the usual tools.

(4) Administering written questionnaires :

A written questionnaire (also referred to as self-administered questionnaire) is a data collection tool in which written questions are presented that are to be answered by the respondents in written form. A written questionnaire can be administered in different ways, such as by :

- Hand-delivering questionnaires to respondents and collecting them later.
- Sending questionnaires by mail with clear instructions on how to answer the questions.
- Gathering all or part of the respondents in one place at one time, giving oral or written instructions, and letting the respondents fill out the questionnaires ; or

(5) Focus group discussions :

A focus group discussion allows a group of 8 – 12 participants to freely discuss a certain subject or task with the guidance of a facilitator or reporter. The interviewer creates a supportive environment, asking focused questions to encourage discussion and the expression of differing opinions and points of view.

Exercise [1]

1. **The science of collecting, organizing, presenting, analyzing and interpreting data to assist in making more effective decisions is called :**
   (a) Statistic
   (b) Parameter
   (c) Population
   (d) Statistics
2. **Methods of organizing, summarizing, and presenting data in an informative way are called :**
   (a) Descriptive statistics
   (b) Inferential statistics
   (c) Mathematical statistics
   (d) Analytic statistics
3. **The methods used to determine something about a population on the basis of a sample is called :**
   (a) Inferential statistics
   (b) Descriptive statistics
   (c) Applied statistics
   (d) Theoretical statistics
4. **A specific numerical value of characteristic of a population is called :**
   (a) Statistic
   (b) Parameter
   (c) Variable
   (d) Sample

5. **A set of all units of interest in a study is called :**
   (a) Sample
   (b) Population
   (c) Parameter
   (d) Statistic
6. **A part of the population selected for study is called a :**
   (a) Variable
   (b) Data
   (c) Sample
   (d) Parameter
7. **Listings of the data in the form in which these are collected are known as :**
   (a) Secondary data
   (b) Raw data
   (c) Quantitative data
   (d) Qualitative data
8. **Data that are collected by any body for some specific purpose and use are called :**
   (a) Qualitative data
   (b) Primary data
   (c) Secondary data
   (d) Continuous data
9. **The data obtained by conducting a survey is called :**
   (a) Primary data
   (b) Secondary data
   (c) Continuous data
   (d) Qualitative data

10. Routine registration is the source of :

(a) Primary data
(b) Secondary data
(c) Qualitative data
(d) Continuous data

11. Questionnaire method is used in collecting :

(a) Primary data
(b) Secondary data
(c) Published data
(d) True data

12. In inferential statistics, we study :

(a) The methods to make decisions about population based on sample results
(b) How to make decisions about mean, median, or mode
(c) How a sample is obtained from a population
(d) None of the above

13. In descriptive statistics, we study

(a) The description of decision making process.
(b) The methods for organizing, displaying, and describing data.
(c) How to describe the probability distribution.
(d) None of the above.

14. Data in the Population Census Report is :

(a) Grouped data
(b) True data
(c) Secondary data
(d) Primary data

15. Statistic is a numerical quantity, which is calculated from :

(a) Population
(b) Sample
(c) Data
(d) Observations

16. **Which branch of statistics deals with the techniques that are used to organize, summarize, and present the data :**
    (a) Advanced statistics
    (b) Probability statistics
    (c) Inferential statistics
    (d) Descriptive statistics

17. **A parameter is a measure which is computed from :**
    (a) Population data
    (b) Sample data
    (c) Test statistics
    (d) None of the above

18. **You asked five of your classmates about their height. On the basis of this information, you stated that the average height of all students in your university or college is 67 inches. This is an example of :**
    (a) Descriptive statistics
    (b) Inferential statistics
    (c) Parameter
    (d) Population

Chapter (2)

Variables and Data

By the end of this chapter, the student should be able to :

- Know different ways of classifications of variables.
- Differentiate between variables and observations.
- Construct a data matrix.

Variable :

A variable is any characteristic under study or investigation, related to different elements (subjects, objects or events), can be *observed* or *measured* , and is liable to *variation* or *change* (assumes different values for different elements or within elements at different occasions). For example, age, sex, weight, marital status and blood group are variables.

Data :

Are the raw materials and the basic building blocks of statistics. A single observation or measurement is called a datum or a data point. Data recorded in the sequence in which they are collected and before they are processed or ranked are called *raw data*.

Measurement or Observation :

The data value of a variable for an element (sampling unit) is called measurement or an observation.

Data Set (Database) :

A data set is the collection of observations or measurements on one or more variables for a set of sampling units (elements) from an investigation or survey.

Data Matrix :

Sample data can be presented in a table, which is often called data matrix. In a data matrix, rows usually correspond to observations and columns to variables.

Explain the meaning of : an element, a variable, an observation, data set, data matrix ?

An example of data matrix, 32 years (for the variable age), or female (for the variable sex).

The observations (sampling units)

The variables

	Age	**Sex**	**Blood group**
Fatma	28	Female	O
Ali	32	Male	B
Mohamed	36	Male	A
Samira	25	Female	AB

The Data

Classification of Variables :

The first step in any statistical analysis is to identify the type of data (variables) you have. The type of data will determine what kinds of statistics you will be able to use.

Two ways of classification :

- Quantitative versus Qualitative.
- Continuous versus Discrete.

1- Quantitative versus Qualitative

❑ *Quantitative (Numerical) Variables :*

They are variables that yield *measurements* for which the value has numerical meaning (countable or noncountable) i.e numbers represent counts or measurements. For example, we can count the number of cars owned by a family, but we cannot count the height of a family member.

If we want to know someone's weight, we can use a weighing machine, we don't have to look at him and make a guess (which would be approximate), or ask how heavy they are (very unreliable). Similarly, if we want to know the diastolic blood pressure we can use a sphygmomanometer.

Examples of quantitative data include height measured in inches or centimeters, blood pressure (mmHg), age (years), weight (Kgm), heart rate (beats/min), …etc.

Suppose we collect information on the ages (in years) of 50 students selected from a university. The data values, in the order they are collected, are recorded in in the following table. For instance, the first student's age is 21, the second student's age is 19 (second number in the first row), and so forth. The data in such table are *quantitative raw data*.

21	19	24	25	29	34	26	27	37	33
18	20	19	22	19	19	25	22	25	23
25	19	31	19	23	18	23	19	23	26
22	28	21	20	22	22	21	20	19	21
25	23	18	37	27	23	21	25	21	24

- *Qualitative (Categorical) Variables :*

Variables that cannot be measured numerically but can be assigned into different categories are called *qualitative* or *categorical* variables. They are variables that yield *observations* on which individuals can be categorized according to some characteristic or quality i.e the value indicates different groupings that are distinguished by some non-numeric characteristics.

Examples include gender (male – female), educational level (illiterate – read and write – high education), marital status (single – married – divorced – widowed), religion, occupation, nationality...etc.

Suppose we ask the same 50 students about their marital status. The responses of the students are recorded in a table. In this table, S, M, D, and W are the abbreviations for single, married, divorced, and widow, respectively. This is an example of *qualitative (or categorical) raw data*.

S	S	M	M	D	W	M	M	D	M
S	S	S	M	S	S	M	S	M	S
M	S	D	S	M	S	S	S	M	D
S	M	M	S	S	M	S	S	S	S
M	S	S	W	D	M	S	W	S	M

2- Continuous versus Discrete

❑ *Continuous Variables :*

These are variables that can assume any numerical value over a certain interval or intervals. A continuous variable is one with potentially an infinite (unlimited) number of possible values in any interval e.g. height (1.83, 1.74…Cm), weight (48.72, 65.83…Kgm)…etc. Notice that all of these variables can be properly *measured* and have *units of measurement* attached to them. This is a characteristic of all continuous variables.

Contrasted with discrete variables, there are *no gaps* in the real values that a continuous variable may assume. A value of a continuous variable can occur at any point along the scale of values. Weight, height, temperature, and time are commonly used continuous variables.

Note that, if we have any two values of a continuous variable, we can be assured that there are other real values between these two. Values of continuous variables are often expressed as whole numbers, possibly conveying the false impression that they are discrete. We may say, "I am 70 inches tall and weigh 185 pounds as of 5:30 p.m. At this moment, the outside temperature is 28 degrees. All of these variables are continuous, even though their values are stated in terms of integers. This use of integers is strictly for convenience.

In contrast to *ordinal* values, the difference between any pair of adjacent values is *exactly the same*. The difference between birth weights of 4000 g and 4001 g is the same as the difference between 4001 g and 4002 g, and so on. This property of *real numbers* is known as the interval property. Moreover, a blood cholesterol level, for example, of 8.4 μg/ml is exactly twice a blood cholesterol of 4.2 μg/ml. This property is known as the ratio property.

❑ *Discrete Variables :*

These are variables whose values are *countable*. In other words, a discrete variable can assume only certain values with no intermediate values. They are variables for which data have distinct categories and a *limited* (finite) number of possible values in any interval.

Counting is the mathematical operation most often used with discrete variables where the data produced are real numbers. The values are usually *whole numbers* (integers) e.g. number of children in a family (two or three children but not 2.5) and number of beds in a hospital. They have the same *interval* and *ratio* properties as continuous data.

Discrete variables *can take values only at specific points along the scale*, such variables *leave gaps* where no real values of the variable are found. Several examples of discrete variables are heart rate (the number of pulses per unit of time), white blood cells in a given sample of blood, and number of chromosomes in a given cell.

All qualitative data are discrete.
Quantitative data may be continuous or discrete.

Chapter (3)

Population and Samples

By the end of this chapter, the student should be able to :

- Define sample and population.
- Recognize the importance and reasons of sampling.
- Understand Technique of sampling.
- Know types of random samples.

A population is the term statisticians use to describe a large set of items (subjects, objects, events) that have *common observable characteristics*. It is the group *to which you want to generalize* your findings.

A sample is a group or a subset of the population, that you observe or collect data from, selected in such a way that it is *representative* of the larger population.

NB : A sample that represents the characteristics of the population *as closely* as possible is called a representative sample. <u>You can not generalize your research findings based upon non-representative (biased) samples.</u>

Parameter and Statistic :

- A number that describes a population is called a <u>parameter.</u>
- A number that describes a sample is called a <u>statistic.</u>

If we take a sample and calculate a statistic, we often use that statistic to infer something about the population from which the sample was drawn.

What is Sampling?

- Measuring a small portion of something and then making a general statement about the whole thing.
- Process of selecting a number of units for a study in such a way that the units represent the larger group from which they are selected.

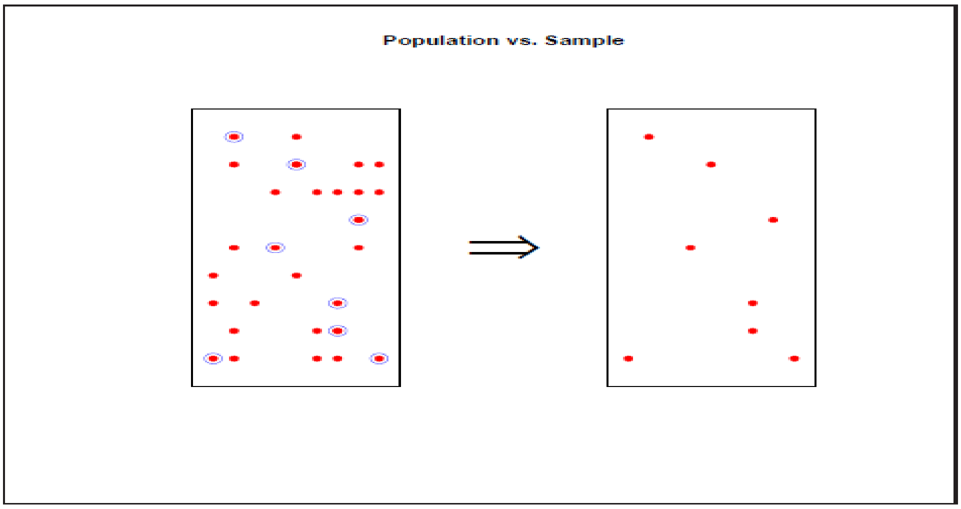

Figure 1: Population and Sample

Reasons for sampling :

1- A study of an entire population is *impossible* in most situations.

2- Samples can be studied *more quickly* than populations. Speed can be an important factor in certain situations.

3- A study of a sample is *less expensive* (cost-effective) than a study of an entire population.

4- Sample results are often *more accurate* than results based on a population.

However, certain occasions necessitate the study of the whole population e.g in tuberculosis survey to treat the diseased and during surveillance to control an epidemic of a communicable disease.

Methods of Sampling (Sampling procedures) :

1- Methods which do not follow probability theory i.e non probability samples :

- Purposive samples.
- Convenience samples.
- Quota samples.
- Snow ball samples.

Characters of non-probability sampling :

- In non-probability sampling, the chance of a member being included in the sample is not known.
- Results of non-probability samples can not be generalized from the sample to the population.
- This procedure also does not allow the researcher to calculate sampling statistics that provide information about the precision of the results.
- Non-probability samples tend to be cheaper, less complicated and less time consuming than probability samples.

2- Methods which follow probability theory i.e probability (random) samples :

- Simple random samples.
- Systematic random samples.
- Stratified random samples.
- Cluster random samples.
- Multisatge random samples.

Characters of probability sampling :

- The researcher knows the exact possibility of selecting each member of the population.
- Probability samples are the only type of samples where the results can be generalized from the sample to the population.
- In addition, probability samples allow the researcher to calculate the precision of the estimates obtained from the sample and to specify the sampling error.
- A probability sample tends to be more difficult and costly to conduct.

Chapter (4)

Vital Statistics

By the end of this chapter, the student should be able to :

- Know different types of morbidity, mortality and fertility indices.
- Calculate and interpret different vital indices.
- Be oriented with raw and standardized rates.

Vital statistics is concerned with vital events of human life (births, deaths and morbidity). Registered data are used for calculation and presentation of vital rates which are indices (indicators) of :

- Health status of the population, especially vulnerable groups.
- Community development including socioeconomic features, which influences health (e.g., education, culture, nutritional status, and environment).
- Effectiveness (efficiency and utilization) of health services.

I- Birth (fertility) statistics :

They are presented as "Birth Rates" and "Fertility Rates".

1- Birth Rate :

Definition : Birth rate is the number of live births per 1000 population of a certain locality (or country) and year.

$$\text{Birth rate} = \frac{\text{No. of live births in a certain locality and year}}{\text{Midyear population of the same locality and year}} \times 1000$$

Birth rate is usually high in developing countries, due to :

- High fertility motives and behaviors, giving repeated un-spaced pregnancies throughout childbearing period, and no practice of birth control.
- Marriage of girls of traditional communities at young age, where fertility is higher through a long childbearing period.
- *Birth rate in Egypt* : Used to be high (40 - 45) then declined to become 37.5 in 1988, reached 29/1000 in 1996 and 26 / 1000 in 1999, and further lowering is expected (the rate is 15 or less in developed countries). What is the current birth rate in egypt?

2- Fertility Rates :

A woman is considered fertile when she has ever born a baby. A number of fertility rates (indices) are calculated each having particular significance.

a) General fertility rate (GFR) :

Definition : it is the number of live births per 1000 females of childbearing period in a certain locality (or country) and year. Childbearing period is 15 – 44, or 15 – 49 years old.

$$GRF = \frac{\text{No. of live births in certain locality and year}}{\text{No. of females in childbearing period of same locality and year}} \times 1000$$

It is about 3.6/1000 in Egypt in 1996. What is current fertility rate in Egypt?

b) Age-specific Fertility Rate : (Age-specific Birth Rate)

Definition : it is "total fertility of a particular age group" (of the seven 5-year groups) to get the average number of live births born to 1000 females in each of the 5 years of the age groups in a given locality and year.

Childbearing period (15 – 49) includes seven 5-year age groups. The total fertility of the such seven age groups is the number of live births born to1000 females of this group in a given locality and year. Total fertility of all females in childbearing period = sum of total fertility of the seven 5-year age groups.

Advantage : Age-specific fertility rate is a better index of fertility than the GFR as it considers differences in age distribution of females in populations of different countries.

c) Fecundity Rate :

Definition : It is the number of live births per 1000 married women of childbearing age in a certain locality and year. It is a valuable index of fertility being calculated for married not all females in childbearing period.

II- Morbidity Measures :

Calculation of disease frequency is based on the calculation of prevalence and incidence. Before calculation we should know the meanings of population at risk ratio, proportion and rate.

Population at risk :

An important factor in calculating disease frequency is the correct estimate of the numbers of people under study (population at risk). Ideally these numbers should only include people who are potentially susceptible to the diseases being studied; e.g., men should not be included when calculating the frequency of cervical cancer.

Ratio :

The simplest relation between numbers is a ratio and is expressed as X:Y (part : part) e.g. there is 20 male students and 10 female students in a classrooms, the ratio of male to female in this classroom is 20:10 or 2:1

Proportion : (part / total)

The relation between 2 numbers where one of them (the numerator) is always included in the other (the denominator). It is expressed as x / (x + y) x k (k is a constant value usually = 100) and in this case the proportion is called percent. In the above example the proportion of males is 20 / 30 x 100 = 66.7%

Rate :

It is a measure of the change of a quantity per unit time. For example if there is 1000 infants are vaccinated with BCG vaccine during 2011 and 200 failed to form scar, the proportion of failure of vaccination will be 200/1000 and when we express this proportion per time it becomes a rate ; the failure rate will be 200 / 1000/ year.

Measuring disease in a population :

1- Prevalence rate :

Prevalence is the frequency of existing cases in a defined population at a given point in time. Prevalence rate (P) of a disease is calculated as follows :

$$P = \frac{\text{Number of people with the disease or condition at a specified time} \times 10^n}{\text{Number of people in the population at risk at the specified time}}$$

Factors influencing prevalence of a disease :

Increased by	Decreased by
Longer duration of the disease	Shorter duration of the disease
Prolongation of life of patients without cure	High case-fatality rate from disease
Increase in new cases (increase in incidence)	Decrease in new cases (decrease in incidence)
In-migration of cases	In-migration of healthy people
Out-migration of healthy people	Out-migration of cases
Improved diagnostic facilities (better reporting)	Improved cure rate of cases

2- Incidence rate :

The incidence of disease represents the rate of occurrence of new cases arising in a given period in a specified population. Incidence rate (I) is calculated as follows :

$$I = \frac{\text{Number of new events in a specified period} \ (\times 10^n)}{\text{Number of persons exposed to risk during this period}}$$

Differences between prevalence and incidence.

	Prevalence	Incidence
Numerator	Number of **existing** cases of disease at a given point of time	Number of **new** cases of disease
Denominator	Population at risk	Population at risk
Focus	- Presence or absence of a disease - Time period is arbitrary ; rather a “snapshot” in time	- Whether the event is a new case - Time of onset of the disease
Uses	- Estimates the probability of the population being ill at the period of time being studied. - Useful in the study of the burden of chronic diseases and implication for health services	- Expresses the risk of becoming ill - The main measure of acute diseases or conditions, but also used for chronic diseases - More useful for studies of causation

III- Mortality Measures :

Causes of death are recorded on a standard death certificate, which carries information on age, sex, and place of residence. The International Statistical Classification of Diseases and Related Health Problems (ICD) provide guidelines on classifying deaths. The procedures are revised periodically to account for new diseases and changes in case-definitions, and are used for coding causes of death. The International Classification of Diseases is now in its 10th revision.

Limitations of death certificates :

Data derived from death statistics are prone to various sources of error and provide invaluable information on trends in a population's health status. The usefulness of the data from death certificate depends on :

- The completeness of records.
- The accuracy in assigning the underlying causes of death, Mortality (death) statistics is important for assessing the burden of disease, as well as for studying changes in diseases over time. So, the provision of accurate cause-of-death information is a priority for health services.

i. Mortality of Diseases :

Deaths of a particular disease can be presented in the following mortality rates :

1) Case-fatality Rate :

It is the number of deaths of a particular disease per 100 cases in a certain locality (or country) and year.

$$\text{Case fatality rate} = \frac{\text{No. of deaths of a particular disease in certain year and locality}}{\text{No. of reported cases of this particular disease in same year and locality}} \times 100$$

In outbreaks of diseases in a confined community, case-fatality rate is the number of deaths per 100 diagnosed cases during the period of outbreak. Case-fatality rate of a particular disease varies with severity of disease and whether complicated, early diagnosed, treatment is available, and health status of cases. For example, in case of meningococcal meningitis, case- fatality rate was high (more than 50%) in the past, and then declined with early diagnosis and availability of chemotherapy to below 5%. Invariably fatal infectious diseases (case-fatality is 100%) :

- Rabies, pneumonic plague and pneumonic anthrax, which are acute rapidly fatal diseases.
- ADIS : chronic infection, which is fatal after some varied period of time (months or years).

2) Mortality Rate of a particular disease : "cause-specific rate"

It is used for chronic disease (e-g pulmonary tuberculosis) in developing countries, where accurate number of cases occurring within a year is not available, due to deficient case finding and reporting.

Definition : Mortality rate of a particular disease is the number of deaths of disease per 100,000 population in a certain locality (or country) and year. Mortality rate of pulmonary tuberculosis in Egypt, for example, was 47/100,000 in 1947 and declined to below 2/100,000 at present (why?).

3) Proportionate Death Rate :

It is the percent proportion of the number of deaths of a particular disease to total deaths in a certain locality (or group of population, or country) and year. It shows the relative mortality role of each disease for a particular group (e.g., infants and preschool children), or population. Therefore, causes of death can be arranged by their magnitude and leading causes (major causes) of death can be found.

ii. Death Statistics :

1) General or Crude Death Rate :

- General death rate : As it represents all deaths, for all ages and causes, and not for specific group or cause.
- Crude death rate : Being not suitable for comparison with other countries and needs adjustment first.

Definition : The general death rate is the total number of deaths per 1000 population of a certain locality (or country) and year. It is about 8/1000 in Egypt in 1996 and 7/1000 in 1999. What is current crude death rate in Egypt?

$$\text{Crude death rate} = \frac{\text{Total number of deaths of a certain locality and year}}{\text{Midyear population of same locality and year}} \times 1000$$

Value of death rate :

1. Death rate is influenced by certain specific and general factors and can thus be used for comparison of these factors :
   - For different years in a particular country.
   - In-between different countries provided they have more or less similar age and sex distribution of the population.

2. Death rate is a direct index of specific factors related to morbidity.
   - Health status of the population, and health problems of the community.
   - Effectiveness (efficiency and utilization) of health services.

3. Death rate is indirect index of genera! factors influencing exposure to morbidity and mortality :
   - Socioeconomic and community development. Unsatisfactory development is characterized by unsanitary environment, poor living conditions, malnutrition and others.

- Education, culture, traditions and health awareness and behavior of the population. Illiteracy, and faulty traditional beliefs, habits and lifestyle predispose to morbidity.

How to explain decline of death rate of Egypt :

General and specific factors contribute to prevention and control of morbidity, and thus lower mortality :

1- Progressive community development, with better socioeconomic and environmental circumstances.
2- Upgraded primary health care, which provide preventive and curative health services for urban and rural population.
3- Prevention and control of communicable diseases that have significantly lowered deaths caused by such diseases.

2) Specific Death Rates :

The general death rate represents total deaths per 1000 population, while specific death rates represent deaths of a particular group of the population per 1000 individuals of the group. The group may be represented by age, sex, social, occupation, or some other variable.

Age-Specific death Rate

Deaths notified to the health office are registered in the "death record" under the following groups, in years :

- Below one year ; Infant Mortality Rate (IMR).
- Children 1 – 5 year's mortality.
- 5 – 14 years old.
- 15 – 44 years old.
- 45 – 59 years old
- 60 years old and over.

Chapter (5)

Hospital statistics

By the end of this chapter, the student should be able to :

- Define and calculate inpatient census.
- Calculate measures of efficiency of bed utilization.

Hospital statistics use three sources of data :

1- The number of patients disposed (discharged, died or transferred to another hospital) during the period.
2- The number of beds available in the hospital.
3- The number of patients occupying a hospital bed each night.

Inpatient census :

It is the number of inpatients present at any time. It may be taken at any daily fixed and convenient time (census-taking time). However, it is usually taken at midnight.

Daily inpatient census :

It is calculated as follows :

The patients remaining in the hospital at the census-taking time for a specific day + (the admissions – the discharges, including deaths for the following day) ⟶ the patients remaining at the next census-taking time.

Inpatient service day (inpatient day) :

It refers to the services received by one inpatient in one 24-hour period. The "24-hour period" is the time between the census-taking hours of two successive days. For example : when the census-taking time is midnight , the 24-hour period will be 12:01 A.M. through 12:00 P.M. (the same as the calendar day).

N:B

- One inpatient day must be counted for each inpatient admitted and discharged during the same day (between two successive census-taking hours i.e inpatient service day should never be reported as a fraction of a day.
- Inpatient census is used to calculate the inpatient service days, as every inpatient receives one inpatient service day each day he is hospitalized. Many inpatient service days are usually provided by a hospital on any one day.

Q- Why the number inpatient service days for a specific day is usually more than the corresponding daily inpatient census for that day?

Example :

At a certain hospital, the census-taking time is midnight, the number of patients in that hospital at midnight June 19 was 475, number of patients admitted on June 20 was 42, number of patients discharged (including deaths) on June 20 was 16. The number of patients both admitted and discharged (including deaths) on June 20 was 6.

- Calculate the daily inpatient census for June 20?
- Calculate the inpatient service days for June 20?

Answer :

Daily inpatient census for June 20 = 475 + (42 – 16) = 475 + 26 = 501

Inpatient service days for June 20 = 501 + 6 = 507

Average daily inpatient service days :

The formula to obtain the average daily inpatient service days for a hospital during a certain period is

$$\frac{\text{Total inpatient service days for the period}}{\text{Number of days of the same period}}$$

Example :

A hospital provided 960 service days to patients during November. Calculate the average daily inpatient service days for during this month.

Answer :

According to the formula, it is 960 / 30 = 32

The average daily inpatient service days during November was 32

How to measure the extent and efficiency of hospital beds utilization ?

There are many summary statistics which are commonly used to measure the degree of bed utilization in a hospital including :

(1) The number of bed-days used :

It is the sum of the occupied bed counts during a certain period.

(2) The bed-days available :

It is the number of beds available in the hospital. We can calculate the number of bed-days available during a certain period by :

The number of beds available X number of days covered by the period.

(3) The bed occupancy rate :

It is the percentage of available bed-days that were actually used during a certain period. That is

$$\text{Bed occupancy rate} = \frac{\text{Number of bed-days used}}{\text{Number of available bed-days}} \times 100$$

-

- **Example :**

If there are 50 beds in a hospital, over a 30 day period → 1500 bed-days available. If the number of bed-days used over that period is 1200, then :

The bed occupancy rate is $\frac{1200}{1500} \times 100 = 80\%$

N:B

Bed occupancy rate over 100% can occur indicates that an extra number of beds have to be provided.

(4) The daily bed occupancy rate :

It is the mean number of patients occupying a bed per day. It is calculated by dividing the average daily inpatient service days by the number of beds available.

(5) The average length of stay :

It is the mean time per patient that a hospital bed is occupied during a period of time. It is calculated by dividing the number of bed-days used during a certain period by the number of disposals during the same period.

Importance :

- It is a measure of the efficiency of hospital care (how quickly patients are dealt with)
- When comparing length of stay between hospitals, it is very important to consider the medical specialty, type of patients and facilities available. (different illnesses require different periods of hospitalization).

(6) The average turnover :

It is the mean number of patients that have occupied any one bed during a period. It is calculated by dividing the number of disposals (discharges) by the average number of available beds.

(7) The average turnover interval :

This is the mean length of time that a hospital bed is left empty between two successive patients.

$$\text{It is} = \frac{\text{Number of bed-days available} - \text{number of bed-days used}}{\text{Number of disposals during a period}}$$

This rate is important to indicate the efficiency of hospital scheduling procedures for non-emergency admissions. Where it is important to avoid delay in replacing departing patients, assuming that the demand for places in hospital is always greater than the supply.

Exercise :

1- Define :

- Inpatient census.
- Daily inpatient census.

2- During 1995 a hospital ward with 20 beds had complete bed availability each day and had no occasion to borrow beds from other wards. The midnight occupied bed counts over the year produced the following distribution :

Number of occupied beds	12	13	14	15	16	17	18	19	20
Number of days	2	14	31	64	116	78	24	18	18

Calculate the following :

a- Daily bed occupancy rate.

b- The average length of stay, given that 850 patients were discharged, transferred or died in 1995.

c- The average turnover.

d- The average turnover interval.

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Table 1: *Percentiles of the standard normal distribution.*

Standard score (z)	Percentile (c)	Standard score (z)	Percentile (c)	Standard score (z)	Percentile (c)
-3.4	0.03	-1.1	13.57	1.2	88.49
-3.3	0.05	-1.0	15.87	1.3	90.32
-3.2	0.07	-0.9	18.41	1.4	91.92
-3.1	0.10	-0.8	21.19	1.5	93.32
-3.0	0.13	-0.7	24.20	1.6	94.52
-2.9	0.19	-0.6	27.42	1.7	95.54
-2.8	0.26	-0.5	30.85	1.8	96.41
-2.7	0.35	-0.4	34.46	1.9	97.13
-2.6	0.47	-0.3	38.21	2.0	97.73
-2.5	0.62	-0.2	42.07	2.1	98.21
-2.4	0.82	-0.1	46.02	2.2	98.61
-2.3	1.07	0.0	50.00	2.3	98.93
-2.2	1.39	0.1	53.98	2.4	99.18
-2.1	1.79	0.2	57.93	2.5	99.38
-2.0	2.27	0.3	61.79	2.6	99.53
-1.9	2.87	0.4	65.54	2.7	99.65
-1.8	3.59	0.5	69.15	2.8	99.74
-1.7	4.46	0.6	72.58	2.9	99.81
-1.6	5.48	0.7	75.80	3.0	99.87
-1.5	6.68	0.8	78.81	3.1	99.90
-1.4	8.08	0.9	81.59	3.2	99.93
-1.3	9.68	1.0	84.13	3.3	99.95
-1.2	11.51	1.1	86.43	3.4	99.97

Percent of area under the normal curve between the mean and z.

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	00.00	00.40	00.80	01.20	01.60	01.99	02.39	02.79	03.19	03.59
0.1	03.98	04.38	04.78	05.17	05.57	05.96	06.36	06.75	07.14	07.53
0.2	07.93	08.32	08.71	09.10	09.48	09.87	10.26	10.64	11.03	11.41
0.3	11.79	12.17	12.55	12.93	13.31	13.68	14.06	14.43	14.80	15.17
0.4	15.54	15.91	16.28	16.64	17.00	17.36	17.72	18.08	18.44	18.79
0.5	19.15	19.50	19.85	20.19	20.54	20.88	21.23	21.57	21.90	22.24
0.6	22.57	22.91	23.24	23.57	23.89	24.22	24.54	24.86	25.17	25.49
0.7	25.80	26.11	26.42	26.73	27.04	27.34	27.64	27.94	28.23	28.52
0.8	28.81	29.10	29.39	29.67	29.95	30.23	30.51	30.78	31.06	31.33
0.9	31.59	31.86	32.12	32.38	32.64	32.90	33.15	33.40	33.65	33.89
1.0	34.13	34.38	34.61	34.85	35.08	35.31	35.54	35.77	35.99	36.21
1.1	36.43	36.65	36.86	37.08	37.29	37.49	37.70	37.90	38.10	38.30
1.2	38.49	38.69	38.88	39.07	39.25	39.44	39.62	39.80	39.97	40.15
1.3	40.32	40.49	40.66	40.82	40.99	41.15	41.31	41.47	41.62	41.77
1.4	41.92	42.07	42.22	42.36	42.51	42.65	42.79	42.92	43.06	43.19
1.5	43.32	43.45	43.57	43.70	43.83	43.94	44.06	44.18	44.29	44.41
1.6	44.52	44.63	44.74	44.84	44.95	45.05	45.15	45.25	45.35	45.45
1.7	45.54	45.64	45.73	45.82	45.91	45.99	46.08	46.16	46.25	46.33
1.8	46.41	46.49	46.56	46.64	46.71	46.78	46.86	46.93	46.99	47.06
1.9	47.13	47.19	47.26	47.32	47.38	47.44	47.50	47.56	47.61	47.67
2.0	47.72	47.78	47.83	47.88	47.93	47.98	48.03	48.08	48.12	48.17
2.1	48.21	48.26	48.30	48.34	48.38	48.42	48.46	48.50	48.54	48.57
2.2	48.61	48.64	48.68	48.71	48.75	48.78	48.81	48.84	48.87	48.90
2.3	48.93	48.96	48.98	49.01	49.04	49.06	49.09	49.11	49.13	49.16
2.4	49.18	49.20	49.22	49.25	49.27	49.29	49.31	49.32	49.34	49.36
2.5	49.38	49.40	49.41	49.43	49.45	49.46	49.48	49.49	49.51	49.52
2.6	49.53	49.55	49.56	49.57	49.59	49.60	49.61	49.62	49.63	49.64
2.7	49.65	49.66	49.67	49.68	49.69	49.70	49.71	49.72	49.73	49.74
2.8	49.74	49.75	49.76	49.77	49.77	49.78	49.79	49.79	49.80	49.81
2.9	49.81	49.82	49.82	49.83	49.84	49.84	49.85	49.85	49.86	49.86
3.0	49.87									
4.0	49.997									

Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	[illegible]	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	$\boxed{0.8997}$	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9031	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9924	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9958	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986

Book Coordinator ; Mostafa Fathallah

General Directorate of Technical Education for Health