UNIT 3 NUTRITIONAL EPIDEMIOLOGY

Contents

3.1 Introduction
3.2 Under-nutrition
3.3 Over-nutrition
3.4 Health Statistics
3.5 Summary
3.6 Glossary

Suggested Reading/References
Sample Questions

Learning Objectives

Once you have read this unit, you will:

➤ understand the concepts of nutritional epidemiology, malnutrition and public health;
➤ get a detailed account of the diseases of under nutrition;
➤ obtain an overview of diseases and complications of overnutrition; and
➤ understand the meaning and significance of health statistics.

3.1 INTRODUCTION

The great Greek philosopher Hippocrates (460–377 BC), emphasized the role of nutrition on human health and commented that “If we could give every individual the right amount of nourishment and exercise, not too little and not too much, we would have found the safest way to health” (Hippocrates, 1955). This observation has stood the test of time and even now the specialists highlight the role of balanced diet and exercise in maintaining proper health.

The mothers of all times throughout the world, traditionally have been the first and the foremost nutritional epidemiologists. The child gets the first nutrition from the mother in the form of her milk. Thereafter at every stage, it is the mother who decides and monitors the amount, the type, the quality, the time and frequency of food to be taken by the child.

Nutritional epidemiology is one of the emerging disciplines of epidemiology. The two cornerstones of this field are the diet and physical activity and both of them are very difficult to study and measure. The methods available for the measurements of diet and physical activity leave a lot of scope for measurement error. However, with the passage of time and with concerted efforts, the methods for the measurement of these would be fine tuned so as to reduce the measurement errors.

In order to understand this subject properly, it is important to know the meaning of nutritional epidemiology, public health nutrition and malnutrition.

*Nutritional epidemiology* is the science that deals with the role of nutrition in the causes and prevention of ill health.
Public health nutrition is a scientific field which stresses the need to improve the status of health primarily with the help of nutrition and by preventing diet related sicknesses among the individuals in the population.

Malnutrition is an acronym of two Latin words; malus means bad and nutrire means to nourish. So malnutrition is a sort of bad nourishment. According to the Mosby’s Medical Dictionary (2009), “Malnutrition is any disorder of nutrition. It may result from an unbalanced, insufficient, or excessive diet or from impaired absorption, assimilation, or use of foods.”

### 3.2 UNDER-NUTRITION

The disorders of nutrition may include two extremes on opposite sides, namely, undernutrition and overnutrition. In case of undernutrition the food consumed is either less than that is required or it has a difficulty in getting digested or assimilated in the body. In both the conditions, the body cannot perform various tasks to the optimal level. In other words the physical efficiency of the body gets affected in case of malnutrition.

Undernutrition results from insufficient intake of essential nutrients. Generally poverty is the root cause of all types of undernutrition. There are areas of the world which are afflicted with natural calamities like drought and floods, crop failure, famine. Man made reasons of inequalities in the social structure and wars also aggravate the situations of undernutrition. Most vulnerable groups which suffer from undernutrition include infants and children, teenagers, pregnant and lactating mothers as well as girl children in many cultures.

Some of the diseases of undernutrition have been described below:

There are mainly two types of diseases caused by lack of protein-calorie intake. These are known as kwashiorkor and marasmus.

**Kwashiorkor**

Kwashiorkor is a type of undernutrition which occurs because of insufficient quantity of protein in the food and is also known as protein-calorie malnutrition. The calorie intake may be adequate in this type of undernutrition. There are three main reasons in the world responsible for the incidence of kwashiorkor, viz., insufficient food availability, famine and illiteracy. The symptoms of kwashiorkor in children include a large and protruding belly, loss of muscles, changes in hair and skin colour, failure to gain body weight, swelling and oedema of the body parts, slow and lethargic body and a decreased immunity. Typically, kwashiorkor in African language means a ‘displaced child’ because most of the patients of this disease were children who were deprived of their mother’s milk because of the arrival of a new born sibling in the family. Digestion and absorption of these patients becomes impaired and the secretion of digestive enzymes is also affected. Liver in this disease also becomes enlarged because of the fatty deposits. Children experience frequent episodes of diarrhea.

Kwashiorkor can be prevented if the child takes enough calories out of which roughly 78 per cent should be from the carbohydrates, 12 per cent from proteins and 10 per cent from fats. Kwashiorkor children are undernourished, therefore they need about 200 calories and 4-5 g of protein per kg of body weight. The recommended diet includes cereals and legumes and milk powder. But many children become lactose intolerant and hence milk can be substituted with other protein rich sources.

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1. Oedema is an abnormal accumulation of fluid beneath the skin or in one or more cavities of the body that produces swelling.
Marasmus

Marasmus is a condition of undernutrition when the diet is inadequate in calories as well as in protein. It is a type of protein calorie malnutrition in which extreme wasting of muscles takes place. The skin becomes wrinkled and loose and the child suffers from dehydration. Insufficient quantities of milk in very young children also results in this disease. Intestinal absorption is not as much impaired as is the case in kwashiorkor and the children respond better to the environmental stimuli. Mortality is also low in this disease. Marasmus is most common in children in developing regions, such as Africa, Latin America, and South Asia. Poverty, inadequate food supplies and contaminated water, are the major factors in most of the countries. Contaminated water is the root cause of most infections which results in diarrhea, thus aggravating the condition.

Besides kwashiorkor and marasmus there are other diseases and disorders that arise from poor nutritional intake. These are described below.

Skeletal disorders

Retarded skeletal development is often the result of the poor nutrition. Bone starts its development from a primary centre of ossification, enlarges and grows in size and ultimately with the fusion of epiphysis the adult characteristic is achieved. There are different stages of development of a bone which are common in every child, only the ages of reaching these stages may be different in different children. There are children who are early in the development of the skeleton as also who are late in the development of the bones. Some of these differences may be due to the genetic reasons whereas most of the delay may be caused by the poor nutrition. The deficiency of vitamin D, phosphorous, proteins and calcium in the diet of the children may cause a delay in the skeletal development.

In the human embryo, condensing of the mesenchyme takes place which lays the foundation stone for the future bone. With the passage of time this tissue is replaced by cartilage. The middle or central part of the future bone is transformed first into cartilage. The central cells and the marginal cells get separated thereafter, the latter develop into a membrane called perichondrium. The inner area contains cells which can develop into future chondrocytes and this now resembles a typical long bone of the child. In small children, most of the bones are yet mostly in the form of cartilage and have not developed into bones. Therefore very young children should not be forced to sit, stand or walk till their bones are mature enough to do so. The maturity of the bone requires the formation and mineralization of the bone matrix. For this process, vitamin A, vitamin C, vitamin D, calcium, phosphorous and proteins are required in sufficient quantities. Tanner et al. (1983) have given a method to assess the skeletal ages of the child from the X-rays of the hand and wrist. With the help of this method, bones of the hand and wrist are first rated for the stage of development of the bone. These stages are converted into scores and thereafter all the scores are added to get a total score. This total score is converted into bone age which can be compared with the actual age of the child in order to find out whether the child is normal, a late maturer or an early maturer.

Rickets and Osteomalacia

Rickets and osteomalacia are diseases, which cause softening and weakening of the bones due to poor bone mineralization. Rickets is a condition of the childhood whereas osteomalacia is an adult disorder. The main reason is the deficiency of vitamin D. Skin also manufactures vitamin D when exposed to sun. Proper absorption of calcium from the digestive gut can only take place in the presence of vitamin D. Calcium metabolism and its regulation are also helped by vitamin D. Therefore lack of vitamin D may result in deficiency of calcium in the body. Major symptoms of the disease include knock knees and bow legs, deformed vertebral column.
dental deformities and defective teeth and general muscular weakness. Adequate consumption of vitamin D, calcium and other minerals can prevent rickets and osteomalacia. In addition to this, exposure to sunlight may also be required in those individuals who don’t get proper sunlight. Now-a-days milk fortified with vitamin D is also available which can be of special help to needy children.

**Osteoporosis**

Osteoporosis is a disease in which loss of bone tissue takes place and the bone mineral density starts reducing. The disease often comes to notice when a person suffers fractures. The fractures of hip, spine and wrist are most prevalent in this disease. The bone density reaches its maximum around 25 years of age. If so then the chances of osteoporosis diminish. It is advised by the doctors that the children must take adequate quantities of calcium, phosphorous and other minerals so that their bones become strong when they reach their adulthood thereby reducing the occurrence of this disease. Osteoporosis develops due to the imbalance between old bone resorption and new bone formation. Either the new bone formation is less or the resorption of the old bone may be more or both may happen. Among the hormonal factors which are responsible for osteoporosis, are the decreased secretions of estrogen in case of females and androgen in males. It happens especially after menopause in case of women when their ovaries become non functional.

**Goitre**

Goitre is the condition when enlargement of the thyroid gland takes place. Normally goitre is not cancerous. It is a fact that a person suffering from goitre can secrete normal levels of thyroid hormone or increased levels or decreased levels of this hormone. Traditionally, the most common cause of goiter is lack of iodine in a person’s diet. But now-a-days, iodine is added to common salt and therefore the iodine deficiency through diet may not be present in the individuals who use iodized salt. But still a large number of people around the world suffer from goitre as they may not be getting enough iodine in the diet. One of the main symptoms of the disease is a swelling of the thyroid gland which may become a lump in the throat. Besides an enlargement of the gland, the patient may have difficulty in swallowing and breathing and a tightness in the throat.

**Avitaminosis A**

Avitaminosis A occurs due to the deficiency of vitamin A or carotinoids. It results in keratinization of the skin and night blindness. The night blindness is a disease when the person is unable to see in the dark. This is due to the deficiency of the production of visual purple of the rods in the retinal layer of the eyes. Xerophthalmia is a condition of the dryness of cornea and conjunctivitis. Xerophthalmia is very prevalent in the developing world. Dietary intake of vitamin A and oral administration of vitamin A in young children can help a lot in correcting this disease.

Besides these nutritional diseases, some other deficiencies like that of riboflavin (vitamin B2) deficiency, scurvy due to vitamin C deficiency, pellagra due to niacin deficiency, beri beri as a result of thiamin deficiency, are also found in different regions of the world.

### 3.3 OVER-NUTRITION

Overnutrition results from eating too much. Generally, there is a very strong regulating mechanism in the brain which makes sure that the intake of energy...
equalizes the energy expenditure. We feel hungry when there is a long time between the meals and we feel satisfied when we have been eating regularly. It is the brain which makes us feel that way on the basis of amounts of nutrition we are having. But when the energy intake of a person exceeds the energy expenditure, it results in the storage of excess energy in the form of fat. The physical expression of excess fat in the body is referred to as obesity.

**Obesity**

Obesity means that a person has too much of fat in the body. Obesity may have an adverse effect on health leading to reduced life expectancy and increased health problem. The fat is generally stored under the skin as subcutaneous fat, in the abdomen and around the visceral organs. The specialized connective tissue cells store the fat as triglycerides in them which are known as adipocytes.

Obesity, however, must be distinguished from overweight which may be due to excessive amounts of muscles and bones. There are three main reasons for developing obesity which are as follows:

- Eating excessive food than the body can utilize
- Consumption of too much alcohol
- No or very little exercise and sedentary life style

**Type 2 diabetes mellitus**

It is a disease when the body does not produce enough insulin or cells do not respond to insulin. As a result of this, blood sugar of the person remains high and he is not in a position to utilize the glucose properly. Though there is enough glucose, yet the body cannot use it. Hence, the disease is often phrased as “starvation amidst plenty”. As per statistics, about 80% of the people suffering from diabetes are either obese or overweight. They have BMI which is above the normal range. Obesity generally inhibits the ability of the insulin to control blood sugar and therefore the body tries to overproduce insulin so as to control blood sugar and therefore runs the risk of developing diabetes. Over a period of time, the body cannot keep the blood sugar levels within the normal range.

**Heart Disease**

Overweight and obese people generally have greater risk of heart disease many of which include heart attack, angina, congestive heart failure, abnormal cardiac rhythm, sudden cardiac death, etc., than those who are in the normal range of body weight and body mass index (BMI).

Why obese people have a greater risk of contracting cardiovascular diseases? It has been found that the obesity has an adverse effect on blood lipids. Obese persons have increased levels of triglycerides and low density lipids or bad cholesterol. On the other hand, the obese people have low levels of high density lipids which are considered to be good lipids. This is a dangerous combination and is most suitable for developing heart disease.

**Hypertension**

Hypertension is a term used to describe high blood pressure. Heart pumps the blood into aorta and onwards to other arteries with sufficient force so that the blood reaches every part of the body. The normal blood pressure is given as 120/80 mmHg where 120 is called systolic blood pressure and 80 is called diastolic blood pressure. High blood pressure or hypertension is a condition when blood pressure values are 140/90 mmHg or more. If the blood pressure values are in between 120/80 mmHg and 140/90 mmHg, then it is referred to as pre-hypertension. Many factors affect blood
pressure which includes the water and salt levels in the body, levels of different hormones and the condition of blood vessels, kidneys and the nervous system. Ageing automatically increases the blood pressure as the vessels become stiff with age. High blood pressure increases the risk of having a heart attack, stroke, heart failure, kidney failure, etc. The sedentary life style and obesity are important factors of high blood pressure of a person.

*Metabolic syndrome (Insulin resistance syndrome; Syndrome X)*

Metabolic syndrome is a cluster of risk factors which are present together and thought to be responsible for increasing the risk of type 2 diabetes, coronary artery disease and stroke. Two main factors of metabolic syndrome include central obesity and insulin resistance. The central obesity is the excessive deposition of fat in the central and upper part of the body. This is called android fat or apple shaped. Insulin resistance means that the body cannot effectively use the insulin to control blood sugar.

As per the American Heart Association and the National Heart, Lung, and Blood Institute, metabolic syndrome would be present if a person has three or more of the following signs:

- Blood pressure equal to or higher than 130/85 mmHg
- Fasting blood sugar (glucose) equal to or higher than 100 mg/dL
- Large waist circumference (length around the waist):
  - Men – 40 inches or more
  - Women – 35 inches or more
- Low HDL cholesterol:
  - Men – under 40 mg/dL
  - Women – under 50 mg/dL
- Triglycerides equal to or higher than 150 mg/dL

### 3.4 HEALTH STATISTICS

Health statistics include the indicators of health and disease, mortality and morbidity, the incidence or prevalence of diseases. The population dynamics of its growth mainly revolve around two parameters of births and deaths.

*The Crude Birth Rate (CBR) and Crude Death Rate (CDR)*

The Crude Birth Rate (CBR) and Crude Death Rate (CDR) are statistical values which are of great interest because of its utility in finding out the status of a population whether it is growing in size, declining in its size or remaining unchanged in its population. The Crude Birth Rate and Crude Death Rate are both calculated by the rate of births or deaths in a given year respectively among a population of 1000 individuals. This can be calculated as follows:

\[
\text{CBR} = \frac{\text{number of births}}{\text{number of individuals in a population}} \times 1000
\]

\[
\text{CDR} = \frac{\text{number of deaths}}{\text{number of individuals in a population}} \times 1000
\]

If a country has a population of 100 crore people and 2 crore babies are born in a given year, then the crude birth rate will be 20 per 1000. Similarly if the same country has 1.5 crore persons dying in a given year then the crude death rate will be 15 per 1000.
The Crude Birth Rate does not take into consideration age or sex differences among the population in determining the birth rate and hence it is called ‘Crude Birth Rate’. In the total population there are children and old people who are not in a position to contribute to the births but still their numbers are included in the calculation of birth rate. Therefore the term crude has been assigned to such rates. Similarly, Crude Death Rate (or Crude mortality rate) includes all deaths due to all causes in both the sexes and at all ages.

**Morbidity and Mortality**

Morbidity means illness or disease. The person may suffer from a single disease or may have multiple of diseases. It does not mean death. There are a great variety of diseases prevalent in the populations and people always have chances of contracting a disease especially when they become old and do not eat healthy or observe healthy life styles.

Mortality means death. People may die of natural causes, due to diseases, accidents, natural calamities or any other reason. Mortality includes all types of deaths taking place in a society or a country. There are different types of mortality which can be explained as follows:

**Maternal Mortality Rate**

Maternal mortality rate is the number of deaths of women as a result of pregnancy or child birth divided by number of live births in the same time period. It is an important indicator of the health of the women and a lower rate would also reflect on the development of a nation as well. The well developed nations have very low maternal mortality rates as compared to those from the developing regions of the world including Asia and Africa.

**Neonatal Mortality Rate**

Neonatal mortality rate is the number of deaths occurring during the first 28 completed days of life per 1,000 live births in a given year or period in a population. Since a lot of children die during the neonatal age, therefore mortality during this age is a very important indicator of the maternal and newborn health.

Neonatal mortality may be subdivided into two categories:

a) early neonatal mortality representing neonatal deaths during the first seven days of life, and

b) late neonatal mortality which occurs after the seventh day but before the 28 completed days of life.

World Health Organization has given the following definition of live birth:

“Live birth refers to the complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of the pregnancy, which, after such separation, breathes or shows any other evidence of life - e.g. beating of the heart, pulsation of the umbilical cord or definite movement of voluntary muscles - whether or not the umbilical cord has been cut or the placenta is attached. Each product of such a birth is considered live born.”

**Infant Mortality Rate**

Infant mortality rate is the number of deaths in children of less than one year of age, divided by number of live births in same time period.

**Under-5 Mortality Rate**

Under-5 mortality rate is referred to as the number of child deaths in the first 5 years of life, divided by number of live births in the hypothetical cohort of newborns. In
other words, it is the number of children who die by the age of five, per thousand live births per year.

**Prevalence and Incidence**

**Prevalence** is an indicator of the disease occurring in a population and it also throws light on the likelihood of a person to have that disease. A prevalence rate refers to the proportion of cases of a disease existing in a population, which includes freshly diagnosed cases as well as those living with the disease, to the total population. Thus,

\[
\text{Prevalence Rate} = \frac{\text{No. of cases of a disease}}{\text{Population size}}.
\]

It is a good measure of the burden of a disease in a society or a population.

If diabetes is taken into consideration in a population of 50,000 people out of whom 2000 are freshly diagnosed cases whereas 5000 are already living with diabetes, then the prevalence of diabetes will be 0.14 \((7000/50000)\) or 14% or 14000 per 100,000 persons.

**Incidence rate** is the number of new cases of a disease reported for a given population in a given time period. It refers to the fraction of a population that develops a disease in a given time or the number of new cases reported for contacting a disease or a condition during a given time period. Incidence is thus an indicator of the risk of developing some new disease or condition within a specified period of time.

The incidence and prevalence are not similar terms but represent very different concepts. Incidence is the rate at which people contract a disease whereas prevalence represents the total number of diseased people in a population at any given time. Prevalence and incidence are demonstrated with the help of the following example:

Let us imagine a sample population of 1000 individuals in whom we want to assess the incidence rate of developing diabetes over a period of 10 years. The individuals were followed up at three cut points of time; at the start, after 5 years and at the end of 10 years.

At the start of the study \((t=0)\), there were already 100 individuals who had diabetes.

A follow up for 5 years \((t=5)\) revealed that 70 more persons have contracted the disease during this period.

At the end of ten years \((t=10)\), 80 more individuals have contracted the disease.

So, at the end of the study after 10 years, the total number of diabetes patients in a sample population of 1000 has been \(100 + 70 + 80 = 250 \) cases.

Therefore, prevalence of diabetes in this sample population = \(250/1000 = 0.25 \) or 25%.

Incidence rate is the number of new cases of a disease reported for a given population in a given time period. Different studies use different time spans to calculate the incidence rate. But if the incidence rate of a disease is calculated for one year, then it would be more accurate. Such an incidence rate is known as person-time incidence rate or incidence density rate. In the above follow up study, after 5 years, 70 more cases of diabetes were reported. Since it is not known when exactly these people contracted the disease therefore the epidemiologists take the mid-way point of time which is 2.5 years. Converting these cases to person-years, it would become 175 person-years \((70 \times 2.5)\). Similarly at 10 years, 80 more cases were found which means they developed the disease anywhere between 5 and 10 years, therefore converting these cases to person-years it would become 600 person-years \((80 \times 7.5)\). The total of 150 persons who contracted the diabetes during a 10 year period under
study amounted to 775 person-years (175 + 600). We also want to know how many person-years can be attributed to those persons who remained free from disease. Out of 1000 persons, at the end of 10 years of study, 750 persons were free from the disease which amounts to 7500 person-years (750 x 10).

So the total person-years = 7500 + 775 = 8275.

Person-year incidence rate of the study for diabetes

\[
= \frac{\text{number of new cases}}{\text{total person-years}}
\]

\[
= \frac{150}{8275} = 0.018
\]

In other words, it means there are 18 cases of diabetes per 1000 population per year. If we have to follow a population of 1000 persons for one year, we would expect 18 new cases of diabetes.

In nutshell numerous studies have indicated that the diet plays a very significant role in the prevention of heart disease. The diet rich in saturated fats (trans fats) and with a high glycaemic index cause and promote heart disease whereas diets rich in fibre, fish oil and polyunsaturated fats decrease the risk of heart disease. Red meat consumption has been found to be highly correlated to the colorectal cancer incidence whereas alcohol consumption seems to increase the risk of a number of cancers. The diets rich in fruits, salads and whole grains seem to work wonders to the human body and keep it healthy and the person stays fit.

3.5 SUMMARY

The two cornerstones of nutritional epidemiology are the diet and physical activity and both of them are very difficult to study and measure. The methods available for the measurements of diet and physical activity leave a lot of scope for measurement error. The disorders of nutrition may include two extremes on opposite sides, namely, undernutrition and overnutrition. In case of undernutrition the food consumed is either less than that is required or it has a difficulty in getting digested or assimilated in the body. In both the conditions, the body cannot perform various tasks to the optimal level. In other words the physical efficiency of the body gets affected in case of malnutrition. Kwashiorkor, marasmus, rickets, osteomalacia and vitamin deficiency diseases fall under the category of undernutrition. Overnutrition means eating too much. Generally, there is a very strong regulating mechanism in the brain which makes sure that the intake of energy equalizes the energy expenditure. We feel hungry when there is a long time between the meals and we feel satisfied when we have been eating regularly. It is the brain, which makes us feel that way on the basis of amount of nutrition intakes. But when the energy intake of a person exceeds the energy expenditure, it results in the storage of excess energy in the form of fat. The physical expression of excess fat in the body is referred to as obesity which may lead to a lot of health complications of heart disease, type 2 diabetes, metabolic syndrome etc. The health statistics tell about the health status of a population with the help of numerous health indicators which have been described in detail.

3.6 GLOSSARY

Nutritional epidemiology is the science that deals with the role of nutrition in the causes and prevention of ill health.

Public health nutrition is a scientific field which stresses the need to improve the
good health among populations primarily with the help of nutrition and by preventing diet related sicknesses from the populations.

Malnutrition is any disorder of nutrition. It may result from an unbalanced, insufficient or excessive diet or from impaired absorption, assimilation, or use of foods.”

Crude Birth Rate (CBR) and Crude Death Rate (CDR) are statistical values which are of great interest because of its utility in finding out the status of size of a population whether it is growing, declining or remaining unchanged.

Morbidity means illness or disease. The person may suffer from a single disease or may have multiple diseases.

Mortality includes all types of deaths taking place in a society or a country. There are different types of mortality which include maternal mortality, neonatal mortality, infant mortality and child mortality.

Suggested Reading/References


Websites:


Sample Questions

1) Describe various diseases of under nutrition and how these can be prevented?

2) Describe in detail some of the health statistics.

3) Give a detailed account of the diseases of over nutrition.

4) What do you understand by nutritional epidemiology?