UNIT 18 NUTRITIONAL REQUIREMENTS FOR SPECIAL CONDITIONS

Structure

18.1 INTRODUCTION

In the previous unit, we saw how involvement in sport or vigorous activities can affect the body's nutrient needs. In this unit, we will focus on nutritional needs of humans who are away from the normal conditions of living environment i.e. affected by calamities or emergencies (natural or man made) or exposed to environmental extremes such as hot, cold, rugged terrain environments as high attitudes. All major emergencies often result in food shortage, impair the nutritional status of population and cause excessive mortality in almost all age groups. In such cases, nutritional awareness becomes important for planning the emergency management.

Human beings can function effectively in extreme environments, provided adequate behavioural precautions (proper clothing, shelter, food and water) are taken. Expeditionary or recreational outdoor activities are generally conducted in hot, cold, rugged terrain environments such as high altitudes. Mountaineering, cross-country skiing, snowshoeing, sledging and backpacking can be physically demanding along with an added element of danger due to environmental wilderness. These areas need to be manned by armed forces personnel if national boundaries run through such locations for security reasons.

In such cases, it has been observed that miscalculation of physical abilities or inadequate preparedness can be life threatening. Nutrition is a prime need for survival, sustaining physical and mental performance. Under this unit, you will read how nutritional requirements vary with the environment and also about the minimum requirements to prevent malnutrition-related diseases and mortality in emergency situations. You will appreciate the role of nutritional sciences in human success on the planet Earth and in space exploration, which is relatively a new frontier with microgravity as main stress factor.

Objective ,

After studying this unit, you will be able to:

- describe nutritional needs during calamities and emergencies,
- understand the nutrient requirements for working under environmental extremes i.e. hot, cold and high altitudes, and
- discuss the nutritional needs during space travels.

18.2 CALAMITY AND EMERGENCY MANAGEMENT

During past many years, we have seen, as well as, realized that natural calamities strikes countries, both developed and developing, causing enormous destruction and creating human sufferings and producing negative impacts on national economies. What are calamities? In simple terms, *calamity refers to any great misfortune or a cause of misery which is applied to events and disasters*. Due to diverse geo-climatic conditions prevalent in different parts of the globe, different types of natural calamities like floods, droughts, earthquakes, cyclones, landslides, volcanoes etc. strike according to the vulnerability of the area. Natural calamities have been broadly grouped into *major* and *minor* types depending upon their potential to cause damage to human life and property. Earthquakes, droughts, floods and cyclones have been identified as *major* type of calamities while hailstorms, avalanches, landslides, fire accidents etc. whose impact is localized and intensity of the damage being much less, are categorized as *minor calamities*. India is considered as the world's most disaster prone country. It has witnessed devastating natural disasters in recent past like droughts, tsunami, floods, cyclones, earthquakes, landslides etc.

The occurrence of both natural and man-made emergencies has risen in the recent years with a large number of affected communities, refugees and displaced persons. Droughts, floods, earthquakes and crop destruction by diseases or pests cause nature-induced famines while war and civil conflicts create man made famines. Regions that produce barely enough food for survival under normal conditions are vulnerable to famines induced by calamities. All major emergencies often result in food shortage, impair the nutritional status of a population and cause an excessive mortality in almost all age groups. Nutrition is therefore a key public health concern in emergency management. Malnutrition in one or more of its various forms is the main feature during calamities. When nutritional needs of an affected population or a subgroup of population are not met completely, it is observed that the signs of malnutrition and deficiency diseases emerge among helpless or vulnerable individuals. Can you think of a few deficiency diseases which might prevail under such conditions? Well, there are underweight children, anaemic mothers and marasmic babies. The cases of vitamin deficiency diseases i.e. blindness, scurvy, beriberi, pellagra and other deficiency diseases are also observed. Knowledge of nutritional requirements for management of emergencies is therefore, important due to the following reasons:

i) Assessment of nutritional needs of individuals, vulnerable groups, families and population.

ii) Monitoring of nutrient intake in these groups.

iii) Ensuring that adequate quantities of food are being procured/made available for rations and supplements etc.

Identification of most vulnerable groups is also essential and generally these are the groups with additional nutrient requirements e.g. *pregnant and lactating women, infants and young children, single adults e.g. widows and widowers in the older age group.*

In the initial stages of disaster (0-6 months), there is instability, acute shortage and mass movement of people. The victims are totally dependent on aid. There are inevitable delays in evaluation, planning, requesting, and receiving donations, transportation and formation of distribution system. At this stage, the management is generally controlled by internal government and NGOs. If an affected population crosses an international boundary, then they are called 'refugees' and United Nations High Commission for Refugees (UNHR) can help them and if they remain in the country, they are called 'internally displaced persons'. The second stage of disaster (usually after 6 months) is stage of *establishment*. The affected people are organized or they organize themselves and use newer coping strategies i.e. start cultivating, set up of small home industry and selling of labour. At this stage, relief can be more targeted towards more needful persons.

Now that we have an overview of what is a calamity and an emergency and who are the most effected, let us next study about the issues specific to the management of emergencies.

18.3 INFORMATION REQUIRED FOR MANAGEMENT OF EMERGENCIES

Management or intervention needs accurate information about the actual situation and includes many non-nutritional components, programmes, although food remains the most compelling basic necessity. The factors which need to be considered are:

1) Population size, geographical dispersal of the population, map of the affected areas, including location of camps etc.
2) Age groups
3) Current nutritional status
4) Nutritional deficiencies and endemic diseases
5) Purchasing power, coping mechanisms and market prices
6) Access to potable water
7) Fuel supply
8) Access to food, seeds, tools etc.
9) Seasonality and forecast system
10) Cultural beliefs and taboos
11) Threats to security, political and military situation
12) Underlying causes of the crisis

In major emergencies, most urgently needed action is to prevent death and illness caused by malnutrition. Basic energy and protein requirements are the primary concerns but micronutrient needs must also be met if blindness, disability and deaths are to be avoided.

Let us now get to know about the nutrient requirements in the following sub-section.

18.3.1 Nutrient Requirements during Emergencies

The nutritional requirements of the people do change during conditions of unforeseen stress and/or any calamity. Certain recommendations for energy, protein and micronutrients have been formulated based on a few assumptions. Let us begin with energy and protein and find out what are the recommendations and assumptions.

Daily energy requirement and safe protein intake

The estimated mean daily per capita energy requirement of 2070 Kcal rounded up to 2100 Kcal is based on WHO technical report No. 724 published in 1985 and on the following assumptions:

- The age/sex distribution of the population is a characteristic of developing countries
- The mean height of adult men and women are 169 cm and 155 cm respectively, which is the approximate value in sub-Saharan Africa
- The body mass index (BMI) (kg/m^2) is between 20-22
- Physical activity is light
- All infants are breast-fed from birth to 6 months, and half of the infants of 6-11 months are still breast-feeding and deriving half of their energy and protein requirement from breast milk
- Safe daily protein intake, from an average mixed diet of cereals, pulses and vegetables is estimated to be 46 g.

Next, we move on to micronutrient requirements.

Micronutrient and other specific nutrient requirements

The recommended average daily per capita intake of various specific nutrients for typical population requiring emergency food aid in developing countries is given in the Table18.1.

Table 18.1: Recommended mean daily per capita nutrient intake for emergency food in developing country

Nutrient	Recommended Daily Intake
Vitamin A (retinol equivalents)	500 mcg
Vitamin D	3.8 mcg
Thiamin (Vitamin B_1)	0.9 mg
Riboflavin (Vitamin B_2)	1.4 mg
Niacin equivalents	12.0 mg
Folic acid	160 mcg
Vitamin B_{12}	0.9 mcg
Vitamin C	28 mg
Iocline	150 mcg
Iron *	22 mg
Calcium	0.5 g

*From diet that provides iron of low or very low bioavailability.

After requirements, let us find out the consequence of not being able to meet the recommendations and review a few major deficiency diseases that occur during emergencies.

18.3.2 Major Nutritional Deficiency Diseases in Emergencies

Earlier, in this unit we leant that energy protein malnutrition along with micronutrient deficiencies like anaemia, blindness etc. may result during emergency situations. Let us briefly review these conditions.

- *Protein-Energy Malnutrition (PEM)*

Even in normal times, PEM is a problem in many developing countries, most commonly affecting children between the ages of 6 months to five years. In times of nutritional emergencies, primarily the more acute form of PEM is observed, that has to be dealt with. This is characterized by the rapid loss of weight and may affect larger number of older children, adolescents and adults than usual. The clinical symptoms of PEM, as you may recall studying in the Public Nutrition Course (MFN-006), are summarized in the Table 18.2. Infants and children suffering from severe PEM must be treated as soon as possible; otherwise they are very likely to die. Let us study the clinical symptoms of PEM in both children and adults.

Table **18.2:** Main clinical symptoms **of PEM**

Population Group	Clinical **Symptoms/Signs**	
	Always Present	Sometimes Present
Children		
Marasmus	Wasting	Hunger, Wizened appearance
Kwashiorkor	Oedema	*Mental change:* irritability, poor appetite *Skin change:* dermatitis *Hair*: sparse, loose, straight
Marasmic kwashiorkor	Wasting and oedema	Any of the above symptoms and signs
Adults	Wasting and weakness	Oedema, mental change

Now, how to prevent or overcome this nutritional deficiency? A large number of government schemes and programmes have been launched about which we have already studied in the Public Nutrition Course. Along with these programmes, new initiatives need to be put in place to deal with these conditions. Selective feeding programme should be initiated for PEM affected individuals and these include supplementary feeding programmes, providing an extra 500-700 Kcal/day from cooked food or by distribution of dry take home rations (1000-1200 Kcal/day). Breast-feeding must be encouraged. Blanket supplementary feeding programmes should be needed only temporarily when the malnutrition rates (weight-for-height below median –2 SD) exceed 15% or 10% in the presence of other aggravating factors. Targeted supplementary feeding (i.e. extra food given to the selected individuals), is indicated if the malnutrition rate exceeds 10% or *5%* in presence of other aggravating factors e.g. high mortality and/or epidemic infections diseases. Therapeutic feeding is required to reduce the death rate among infants and young children. A rehabilitative diet, with high-energy foods (p oviding 150-20 Kcal and 2-3 g of protein/kg body weight daily) should be served at frequent intervals. For the first few days, there should be a close medical supervision and feeding should be made at every **3** hours on a 24 hour basis. Mothers should feed their sick children themselves. Broad spectrum antibiotics for the treatment of emerging infections, immunization against measles andnorinal doses of vitamin A should be made available.

Let us next move on to micronutrient deficiencies.

- *Micronutrient Deficiencies*

Micronutrient deficiencies are more common during calamities. Can you guess, why? This is due to the lack of diversified food items and nonavailability of fresh foods. All forms of vitamin and micronutrient deficiency diseases can be seen in an affected population if preventive measures have not been taken in time. These include iron deficiency anaemia, vitamin A deficiency blindness, beriberi, pellagra, oedema and goitre. There are several approaches for preventing the onset of micronutrient deficiencies in emergency situations' affecting large populations. These include:

- increasing the daily ration that will allow a surplus to be sold for other purposes like procuring fruits and vegetables,
- varying the composition of food basket such as pulses, groundnuts, fresh fruits and vegetables and red palm oil. A better alternative is the local production of fruits and vegetables in home gardens,

- including micronutrient fortified foods in ration e.g. cerealslpulse blends, iodized salt, vitamin A enriched skim milk or vegetable oils, and
- providing supplementation when there is likely to be a specific deficiency based on dietary assessment and overt signs and symptoms.

Another important aspect to be considered for the management of emergencies is monitoring assessment and surveillance of nutritional status and relief measures in emergencies. The next sub-section focuses on this aspect.

18.3.3 Monitoring Assessment and Surveillance of Nutritional Status and Relief Measures in Emergencies

What do we mean by the terms monitoring and surveillance? Do you recall studying about this aspect in the Public Nutrition Course in Unit 10? Well, we suggest you look up this unit again before you continue with your study on this topic here in this unit.

What is their need during an emergency? Let us find out. Monitoring, we know, is *the act of observing something and sometimes keeping a record of it* while surveillance is *a repeated survey using a standard methodology*. During nutritional emergency, relief foods may be scarce and may need to be provided preferentially (targeted) to the people in greatest need. Food relief programmes should be planned and implemented on the basis of initial, rapid nutrition assessment followed by systemic surveys and continued monitoring and surveillance of nutritional conditions. Suitable arrangements must be made for evaluating the nutritional status at levels of communities (to assess extent of severity of malnutrition and micronutrient deficiencies, and composition of emergency ration; to ensure that fuel and cooking utensils are available and to monitor the changes in nutritional status over a period of time) and of individuals (to screen for supplementary or therapeutic feeding programmes).

Various simple indicators may be used such as:

1) Weight-for-height
2) Body mass index (weight in kg/square of height in meters) of adults
3) Mid upper arm circumference (MUAC) can be used as an alternative for initial screening
4) Oedema is an essential indicator when kwashiorkor is present

Let us next review at the nutritional relief programmes and interventions required during an emergency condition.

Nutritional Relief Programme and Interventions

A general feeding programme is required during first stage when the affected population does not have sufficient food to meet the nutritional needs. If the population is entirely dependent upon external aid, the general ration must provide for a minimum intake of 2100 Kcal per person per day and more, if population is already malnourished, exposed to cold, or engaged in heavy work. Refer to Table 18.3 where the requirements based on activities are given. Besides being nutritionally balanced, the general ration should be acceptable culturally, fit for consumption and easily digestible for children and other affected vulnerable groups. Although nutrient needs are different for different age groups in a family but same general ration components should be provided for each person, regardless of age, families would divide ration among themselves. The general ration is normally provided dry, for cooking at home.

Distribution of cooked food should be avoided except as a short term measure that should be stopped as soon as people have necessary arrangements to prepare their meals due to following reasons:

- Such programme is often culturally inappropriate and may cause offence

- Hygiene is difficult to ensure
- Food intakes are often lower and difficult to meet needs of young children.

Table 18.3: Mean Energy Requirements and Recommended Adjustments for diierent activity levels, environmental temperatures and food losses during transport

		Developing Country	Industrialized Country
Mean energy requirement (Kcal)		2080	2180
Adjustment for activity level			
Moderate	Adult male	+300	+370
	Adult female	+100	+105
	Whole population	+140	+180
Heavy	Adult male	+850	+890
	Adult female	+330	+340
	Whole population	+350	+460
Adjustment in Kcal for mean daily temperature			
	20°C	–	
	15°C	+100	
	10°C	+200	
	5°C	+300	
	0°C	+400	
Adjustment in energy requirement (Kcal) for food losses in transport			
Country with port		+5%	
Land locked country		+10%	

Source: WHO 2000, The Management of Nutrition in Major Emergencies.

For distribution of cooked food, locally available fuel and local methods for making fire can be used. Individuals may be asked to collect and bring wood, cow dung etc. for fuel and if collection is difficult or there are chances of deforestation in area, kerosene oil should be used as an alternative.

In second stage, supplementary feeding programme (SFP) is given for vulnerable groups and therapeutic feeding programmes (TFP) are provided to those already severely affected due to malnutrition or deficiency diseases as mentioned in earlier sections.

For distribution of items, ration cards should be issued and maintained. Effectiveness of programme should be monitored at the regular intervals.

With this, we come to an end on our discussion on the management of emergency situations. In our next section, we shall deal with nutritional needs during extreme environmental conditions. But before that, let us find out what we have learnt so far.

Check Your Progress Exercise 1

1) What do you understand by the terms 'calamity' and 'emergency'? State the major nutritional deficiency diseases in calamity affected area.

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2) What factors must be considered for the management of emergencies?

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3) Mention the basic assumptions on which per capita energy requirements are recommended by WHO.

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4) Discuss the approaches for preventing the onset of micronutrient deficiencies. How many calories must be provided during the emergency situation?

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5) Match column **A** with column B:

	A		**B**
a)	Marasmus	i)	Iodine deficiency
b)	Kwashiorkor	ii)	vitamin C deficiency
c)	Night Blindness	iii)	Oedema
d)	Goitre	iv)	vitamin A deficiency
e)	Scurvy	v)	Wasting

6) Tick the correct answer.

i) Micronutrient deficiencies are common during calamities because of
   a) Lack of diversified food items and fresh foods.
   b) Lack of cooked foods.
   c) Lack of fried foods.

ii) Targeted supplementary feeding is indicated
   a) if the malnutrition rate exceeds 15% or 10%
   b) if the malnutrition rate exceeds 10% or 5%
   c) if the malnutrition rate exceeds 20% or 10%

iii) Recommended daily per capita vitamin **A** intake for emergency food in developing country is
   a) 3.8 mcg
   b) 500 mcg
   c) 160 mcg

iv) Recommended daily per capita riboflavin intake for emergency food in developing country
   a) 14 mg
   b) 1.4 mg
   c) 0.14 mg

v) Mean energy requirement for a moderately active adult male living in refugee camp
   a) 2080 Kcal
   b) 2380 Kcal
   c) 300 Kcal

18.4 NUTRITIONAL REQUIREMENTS FOR EXTREME ENVIRONMENTS

Human beings have been able to survive and work under extreme environments of almost all regions of the earth, from poles to equator and also in space. Some of these places are visited for very brief periods due to inhospitable environment. An extreme environment can be defined as *an environment where basic needs, like acquisition of food, shelter and protection, require extraordinary efforts*. One important feature of these environments is that an error in judgment and behaviour can have serious, even fatal consequences. These environments can be natural, as well as, man-made and are listed in the Table 18.4.

Table 18.4: Condition and environmental extremes

Primary Natural	Primary Man made	Condition	Environment
X		Low temperature	Arctic/Antarctic/ Altitude
X		High temperature	Tropics
X	X	Reduced pressure	Altitude/flight
	X	Increased pressure	Diving
X		Reduced gravity	Space
	X	Increased gravity	Flight
X		Decreased oxygen availability	Altitude
	X	Increased oxygen availability	Diving
	X	Change in inspired air composition	Diving
X		Lack of water	Desert
X	X	Lack of food	Anywhere
X		Increased radiation	Space/Altitude
X	X	Isolation	Arctic/Antarctic/Space

When faced with hot, cold, high altitude (terrestrial heights above 2700 meters) or space environments, human beings either try to modify the microenvironment accordingly or physiologically adapt themselves to fit the environment or use a combination of these two strategies. Let us review these adaptive mechanisms.

18.4.1 General Adaptive Mechanisms to Environmental Extremes and Role of Nutrition in Successful Acclimatization

Although human beings are remarkably adaptive but the main limitation is *homeothermy* which means 'regardless of environmental temperature, the normal body temperature must be maintained within a relatively narrow range'. We have several physiological defense mechanisms to overcome this problem e.g. shivering, sweating, vasodilatation or vasoconstriction. When the capacity of these mechanisms is exceeded and body core temperature drops below 35°C (95°F) or rises above 41°C (106°F), the physical and mental performance deteriorates rapidly and both these conditions may be life threatening. Similarly, hypoxia associated with cold at high altitude imposes severe restriction on adaptability. Metabolic adaptations to heat, cold and high altitude hypoxia may in some instance be accompanied by the changes in nutrient requirements. Inadequate nutrition can impair metabolic response as illustrated in Figure 18.1.

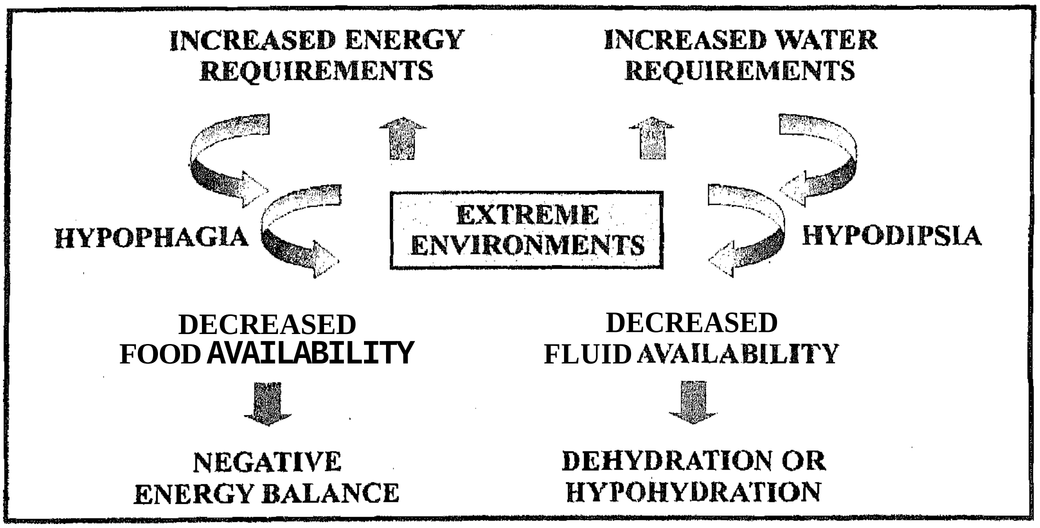

Figure 18.1: Cascade effect of environmental extremes

The energy and nutrient requirements are generally more under environmental extremes as can be seen from Figure 18.1 and also highlighted in Table 18.5. Appetite and thirst perceptions are generally inappropriate in these environmental extremes, which lead to an inadequate food and water intake. The availability of food and water is often limited due to logistic constraints or often get second priority for carrying of essential equipments, clothing and gear. Proper nutrition is often overloolted but is a critical component of effective work under these conditions.

Table 18.5: Energy requirement for physical activity in temperate, cold and hot environment (Kcal/kg body weight)

		Environment	
Physical Activity	**Temperate**	**Cold**	**Hot**
Light	32 - 44	35 - 46	40 - 54
Moderate	45 - 52	47 - 55	55 - 61
Heavy	53 - 63	56 - 68	62 - 75

Altitude energy requirements are similar to temperate. Hot > 30°C / 86°F, Cold < 0°C/ 32°F, High altitude > 3050 in or 10,000 ft elevation.

The diet of humans differs in quantity and cornposition in different climatic regions. Although much of this variation may be due to availability of food in that area, there is an intriguing possibility of selection of certain classes of foods or adaptation to some dietary habits, which help in acclimatization process in that environment. Several studies on relationship of diet and extreme environment are the outcome of military research or expeditions to mountains and Polar Regions. *Captain* Cook kept his crew entirely free of scurvy during his second voyage to South Seas (1772-75) by using germinating seeds and lime juice along with food items. Beriberi was the scourge of the Japanese Navy prior to 1882 when *Admiral Takaki* eliminated it by increasing allowances of vegetables, fish, meat and barley in addition to staple diet of polished rice.

Another important aspect linked to high altitude is *hypoxia*. Let us understand about this adaptive mechanism.

Decreased oxygen availability at high altitude (Hypobaric hypoxia)

The governing biophysical factor at high altitude is decrease in barometric pressure with increase in altitude. Although atmospheric concentration of oxygen remains at a constant 20.93% at all terrestrial altitudes, the partial pressure of oxygen falls along with decline in barometric pressure (PO_2 = 0.2093 x baromet ic pressure). As the altitude increases, the lowered oxygen pressure (PO_2) in pulmonary alveoli causes a decline in saturation of haemoglobin in arterial blood, and a lower oxygen pressure gradient throughout the body, especially at the level of capillaries, where PO_2 may be close to zero. With low PO_2, the blood flow is too rapid to allow appropriate gaseous exchange, resulting in unfavourable oxyhaemoglobin dissociation. The CO_2 that is produced metabolically exerts a tension of 40 mm Hg at sea level while at high altitude, it is'decreased to a minimum of about 24-27 mm Hg while water vapours exert a tension of 47 mm Hg at all altitudes. Thus, PCO_2+ PH_2O, that is, 71 mm Hg is always to be deducted from total available gas pressure in alveoli at a given altitude. When breathing pure oxygen, the nitrogen present in alveolar air can be replaced by oxygen (but not CO_2 and H_2O vapour) and alveolar PO_2 can be increased. The barometric pressure, PO_2 in the air and alveoli at different altitudes are given in Table 18.6.

Table 18.6: Effect of low atmospheric pressures on alveolar gas concentration and arterial O_2 saturation

		Breathing Air				Breathing pure oxygen		
	Barometric Pressure (mm Hg)	**PO_2 in Air (mm Hg)**	**PCO_2in Alveoli (mmHg)**	**PO_2 in Alveoli (mm Hg)**	**Arterial Oxygen Saturation (%)**	**PCO_2 in Alveoli (mm Hg)**	**PO_2 in Alveoli (mm Hg)**	**Arterial Oxygen Saturation (%)**
0	760	**159**	**40 (40)**	104 **(104)**	**97 (97)**	40	**673**	**100**
10,000	**523**	**110**	**36 (23)**	**67 (77)**	**90 (92)**	40	**436**	**100**
20,000	**349**	**73**	24 (10)	40 (53)	73 (85)	40	**262**	100
30,000	226	**47**	**24 (7)**	**18 (30)**	**24 (38)**	40	**139**	99
40,000	**141**	29				**36**	**58**	**84**
50,000	87	**18**				*24*	**16**	15

Numbers in parentheses are acclimatized values.

Source: Guyton and Hall, **1996,** Textbook of Medical Physiology, ninth edition.

Arterial hypoxia precipitates the immediate physiological adjustments to altitude and process of acclimatization in case of longer duration of exposure. Table 18.7 presents the immediate and longer term adjustment to altitude hypoxia.

Table 18.7: Immediate and longer term adjustment to altitude hypoxia

System	**Immediate Adjustment**	**Long Term Adjustment**
Pulmonary	Hyperventilation	Hyperventilation
Acid base balance	Body fluids become more alkaline due to reduction of CO_2 with hyperventilation	Excretion of base via the kidneys and concomitant reduction in alkaline reserve
Cardiovascular	Increase in submaximal heart rate	Submaximal heart rate remains elevated
	Increase in submaximal cardiac output	Submaximal cardiac output falls below sea level values
	Stroke volume remains same or slightly lowered	Stroke volume is lowered
	Maximum cardiac output remains the same or slightly reduced	Maximum cardiac output is lowered
Haematological		Decreased plasma volume
		Increased haematocrit
		Increased haemoglobin concentration
		Increased total number of red blood cells
Local		Possible increase capillarization of skeletal muscle
		Increased red blood cell 2,3-DPG
		Increased mitochondria1 density
		Increased aerobic enzymes in muscle
		Loss of body weight and lean body mass

After going through the above discussion, the variations in oxygen availability at altitude and the extent of adjustments to be made accordingly, it is quite obvious that such a condition could possibly lead to health hazards. What are these? What are their symptoms and the remedies? Let us find out in the following sub-section.

18.4.2 Health Hazards Associated with High Altitude

Abrupt exposure to altitudes greater than 10,000 ft (3050 in) elevation is frequently associated with symptoins of altitude sickness. Altitude sickness or acute mountain sickness (AMS) is a general term referring to *a combination of symptoms, including headaches, anorexia, nausea, vomiting and malaise.* The condition improves automatically with acclimatization. Best way to avoid AMS is gradual ascent at heights above 3000 m and stay for 2-3 days at every 1000 m elevation. The gradual acclimatization to progressively higher altitude exposure is the best preventive medicine for high altitude sickness. Life threatening conditions in susceptible individuals are high altitude pulmonary oedema (HAPE) and high altitude cerebral oedema (HACE). In both the cases, immediate evacuation to lower altitude is prescribed after the initial treatment. Other problems are cold injuries such as frostbite and chilblains, and can be prevented using adequate precautions.

Let us now move on to the nutritional requirements and varying food. intake patterns for high altitude.

18.4.3 Nutritional Requirements for High Altitude

High terrestrial altitudes and mountains have aroused great fascination and charm for mankind. Every year millions of people go to mountains for recreation and adventure sports. Besides these visitors, there are some 140 million permanent inhabitants of high lands in the Himalayas, Central Asian, East African Andean and Rocky mountain regions. Permanent residency is restricted to about 4300 m, although some ethnic groups e.g. miners in the Peruvian Andes are reported to live at heights 5500 m for a short period of time.

Himalayas constitute the northern frontiers of our country with human habitation up to an altitude of 4300 m, while soldiers are deployed even up to 5800 m for fixed tenure. High altitude, we have studied above, presents an extreme environment with hypoxia, cold, high solar radiation as physical stresses beside the psychological stress. These areas are also arid in nature with sparse vegetation and shortage of potable water. These factors vary in magnitude depending upon the location and season, and set a formidable challenge to human adaptability and nutrition.

Let us then learn about nutrient needs, food intake, basal metabolism and energy expenditure at high altitude.

Food Intake and Energy Requirements

Many studies have shown that the subjects loose significant amounts of body mass, fat mass, as well as, fat free mass during a climb to and/or a stay at the high altitudes. High altitude-induced weight loss is mainly caused by malnutrition probably due to hypoxia related anorexia, independent of acute mountain sickness. Hypophagia is more pronounced during the first three days of exposure to high altitude even when the best possible food is available. The decreased calories consumption by 40% at 4300 m leads to a negative nitrogen balance. This, coupled with an increased metabolic rate, induced by high altitude exposure, is considered as a major cause of weight loss. The taste thresholds for sweet and salt modalities have been found to be elevated while for bitter and sour were reduced. This means we have to add more sugar to our cup of tea to get same sweet taste as at plains. The feeding behaviour is governed by several hormones, endocrine substances and can be modulated by environmental factors. Alterations in appetite regulatory hormones are the current focus of modem research for appetite regulation.

Let us now move on to the concept of BMR and energy expenditure.

Basal Metabolism and Energy Expenditure at High Altitude

The energy and nutrient requirements depend upon total energy expenditure and metabolic rate of the individual. Total energy expenditure (TEE), as you may recall studying in Unit 2, has three components i.e. *basal metabolic rate (BMR), diet induced energy expenditure* and *expenditure related to activities.* Short-term measurements of gas exchange during field studies suggest that altitude hypoxia increases BMR. Some studies show these acute increases (20-30%) to be sustained for 1-2 weeks while others show elevation to be maintained throughout a three week stay. The decline in BMR with acclimatization seems to be the result of an inadequate energy intake and a decrease in metabolically active tissue that accompanies weight loss. The decrease in metabolic rate is expected to be approximately 20-25 Kcal/d/kg lean tissue lost. Finally, the stress of high altitude (HA) decreases over a period of time as indicated by a decrease in the epinephrine levels in both men and women.

Increased energy expenditure ranging from 6.9 lo 25% has been reported. As regards the energy cost of various activities under stationary conditions, there is no variation as compared lo the sea levels. Increased energy expenditure may be due to the heavier load carried by the troops, as cold protective garments and efforts in walking in snow bound hilly terrain.

The energy expenditure of 3250 Kcal/day is reported in climbers to Mt. Everest using doubly labeled water technicjue. Out of this, 1610 Kcal/day was required just for climbing activities. The physical activity level (PAL) calculated using doubly labeled water and expressed as a multiple of BMR in trained subjects during climbing reached 2.0-2.7, which was lower than the upper limit (4.0-5.0) at sea level. In a study by *Reynolds et al* (1999), energy expenditure in 7 climbers to Mt. Everest was in the range of 2675- 7872 Kcal/day. On the basis of data obtained from climbers who are highly motivated people, generalization of nutrient and energy requirements for the general population is difficult.

Having looked at the energy expenditure and energy requirements, let us study about the other nutrient requirements. We shall first have a look at the macronutrients followed by the fluids and micronutiients.

Macronutrient Requirements

Carbohydrates: High carbohydrate diets are beneficial at HA. The advantage of high carbohydrate diet is that respiratory quotient (RQ) of carbohydrate diet is around 1.0; on the other hand, if fat is exclusively taken, then RQ is 0.7. In high terrestrial altitudes, alveolar PO_2 falls with a fall in barometric pressure and when there is a shift of RQ from 0.7 to 1.0, there is an increase in PO_2 and this gives rise to the increase in arterial oxygen saturation. Carbohydrates provide a higher yield of energy per mole of oxygen. The energy equivalent of oxygen is 4.48 Kcal/L for protein, 4.7 Kcal/L for fat and 5.06 Kcal/L for carbohydrate. Diets high in carbohydrates are shown to enhance the glucose metabolism at high altitude. Studies on dietary habits of Indian sea level residents and natives of high altitude show that up to 60% energy is derived from carbohydrates.

Negative nitrogen balance is reported at high altitude and this is mainly due to decreased food intake. Extensive studies on nitrogen metabolism at both acute and after long-term stay at high altitudes on Indian soldiers indicate positive nitrogen balance at 12 g/day dietary nitrogen intake.

- *Fut:* There is no change in fat digestibility at altitude of <4500 m. However, at extreme altitude, there are reports that fat absorption gets impaired. Intake of fat decreases due to anorexia.

D-xylose excretion, which is used as test of the absorptive activity of upper part of small intestine also remains normal, indicating that absorptive functions of the small intestine are not disturbed at high altitude up to 5000 m.

Fluid, Electrolyte and Micronutrient Requirements

- *Fluids and Electrolyte:* In addition to cold induced diuresis, hyperventilation together with a dry environment at HA makes an individual prone to hypohydration. Acute exposure to inoderate altitude causes transient hypohydration, which is due to an increased diuresis and reduction in thirst perception. Prolonged stay at extreme altitudes may cause severe salt and water retention. The role of hormones in normal fluid metabolism at high altitude is not clear, but a number of hormones play a role in retention of salt and water in pathologic states like acute and sub-acute mountain sickness.

- *Minerals*: Increased urinary excretion of Na^+ and K^+ on exposure to hypoxia is reported while some workers have found only increase in Na^+ with a decrease in K^+ excretion.

  At high altitudes, though there is always a balance between blood formation and destruction, still there is no evidence for increased dietary iron requirements. The requirements of increased haemoglobin synthesis during early phase of stay at altitude are fulfilled by redistributing body stores and from dietary iron. Urinary excretion of $Zn^{2+}$is more during physical exertion as observed during an expedition to Mt Everest. Reduced zinc levels are associated with anorexia.

- *Vitamins:* It is observed that requirement of vitamins is not different as compared to plains. In humans, exposure to high altitude has been reported to cause a marked increase in lipid peroxidation. Antioxidant nutrients such as vitamin E, C and A (β-Carotene), as well as, selenium, copper, zinc and manganese may be required in greater amounts in cold and high altitude environments to prevent oxidative stress. These antioxidants act in a concerted manner to combat the oxidative stress arising from different sources, β-Carotene protects against photo-immuno-suppression caused by long-wave UV radiation encountered in outdoors. During rough weather, when supply of fresh fruits and vegetables becomes limited at high altitude, vitamin C supplements are recommended due to its antioxidant role.

Now that we are well versed with the nutrient requirements, let us test our knowledge of the topic by answering the check your progress exercise 2.

Check Your Progress, Exercise 2

1) Define extreme environment. List a few factors which present high altitude as an extreme environment.

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2) State three characteristics of high altitude environment.

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3) Discuss the micronutrient requirements at high altitude.

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4) Multiple choice:

i) An increase in body size and lean body mass leads to:.

a) decrease in BMR

b) increase in BMR

c) no change in BMR

ii) During the first few days of ascent to high altitude haematocrit value:

a) increases

b) decreases

c) unchanged

iii) The respiratory quotient of carbohydrate is:

a) 1.0

b) 0.85

c) 0.7

iv) High altitude induced weight loss is mainly attributed to:

a) hypobaric hypoxia induced anorexia.

b) chemical hypoxia induced anorexia.

c) intense solar radiation

v) The best way to avoid acute mountain sickness is:

a) immediate evacuation to lower altitude

b) gradual ascent at heights above 3000 m

c) say at high altitude and get treated for the symptoms first

5) Match column A with B:

A	B
a) Negative nitrogen balance	1) Diving
b) Antioxidants	2) Decreased food intake
c) photo-immunosuppression	3) Oxidative stress
d) Increased pressure	4) W irradiation

6) State whether the following statements are true (T) or false (F):

a) The atmospheric concentration of oxygen remains at a constant 20.93%. (T/F)

b) Ascent to high altitude possibly increases capillarization of skeletal muscle. (T/F)

c) Intake of fat increases above 4500 m due to high energy requirement. (T/F)

d) The PO_2 in air at an altitude of 20,000 ft is 110 mm of Hg. (T/F)

e) The energy equivalent of oxygen for carbohydrate is 5.06 Kcal/L. (T/F)

Let us now proceed with our journey to the poles now and see how our nutrient needs vary due to extreme cold conditions, the various mechanisms by which our body adapts to such conditions and thrives successfully.

18.4.4 Nutritional Requirements in Cold and Polar Environment

Energy requirements are the major consideration for providing nutritional support in a cold environment. Energy expenditure is usually limited by the rate of heat buildup and hypoxia, respectively in hot and altitude environments whereas in cold, no such type of restriction exists. Energy requirements in cold environment are influenced by the intensity of the cold, wind speed, physical factors (like melting snow, locomotion on icy or snow covered surfaces etc.) and altered solar periodicity in Arctic and Antarctic areas. Cold exposure increases energy requirements. It is reported that people in cold climate normally eat more than those in warm climate. The increased energy requirements are due to the 'hobbling' effect of the clothing weight (7-10 kg) and are associated with the efforts of locomotion. The weight of cold weather clothing has decreased as technology has improved; however, clothing is still a considerable burden. It appears that the heat loss in a cold environment is considerably reduced through thermoregulation, clothing and behaviour i.e. seeking shelter whenever possible, creating or moving to warmer environments. Moreover, skeletal muscle contractions, either during voluntary exercise or involuntary shivering are the major source of metabolic heat produced to protect against cold stress. These are a few mechanism adapted by our body to regulate, the body temperature in conditions of cold. Let us next get to know about the concept of *thermoregulation*. How is it beneficial, as well as, essential to us?

Thermoregulation in Cold

Heat production parallels the increase in O_2 uptake, the magnitude of which depends on the muscle mass .engaged in shivering or work and the duration of activity. Shivering alone can produce only a four-fold increase above basal rates of heat production. The increase in O_2 uptake during shivering thermogenesis is also accompanied by an increase in cardiac output. This increase is due to increase in stroke volume, which is associated with cold-induced peripheral vasoconstriction. The effect of the mechanisms used to protect against heat loss depends on the body surface area in comparison with body mass. The problems may arise in malnourished subjects who have lost both fat mass, as well as, lean body mass. Cold acclimatization can occur in human subjects but it is minimal. An important modifying factor on the thermoregulatory response to cold is the individual's provision of subcutaneous fat, since fat reduces thermal conductance from the core to the body surfaces. Physical fitness has mixed effects; the fittest individuals show more heat production but at the same time, being lean in structure, they lose heat more quickly. Severe losses of body weight in a cold environment complicate the normal physiological responses to cold. Thus, maintaining an adequate intake in cold environment especially under physically active conditions is important. There is a common belief that cold climatic conditions lead to an increased appetite. The evidence for this conclusion is derived from changes in body weight; self reported intakes in cold environment at sea level (SL). However, the reported increase in appetite is also associated with changes in other aspects of subject's environment such as increased activity levels, energy expenditure due to thermogenesis, social isolation and modification in the diet. In animals, increased energy expenditure caused by increased thermogenesis due to cold environment is compensated by increased intakes,

In human subjects, increased energy intake requirements do not always trigger an increase intake and appetite immediately. Humans can adapt over **a** period of time to a high fat diet to make the food energy dense.

Now that we are aware of the concept of thennoregulation, let us look at the dietary patterns and the factors affecting food intake of the people residing in cold conditions.

Food Intake during Polar Expeditions

Observations made by *Easty* (1967) at Halley Bay, the British Antarctic survey base during 1961-62 expeditions indicate mean calorie intake 3600 Kcal/man day and 12.7% of those calories were supplied by protein, 39.8% by fat and 48.1% by carbohydrates. During winter months (polar night), when men were confined to the limits of base and activities showed a marked fall and there was a gain of body weight ~ 2.5 kg. Various Indian Antarctic expeditions have a common observation of increase in body weight that is mainly due to an increased intake. Several factors are responsible for an enhanced appetite in cold regions, that include the palatability of food, cold temperature, emotional factors (e.g. loneliness) and changes in physical activity and habits. The average energy expenditure was found to be 3100 Kcal/day indicating an active life style of expedition members.

The dietary pattern of natives of arctic and sub arctic regions and their obvious success in coping with harsh environment have influenced arctic explorers to choose diets high in fat in general belief that this may be helpful. Such information is largely anecdotal and probably relates more to the availability of local foods (seal, fish, whale, caribou) and familiarity of Eskimos with these foods. However, such diets are rich in n-3 fatty acids, which play an important role in the prevention of cardiovascular diseases.

Despite the arguments that can be made for suitability of high fat diets in the cold, there is an evidence suggesting that carbohydrates are more important than fat in fueling metabolic heat production during cold exposure. Increase in energy expenditure resulted in an increase in carbohydrate and fat oxidation while protein oxidation remains unaffected.

Let us go through the Do's and Don'ts to be followed during polar expedition which are highlighted in Box 18.1.

Box **18.1** Do's and Don'ts for Recreational and Expedition Meal Planning	
DO provide groupkot meals whenever possible. People will generally eat more when warm meals are consumed 'socially'.	DON'T assume that everyone is eating adequately in group as a meal prepared is not essentially meal consumed.
DO schedule breaks for meals and snacks even when individual food has to be consumed for meal or snack. Left to their own, people generally skip meals to accomplish tasks.	DON'T allow junk food to substitute for meals. Snacks should augment or supplement daily meals to increase total energy intake and carbohydrates.
DO encourage increased fluid intake as water, soups and nonalcoholic beverages to ensure proper hydration.	DON'T compromise with personal hygiene. Clean hands, clean water and clean utensils are requisite for food safe meal preparation.
DO observe what food items are being consumed. Picky dietary habits can lead to imbalance in rnicronutrients.	DON'T permit individuals to use the expedition as 'crash' weight loss programme as this can be harmful for individual, as well as, team mission.

Check Your Progress Exercise **3**

1) State.the factors responsible for the increased energy requirements in cold and polar environment.

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....

2) What is the role of an individual's subcutaneous fat and lean body mass in thermoregulatory response?

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....

3) Mention the factors which increase food intake in Antarctica.

....

....

4) Multiple choice:

i) The gain of body weights in polar nights is due to:

a) increase in food intake

b) increase in food intake and decrease in physical activity

c) decrease in physical activity

ii) Arctic explorers choose high fat diet because:

a) fat is responsible for producing more metabolic heat

b) it contains n-3 fatty acids which reduce the risk of cardiovascular disease.

c) they were influenced by the dietery pattern of the natives of Arctic regions.

iii) An average energy expenditure of Indian Antarctic expedition:

a) 3100 Kcal/day

b) 4500 Kcal/day

c) 1300 Kcal/day

iv) Increase in energy expenditure in cold results in:

a) increase in carbohydrate and fat oxidation

b) Increase in protein oxidation

c) Increase in carbohydrate oxidation

5) Match the following:

A		B	
a)	Shivering	1)	Peripheral vasoconstriction
b)	Increased cardiac output in cold	2)	Prevents loss of core temperature
c)	Subcutaneous fat	3)	Thermogenesis

From cold environments, we now move on to hot environmenls. So, from the poles, let us move towards the equator and find out nutritional requirements of people in extreme hot conditions.

18.4.5 Nutritional Requirements in Hot Environments

Hot environments may be of two types: dry hot, as in the case of deserts or hot and humid in tropical rain forests and coastal regions. Factors other than air temperature determine physiological strain imposed by the heat stress. These factors include individual variations in body size and fatness, acclimatization, and external factors such as air currents, heat gain due to radiation, intensity of work, clothing and relative humidity. Various practical heat stress indices (e.g. wet bulb-globe temperature, Heat Stress Index) make use of, ambient tempe ature, radiant heat and relative humidity to evaluate the environmental potential heat challenge for humans working under that environment. Refer to Table 18.8, which highlights the effects of heat stress.

Table 18.8: Effects of heat stress

• Decreased Gastrointestianl Functioning
• Increase in Core Temperature
• Decrease in Gastric Emptying and Intestinal Motility
• Hypohydration
Leads to Decreased Physical and Mental Functions
• Heat Cramps, Flatulence, Vomiting, Diarrhoea and Nausea
Heat Stroke

However, it is important to know that an adequate fluid replacement overshadows all other considerations of nutrient requirements for work in a hot environment. Drinking adequate amount of water at regular intervals prevents dehydration, heat, illness and maintains work performance. Heat acclimatization relatively has no effect on water requirements. Thirst is a poor indicator of hydration status. Intense thirst is usually noticed at 5 to 6% body weight loss due to hypohydration (removal of water). By this time, the physical performance is compromised. Severe hypohydration can lead to a decreased blood volume and an increase in the plasma osmolality, which can result in decreased sweating and heat dissipation.

Eighty percent of the energy metabolized during exercise in hot environment is liberated as heat (only 20% is utilized as mechanical work) and 80-90% of heat dissipation during work in a hot-dry environment is accomplished by the evaporation of sweat. Each milliliter of sweat evaporated from the skin leads to heat loss of approximately 0.6 Kcal. Sweat rates vary to a great extent from an individual to individual, but can reach *2* L/h for prolonged time periods. Hypohydration depends in a large part upon sweat rate, which, in turn, is determined by workload and duration. Other environmental factors are solar load, wind speed, relative humidity and clothing, The influence of these factors on water requirement is given in Table 18.9.

Table 18.9: Water requirements (L/h) far rest and work in the heat as influenced by solar load and temperature

	Indoor				Outdoor			
Temp °C & relative humidity %	**Rest**	**Light**	**Medium**	**Heavy**	**Rest**	**Light**	**Medium**	**Heavy**
30 @ 50	0.2	0.5	1.0	1.5	0.5	0.9	1.3	1.8
36@50	0.3	0.9	1.3	1.9	0.8	1.2	1.7	2.0
41 @ 30	0.6	1.0	1.5	2.0	0.9	1.3	1.9	2.0
46 @ 20	0.8	1.2	1.7	2.0	1.1	1.5	2.0	2.0
49 @ 20	0.9	1.3	1.9	2.0	1.3	1.7	2.0	2

The values for water requirement in L/hr are calculated according to the prediction model of *Shapiro et al.* (1982). Eur J Appl Physiol 48, 83.

Conditions assumed are clothing, tropical fatigues, heat acclimatized subjects, wind speed *2* m/s. To prevent hypohydration, fluid should be taken periodically whether one is thirsty or not.

Let us now have to look at the energy expenditure patterns and nutrient requirements.

Energy Expenditure in Hot Environments

Energy expenditure in hot environments is increased by a small but significant amount because of additional work of ventilation and increased sweat gland activity. There is a rise of ~ 10% in energy requirement at 38°C. Very few studies exist for energy determinations using doubly labeled water technique during heat exposure; energy expenditure is reported to be 4750 Kcal/day in hot and humid jungle environment and 4000 Kcal/day for hot wet and 4200 kcal/day for hot dry desert conditions. Excessive nitrogen losses are reported in perspiration of unacclimatized people but not in acclimatized persons. The nitrogen'concentration in perspiration is small and decreases with an increase in perspiration rate; as 90% of the excretion of nitrogen is in faeces and urine and it is not significant enough to warrant extra protein in the diet in tropics

We shall now proceed with nutrient requirements.

Vitamin and Mineral Requirements

There is no extra need of vitamins. Although loss of water-soluble B-vitamins is minimal, a deficiency could occur over time from profuse sweating coupled with an insufficient dietary intake.

Because thiamin, riboflavin, niacin and vitamin B_6 are important to energy metabolism, the level of these vitamin intakes should be related to amount of food consumed. Role of vitamin B_6 in carbohydrate metabolism was established in 1990. As much as 80% of the body's vitamin B_6 is present in muscle, as coenzyme of glycogen phosphorylase, that is first enzyme in glycogenolysis. If calorie intake is not sufficient to meet the demands of work in heat, then vitamin intake will be compromised as well and supplementation would be required. Ascorbic acid may have some unexplained benefits when consumed above the usual dietary requirements during work in heat.

Minerals and Electrolyte Requirements: It was found that no extract intake of iron is needed and NaCl requirements increase due to loss in sweat; 15 to 16 gm of salt normally taken in diet is quite adequate for acclimatized people. With acclimatization for three days, the sodium losses in sweat gel reduced. However, body is not able to conserve for potassium losses. Therefore, supplementation of potassium in drinks may enhance the process of acclimatization. Coconut water is a good source of potassium.

Finally, let us study about the nutritional requirements for astronauts involved with space missions.

18.4.6 Nutritional Requirements for Space Missions

Space exploration represents a new frontier in the nutritional sciences and humans are eating in space since Cosmonaut *Yuri Gagarin's* 108 min flight in 1961. Human presence in space has been almost continuous since these early flights. Missions have ranged from about 15 minutes to 14 months. Until the beginning of the International Space Station, all human habitable spacecrafts were built by Soviet Union or the United States, and both countries have made enormous contributions to the human space flight capabilities, sciences and technology. Throughout the history of human space flight, life sciences research has been an integral part of the missions. As the mission duration increased, the framework of nutrition/research has expanded dramatically. Defence Food Research Laboratory (DFRL), Mysore developed foods for *Sqdn. Ldr. Rakesh Sharma* for his 7-day space voyage in joint Indo-Soviet manned space mission in April 1984 under programme named 'Pavan'.

Varied environmental conditions away from the planet earth are bound to bring certain changes in the body composition of astronauts which might influence the nutrient needs. So before we move on to the nutrient needs, let us study about these changes in the body composition.

Changes in Body Composition

Major stress in space is *microgravity*. Microgravity refers to *an environment in which there is very little net gravitational force, as of a free-falling object, an orbit, or interstellar space.* Now let us look at the effects of microgravity, which are listed in Table 18.10.

Table **18.10: Effects of microgravity on humans**

Space motion sickness	Experienced by 60-70% of astronauts and cosmonauts; produces malaise, headache, anorexia, nausea and vomiting. Symptoms appear early in flight and last about -7 days.
Cardiovascular deconditioning	Ceplialad shift of fluid estimated at 1.5 to 2.0 litres from lower extremities, decreased orthostalic tolerance, increased heart rate, decrease in pulse pressure, tendency towards spontaneous syncope.
Haematological changes	Reduction in plasma volume and red blood cell mass.
Bone mineral loss	Loss of total body calcium in both humans, as well as, animals flown to space from 1 week to more than 237 days.
Muscle deconditioning	Loss of lean tissue and decreased muscle strength.

Several of the pathophysiological changes associated with space flight manifest themselves as the changes in bocly composition. Space flight presents a unique challenge for quantifying body composition changes since fluid, bone, muscle and adipose tissue levels all vary independently of one another in space, and body weight loss does not follow classical pattern. The body mass measurements were taken for the first time during 28 to 84 day Skylab mission and revealed 0.91 to 3.64 kg losses of preflight body weight, Analysis of component of the weight loss was based on both direct whole body measurements and on indirect metabolic balance data. A conclusion from the analysis was that more than half of the weight loss was from fat free mass and remaining from the fat stores. About half of the total weight loss that occurred within the first two days of flight was due to water loss. All studies of fluid balance during microgravity liave indicated a decrease in total body fluids of approximately 500-900 ml.

Most important is muscle loss and limited resistive exercise by crewmembers liave been helpful in prevention upto some extent. Skeletal losses unlike muscle losses do appear to be related to the length of flight. About 0.4% to 1.0% of bone minerals are lost per month during space-flight. The role of nutrition in musculoskeletal losses during space flight has not been clearly defined, but data from Skylab missions demonstrate negative nitrogen and potassium balance despite supposedly adequate ingestion of energy and protein. Return to earth poses a major concern. Stress fractures, muscle pulls, ligament stress and inability to ambulate occur and may take 2-8 weeks to resolve. Although experience with long-term space flight has provided considerable confidence in the ability **of** human body to recover from space flight and readapt to the earth environment, effects observed on the long Sky lab, Mir and Shuttle-Mir missions have convinced the researchers that countermeasures and monitoring are essential to success of space flight.

Now with this basic knowledge about changes in the body composition, let us find out the nutritional requirements meant for space flight. Review the nutritional recommendations given in Table 18.11 to find out how these are different from the normal recommendations.

Nutrient Requirements

The nutritional recommendations for space flight are listed in Table 18.11.

Table 18.11: Nutritional recommendations for space flights

• **Men**	18 - 30 yrs.	Kcal/d = 1.7 (15.3 w + 679)
	> 30 yrs	Kcal/d= 1.7 (11.6 w + 879)
• **Women**	18-30y	Kcal/d= 1.6 (14.7 w + 496)
	>30 y	Kcal/d= 1.6 (8.7 w + 829)
• **Fluid**	~2 lit/d	

- **Macronutrients**

Protein	12 - 15% of total calories and animal to plant ratio 60:40
Fat	30 - 35%
	(PUFA:MUFA:SFA 1: 1.5 - 2.0 :1
CHO	50 - 58%
Sodium	1.5 - 3.5 g/d
Potassium	3.5 g/d
Calcium	1.2 g/d
Phosphorous- not more than 1.5 times of calcium	
Magnesium	350 mg/d

- **Micronutrients**

Vitamins

Vitamin A	1000 yg RE/d
Vitamin D	10 µg/d
Vitamin E	20 mg/d
Vitamin K	80 µg/d (men), 65 µg/d (women)
Vitamin C	100 mg
Folate	400 µg
Vitamin B_{12}	2.5 µg
Thiamin	1.5 mg
Riboflavin	1.5 mg
Niacin	20 NE
Vitamin B_6	2.0 mg
Biotin	50 µg
Pantothenic Acid	5.0 mg

Trace Elements

Iron	10 mg
Manganese	2-5 mg
Zinc	15 mg
Chromium	100-200 µg
Copper	15-3.0 mg
Iodine	150 µg

Now that we have learnt about the nutrient needs, let us get to know how to meet these requirements through food systems. Space food systems are unique. Why these are unique from our normal day-to-day life and the modifications and are essential to meet altered requirements, are highlighted next. We shall begin our study with a review on how these space food systems got introduced. Interestingly, these food systems were faced with a few drawbacks and then improved with each space programme and got into present shape, meeting nutritional demands and food preferences of consumers. So then let us get started.

Space Food System

Mercury (1961-1963) astronauts had to eat bite-sized cubes, freeze dried powders, and semi liquids stuffed in aluminium tubes. For most astronauts, the foods were unappetizing and squeezing the tubes was disliked. Moreover, it was difficult to rehydrate freeze-dried foods and crumbs had to be prevented.

Further, during the Gemini missions (1964-1967), eating improved somewhat. The first things to go were the squeeze tubes. Bite-sized cubes were coated with gelatin to reduce crumbling, and the freeze-dried foods were encased in a special plastic container to make reconstituting easier. With improved packaging came improved food quality and menus. Gemini astronauts had food choices as shrimp cocktail, chicken and vegetables, butterscotch pudding, and apple sauce, and crew was able to select meal combinations.

By the time of the Apollo programme (1968-1972), the quality and variety of food increased. Apollo astronauts were the first to have hot water, which made rehydration of foods easier and improved the taste of food. Astronauts were also first to use the "spoon bowl," a plastic container that could be opened and its contents eaten with a spoon.

The task of eating in space improved to a great extent in Skylab (1973-1974). Unlike previous space vehicles for astronauts, Skylab featured a large interior area where space was available for a dining room and a table. Eating for Skylab's three-member teams was a fairly normal operation: footholds allowed them to situate themselves around the table and "sit" to eat. Added to the conventional knife, fork and spoon, was a pair of scissors for cutting open plastic seals. Because Skylab was relatively large and had ample storage area, it could feature an extensive menu: 72 different food items. It had a freezer and a refrigerator also.

Shuttle (1981onwards) astronauts have a variety of food items to choose from. They may eat from a standard menu designed around a typical Shuttle mission of 7 days, or may substitute items to accommodate their own tastes. Astronauts can design their own menus. But a dietitian has to ensure balanced supply of nutrients from these astronaut-designed menus.

The standard Shuttle menu repeats after 7 days. It supplies each member with three balanced meals plus snacks. Each astronaut's food is stored aboard the Shuttle and is identified by a coloured dot affixed to each package.

On the Space Shuttle, food is prepared at a galley installed on the orbiter's rnid-deck. The galley is a *modular unit that contains a water dispenser and an oven.* The waler dispenser is used for rehydrating foods and the galley oven is available for warming foods.

Conventional eating utensils are used in space. Astronauts use knife, fork and spoon. The only unusual eating utensil is pair of scissors used for cutting open the packages. Following the meal, food containers are discarded in the trash compartment below the mid-deck floor. Eating utensils and food trays are cleaned at the hygiene station with premoistened towelettes.

Shuttle food system functions well in space. It consists of familiar, appetizing, well-accepted food items that can be prepared quickly and easily. A full meal for a crew of four can be set up in about 5 minutes. Reconstituting and heating the food takes an additional 20 to 30 minutes about the time it takes to fix a snack at home, and far less than it takes to cook a complete meal.

Let us find out the different types of foods that are included in the space food system next.

Types of Foods

Weight and volume have always been the primary design factors for every piece of hardware launched into space. The shuttle is no exception. Weight allowed for food is limited to 1.72 kg per person per day, which includes the 0.45 kg of packaging weight. This as you would realize, require special processing and packaging technique. What are these? Let us see.

Foods are individually packaged and stored for easy handling in the zero gravity of space. All food is precooked or processed so it requires no refrigeration and is either ready-to-eat or can be prepared simply by adding water or by heating. The only exceptions are the fresh fruits and vegetables stored in the fresh food locker. Without refrigeration, the carrots and celery must be eaten within the first two days of the flight.

The various types of foods are enumerated herewith. Figure 18.2, illustrates space food items.

Thennostabilized (T): Heat processed foods ("off-the-shelf' items) in aluminium or bimetallic tins and retort pouches.

Irradiated (I): Foods preserved by exposure to ionizing radiation and packed in flexible foil-laminated pouches.

Intermediate Moisture (ZM): Dried foods with a low moisture content such as dried apricots, which are packed in flexible pouches.

Freeze Dried (FD): Foods that are prepared to the ready-to-eat stage, frozen and then dried in a freeze dryer which removes the water by sublimation. Freeze dried foods such as fruits may be eaten as it is while others require the addition of hot or cold water before consumption.

Rehydratable (R): Dried foods and cereals that are rehydrated with water produced by the Shuttle Orbiter's fuel cell system, packed in a semi-rigid plastic container with septum for water injection.

Natural Form (NF): Foods such as nuts, crunch bars and cookies. Packed in flexible plastic pouches.

Beverages (B): Dry beverage powder mixes packed in rehydratable containers.

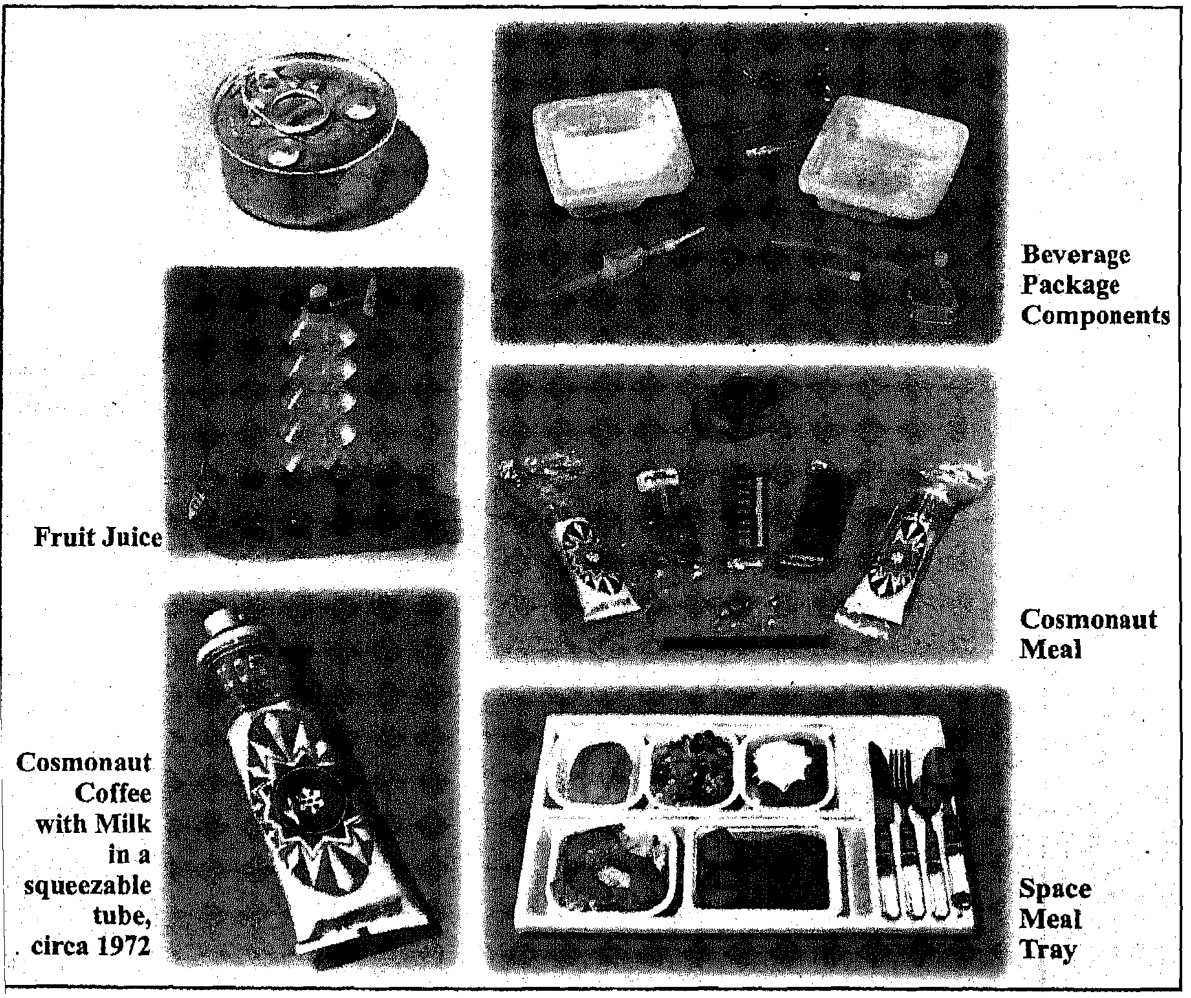

Figure 18.2: Space food items

Another aspect which requires mention while talking about space nutrition is space crop and bioregenerative system. What is this concept? Read the subsequent discussion and find out.

Space Crops and Bioregenerative System

What is a bioregenerative system? Why is it essential?

Nutritional requirements for long flights have been refined, placing more demands on food development. Despite the technological advances and increased variety, most space crews, with the exception of **Sky** labs Astronauts have not met the nutritional requirements. This problem must be solved. An integrated approach for various studies has been proposed during the meeting at Bad Honnef, Germany in September 1998. Biotechnology holds great promise for devising specific foods that would meet many of the stringent mission requirements. The use of plants in coinbination of physicochemical technologies for supply of fresh food, water and oxygen has shown to be promising for human life support during planetary exploration. The bioregenerative system for growing food in hydroponic plant growth chambers may be advantageous. However, this will require an additional training of growing and harvesting of crops and selection of various plant species and even use of genetically modified ones for high yields. A primary concein in use of plants is requirement of high light intensity for better yield. Various studies on plants growth under controlled environments have been carried out and some of the plants selected are wheat, lettuce, soybean, potato, sweet potato, tomato, radish, spinach and strawberry. Significant research and development is still required using ground based models and real flight before a bioregenerative food system can be chosen for the sojourn on the Moon or Mars.

Check Your Progress Exercise 4

1) Mention the names of a few plants which has been selected for space crops and bioregenerative system.

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....

2) Mention briefly the effects of microgravity on humans.

....

....

....

3) How does an intermediate moisture food item differ from a rehydrated food item?

....

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4) NASA provides 1.2 g calcium in diet to an astronaut in a space shuttle. Why?

....

....

....

5) Tick the correct answer:

i) More than half of the weight loss in space was from

a) fat free mass

b) fat reserves

c) water

ii) The amount of estimated bone mineral loss per month in space flight is

a) 0.1% - 0.4%

b) 0.4% - 1.0%

c) 1.0% - 4.0%

iii) Microgravity effect on humans can cause

a) decreased plasma volume and decrease in RBC mass

b) decreased plasma volume and increase in RBC mass

c) increased plasma volume and decrease in RBC mass

iv) Galley is a modulator unit which contains

a) a water dispenser and combustion fuel chamber

b) a toaster and water dispenser

c) a water dispenser and an oven

v) The nutritional recommendation for vitamin D in space flight is

a) 10 mcg/day

b) 100 mcg/day

c) 20 mcg/day

6) Match the following:

	A		B
a)	Freeze dried food	i)	Stress factor
b)	Natural form food	ii)	Increases taste of food
c)	Hot water	iii)	Semi-rigid plastic containers
d)	Microgravity	iv)	Crunch bars
e)	Rehydrated foods	v)	Fruits

18.5 LET US SUM UP

This unit discussed important aspects of nutritional needs during emergency situations and under environmental extremes.

Under emergency situation, energy intake of 2100 Kcal along with safe protein intake of 46 g is required. To prevent micronutrient deficiencies, variety of food items should be included in emergency ration for general feeding programme. On the basis of nutritional assessment, the supplementary feeding and therapeutic feeding programmes should be conducted.

For successful adaptation to environmental extremes such as hot, cold, hypoxic (high altitudes) and microgravity (space travel), nutrient requirements are different from normal condition. Various physiological changes take place as adaptive response to such environments. Proper planning, adequate intake of nutrients and fluids is **a** must for successful acclimatization during expeditions and stay under extreme environments.

18.6 GLOSSARY

Acclimatization	physiological and metabolic changes response to particular environment which help in adaptation to individual.
Acute Mountain Sickness:	a general term referring o a combination of symptoms, including headache, anorexia, nausea, vomiting and malaise.
Anorexia :	loss of appetite.
Calamity :	any great misfortune or cause of misery which is generally applied to events or disasters.
Cardiac output	total amount of blood being pumped by the heart over a particular period of time.
Chill blains	inflammation of the hands and feet caused by exposure to cold and moisture.
Cosmonaut :	a person trained to travel in a spacecraft.
Diuresis	is the production of urine by the kidneys.
Emergency :	an unforeseen occurrence or a combination of circumstances which calls for an immediate action.
Extreme environment :	an environment where basic needs, like acquisition of food, shelter and protection, require extraordinary efforts.
Famine	a widespread lack of access to food due to disaster that causes a collapse in the food production and marketing system.
Frostbite	damage to the skin from freezing clue to prolonged exposure to cold temperatures, usually below 32°F.
Galley	a modular unit that contains a water dispenser and an oven
Homeothermy	regardless of the environmental temperature, the normal body temperature must be maintained within a relatively narrow range.
Heat stroke	elevated body temperature as a result of fluid loss and failure of temperature regulatory center in hypothalamus.
High altitude	terrestrial heights above 2700 m, characterized by decreased barometric pressure resulting in hypobaric hypoxia.
Hydroponic	growing of plants without soil.
Hypohydration	decreased water intake induced by high altitude exposure.
Hypoxia :	decreased availability of oxygen at tissue level. Four types are 1) hypoxic hypoxia or hypobaric hypoxia when PO_2 is reduced 2) anaemic hypoxia is due to low haemoglobin **3)** ischemic hypoxia due to decreased flow of blood 4) histotoxic hypoxia is due to toxic chemicals.

Kwashiorkor	:	a form of protein energy malnutrition in which only protein is deficient.
Marasmus	:	a form of protein energy malnutrition in which a deficiency of energy in the diet causes severe body wasting.
Microgravity	:	reduced gravity to near zero due to lack of gravitational force in space.
Monitoring	:	an intermittent (regular or irregular) series of observations in time, carried out to sow the extent of compliance with **a** formulated standard or degree of deviation from an expected norm.
Protein-energy malnutrition (PEM)	:	a condition characterized by wasting and increased susceptibility to infection that result from the long term consumption of insufficient energy and protein to meet needs.
Respiratory Quotient	:	the ratio of the volume of carbon dioxide expired to the volume of oxygen consumed by an organism or cell in a given period of time.
Stroke volume		the amount of blood pushed into the aorta with each beat of the heart.
Surveillance	:	a repeated survey raising a standard methodology undertaken to provide a series of observations over time.
Syncope		Partial or complete loss of consciousness with interruption of awareness of oneself and ones surroundings. When the Ioss of consciousness is temporary and there is spontaneous recovery, it is referred to as syncope
Thermogenesis		the process of heat production.
Thermoregulation		the ability of an organism to keep its body temperature within certain boundaries, even when temperature surrounding is very different.
Vasodilation	:	the expansion of a blood vessel or capillaries of the skin in response to warm temperature, thus increasing the flow of blood to the surface.

18.7 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) Calamity is any great misfortune or cause of misery which is generally applied to events or disasters. Emergency is an unforeseen occurrence or a combination of circumstances which calls for immediate action or remedy. The major nutritional deficiency diseases effecting individuals include underweight, anaemia and marasmus. The cases of vitamin deficiency diseases i.e. blindness, scurvy, beriberi, pellagra and other deficiency diseases are also observed.

2) The factors which need to be considered are given in section 18.3. Read them and answer on your own.

3) The basic assumptions on which per capita energy requirements are recommended include:

- The age/sex distribution of the population is a characteristic of developing countries
- The mean height of adult men and women are 169 cm and 155 cm respectively, which is the approximate value in sub-Saharan Africa
- The body mass index (BMI) (kg/m^2) is between 20-22
- Physical activity is light
- All infants are breast-fed from birth to 6 months, and half of the infants of 4-11 months are still breast-feeding and deriving half of their energy and protein requireinent from breast milk

4) There are several approaches for preventing the onset of micronutrient deficiencies in emergency situations affecting large populations. These include: increasing the daily ration, varying the composition of food basket, including micronutrient fortified foods in ration, and providing supplementation when there is likely to be a specific deficiency based on dietary assessment and overt signs and symptoms. The general ration must provide for a minimum intake of 2100 Kcal per person per day.

5) a) - v)
b) - iii)
c) - iv)
d) - i)
e) - ii)

6) i) - a)
ii) - b)
iii) - b)
iv) - b)
v) - b)

Check Your Progress Exercise 2

1) An environment where basic needs, like acquisition of food, shelter and protection, require extraordinary efforts.

2) Any three of the following: decrease oxygen availability and barometric pressure, decrease in haemoglobin saturation, increased energy expenditure, hypoxia, and altered taste thresholds.

3) Refer to the micronutrient requirements given in sub-section 18.4.3 and answer the question on your own.

4) i) - b)
ii) - a)
iii) - a)
iv) - a)
v) - b)

5) a) - ii)
b) - v)
c) - iv)
d) - i)
e) - iii)

6) a) True
b) True

c) False

d) False

e) True

Check Your Progress Exercise 3

1) The factors responsible for the increased energy requirements in cold and polar environment include:

   a) The increased energy requirements are due to the 'hobbling' effect of the clothing weight (7-10 kg) and are associated with the efforts of locomotion.

   b) Energy expenditure in hot environments is increased by a small but significant amount because of additional work of ventilation and increased sweat gland activity.

2) An important modifying factor on the thermoregulatory response to cold is the individual's provision of subcutaneous fat, since fat reduces thermal conductance from the core to the body surfaces. The effect of the mechanisms used to protect against heat loss depends on the body surface area in comparison with body mass.

3) Individual variations in body size and fatness, acclimatization, and external factors such as air currents, heat gain due to radiation, intensity of work, clothing and relative humidity increases food intake in Antartica.

4) i) - a)
   ii) - a)
   iii) - a)
   iv) - c)

5) a) - iii)
   b) - i)
   c) - ii)

Check Your Progress **Exercise** 4

1) Wheat, lettuce, soybean, potato, sweet potato, tomato, radish, spinach and strawberry.

2) Refer to Table 18.10 in sub-section 18.4.6 and answer the question on your own.

3) Intermediate moisture food item are those with low moisture content such as dried apricots, which are packed in flexible pouches. Rehydrated foods are dried foods rehydrated with water, packed in a semi-rigid plastic container with septum for water injection.

4) NASA provides 1.2 g calcium in diet to an astronaut in a space shuttle because about 0.4% to 1.0% of bone minerals are lost per month during space-flight.

5) i) - a)
   ii) - b)
   iii) - a)
   iv) - c)
   v) - a)

6) a) - v)
   b) - iv)
   c) - ii)
   d) - i)
   e) - iii)

UNIT 5 NUTRITION DURING STRESS

Structure

5.1 INTRODUCTION

We all experience stress at some time or the other in life. Stress is the condition or stimulus that threatens the body's homeostasis. Stress may be physical and/or mental and may develop due to a number of reasons. Emotional stress results from feelings of ambition, divine and desire but is perceived as positive. However strain, tension and anxiety due to death of a dear one, financial problems, divorce, unemployment, sickness and injury, etc. are negative forms of emotional stress. Physical stress may occur in the form of starvation, illness, surgery, infection, injury, burns or trauma. We must also remember here that following a major stress, patients often exhibit a characteristic behaviour. These include immobility, when patients are fearful of moving or interacting; withdrawal, when patients may cease being aware of their environment and become incommunicative; and antagonism, when patients may resist interaction and display hostility to those around them. Altered cerebral blood flow may also be a reason for altered mental state.

In this unit, we shall be discussing the metabolic alterations and the importance of good nutrition in combating the ill effects of stress such as surgery, burns, trauma and sepsis. We shall first however, brief ourselves regarding the major physical/metabolic changes which may develop once the stress response has been activated.

Objectives

After studying this unit, you will be able to:

- define a stress response,
- enlist the various phases of a stress response,
- discuss the physiological, hormonal and metabolic changes during situations of stress such as surgery, burns, trauma and sepsis, and
- describe the nutritional support required for these stress conditions.

5.2 THE STRESS RESPONSE

The terms trauma, stress, shock are very often used interchangeably and encompass a variety of conditions such as sepsis (infection), burns, injury (accidents, wounds), surgery (elective/emergency) etc. Before we proceed towards understanding the physical and metabolic responses of the human system towards stress, it is important to remember that whether the event is in the form of sepsis (infection), trauma (including burns), or surgery, once the systemic response is activated, the physiologic and metabolic changes that follow are similar and may lead to shock and other outcomes. Variable responses relate to patient's age, previous state of health, pre-existing disease, type of infection and presence/absence of multiple organ dysfunction syndrome (MODS).

It has long been recognized that the physiological response of the patient to a stress or disease process will very largely determine the outcome. To an extent this will depend on the extent of the shock and injury; this tends to be minimal for minor surgery or injury and extensive for major accidental or surgical trauma. However, the physiological reserve of the individual is also important. Signals that are initiated in injured or ischaemic tissues communicate the extent of the injury systemically. These stress responses are necessary for the process of recovery from injury. However, when trauma is severe, the resultant physiological responses are extensive and sustained, such that the same responses may be detrimental and contribute to the progression to critical illness and even death. Stress response means major changes in metabolism that occur after severe injury, illness or infection. The nutrient needs of the body are greatly altered as a result of this response. There is accelerated catabolism of lean body or skeletal mass resulting in muscular wasting and a negative nitrogen balance. The metabolic responses to critical illness have been studied in a variety of critically ill patients, especially those with trauma, burns, or sepsis. The responses are often grouped into phases on the basis of their temporal relation to the injury or insult. The stress response is therefore referred to as a dynamic process that has an *ebb phase*, a *flow phase* and an *anabolic phase*. Let us discuss these phases one by one.

***Ebb - Phase*:** This occurs immediately following injury and lasts for approximately 24-hours. The so-called ebb phase, which is the early phase of the injury response, is characterized by:

- an elevated blood glucose level,
- normal glucose production,
- elevated free fatty acid levels,
- low insulin concentration,
- elevated levels of catecholamines and glucagon,
- an elevated blood lactate level,
- depressed oxygen consumption,
- below-normal cardiac output, and
- below-normal core temperature.

The ebb phase is dominated by cardiovascular instability, alterations in circulating blood volume, impairment of oxygen transport, and heightened autonomic activity. Emergency support of cardiopulmonary performance is of paramount therapeutic concern. Shock is the clinical manifestation of the ebb phase. After effective resuscitation has been accomplished and restoration of satisfactory oxygen transport has been achieved, the next phase i.e flow phase comes into play.

Flow Phase**:** This is a neuro-endocrine response to physiological stress following the ebb phase. This phase is characterized by:

- normal or slightly elevated blood glucose level,
- increased glucose production,
- normal or slightly elevated free fatty acid levels, with flux increased,
- a normal or elevated insulin concentration,
- normal or elevated levels of catecholamine and an elevated glucagon level,
- a normal blood lactate level,
- elevated oxygen consumption,
- increased cardiac output, and
- elevated core temperature.

It is characterized by hyper metabolism /catabolism. Increased cardiac output, urinary nitrogen losses, oxygen consumption, body temperature and energy expenditure occurs during the flow phase. There are also profound hormonal changes. As a result, there is breakdown of body protein stores to provide glucose and hence a rapid loss of nitrogen in the urine. Blood flow to the gastrointestinal tract is often reduced during this phase. This decreases the supply of oxygen and nutrients to the gastrointestinal tract. The secretion of mucus is decreased, whereas, gastric acid secretion is increased. This leads to wasting of the cells lining the gastrointestinal tract resulting in diarrhoea and bloating.

Recovery or Anabolic Phase**:** When wounds are closed and infection has resolved, repletion of lean tissue and fat stores along with restoration of strength and stamina can begin. This final, anabolic phase often begins near the time of hospital discharge and may persist for months before the patient fully recovers and is characterized by building up of body tissue and nutrient stores (anabolism). This phase is also marked by hormonal changes. There is an increase in the release of insulin and growth hormones. The patient's progress to the anabolic phase is important and depends on a number of factors. Age, severity and duration of the stress, as well as, the individual's prior nutritional status influence tissue growth and anabolism. Attempts to restore body mass and nutritional status rapidly may induce adverse metabolic consequences. Underweight and overweight patients and the elderly are particularly vulnerable to overfeeding, because of the difficulties in assessing true requirements.

Patients with ample nutrient stores to draw on during stress are better able to tolerate the negative effects of the stress, especially in case of emergency or unexpected stress. Having learnt about the stress response and its three phases, next let us move on to the study of the stress conditions, namely surgery, burns, trauma and infections, which have a great impact on metabolism

We shall first begin with surgery. We will learn about the changes in the metabolism of the body before and after surgery and how can an appropriate nutrition support minimize the stress/contraindications of surgery thereby promoting a speedy recovery.

5.3 SURGERY

Surgery ! Does the word itself not create a feeling of anxiety and bring our thoughts towards a debilitating state of health which would be accompanied by pain, inability to move and a high susceptibility for severe morbidity/mortality! Well, surgery, in fact, is one of the most stressful situations encountered in life. But have you ever focused your thoughts as to what exactly does the term surgery mean? or during which situations is surgery performed? What is the impact of a surgical procedure on our health and how can judicious utilization of medical and dietary services improve the ultimate outcome? Let us discuss these aspects one by one.

Well, surgery is that branch of medical science which has for its object the cure of local injuries or diseases, as wounds or fractures, traumas etc., whether by manual operation or by medicines along with constitutional treatment. A surgical procedure may be conducted in response to a sudden injury/trauma as you may have witnessed in case of road accidents/crush injuries. This is referred to *'Emergency Surgery'* during which the patient is in a variable state of resuscitation and the objective of treatment is to preserve as many organs and bodily functions as possible with minimum further trauma. Surgery however may not always be an outcome of an emergency. It may be undertaken as part of a well planned patient care process and involves removal or reconstruction of organs/body parts to promote treatment or for cosmetic purposes. Such surgical procedures are referred to as *'Elective Surgery'*. By-pass surgery of the heart, removal of organs, limb amputations, laproscopies are some common examples of elective surgery. The difference between elective and emergency surgery lies in the ability to prepare the patient for the injury and to control homeostasis/stress response in the elective surgical patient, while this is not possible in the traumatized patient. We must however remember here that whatever may be the form of surgery or its subsequent prognosis, the response of the human body to both forms of surgeries is quiet similar. In our subsequent discussions we will help you in understanding some of the key physiological/metabolic responses to surgery which in-turn affect the nutritional requirements of the patient.

5.3.1 Physiological Response to Surgery

Although advances in medicine and nutrition support have greatly reduced the morbidity and mortality associated with surgery, *debility* commonly accompanies surgical illness. It occurs in varying degrees after elective/emergency operations and other critical illnesses. Debility is caused by a variety of factors, including specific biochemical and physiologic alterations that usually occur in response to injury and disease, especially those that persist for a long time. Virtually all surgical patients experience some pain. Pain usually occurs in association with an incision or with a wound resulting from fracture, burn, contusion, or any other type of injury. In addition to creating an unpleasant subjective experience, pain often limits physical activities, such as turning in bed, deep breathing, coughing, and walking, and thereby directly interferes with recovery. Elevation of body temperature above normal, leukocytosis, and other signs of inflammation are common features of critical surgical illness and should be expected. The extent of temperature elevation is generally proportional to the severity of illness. In a patient with a major burn — an extreme example of critical surgical illness — body temperature may be as high as 39°C (102.2°F). The leukocyte count is also typically elevated and may be as high as 20,000 cells/ mm^3 during satisfactory recovery.

Food is commonly withheld from the patient before and during various diagnostic and therapeutic procedures. Patient is kept nil per oral (NPO) at least 6 hours prior to surgery. This restriction in diet before operation appears to be well tolerated by patients who were relatively well nourished before their critical illness. However, if food deprivation is prolonged, the complications of starvation will compound the effects of critical surgical illness. It is generally recommended that total starvation should usually be limited to a period no longer than 6-7 hours. However, patient is recommended to have liquitd or low residue diet one day prior to surgery.

Several metabolic changes also occur as a consequence of injury/surgery. For instance, injury caused by the operation initiates an inflammatory response resulting in the release of cytokines and acute phase proteins, along with the activation of stress hormones. The release of these mediators causes a change of metabolism into a catabolic state. There is a rise in the levels of circulating cortisol due to increased production of the adreno-corticotropic hormone from the pituitary gland. Cortisol mobilizes amino acids from skeletal muscle to provide the substrate for wound healing and for hepatic synthesis of new glucose. The excitement, pain, fear and hypovolemia that accompany surgery stimulate the sympathetic nervous system which leads to increased production of epinephrine by the adrenal medulla. Injury also initiates the release of aldosterone, (a corticosteroid that causes renal sodium retention, and of vasopressin (anti-diuretic hormone), which stimulates renal tubular water resorption. The action of these hormones results in conservation of water and electrolytes. Weight gain secondary to salt and water retention occurs due to changes in the response of pancreas. There is diminished secretion of insulin, whereas, glucagon production is increased. These responses are also a result of increased sympathetic nervous system activity. A rise in glucagon and fall in insulin levels are signals to accelerate glucose production and maintain gluconeogenesis. The postoperative hormonal responses are beneficial to the patient. Salt and water conservation support the circulating blood volume. Increased glucose production provides adequate fuel for the nervous system. Skeletal muscle protein breaks down at an accelerated rate after surgery resulting in the release of a variety of substances into the circulation, including creatinine, creatine, 3 methyl histidine, potassium, magnesium and amino-acids. The amino acids serve as precursors for protein synthesis in wound healing and in the liver. Lipid metabolism is also affected by critical illness. There is almost a two fold increase in glycerol turnover which is indicative of an accelerated rate of triglyceride hydrolysis to form free fatty acids and glycerol. There is also a high rate of free-fatty acid recyling.

Finally, a word about the convalescence stage.

Stages of Convalescence **:** This period of catabolism and alteration of the hormonal environment is known as the 'adrenergic – corticoid phase'. This is followed by a set of anabolism, which, in the absence of any postoperative complications, starts 3 to 5 days after a surgery. This 'turning point' from catabolism to anabolism is termed as 'corticoid – withdrawal phase' as there is spontaneous sodium and water diversion, and a reduction in nitrogen excretion. This phase lasts for 1 to 3 days. The patient then enters a period of early anabolism characterized by positive nitrogen balance and weight gain. Sustained feedings lead to protein synthesis and there is formation of lean mass and return of muscular strength. Then there is a final phase of late anabolism when there is much slower weight gain. There is deposition of body fat and nitrogen equilibrium is achieved.

Now that we are aware of the physiological response to surgery, let us in this context also understand dietary management of surgery.

5.3.2 Dietary Management during Surgery

Surgery increases the nutritional demands of the body and can lead to the elicitation of several nutritional deficiencies/imbalance. Malnutrition compounds the severity of complications as far as surgery is concerned and is associated with a high incidence of postoperative morbidity and mortality. The cellular processes involved in wound healing are critically dependent on adequate perfusion (delivery) of oxygen, glucose, and other essential nutrients. Inadequate perfusion may result in relative tissue ischemia (flow or flood restricted) and delayed wound healing. Nutritional support of critically ill patients is important both for promoting protein synthesis and other anabolic processes essential to recovery and for reducing the net drain on the patient's fuel and protein stores. Enteral nutrition is preferred, but the availability of effective intravenous techniques allows the clinician to provide appropriate nutrition to virtually all patients as you may recall reading in the last unit. Exercise and mobility have clear anti-catabolic effects and should be initiated as early as is practicable. A principal responsibility of the dietician is therefore to ensure adequate tissue perfusion during the entire period of wound healing. Thus, a complete nutrition and health assessment of the patient is essential to determine the macro-and micronutrient requirements before and after surgery. A complete assessment must include:

- Physical examination (anthropometric measurements such as ideal/usual body weight, skinfold thickness etc.);
- Clinical examination (presence/absence of oedema; abnormal changes in the skin, eyes, hair etc. cardio-pulmonary function, functional status of vital organs-kidney, pancreas, brain etc.);
- Bio-chemical examination (all important blood, urine, faecal components, as well as, enzymes/hormone levels that may be of immediate metabolic consequence)
- Medical and diet history.

A comprehensive dietary management regime of the patient should be based on the patient profile as gathered pre and post operatively and should be able to minimize the physiological and metabolic alterations associated with surgery. It should therefore be planned by keeping the following *objectives* in mind:

- To minimize/reduce the reasons of weight loss and depletion of tissue reserves
- To maintain an optimum energy and nitrogen ratio
- To achieve and maintain a healthy body weight
- To promote anabolism and hence wound healing
- To help in replenishing the depleted nutrient reserves

In view of the above mentioned objectives, we shall now discuss the nutritional management of patients before and after surgery. Let us start with the pre-operative nutritional care/patient preparation for an elective surgery.

A. Preoperative Nutritional Care

It can be provided only to prospective candidates of elective surgery and is not feasible for emergency cases. Preoperative malnutrition is often a cause of poor postoperative outcome. Nutritional support should be given for 7-14 days to moderately or severely malnourished patients undergoing a major surgery. Any nutritional deficiency should be corrected and nutritional reserves must be maintained for the surgery period as well as, for the immediate postoperative period to ensure proper rehabilitation.

Energy: The energy requirements of the patient should be based upon his present body weight which should be followed by a comparative assessment with his usual body weight (if data is available) or his ideal body weight. Adequate energy intake is important to build up weight deficit and build glycogen/adipose tissue reserves which are essential to provide energy to the body immediately after surgery when the nutrient intake may not be adequate enough to meet the increased requirements. Depending upon their nutritional status the energy requirements of the patients would be as follows:

Underweight: ~ 35 Kcal/kg ideal body weight per day

Normal weight: ~ 30 Kcal/kg ideal body weight per day

Overweight: ~ 20-25 Kcal/kg ideal body weight per day

Carbohydrates: Carbohydrates are needed to build up glycogen stores and spare the proteins for tissue synthesis. Around 60% of the total energy should be provided from carbohydrates. Maintaining blood glucose levels around 4.5-6.0 mmol/litre (with/without insulin) helps in marked reduction in septic episodes, renal failure, time on the ventilator, polynephropathy and mortality.

Protein: Negative nitrogen balance is the most common nutritional deficiency related to surgery. Reserves of protein in the tissues and plasma help to overcome blood losses during surgery and tissue catabolism in the postoperative period. The optimal protein requirements for critically ill patients in the absence of end stage renal/liver disease is 1.5-2.0 g/kg/day. Emphasis should be laid on the inclusion of foods rich in high biological value proteins such as eggs, milk, yoghurt, curd, cheese, flesh foods, legumes and pulses. Foods should be selected according to the age and pathophysiological condition of the patient. We must also keep a close watch on the liver and renal function tests while giving a high protein diet to terminally ill patients.

Vitamins and Minerals: Normal tissue stores of vitamins are required for the metabolism of carbohydrates and protein. Deficiency states like anaemia should be treated before a surgery, water and electrolyte balance should be maintained and dehydration, acidosis or alkalosis, if present, must be corrected. Inclusion of appropriate (disease specific) fresh fruits and vegetables, if on an oral intake/ selection of an appropriate enteral/parenteral formula can help in alleviating specific nutrient deficiencies.

Immediate Preoperative Period: Nothing should be given by mouth for at least 8 hours before a general surgery so that the stomach has no left over food at the time of surgery. In case of emergency surgery, gastric suction is used to remove the food if the patient has recently eaten a meal. This is important because food in the stomach may be vomited or aspirated during the surgery or during recovery soon after the surgery. It may also interfere with the surgery itself if it is related to the abdomen or gastrointestinal tract. In such cases a low residue or residue free diet is given several days before the surgery to clear the operative site. Elemental or chemically defined formulas are given either orally or through tube feeds.

Next, let us learn about the nutrient intake postoperatively.

B. Postoperative Nutritional Care

The therapeutic goal for the post-operative patient is rapid recovery to normal function and well being, minimum complications and early discharge. Nutrition plays an important role in minimizing the development of catabolism and returning the patient from the catabolic state to one of anabolism. As the nutrient losses due to catabolism during surgery are great, nutritional support is extremely important to aid recovery. In the post-operative period, nutrition support is used to reduce nutrition deficits that ordinarily develop in untreated patients during the period of NPO (nil orally) after surgery. we will now discuss the calorie and nutrient requirements during post-operative period. Let us start with energy.

Energy: Adequate calorie intake is critical for successful outcome of surgery and should be provided in the form of carbohydrates and fat. Energy requirements are generally high post operatively due to hyper-metabolism.

The energy requirement of the patient should be such as to be able to maintain a energy equilibrium or in other words stabilization of body weight at the pre-operative level. The energy requirement may be as high as 30-35 kcal/kg ideal body weight.

Protein: Increased catabolism leads to protein deficiency and hence negative nitrogen balance which amounts to loss of tissue proteins which can be as high as 1 lb per day. In addition, plasma proteins are lost through haemorrhage, wound bleeding and exudates. Metabolic losses also result from tissue inflammation, infection, trauma, immobilization and poor calorie intake. The protein deficit may cause serious complications, especially if the patient has some degree of previous malnutrition. Adequate intake of protein, is therefore, required to replace losses and meet the increased demand for the following reasons:

- *Tissue Synthesis for Wound Healing* : Tissue proteins are synthesized only by amino acids brought to the tissues by circulating blood. The necessary amino acids are provided either by ingested proteins or intravenous feeding. Concentrated liquid diets or commercial formulas may be used to overcome a poor appetite. The protein intake should be slowly increased according to the patients' tolerance.

- *Avoidance of Shock*: Loss of plasma proteins lead to decrease in blood volume (hypovolemia) and lowered red blood cell volume causing a potential danger of shock. Adequate intake of protein is, therefore, required as protein deficiency enhances the danger.
- *Control of Oedema*: Low levels of circulating proteins lead to oedema due to loss of colloidal osmotic pressure to maintain the normal fluid shift mechanism between the capillaries and the surrounding tissues prior to clinical oedema, considerable fluid collects in the interstitial spaces affecting heart and lung action. Local oedema at the site of surgery also delays closure of the wound and the healing process.
- *Bone Healing*: Protein is essential for callus formation, calcification and bone healing especially in cases of orthopaedic surgery. The protein matrix is required for mineral deposition in bone tissue.
- *Resistance to Infection*: Amino acids help to build the body's defense mechanisms like antibodies, blood cells, hormones and enzymes so as to prevent infection. Tissue integrity is the first line of defense against infection.
- *Lipid Transport*: Proteins provide the transport mechanism for lipids by forming lipoproteins. This helps to prevent fatty infiltration and hence protection of the liver which is the main site of fat metabolism.
- *Protein Deficiencies*: A depleted amino acid pool leads to poor wound healing (dehiscence), delayed healing of fractures, anaemia, depressed pulmonary and cardiac function, reduced resistance to infection, weight loss, liver damage and hence increased risk of mortality.

Carbohydrates: Carbohydrates ensure the use of protein for tissue synthesis and energy required for increased metabolic demands. With a high protein intake in extensive surgery or burns, the energy requirement may be as high about 35 kcal/kg ideal body weight. This will help to spare proteins for tissue repair and prevent them from being diverted to provide energy. Carbohydrates also provide glycogen reserves to avoid liver damage.

If oral intake can be resumed, emphasis should be laid on the inclusion of foods rich in simple carbohydrates which are easy to digest and can be used to prepare calorie dense dishes which have a small volume and hence facilitate an enhanced food intake. Glucose is the preferred form of energy in case of enteral or parenteral tube feeding.

Fat: Adequate amount of fat is needed to build up and maintain tissue fat reserves. Depending upon the existing health and nutrition status of the patient, fat may be incorporated in the diet to provide 15% to 30% of the total energy intake to prevent the deficiency of essential fatty acids and to meet the increased energy requirements particularly in the presence of glucose intolerance. Emulsified fats and medium chain triglycerides are generally well tolerated in the presence of sluggish gastrointestinal function.

Fluid: Extensive fluid losses may occur through vomiting, haemorrhage, diesis, excudate, fever and sweating after a surgery. An adequate fluid intake is, therefore, required to meet the increased needs. Fluids may be provided by intravenous therapy initially but oral intake should begin as soon as possible. The fluid intake should be sufficient to avoid dehydration on one hand and intoxication on the other.

Vitamins and Minerals: Vitamins are required for wound healing after a surgery. Vitamin C provides the cementing material of connective tissue, capillary walls and for building up of new tissues. Supplements of vitamin C are needed for aiding extensive tissue regeneration. With increase in energy and protein intake, intake of B group vitamins must also be increased as they are the coenzyme factors for energy and protein metabolism. Vitamin K helps in the blood clotting mechanism and is, therefore, essential for preventing blood loss. Potassium and phosphorus are lost during tissue catabolism. Electrolytes, accompany fluid losses. Overloading of patient with fluids and electrolytes can affect gastric function. Restricting postoperative maintenance fluids to 2000 ml and NaCl to 77 mmol/day has been shown to enhance substantially gastric motility and speed up the recovery. Iron deficiency occurs from blood loss or due to faulty iron absorption. Mineral intake, therefore, should be adequate to replace losses and correct deficiencies.

Nutrition Support: Aggressive nutritional support is important to avoid postoperative complications and mortality. Routine postoperative intravenous fluids are given to meet hydration needs and provide electrolytes but cannot meet the high nutritional needs. Majority of general surgery patients, therefore, should progress to oral feedings as soon as possible to provide adequate nutrition. In case of major tissue damage or trauma, or when a patient is unable to take sufficient oral feeds, parenteral feeding must be done. A high amount of glucose, amino acids, electrolytes, minerals and vitamins have to be provided.

As soon as intestinal peristalsis returns, water and clear fluids such as tea, coffee and juice may be given to supply fluids and electrolytes. These fluids help stimulate normal gastrointestinal function and return to a normal, nutritionally balaned diet. With improvement, milk and milk products, pudding, cream soups and high protein beverages should be started. Progression to solid foods in the form of soft or regular diets should be done with improved tolerance.

Having learnt about surgery, its nutritional implications and dietary management, we shall now proceed towards learning about another form of stress viz., burns. But let us first check our learning and understanding about surgery by answering the questions given in check your progress exercise 1.

Check Your Progress Exercise 1

1. What is the difference between the ebb and flow phase in a stress response?

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   ....

2. Explain giving examples the different types of surgeries?

   ....

   ....

3. Enlist any five physiological consequences of a surgery?

   ....

   ....

4. Discuss the importance of protein intake in postoperative nutritional care.

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5. "Oedema is a postoperative complication". Explain this statement.

   ....

   ....

5.4 BURNS

Burns are injuries to tissues that result from heat, electricity, radiation or chemicals. They are usually caused by heat (thermal burns), such as fire, steam, tar or hot liquids. While burns caused by chemicals are similar to thermal burns those caused by radiation, sunlight and electricity tend to be different. Thermal and chemical burns usually occur because heat or chemicals come in contact with part of the body's surface, most often the skin. Thus, the skin usually sustains most of the damage. However, severe surface burns may penetrate to deeper body structures, such as fat, muscle, or bone.

When tissues are burned, fluid leaks into them from the blood vessels, causing swelling and pain. In addition, damaged skin and other body surfaces are easily infected because they can no longer act as a barrier against invading organisms.

The classification of burns is presented next.

5.4.1 Classification of Burns

Burns can be classified on the basis of the extent, depth, patient age and associated illness or injury. On the basis of depth, burns are usually classified by degree. *First degree burns or erythema,* i.e., redness of the skin produced by coagulation of the capillaries with cell destruction above the basal layer of epidermis. First degree burns are not blistered. *Second degree burns* is erythema and is characterized by blistering with necrosis within the dermis. *Third degree burns* lead to total loss of skin including the fat layer, hair follicles and sweat glands (refer to Figure 5.1).

First- and second-degree burns heal in days to weeks without scarring. Deep second-degree and small (less than 1 inch) third-degree burns take weeks to heal and usually cause scarring. Larger third-degree burns require skin grafting. Burns that involve more than 90% of the body surface, or more than 60% in an older person, usually are fatal.

First degree or partial thickness burns regenerate new skin tissue from the epithelial cells of the skin or hair follicles, sweat glands and sebaceous glands. Second and third degree or full thickness burns do not have sufficient skin for healing and therefore extensive burns require skin grafting.

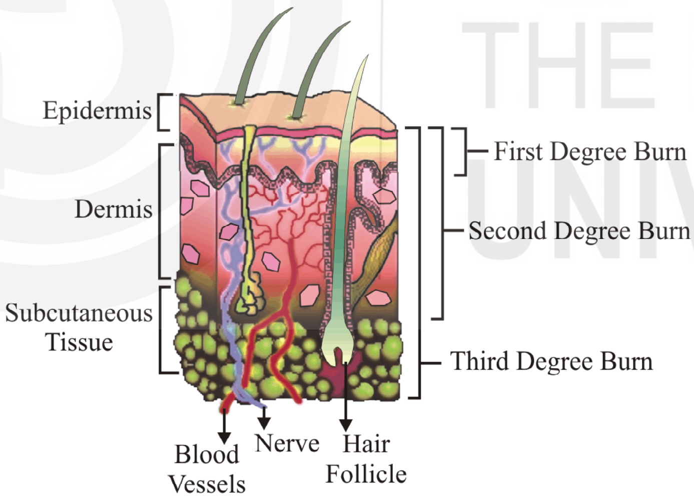

Figure 5.1: Diagramatic representation- categorization according to depth of burns

You have often heard or read about description of an individual who has got burnt being ascribed as '40% burns', ' 90% burns' etc. What does this mean? This is a method of assessing the total body surface area that is burnt. It is often spoken of as "rule of nines" as illustrated in the Figure 5.2 . Figure 5.2 shows the per cent of a particular area burnt, adding these would give the total body surface area burnt. This information as you will learn later in this unit is utilized for computing the energy and other nutrient requirements of the patient. Data on age of patient can help in predicting the prognosis of a burn's injury. The most accurate rule of thumb for predicting mortality after severe burn injury is the Baux Score (age + percent burn, e.g. age 50 years + 20% burns = 70% mortality).

A more recent revised baux formula is used in case of severe burn with inhalation injury.

Revised Baux Score = Age + Surface area burnt + 17.

(Here 17 accounts for inhalation injury, which is constant).

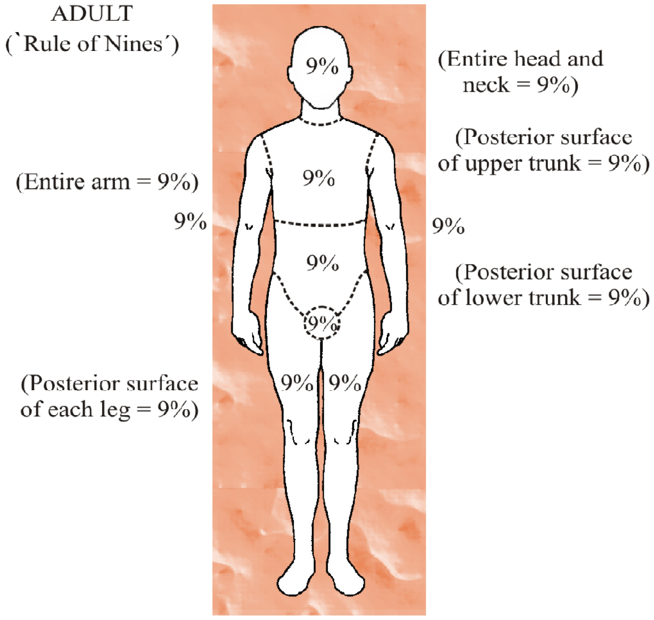

Figure 5.2: Diagramatic assessment of the total body surface area burnt – "Rule of Nines".

Source: Tierney LM, McPhee SJ and Papadakis MA. Current medical diganosis and treatment 42nd e (2003).

5.4.2 Complications of Burns

Most minor burns are superficial and do not cause complications. However, deep second-degree and third-degree burns swell and take more time to heal. In addition, deeper burns can form a scar tissue. This scar tissue shrinks (contracts) as it heals. If the scarring occurs at a joint, the resulting contracture may restrict movement.

Severe burns can result in serious complications due to extensive fluid loss and tissue damage. Complications from severe burns may take hours to develop. The longer the complication is present, the more severe are the problems it tends to cause. Young children and older adults tend to be more seriously affected by complications than other age groups.

Dehydration eventually develops in people with widespread burns, because fluid seeps from the blood to the burned tissues. Shock develops if dehydration is severe. Destruction of muscle tissue occurs in deep third-degree burns. The muscle tissue releases myoglobin, one of the muscle's proteins, into the blood. If present in high concentrations, myoglobin harms the kidneys.

Thick, crusty surfaces (eschars) are produced by deep third-degree burns. Eschars (a dry scab) can become too tight, cutting off blood supply to healthy tissues or impairing breathing.

The non-dietary treatment is emphasized in sub-section 5.4.5. This is additional information which is quite useful.

Treatment of burned patient is incomplete and often unsuccessful if proper nutritional care is not provided. Through our subsequent discussions we will learn about the dietary management of patients suffering from burns.

5.4.3 Dietary Management for Burns

Nutritional support is a major part of therapy for a patient with burns in view of the large catabolic losses, essential anabolic demands and to meet personal support needs.

Nutritional care plan and outcome is dependent on factors, like

- *Age* – Elderly people, very young children pregnant women and lactating mothers are highly vulnerable.

- *Health condition* – Presence of diabetes, cardiovascular or renal disease complicates the care process.
- *Severity of burns* – The location and severity of the burns and time lapse before treatment.

Nutritional support needs are calculated on the basis of body surface area burnt. Second and third degree burns covering 15-20% or more of body surface, or even 10% in children and elderly persons cause extensive fluid loss and therefore require intravenous fluid therapy. Severe burns covering more than 50% of the body surface area are often fatal. Nutritional care for a patient in the burns is adjusted to individual needs and is given in three stages:

Ebb or shock period: During the initial burns after injury, the focus is on counteracting the stress induced neurohormonal and physiologic responses that accelerate the body's metabolism by a series of events. Loss of skin on the burn site and exposure of extra cellular fluids lead to immediate loss of water and electrolytes, mainly sodium and also protein depletion. As a result, the body water shifts from extra cellular spaces in other parts of the body to the burn site adding to continuous loss of fluids and electrolytes. Due to this there are changes in the capillary fluid shift mechanism resulting in decreased volume hypotension, low haemo-concentration and diminished urine output. Intracellular water is also drawn out to balance extra cellular fluid losses leading to cellular dehydration. Patients with extensive burns need immediate fluid and electrolyte replacement during the first 12 to 24 hours after injury. A balanced salt solution such as *lactated Ringer's solution* is given to correct hypovolemia and prevent metabolic acidosis. Because the exact volume of fluid and infusion rate depend on the patient's response to fluid delivery, ongoing fluid replacement is based on close monitoring of the patient. The goal is to maintain an adequate blood pressure and haematocrit and a urine output of > 50 to 100 ml/hr (0.5 to 1 ml/kg/hr) in an adult or 1 ml/kg/hr in a child while avoiding circulatory overload. To maintain hydration status of patient parkland formula is used which is given below:

Total fluid requirement in 24 hours =

4 ml × (total burn surface area (%)) × (body weight (kg))

50% given in first 8 hours

50% given in next 16 hours

Children receive maintenance fluid in addition, at hourly rate

4 ml/kg for first 10 kg of body weight plus

2 ml/kg for second 10 kg of body weight plus

1 ml/kg for >20 kg of body weight

End point

Urine output of 0.5-1.0 ml/kg/hour in adults

Urine output of 1.0-1.5 ml/kg/hour in children

This ensures the hydration status of burn patient. Example of fluid management in burn patient is given in Box 5.1.

Box 5.1: Example of Flluid Management in Burn Patients

A 25 year old man weighing 70 Kg with 30% flame burn was admitted at 4 pm. His burn occurred at 3 pm and received 1000 ml in emergency services. Plan Fluid resuscitation regimen for an adult. Also pIan for a child weighing 24 kg.

FOR **ADULT**

1) *Total fluid requirement for first* 24 *hours*
   4ml * (30% total burn surface area) * (70 Kg) = 8400 ml in 24 hours
2) *Half to be given in first* 8 *hours and half over the next* 16 *hours.*
   Will receive 4200 ml during 0-8 hours and 4200 ml during 8-24 hours
3) Subtract any fluid already received from amount required for first 8 hours
   He has already received 1000 ml. Therefore, he needs 3200ml in first 8 hours after injury.

4) *Calculate hourly infusion rate for first 8 hours.*
Divide amount of fluid calculated by time left until it is 8 hours after burn.
Burn occurred at 3 pm, so 8 hour point is 11 pm. Patient was admitted at 4 pm. So, he needs 3200 ml over next 7 hours.
Therefore, 3200 ml/7 hours= 457 ml/hour from 4 pm to 11 pm.

5) *Calculate hourly infusion rate for next 16 hours.* Divide rest of the fluid with hours left.
4200ml/16 hours= 262.5 ml/hour from 11 pm to 3 pm next day.

FOR CHILD

Apart from above fluid requirement a child weighing 24 kg would need following maintenance fluid in addition on an hourly basis.

4ml/Kg/hour for first 10 kg weight < 40ml/hour *plus*

2ml/Kg/hour for next 10 kg weight = 20 ml/hour *plus*

1ml/Kg/hour for next 4 kg weight = 4 ml/hour

Total 64 ml/hour

During this initial period, nutritional requirements of protein and energy are not attempted to be met as the entire focus is on rapid and effective fluid and electrolyte therapy so as to prevent shock.

Flow or Recovery Period : After 48 to 72 hours, fluids and electrolytes are reabsorbed into the general circulation and excess fluid is excreted. Fluid balance is gradually reestablished and massive tissue loss is reversed. Fluid intake and output must be checked to prevent dehydration or over hydration. The patient usually returns to pre-injury weight by the end of first week and adequate bowel function returns. At this time, increased nutritional needs must be met for the following reasons:

- Replace losses of protein and electrolytes due to burn injury.
- Replace lean body mass due to extensive tissue breakdown.
- Meet increased metabolic needs for energy due to sepsis or fever, increasing the need for carbohydrates and B vitamins. Minerals and vitamins are also needed for tissue regeneration.
- Providing healthy tissue for subsequent successful skin grafting.

Anabolic Phase: During this period the patient is well hydrated and the reactions due to metabolic stress are under control. The patient may still be hypermetabolic and has depleted reserves of all nutrients. Rigorous nutrition support during this period is essential to promote fast recovery and proper rehabilitation. Proper nutritional care during this period can help in preparing patient physically for undergoing successful skin grafting/ any other surgery. Transplantation of organs or body parts is done much latter during the anabolic phase.

The nutrient requirement and dietary management during the flow and anabolic phase is discussed next.

Nutrient requirement and dietary management during the flow and anabolic phase

You must have understood by the discussion above that by the end of the flow phase, the patient usually is well hydrated and has body weight close to the pre-injury weight. The return of bowel movements is an indication that the patient can now be slowly introduced to nutrition support in the form of oral intake, enteral feeds or parenteral nutrition. A combination of any two alterations in these routes is required on a day-to-day basis depending upon the changing clinical parameters and the severity of burns. Dietary management should be such as to fulfill the following *objectives*:

– providing enough calories to prevent subsequent weight loss

– maintaining fluid and electrolyte balance

– minimizing stress response to pain and anxiety

- maintaining a positive nitrogen balance
- replenishing the depleted reserves of vitamins and minerals
- preventing curling's ulcers, ileus and other complications

As always we shall first discuss about the energy requirements of the patient during the flow and anabolic phase. Thereafter we shall learn about the contribution of various macronutrients for providing the required amount of calories.

Energy: The energy needs of the burned patient vary according to the depth and size of the burn. The requirements of course would be highest in third degree burns Although several formulas have been developed to determine the energy needs; Currie formula is most commonly utilized and is mentioned below:

Calories needed per day = 24 Kcal × kg usual body weight + 40 Kcal × % total body surface area (TBSA) burned (using a maximum of 50% burn).

The energy requirements thus calculated may be slightly higher than the actual needs in lieu of the improved medical facilities now available. At times therefore the *Ireteon-Jones Equation* is utilized which is based on assessment of total energy expenditure

Estimated energy expenditure (Kcal/day) = 1784 – 11 (A) + 5 (W) + 244 (G) + 239 (T) + 804 (B)

Wherein, A : Age; W : Weight (kg); G : Gender (female = 0; male = 1); T : Diagnosis of trauma (absent = 0; present =1); B : Diagnosis of burn (absent = 0, present = 1).

Some additional calories may be added to this for supporting energy expenditure due to fever, sepsis, multiple trauma or stress of surgery.

For assessing the energy requirements of pediatric patients; *Galveston formula* may be utilized i.e. :

Energy requirements for 24 hrs. = 1800 Kcal/m^2 + 2200 Kcal/m^2 of burns.

For children below 3 years of age the *Mayes and colleagues formula* may be utilized i.e

Energy requirements for 24 hrs = 1008 + (68 × Kg weight) + 3.9 × % body surface area burnt)

We shall do some exercises to help you in using these formulas in the check your progress exercise section.

It must be evident from these formulas that the energy requirement of burnt patients are much higher than those for their healthy counter parts.

Let us now learn about the contribution towards the total energy through various macronutrients viz; carbohydrates, proteins and fat.

Carbohydrates: Liberal amounts of carbohydrates should be given i.e. around 60% to 65% of the total energy. However, care must be taken regarding the maximum rate of administration feasible keeping in mind the fact that the maximum tolerance level is about 7 mg/kg/min above which glucose is not oxidized to release energy but is converted to fat. Blood glucose levels should be closely monitored to prevent hyperglycemia and its associated complications such as dehydration, coma, respiratory problems etc. During the anabolic phase when the patient can eat orally and has normal defecation process, a combination of simple and complex carbohydrates may be given. Providing good amounts of foods rich in mono and di saccharides, as well as, starches help in preparing meals which are nutrient dense, have small volume and are easy to digest. Thus, rice, refined wheat flour, semolina, sago, arrowroot, rice, rice flakes, murmura, pastas, dextrose, glucose, honey, potato should be incorporated liberally in the diet.

Fat : As we have learnt earlier in the Unit 4 on enteral and parenteral feedings; administration of lipids should be carried out carefully in all critically ill patients. A careful monitoring of immune function, feeding tolerance and serum triglycerides is required during lipid administration. Most of the patients are able to tolerate around 12-15% of the total calories in the form of lipids. Structured lipids and medium chain triglycerides are currently being preferred. A low fat diet is preferred during the initial phases of recovery in view of its association with improved respiratory function, reduced incidence of pneumonia, faster recovery. During the later phases of anabolism (near discharge) the fat intake may be normalized. In view of the impaired gastro-intestinal function among many patients it is advisable to lay emphasis on foods rich in emulsified fat and medium chain triglycerides (MCT's).

Protein: It is one of the most crucial nutrient which determines the ultimate outcome of burns. Amino acid requirements are high due to increased losses through wounds and urine, increased requirement for promoting synthesis of blood proteins and wounds. Fluid loss from a burn wound may be considerable and can contain 4-6 g protein/100 ml, representing 25-50% of total nitrogen loss. Nitrogen losses via faeces have been estimated to be around 1-3g N/day. Thus, adult patients should be given 20-25% of the increased energy from protein. Among children the requirements are still higher i.e. 2.5 to 3.0 g per kg usual body weight per day. Protein intake beyond this level is not recommended in view of the increased burden on the kidneys. Blood urea nitrogen, serum creatinine and level of hydration must be monitored carefully. The protein intake may need to be curtailed if the burnt area has involved the kidney / excretory system. High biological value protein food sources such as eggs, milk, cheese, yoghurt, marine food, meat, poultry, legumes and pulses should be included liberally but in an easy to digest form. Hospital based tube feeds may be prepared by using soya milk, milk proteins (casein, whey protein, lactalbumin), eggs and flour of pulses particularly soyabean.

Vitamins and Minerals : Although the exact requirements are not known, it is generally recommended to give plenty of fresh fruits and vegetables if an oral intake is feasible. When the patient is on tube feeds it is suggested to provide around 500 mg (twice daily) vitamin C and 5000 I.U of vitamin A per 1000 Kcals of energy being provided. Hyponatremia which is frequently observed due to fluid losses during change of dressings/ application of grafts, can be corrected by restricting the oral consumption of sodium-free fluids /water. Supplements of calcium, phosphate, zinc and iron are generally required. Anaemia may need to be treated with administration of red packed blood cells.

Other considerations

- oral intake is generally feasible only during the anabolic phase wherein the patient should be given a high-energy, high protein, micronutrient rich diet. The diet should have a small volume, it should be nutrient dense and easy to digest. A two hourly feeding schedule or a 6-7 meals/ day pattern should be adopted.
- Oral feeding may be supplemented with enteral nutrition to be able to replenish the depleted nutrient reserves.
- Most of the patients are depressed and may need encouragement by family and medical team to promote adequate food consumption.
- Anabolic steroids such as oxandrolone are often combined with a high protein diet to promote weight gain and enhance anabolism at the site of wound.

Now that we are aware of the nutrient requirement let us take a closer look on the methods we can use to feed burn patients.

5.4.4 Mode of Feeding/ Nutrition Support

Do you recall studying about the nutrition support methods, namely enteral and perenteral feeding, discussed earlier in Unit 4 of this course. These two methods form the common nutrition support strategy for burns patients. Let us review these methods in the context of burn patients.

Oral feeding is desirable if tolerated by the patient. Concentrated oral liquids with protein hydrosylates or amino acids must be given to ensure adequate intake. Solid food should be gradually introduced according to food preferences. Support and encouragement help the patient to eat better. Food should be attractive and appetizing and individual like and dislikes must be considered.

Enteral nutrition can be utilized judiciously alone or in combination with other forms of feeding during various stages and purposes during the course of treatment for instance some patients may initially require tube feeding, low bulk defined formula solutions may be given. Commercial high protein formulas may also be used.

Parenteral Feeding is required for some patients to provide extra nutritional support if oral intake and tube feedings are inadequate to meet the high nutritional needs. This form of feeding is more commonly used during the ebb and flow phase.

Continuous nutritional support is important to maintain tissue integrity for successful skin grafting or plastic reconstructive surgery. Persistent supportive care – medical, nutritional and nursing helps the patient to cope with the stress situation.

5.4.5 Non-Dietary Treatment of Burns

While good nutritional care should be provided to the patient as soon as feasible it is equally imperative and at times critical to provide efficient and appropriate physical care to the patient to minimize trauma, pain and ensure re-habilitation. Some important aspects of non-dietary treatment are being briefed below.

The most immediate step is removal of the burning agent from the patient to prevent further damage. For example, fires are extinguished. Clothing — especially any that is smoldering (such as melted synthetic shirts), covered with hot tar, or soaked with chemicals should be immediately removed.

Hospitalization is sometimes necessary for optimal care of burn injuries. For example, elevating a severely burned arm or leg above the level of the heart to prevent swelling is more easily accommodated in a hospital. In addition, burns that prevent a person from performing essential daily functions, such as walking or eating, make hospitalization necessary. Severe burns, deep second- and third-degree burns, burns occurring in the very young or the very old, and burns involving the hands, feet, face, or genitals are usually best treated at burn centers. Burn centers are hospitals or wards in a hospital that are specially equipped and staffed to care for burn victims.

***Superficial Minor Burns*:** Superficial minor burns are immersed immediately in cool water if possible. The burn is carefully cleaned to prevent infection. If dirt is deeply embedded, a doctor can give analgesics or numb the area by injecting a local anesthetic and then scrub the burn with a brush. Often, the only treatment required is application of an antibiotic cream, such as silver sulfadiazine which prevents infection and forms a seal to prevent further bacteria from entering the wound. A sterile bandage is then applied to protect the burned area from dirt and further injury. A tetanus vaccination is given if needed. Care at home includes keeping the burn clean to prevent infection. The burn can be covered with a nonstick bandage or with sterile gauze. The gauze can be removed without sticking by first being soaked in water.

***Severe Burns*:** Severe, life-threatening burns require immediate care. Dehydration is treated with large amounts of fluids given intravenously. A person who has gone into shock as a result of dehydration is also given oxygen through a face mask.

Destruction of muscle tissue is also treated with large amounts of fluids given intravenously. The fluids dilute the myoglobin in the blood, preventing extensive damage to the kidneys. Sometimes a chemical, sodium bicarbonate, is given intravenously to help dissolve myoglobin and thus also prevent further damage to the kidneys.

Eschars that cut off blood supply to an extremity or that impair breathing are cut open in a surgical procedure called escharotomy. Escharotomy usually causes some bleeding, but because the burn causing the eschar has destroyed the nerve endings in the skin, there is little pain.

Keeping the burned area clean is important, because the damaged skin is easily infected. Cleaning may be accomplished by gently running water over the burns periodically. Wounds are cleaned and bandages are usually changed 1 to 3 times per day.

Let us now make an attempt to answer the questions mentioned in the check your progress exercise 2 to find out our level of understanding. You may need to read the details discussed above to recapitulate and answer these questions.

Check Your Progress Exercise 2

1. Define and classify burns on the basis of their depth.

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2. What is lactated Ringer's solution?

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3. Mrs. Asha is a 57 years old women who has suffered from second degree burns with 33% total body surface area burned. Calculate her energy requirements by using the Currie formula.

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4. What is the significance of protein in the diet of burn patients during the anabolic phase?

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5. What are the benefits of vitamin A and C for promoting recovery during anabolic phase?

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   ....

So far we have learnt about the physiologic/ metabolic effects and dietary management of two forms of stress viz. surgery and burns. We shall now discuss about the physiology and nutritional care during trauma.

5.5 TRAUMA

The term "trauma" comes from a Greek word which means "a wound" (and or damage or defect). Trauma is a form of shock to the human body which may occur in the form of crush injuries, diving/ air compression or specific wounds on body part/ organs such as head/spinal cord. Accidental or crush injury – a form of acute trauma is a major cause of death and disability. Crush injuries generally result from serious road accidents, industrial mishaps, explosions etc. It may involve several fractured bones, profuse multiple external bleeding, internal bleeding, shock and deterioration into unconsciousness. Optimal care of the injured patient is often intensive and prolonged. Survival rate is low and may be followed by years of rehabilitation. Metabolic and nutritional support of the injured patient is a major component of overall care. Let us first discuss about the physiological response of the body towards a crush/ sudden injury to the body-a form of trauma.

5.5.1 Physiological Response to Injury

The physiological events are related to the severity of injury that is, greater the insult, the more pronounced is the response. Two distinct periods of post-traumatic responses have been identified:

Early ebb or shock phase: This is usually brief in duration lasting 12 to 24 hours and occurs immediately following injury. Blood pressure, cardiac output, body temperature and oxygen consumption are reduced. These are often associated with haemorrhage and result in hypo perfusion and lactic acidosis. As the blood volume is restored, more accelerated responses occur.

Flow Phase: It is characterized by hyper metabolism, increased cardiac output, increased urinary nitrogen losses, altered glucose metabolism and accelerated tissue catabolism. These flow phase responses to injury are similar to those following surgery but are usually more intensive and extend over a longer period of time. This phase is characterized by hyper metabolism and alterations in the metabolism of glucose, protein and fat.

Next, let us learn about the metabolic aberrations developing during and after a trauma.

5.5.2 Metabolic Response to Injury

There is an increase in the basal metabolic rate above the normal. The degree of hyper metabolism is related to the severity of the injury. Long-time fracture usually result in a 15 to 25 % increase in metabolic rate, multiple injuries increase metabolic rates by 50% and severe burn patients have metabolic rates raised by 100%. The body temperature of a trauma patient rises by 1-2^{O}C due to an upward shift in the thermoregulatory set point of the brain. The changes in glucose, protein and fat metabolism are being discussed below.

– *Altered Glucose Metabolism*: Following injury, hypoglycemia commonly occurs and is related to the severity of the stress. In the ebb phase, insulin levels are low and glucose production is slightly elevated. During the flow phase, hyperglycemia persists although insulin levels are normal or even high. Hepatic glucose production and gluconeogenesis are increased.

– *Altered Protein Metabolism*: Urinary nitrogen loss is extensive following injury. Trauma accelerates nitrogen turnover. In unfed patients, tissue breakdown rates exceed synthesis and a negative balance occurs. Providing exogenous calories and increase in nitrogen synthesis and thus helps in restoring the nitrogen balance.

– *Altered Fat Metabolism*: The stored fat deposits are mobilized and oxidized at a high rate in order to support hyper metabolism and increased gluconeogenesis. Severely injured patients, if unfed, deplete their fat and protein stores rapidly.

The resulting malnutrition increases their susceptibility to haemorrhage, infections, organ system failure, sepsis and death.

Next, after metabolic aberrations we move on to the hormonal responses, specific to trauma viz./injury..

5.5.3 Hormonal Responses to Injury

A number of hormonal changes take place in patients following injury. There is a marked rise in the counter regulatory hormones, viz., glucagon, glucocorticoids and catecholamine. Glucagon has glycogenolytic and gluconeogenic effects the liver, Cortical mobilizes amino acids from skeletal muscle, increases hepatic gluconegenesis and maintains body fat stores. The catecholamine also stimulates hepatic gluconegenesis and glycolysis and increase lactate production from skeletal muscles. They also increase metabolic rate and lipolysis. Growth hormone is elevated while thyroid levels are reduced.

Now that we are familiar with the physiological, metabolic and hormonal changes specific to trauma, you will find yourself better equipped to understand dietary management of this stress response. Since the dietary considerations/requirements are quite similar to that in the post operative period in surgery, which has aleady been discussed in greater detail in section 5.2 earlier. The dietary management of trauma/ injury dealt here in this section is brief.

5.5.4 Dietary Management – Trauma

As a result of metabolic responses to injury, there is an increase in the energy expenditure. Oxidation of body fat stores takes place causing loss of weight. Most injured patients can tolerate a loss of 10% of their pre-injury body weight prior to injury. If weight loss exceeds 10% body weight, under nutrition increases the morbidity and mortality rates. The patients are exposed to a variety of infectious agents in the hospital, due to use of catheters and nasogastric tubes. Under nutrition increases the likelihood of sepsis, multiple organ system failure and death. It also delays wound healing. The purpose of nutrition support for a trauma patient is to aid in the defense mechanisms of the body. Adequate nutrition allows normal responses that optimize wound healing and recovery. Nutritional support should be provided before significant weight loss occurs. Intravenous administration of hypertonic nutrient solutions, use of peripheral vein feedings with fat emulsions and use of specific diets provide effective nutrition support to injured patients.

Nutrient Requirements during Trauma

Nutritional assessment of the trauma patient is done to determine energy and protein requirements. Basal energy requirements are determined from standard tables based on age, sex and body surface area. These requirements are adjusted for increase in metabolic rate due to injury or disease. Dietary protein is required in greater amounts to achieve nitrogen balance. Approximately, 15 to 20% of calorie intake should be from protein. Carbohydrates (glucose) should provide 60% of caloric needs and the rest of energy needs should be met by fat. Multivitamins are given daily along with supplements of vitamin C, which is required in increased amounts after injury. Electrolytes may be added to feed formulas so as to maintain normal serum levels. Potassium, magnesium and phosphate supplements are added to parenteral fluids. Zinc supplements should be given to severely malnourished patients or those with a history of poor nutrient intake, e.g. alcoholics.

The routes of nutrition support are oral, enteral and parenteral. Oral and enteral routes are generally preferred over the parenteral (intravenous) administration. Oral liquid supplements should be administered to increase the nutrient intake. The patient's injuries may interfere with oral feedings. Patients with facial and head injuries, disorders of the jaw, mouth or oesophagus and those receiving artificial ventilation are not able to take feeds orally. Such patients have to be fed by use of tubes. Enteral or parenteral tube feed formulas are usually balanced mixtures of fat, carbohydrate and protein. Intravenous or parenteral feedings may be necessary to supplement enteral feedings or when enteral feeds cannot be tolerated.

With nutritional requirements, we end our study on trauma. Next, let us get to know about sepsis-a complication which may arise on its own or as a consequence of any long-term stress.

5.6 SEPSIS

Sepsis is defined as the presence of an infection due to an identifiable organism. Bacteria and their toxins lead to a strong inflammatory response. Viruses, fungi and parasites also cause infection and inflammation. The Systemic Inflammatory Response Syndrome (SIRS) is the term used to describe the inflammation that occurs in infections, burns, multiple trauma, shock and organ injury. The inflammation is usually present in areas much away from the primary site of injury and affects healthy tissues. The association between the terms sepsis and SIRS can be better understood by the diagnostic criteria given in Box 5.2. SIRS commonly leads to development of Multiple Organ Dysfunction Syndrome (MODS). It generally begins with lung failure followed by failure of the liver, intestines and kidney.

Multiple hypothesis have been proposed to explain the development of SIRS or MODS. The progression of SIRS to MODS appears to be mediated by excessive production of pro-inflammatory cytokines and other mediators of inflammation. According to the "gut hypothesis" disruption of the gut barrier function results in translocation of enteric bacteria into the mesentery lymph nodes, liver and other organs.

Box 5.2 Diagnostic Criteria for Sepsis/SIRS

Sepsis can be diagnosed if infection is proven by means of a positive blood culture and two or more of the following:

- Heart rate > 90 beats per minute
- Body temperature < 36 (98.6°F) or > 38°C (100.4°F)
- Hyperventilation (high respiratory rate) > 20 breaths per minute or, on blood gas, a $PaCO_2$ less than 32 mm Hg
- White blood cell count < 4000 cells/mm^3 or > 12000 cells/mm^3 (< 4×10^9 or > 12×10^9 cells/L), or greater than 10% band forms (immature white blood cells).

When two or more of these clinical parameters are met without confirmation of infection it is called systemic inflammatory response syndrome.

Despite a number of advances in the treatment of infections and a better understanding of its path physiology, the mortality and morbidity rates from septicemia are high. Unlike elective surgery and trauma, the response patterns following major infection are unpredictable. The variability in metabolic and physiological response is relied partly to the patient's age, previous health status, preexisting disease, previous stress, site of infection and the infective agent. Moreover, the organ system failure may mask the manifestation of systemic infection. Based on cardiac output, two physiological responses have been described. The first is characterized by an increased cardiac output and high systemic perfusion. The second response is characterized by cardiac decomposition, inadequate tissue perfusion and acidosis, and is described as low flow sepsis. Both these responses reflect the body's reaction to systemic infection and are modified by the underlying disease and physiologic reserves of the patient. The invasion of the body by infective agents initiates host responses. There is mobilization of phagocytes and inflammation at the local site. As the infection progresses, fever, tachycardia and other responses occur.

5.6.1 Systemic Metabolic Responses

Many of the metabolic responses to infection are similar to those following injury. The key changes include:

Hyper metabolism: Oxygen consumption is elevated in the infected patient. It may be 50-60% higher than normal and is related to the severity of the infection ($PaCO_2$ of < 32 mmHg-hyperventilation). In the pre-operative and post injury period, such a response often occurs secondary to severe pneumonia, abdominal infection or wound infection. Increased metabolism is related to fever – being 10-13% for every $1^{O}C$ elevation in temperature. The metabolic rate returns to normal as the infection resolves.

Altered Glucose Metabolism: Blood glucose levels are generally elevated in the infected patient but plasma insulin levels are normal or even higher in previously healthy patients who develop infection. Increased glucose production in infected patients is in addition to the increased gluconegenesis following injury. Glucose metabolism following infection is, however, complex as hypoglycemia and diminished hepatic glucose production has also been seen in patients.

Altered Protein Metabolism: There is increased proteolysis and nitrogen excretion resulting in negative nitrogen balance following an infection. Amino acids flow from skeletal muscle is accelerated in patients with sepsis.

Altered Fat Metabolism: Fat is the major fuel oxidized in infected patients. If nutrition support is inadequate, the peripheral fat stores are mobilized. Increase in the sympathetic nervous system activity mediates the increase in lipolysis.

Changes in Trace Minerals: Changes in the balance of magnesium, phosphate, zinc and potassium follows alterations in nitrogen balance. Iron and zinc level in the blood are decreased. This is not only due to body losses of these minerals but due to accumulation of these within the liver as a part of the lost defense mechanism. We will now move on to the catabolic responses to sepsis

5.6.2 Catabolic Responses

Hormonal responses during the hyper metabolic phase of infection are same as in case of injury. Serum cortisol levels are elevated, glycogen is incurred and insulin levels may be normal or higher. The levels of catecholamine, growth hormone, antidiuretic hormone (ADH) and aldosterone are also elevated. The growth hormone level remains elevated during convalescence, to promote anabolism.

Interleukin-1 is an endogenously produced pyrogen which produces fever and has direct effects on the liver; it promotes hepatic repletion of zinc and iron, increases plasma copper levels and stimulates hepatic synthesis of plasma amino acids.

The metabolic and hormonal changes discussed above can result in reversible or irreverisble alteration in the structure and/or function of one or more organs over a period of time. This is often referred to as multiple system organ failure and is being discussed below.

Multiple Organ Dysfunction Syndrome (MODS)

Failure of essential organs is the most severe complication of sepsis and may result in death. The treatment of systemic infection, therefore, consists of use of antibiotics, support of cardiovascular and respiratory function, supportive therapy of specific organs and vigorous nutrition support. Septic shock may lead to a decrease in peripheral resistance and cause pulmonary insufficiency. Patients often require ventilator support. Inadequate cardiac output may lead to impairment and malfunction of the kidney. The resulting uremia superimposed on the sepsis further impairs the hyper catabolic infected host. Sepsis causes marked changes in the structure/ function of gastrointestinal tract and may lead to stress ulcers and bleeding. Septicemia also commonly leads to hepatic dysfunction causing jaundice, hyperbilirubinemia and liver failure. Multi-system organ failure or MODS is associated with a high incidence of death.

5.6.3 Dietary Management of Sepsis with or without MODS

Before we begin with the dietary management of patients suffering from sepsis with or without MODS let us read a case below.

Mr. Sunder a 71 years old man was admitted to the ICU of a multi-speciality hospital suffering from moderate urinary tract infection and difficulty in breathing due to aspiration pneumonia. He was immediately put on ventilator to facilitate breathing. His medical history indicated that he was an old case of non-insulin dependent diabetes mellitus. Due to aspiration pneumonia and resultant intubations; the patient had to be fed through external tube feeds. Presence of infection however exacerbated hyperglycemia and there was a marked reduction in WBC count. Gradually, the patient had to fed through the parenteral route. Due to persistent infection there was considerable wasting and under-nourishment. On one hand the infection entered the blood stream and affected other organs whereas on the other hand feeding through parenteral route resulted in atrophy of the small intestine. The patient ultimately expired after three months due to the septic shock, renal failure and diabetic coma.

This is an example of the most common pathways which develop in critically ill patients. Keeping these complications in mind let us briefly discuss the nutrient requirements and the various forms of nutritional support which can be provided to such patients.

Dietary Management of Sepsis and MODS

Patients suffering from sepsis and/or resultant multiple system organ dysfunction are critically ill and admitted in the intensive care unit of the hospital. They usually have an impaired immune function and compromised cardiopulmonary functional capacity. Such patients may also have reduced functional and regulatory capacities of renal and/or gastrointestinal tract and impaired immune function along with compromised cardiopulmonary function capacity. They generally have altered blood/ urine indices (abnormal serum albumin) and are hypermetabolic. The Urine Urea Nitrogen (UUN) excretion in grams per day has been used to evaluate the degree of hypermetabolism. The UUN can be used to interpret the level of hypermetabolism as follows:

Urine Urea Nitrogen

$\leq$ 5 gm/24 hrs.	=	No stress
5 to 10 gm/ 24 hr	=	mild hypermetabolism or level 1 stress
10 to 15 gm/24 hrs	=	moderate hypermetabolism or level 2 stress
< 15 gm/ 24 hrs	=	severe hypermetabolism or level 3 stress

Meeting the nutritional requirements of such patients can be a challenging issue as they suffer from not one but several metabolic/ physiological abnormalities. For example, a diabetic patient may be suffering from urinary tract infection and end-stage renal disease wherein; the dietary management of one may be contradictory for the other form of illness. Further, these patients may be on life-support system (such as ventilator, catheters, dialysis) and oral intake may not be feasible. Multiple abnormalities may appear in the metabolism of energy, protein, carbohydrates, fat and several vitamins/ minerals. While meeting the nutrient requirements may not be always feasible; our endeavour should be to help the patient in maintaining a good nutritional status and prevent the progression of the disease. It is important to remember here that the nutritional care process undergoes several modifications over a small period of time and may require immediate implementation. However, the major/broad objectives of nutritional care are:

- to minimize the development of nutrient imbalance.
- to maintain fluid and electrolyte homeostasis
- to promote energy equilibrium
- to help in achieving and maintaining normal/ safe levels of all macro - and micro-nutrients.

The nutrition care plan for meeting the above mentioned objectives can come into play only when the patient is haemodynomically stable. We shall now proceed towards learning about the dietary management during sepsis/MODS. It is important to note that over-enthusiastic feeding of the patient would only worsen his disease condition. Patients suffering from sepsis and / or MODS should not be expected to gain weight/ body mass or strength until the source of hypermetabolism is treated.

So, let us first discuss about the energy requirements during sepsis.

Energy: Patients suffering from septicemia with or without MODS are generally hypermetabolic which results in weight loss. Critically ill patients are generally able to tolerate around 25-30 Kcals per kg usual body weight. Although adequate energy is essential for metabolically stressed patients excess calories intake may elicit complications such as hyperglycemia, excess carbon-dioxide production, which can exacerbate respiratory insufficiency or prolong weaning from mechanical ventilator. Whatever may be the amount of calories given to the patient, our objective should be to maintain blood glucose levels ≤ 100 mg/dl, if required by the help of insulin.

Proper choice of enteral/ parenteral tube feeds along with insulin infusions is advocated. A combination of two or three types of feed formulas may be required to meet the individualistic requirements of a patient. However, in isolated cases if oral intake is feasible; it is usually in the form of full-fluid/semi-liquid diets (mild sepsis/ MODS).

Protein: Adequate amount of protein is required by these patients to improve immunity against infections, promote recovery, spare lean body mass and reduce the amount of endogenous protein catabolism for glyconeogenesis. The requirements may vary from 1.2 gm to 2.0 gm per kg usual body weight per day.

During mild sepsis with adequate organ function, the protein intake can be maintained at 1.0-1.2 gm/kg usual body weight per day. Intact protein or protein rich foods can be included in the form of enteral tube feeds or as liquid or semi-soft diets. However, if the patient is having complications particularly of liver or kidneys, it is advisable to give specific amino-acids according to the underlying disease condition.

Carbohydrates and Fat: Carbohydrates should constitute nearly 60% to 70% of the total energy. Glucose is the primary calorie substrate in a parenteral nutrition formulation. Parenteral nutrition should be initiated with a low dextrose infusion rate.

Fats may provide 20% to 30% of the total calories depending on the underlying complications. Fat helps in preventing the deficiency in the presence of hyperglycemia. However, intravenous fat emulsions may create problems in patients having severe infection, liver or gall bladder disorders.

Micronutrients: The requirement of almost all vitamins and certain mineral increases due to infection and inflammation. In the absence of underlying complications adequate intake of all minerals and trace-elements like iron, calcium, zinc, sodium, potassium and magnesium is suggested. However, if the patient is suffering from complications of liver, kidney or oedema then the sodium and potassium intake should be regulated. Liberal amounts of foods rich in B-group vitamins, vitamin A and C should be included in the diet. Adequate amount of fluids should also be provided to prevent complications arising due to dehydration or hypovolemia.

Other Feeding Considerations/Nutrition Support

The preferred route for feeding the patient should be oral intake/ via the utilization of gastrointestinal tract. If oral intake is feasible, natural foods may be given in the form of semi-soft/ full-fluid diets. However, if oral intake is not possible then we should opt for enteral feedings which can be prepared from natural foods (absence of MODS/ complications) Commercially available foods (intact, hydrolyzed or semi-hydrolized formulas) parenteral nutrition should be provided if other forms of feeding can not be provided.

From the above discussion it must be clear to you that the dietary management of septic patients, especially those suffering from MODS is complex and needs to be altered after every few hours depending on the clinical parameters which are analyzed atleast 24 hourly.

In this section we learnt about sepsis and MODS which are among the most critical and life threatening conditions for human beings. Let us attempt the check your progress exercise 3 to recapitulate the concepts learnt so far.

Check Your Progress Exercise 3

1. What is trauma? Enlist the key features of the Ebb and shock period during trauma.

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2. Describe the term "sepsis" and its association with SIRS and MODS.

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3. Enumerate the energy and protein requirements of patients suffering from sepsis with or without MODS.

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4. What is the significance of providing feeding support during trauma and MODS.

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5.7 LET US SUM UP

In this unit we studied about the physiological and metabolic consequences of stress in its various forms viz. surgery, burns, injuries, sepsis and multiple organ dysfunction syndrome. We learnt that stress is a psycho-physiological response to a non-conducive environment within or outside the body which results in excessive or inappropriate activation of the body's defense mechanism.

In the first section we briefed ourselves regarding the stress response in the form of ebb and flow phase which is followed by the anabolic phase. The ebb phase is the most critical period with respect to survival of the patient. Efficient and prompt emergency treatment (first-aid) during this stage can help in reducing the incidence of mortality to a great extent. The flow phase which develops thereafter is characterized by elevated O_2 requirements, increased cardiac output, and marked catabolism. The dietician plays an important role in providing judicious and prompt care to manage the fluctuations in the nutrition status during the three phases.

The second section discussed about elective and emergency surgeries. The importance of a pro-active approach both pre - and post-operatively was discussed with regards to nutritional care.

We also learnt about a critical form of stress viz. burns which can be described as injuries to the tissues due to heat, electricity, radiation or chemicals. A briefing on classification of burns as per the common methods employed in the hospitals (rule of nines, degree/depth of burn etc.) was followed by overall treatment of superficial/ severe burns. The importance of adequate resuscitation during the ebb/ shock period was also explained. The nutrient requirements and mode of feeding during the flow and anabolic phase is also critical for ensuring proper treatment and rehabilitation of the patient.

This unit finally dealt with the most critical forms of illness viz. trauma related to injuries due to cold, radiations, altitude, accidents etc. Sepsis may result on its own or as a consequence to surgery, burns, injuries etc. Sepsis can result in multiple organ dysfunction syndrome which is often difficult to handle as it involves structural/ functional changes in not one but several organs. Such patients are usually referred to as those suffering from terminal illness and their nutritional care generally involves utilizaton of specialized formula foods through enteral or parenteral route.

5.8 GLOSSARY

Adreno-corticoid : a hormone secreted by the adrenal cortex.

Cortisol : a gluco-corticoid produced by the adrenal cortex.

Homeostasis : A balanced, normal state of the body's metabolic and physiological functioning.

Hypermetabolism : metabolism at an increased or excessive rate.

Hypovolemia : decrease in volume of blood.

Hypoxia : lack of oxygen.

Sepsis : a systematic response typically to a serious usually localized infection (abdomen/lungs) especially of bacterial origin.

SIRS : a severe systemic response to a condition that provokes an acute inflammatory reaction.

5.9 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

EBB Phase	Flow Phase
1. Develops immediately after injury and lasts for about 24 hours	1. It occurs within 24-48 hours of injury and may last for several days or weeks
2. Normal glucose production	2. Increased glucose production
3. Low insulin concentrations	3. Normal or elevated insulin concentrations
4. Elevated blood lactate level	4. Normal blood lactate level
5. Below-normal cardiac output	5. Increased cardiac output

2. Surgeries are generally categorized as elective or emergency. Elective surgery is a well planned form of medical treatment and involves removal or reconstruction of body parts/ organs. An emergency surgery is usually a life saving strategy with the major objective of preserving the body organs/ functions to the best possible extent. These are usually conducted for instance after an accident/ crush injury. By-pass surgery, removal of a tumor, organ transplants are examples of elective surgery.

3. Several physiological changes occur during and after a surgery such as: elevated body temperature; high leukocyte count; inflammation resulting in the release of cytokines, acute phase proteins and stress hormones; changes in carbohydrate metabolism characterized by rise in glucagon and fall in insulin levels, and changes in lipid metabolism in the form of increased glycerol turnover and enhanced free fatty acid recycling.

4. A high protein diet is suggested to promote wound healing and prevent wound dehiscence, to avoid hypovolemia which may develop due to low levels of circulating blood cell, to provide resistance to infection particularly at the site of surgery; to control/ prevent oedema and promote bone healing and to prevent the development of protein deficiency.

5. Negative nitrogen balance frequently develops post-operatively. This results in low levels of serum proteins especially albumin which leads to reduction in intravascular oncotic pressure and outflow of fluids/ water into the extra vascular space. This results in oedema in the interstitial spaces which affects the working capacity of heart and lungs.

Check Your Progress Exercise 2

1. Burns are injuries that are caused by heat, friction, electricity, radiation or chemicals. Burns are categorized by degree, based on the severity or depth of tissue damage as first, second or third degree burns. Read sub-section 5.4.1 for details.

2. Lactated ringers solution is used during the Ebb or Shock period to provide fluids and electrolytes as an emergency measure to prevent death due to burns. It is used in combination with colloid solution during the resuscitation period.

3. According to the Currie formula:

   Calories needed per day = 24 Kcal × kg usual body weight + 40 Kcal × % TBSA burned .

   Putting the patient values in this formula:

   $$24 \text{ Kcal} \times 62.5 + 40 \text{ Kcal} \times 33 = 1500 \text{ Kcal} + 1320 = 2820 \text{ Kcal} / 24 \text{ hrs.}$$

4. Burn Patients should be given a high protein diet during the anabolic phase to maintain a positive nitrogen balance for promoting healing of wounds, to resplenish amino acid stores in the liver for synthesis of blood proteins, to maintain normal blood picture, to facilitate successful skin grafting etc. and to prevent infections.

5. Vitamin C is involved in collagen synthesis and immune function and may be required in increased amounts (500 mg twice daily) for wound healing. Vitamin A is an important nutrient with respect to maintenance of immune function and epithelialization. Provision of 5000 I U of Vitamin A per 100 Kcal of enteral nutrition is often recommended.

Check Your Progress Exercise 3

1. Trauma refers to any physical injury or emotional stress inflicted on the human body. Medically trauma refers to a serious or critical bodily injury, wound or shock. Some characteristic features of the Ebb and Shock period include:

Ebb Phase	Flow Phase
– Low blood volume – Cardiogenic shock – Hypotension – Hyperventilation – Weak rapid pulse – Oliguria	– Increased cardiac output – Increased urinary nitrogen loss – Alterations in metabolism of carbohydrates, proteins and fat – Hypermetabolism

2. Sepsis is commonly referred to as a "blood stream infection". It is a severe form of infection in an organ wherein the causative organism is known and can result in septic shock or septicemia (infection in the blood). If a proven source of infection is lacking but the other criteria of sepsis are met, the condition typically meets the criteria for SIRS. SIRS leads to widespread activation of inflammation and co-agulation pathways. This may progress to dysfunction of the circulatory system and even under optimal treatment results in the development of multiple organ dysfunction syndrome (MODS) and eventually death.

3. Nutrient requirements during sepsis with or without MODS:

   – Majority of the patients being hyper-metabolic and usually malnourished need to be given adequate amount of calories i.e. around 25-30 Kcal per kg usual body weight per day.

   – The protein requirements are generally high varying from 0.8 to 2.0 g/kg usual body weight per day depending upon the status of organ efficiency particularly of liver and kidneys..

   – Principal source of carbohydrate is glucose which needs to provide 60% to 70% of the modified requirements of energy. The requirement is generally governed by maximum rate of glucose oxidation (5-7 mg/kg/minute) and the insulin infusion feasible for the patient.

   – Depending upon the presence/ absence of diseases associated with the gastro-intestinal tract and associated organs; the fat requirements/ intake may vary from 20% to 30% of total calories.

   – Micronutrient intake should be governed by the medical reports (biochemical tests) and mode of feeding (oral, enteral or parenteral).

4. The feeding support particularly the time, type and composition of nutrition support (enteral or/ and parenteral feeds) has a direct impact on the future morbidities and eventual mortality of the patient. Refer section 5.6.3 for details.

Nutrition in Emergencies

Emergency: Any situation where there is an exceptional and widespread threat to life, health and basic subsistence, which is beyond the coping capacity of individuals and the community" (Oxfam Humanitarian Policy, 2003.)

Introduction

- Most deaths in emergencies, 33% to 50% associated with malnutrition.

- Food and nutrition programmes cost up to 50% of the budget for humanitarian aid.

- Food and nutrition issues in Emergencies
  - The right to food is more critical than any other human right
  - Food security is usually an issue in emergencies and if prolonged ends in nutritional emergency

Causes of nutrition emergencies

- A natural disaster due to climatic or other environmental conditions such as drought, flooding, major storms, or insects infestation such as locusts; global warming might also contribute to an increase in droughts and floods
- Armed conflict, war or political upheaval
- Disruption or collapse of the food distribution network and/or the marketing system of a population. This might be the result of an environmental, political or economic crisis.
- Lack or disruption of the provision of emergency food distribution to a population experiencing food shortage.
- HIV/AIDS
- Extreme poverty of marginalized populations e.g. the elderly and urban slum populations who have poor access to water, health care and livelihoods.

Major emergencies

- food shortage
- impair nutritional status
- excessive mortality

Major deficiency diseases in emergencies

- Protein energy malnutrition.
  - Nutritional marasmus
  - Kwashiorkor
  - Marasmic kwashiorkor.
- Micronutrient & vitamin deficiencies
  - Scurvy, pellagra and beriberi
  - Nutritional anemia
  - Iodine deficiency
  - Vitamin-A deficiency.
  - Other vitamin and mineral deficiency

How do disasters affect the status of food and nutrition?

- Not all disasters produce food shortages to have a critical impact on the nutritional status of the affected population.

- Any type of disaster will disorganize transportation systems, communications, and social and economic routines.

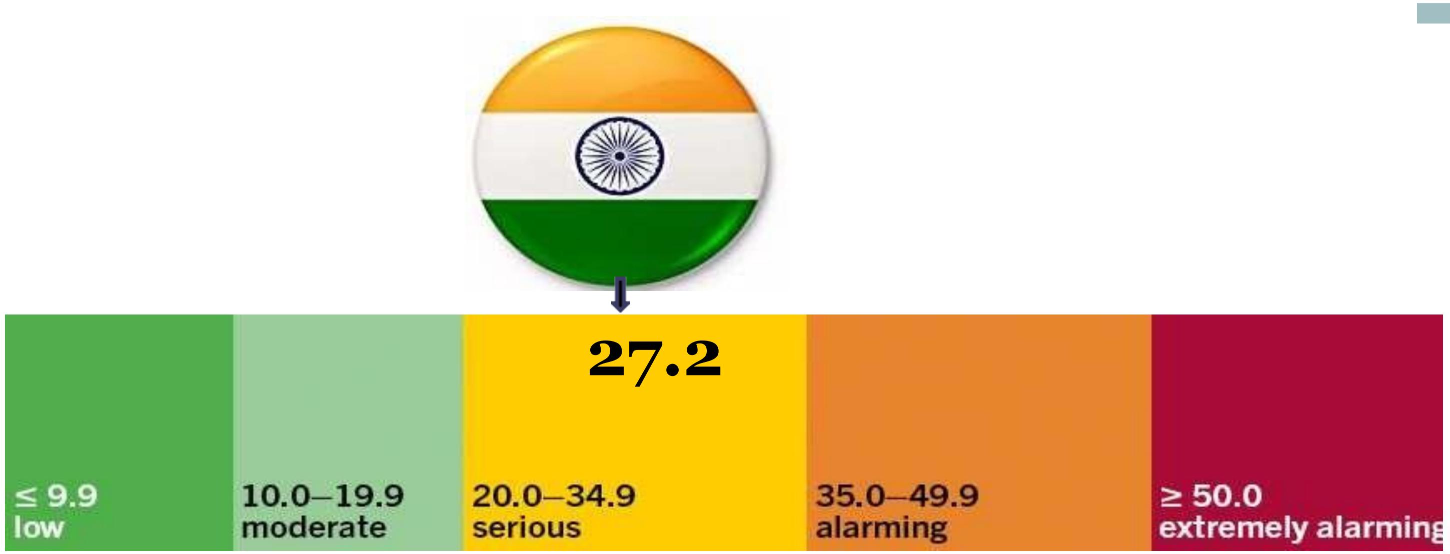
contd....

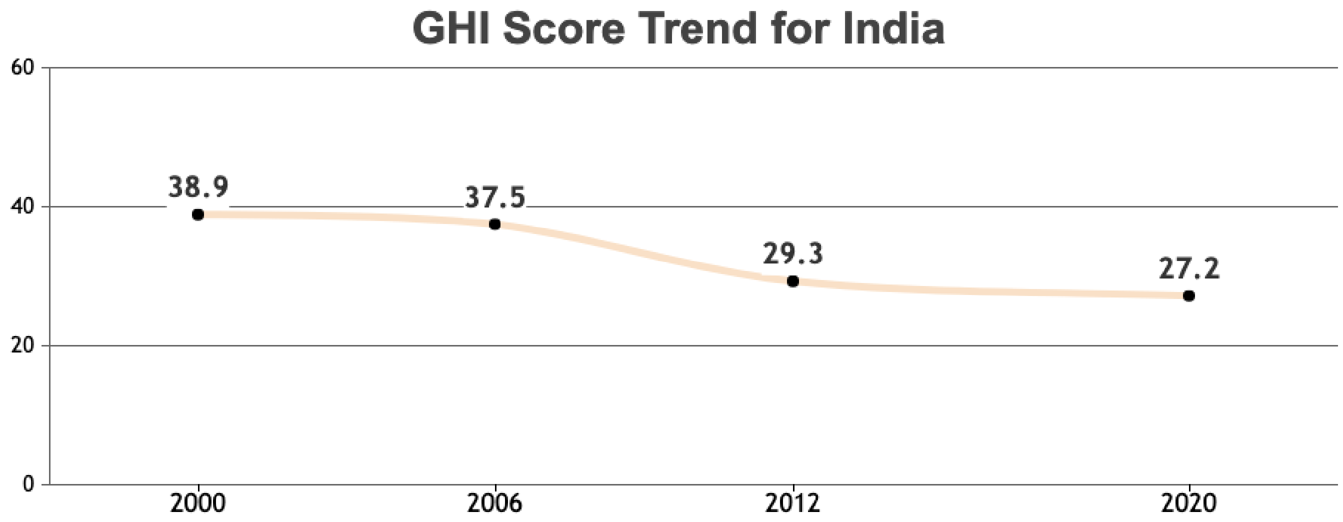
Food and Nutrition Problems

- Type of disaster
- Duration and the size of the area affected
- Nutritional status prior to disaster

Global Hunger Situation, 2020

- Nearly 690 million people are undernourished
- 144 m children stunted(21.3%)
- 47 m childrenwasted (6.9%)
- 8.9 percent of the world’s population undernourished





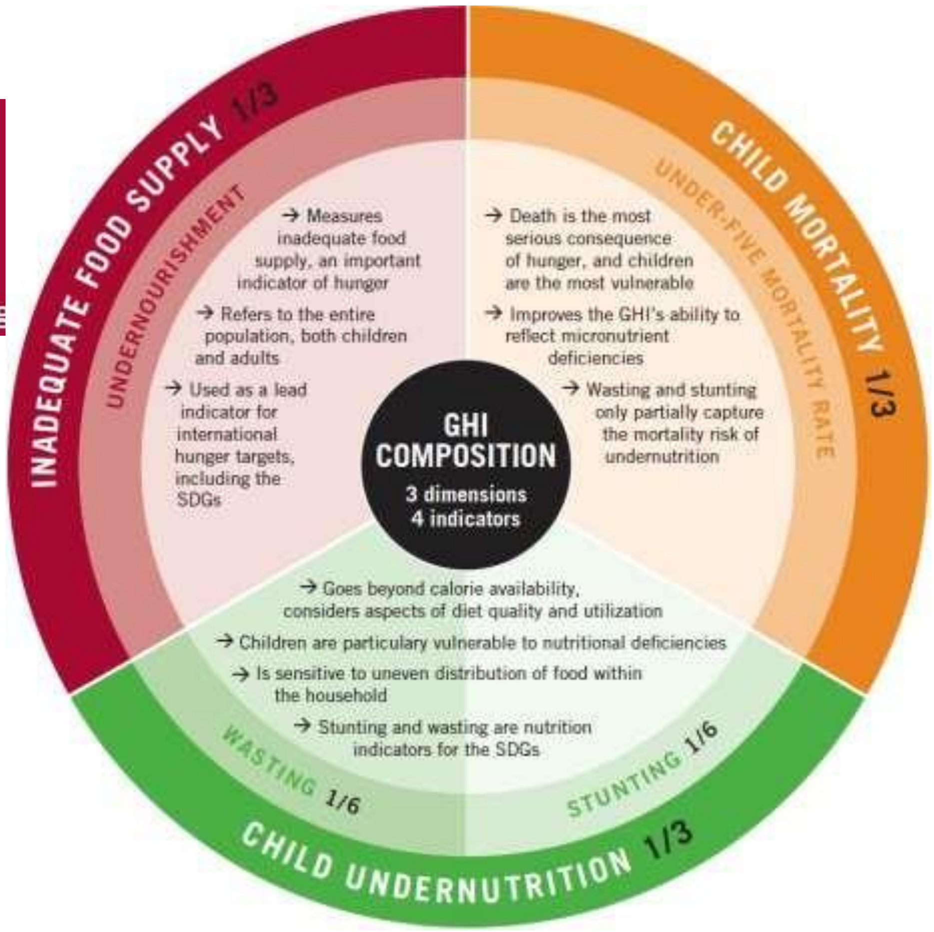
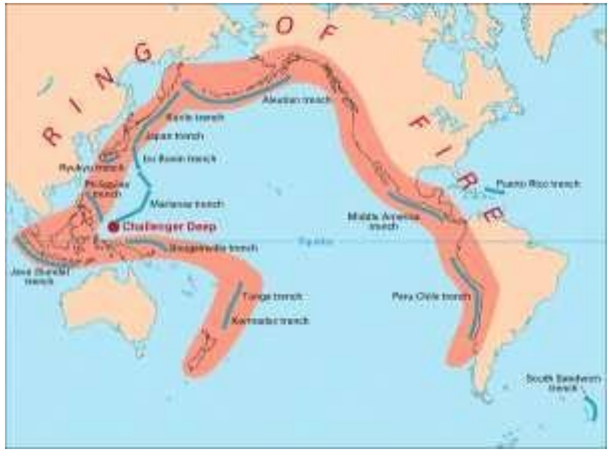


Fig: Composition of the Global Hunger Index

Who are vulnerable?

- Physiological vulnerability
- Geographical vulnerability
- Political vulnerability
- Internally displaced and refugees



Management of nutrition in major emergencies

- Food aid to prevent malnutrition in the population affected by the disaster.
- Plan for the treatment and management of cases of malnutrition that existed prior to the disaster or which have become acute, and will become evident during aid operations.

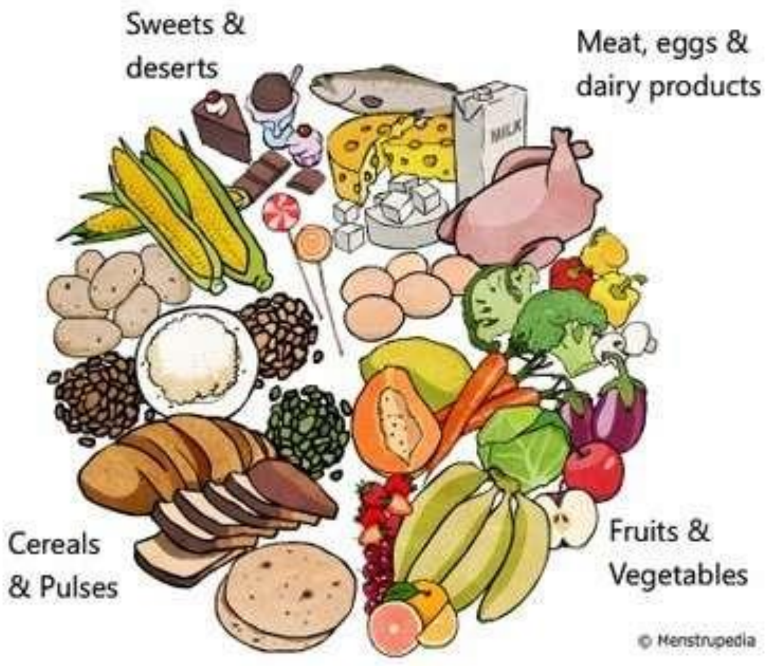
Management of nutrition in major emergencies

Principles

- Knowledge of nutritional requirement
- Essential to identify most vulnerable group
- Meeting energy & protein requirements
- Meeting micronutrient & other specific nutrient requirement
- Monitoring the adequacy of food access & intake

Management of nutrition in major emergencies

- Energy requirement - 2100 kcal/day
- Protein requirement – 46gm/day

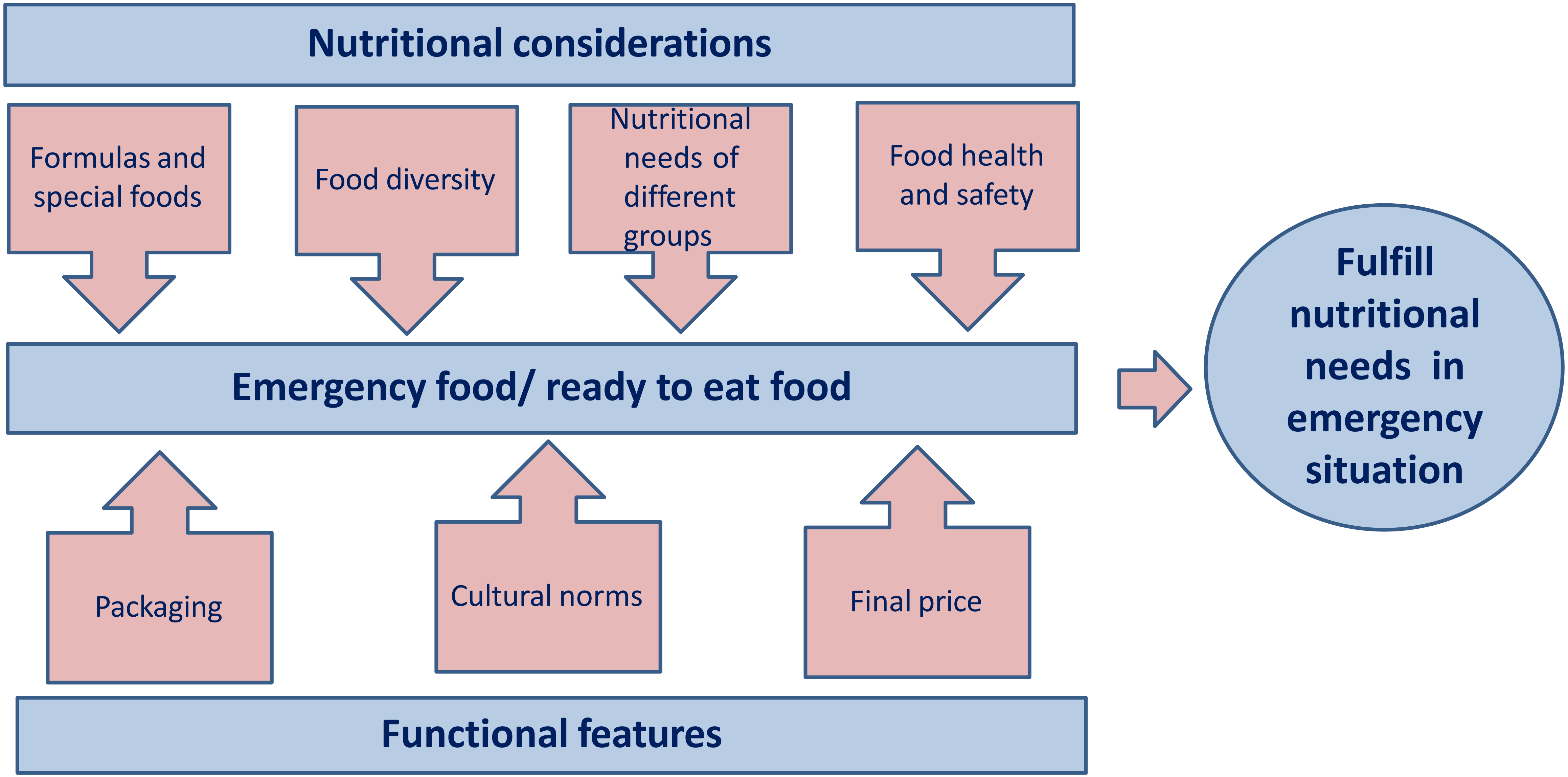


FAO/WHO/UNN Expert Consultation, 1985

Emergency phases and planning

Phase 1 of emergency	
From the outset and during initial stages of emergency (i.e. during initial rapid assessments)	• Adopt 2100 kcal/person as a reference figure • Adjust the 2100 kcal figure based on information available immediately. • Ensure that food ration is adequate to address protein, fat and carbohydrate and micronutrient requirements. • Ensure that food ration is adequate to address the nutritional needs of all sub groups • Outline strategies for collecting information to make –further adjustment • Consider food management issues Consider food related conditions Establish a monitoring system.
Phase 2 of the emergency	
Situation stabilized	• Through periodic reassessment, further revise and adjust the reference figure based on additional information about all the factors affecting energy requirements. • Plan for longer term assistance or phase down and phase out strategies.

Characteristic features of emergency food



Planning a ration

- Following adoption of the initial planning figure of 2100 kcal/person/day, adjustments are made based on factors such as temperature, health or nutritional status of the population, distribution of the population and activity levels.

1. Calculate the energy requirements of the population.
2. Select commodities that meet the energy, protein, fat and micronutrient requirements of the population.
3. Implement monitoring and follow up actions, data collection and analysis.
4. If necessary , assess the ability of the population to access other food sources and adjust the ration.
5. Monitor the situation following any such adjustments.

Macronutrient requirements

- Energy needs are usually met through a range of commodities with ample protein content.
- According to WHO/FAO, protein should provide at least 10-12% of total energy.
- At least 17% of energy in the ration should be provided in the form of fat.
- An acceptable ration also takes into consideration local dietary preferences.
- The requirements of macronutrients of a population can be readily satisfied with mixtures of proteins of plant origin.

Examples of rations for nutrition emergency (macronutrients)

ITEMS	RATIONS(quantity in gm)		
	Example 1	Example 2	Example 3
Cereal Pulses Oil(vit. A fortified) Fish/meat Fortified blended foods Sugar Iodized salt	400 60 25 - 50 15 5	450 60 25 10 40 - 5	350 100 25 - 50 20 5
Energy: kcal	2113	2075	2113
Protein(in gm and in % kcal)	58 g; 11%	71 g ; 13%	65 g ; 12%
Fat(in gm and in % kcal)	43 g ; 18%	43 gm ; 18%	42 gm ; 18%

Micronutrients requirement

- In emergency situations, the affected population may have suffered endemic micronutrient deficiencies, often exacerbated by a general deterioration in nutritional status.
- Determining the micronutrient adequacy of a ration requires a straightforward comparison of the population's daily micronutrient requirements with the estimated level of micronutrients in the basic ration.
- Populations that are highly dependent on food assistance are often at risk of micronutrient deficiency diseases.
- Efforts should be made within the context of emergency food assistance programs to recognize factors that increase the likelihood of micronutrient deficiency diseases.

Daily requirements of micronutrients in nutrition emergency

VITAMIN/MINERAL	RECOMMENDED DAILY INTAKE
Vitamin A	500 µg
Riboflavin	1.4 mg
Niacin	12.0 mg
Folic acid	160 µg
Vitamin C	28.0 mg
Vitamin D	3.8 µg
Iron	22 mg
Iodine	150 µg

Fortification of food in nutrition emergency

- Food fortification is the process whereby one or more nutrients (vitamins and minerals) are added to food –during processing.
- The inclusion of a fortified blended food – an effective vehicle for a number of micronutrients- is an important part of the basic ration in an emergency situation, particularly for the micronutrient needs of young children, pregnant and lactating mothers, and the elderly.
- Different foods should be fortified with the appropriately matched micronutrients.

Fortification of food in nutrition emergency

Vegetable oil	Vitamin A and D
Salt	Iodine
Wheat and maize flour	Vitamin A, thiamine(B1), riboflavin(B2), Niacin, folic acid and iron
Blended foods	Vitamin A, thiamine, riboflavin, niacin , folic acid, vitamin c and B12, iron, calcium and zinc

Adjusting the ration according to people's access to food

- Emergency food needs assessments : should be conducted keeping in mind the overall goals and operational objectives of food assistance. They should include
- To save lives
- To preserve productive assets
- To prevent mass migration
- To maintain nutritional status with special attention to pregnant and lactating women and other groups at high risk.
- To ensure access to an adequate diet for all population group
- To minimize damage of food production and marketing systems due to the emergency situations

Meeting special nutritional needs of the most vulnerable persons

Infants and young children:

- Malnutrition during the early years of life has a negative impact on cognitive, motor-skill, physical, social and emotional development.
- Specific interventions are required during emergencies to protect and promote optimal infant and child feeding practices.
- These interventions should be routinely included in any relief response and should be sustained throughout the period of response.

Meeting special nutritional needs of the most vulnerable persons

- The availability of nutrients from breast milk exceeds that from any other substitute.
- Breast milk not only provides all the nutrient requirements for infants but also protects children from infection .
- In most emergencies, breastfeeding becomes even more important for infant nutrition and health.
- Artificial feeding in emergencies increases the risk of diarrheal diseases and malnutrition, which in turn substantially increases the risk of infant death.
- If absolutely required, infant formula should only be used when all other options have been exhausted.
- Supplementary feeding may be an important intervention for protecting the nutritional status of lactating mothers.

Guiding principles for feeding infants during emergency

All infants, including those born into populations affected by emergencies should normally be exclusively breast fed for the first six months as recommended by WHO Every effort should be made to identify ways to breast feed infants whose mothers are absent or incapacitated.
Re lactation should be attempted before use of infant formula is considered.

Every effort should be made to create and sustain an environment that encourages exclusive breastfeeding for the first six months, and continued frequent breastfeeding thereafter for up to two years.

The quantity, distribution and use of breast milk substitute e.g. infant formula at emergency sites should be strictly controlled, using the following guidelines:

- Nutritionally adequate infant formula, fed by cup, should be available for infants who do not have access to breast milk.
- Those responsible for feeding infant formula should be adequately trained and equipped to ensure its safe preparation and use.
- Feeding infant formula to a minority of children should in no way interfere with protecting and promoting breastfeeding in majority.
- The use of infant feeding bottles in emergency setting should be discouraged and cup feeding promoted instead.

Complementary feeding for older infants and young children

- Complementary food can be a significant challenge during emergencies, since constraints often exist. Available food may be difficult to prepare into a soft, semi solid form.
- Furthermore, basic food aid commodities- cereals, pulses and oil- do not by themselves readily meet nutritional needs of young children.
- In emergency situations, there are a number of foods that can be used for the preparation of suitable complementary foods.

Options for addressing nutritional needs of older infants and young children

Source of food	Examples of food	Remarks
1.Basic food aid commodities from general ration with supplements of inexpensive locally available foods	Cereals, pulses, oil and sugar combined together with a variety of vegetables and fruit	Recipes can be developed using local foods with input from nutrition and/or health expertise. Traditional complementary feeding practices must be observed and understood.
2. Blended foods(as parts of general ration)	Com—soya blend, wheat- soya blend	Blended foods processed by roasting or extrusion to improve digestibility. For growth and development, blended foods are fortified with zinc and iron and other micronutrients.
3. Additional foods in supplementary feeding programs	Fruit, vegetables, fish, eggs or other suitable locally available foods	Valuable source of vitamins and minerals

Complementary intervention of nutrition for pregnant and lactating women in emergency

1. Fortified food commodities :

- Provision of a fortified blended food commodities, designed to provide 10-12 % of energy from fat. The blended food must be fortified to meet two-thirds of daily requirements for all micronutrients, particularly iron, folic acid and vitamin A.
- The food commodities can be provided through maternal and child health structures or through blanket supplementary programs.

2. Micronutrient supplement :

- Pregnant women: daily supplements of iron(60mg/day) and folic acid(400µg/day)
- Lactating women: vitamin A: 400000 IU in 2 doses 200000 IU in an interval of at least 24 hours within six weeks after delivery.

Conti……

3. Drinking water :

- Women are ensured access to sufficient drinking water (extra 1 liter of clean water per day)

4. Malaria management in pregnancy :

- In areas where malaria is endemic, sulphadoxine- pyrimethamine can be administered through clinics at the beginning of the second and third trimesters.
- Encourage women to use an impregnated bed net during pregnancy.

5. Prophylaxis for management of intestinal parasites :

- Give each affected women 500g mebendazole, in the second and third trimester.

6. Nutrition/Education counseling for women and communities.

Considerations to the nutritional needs of older persons

- The energy requirements for older persons usually decreases in comparison with younger adults as a result of less physical activity and decreased basal metabolism.
- The requirements for micronutrients, however, do not decrease.
- Hence, an adequate diet for older persons must ensure that micronutrients are still met even with reduced energy intakes.
- Another important consideration for older persons is that sufficient intakes of fluids are required to prevent dehydration and improve digestion.
- Theoretically, a well planned general ration is usually adequte for older persons.

Considerations to the nutritional needs of older

1. Access to easily digestible micronutrient rich foods
•Older persons, or families including older persons, should be provided with blended foods. In situations where blended food is not provided to the whole population, under 5 years olds, pregnant and lactating women and older persons should be prioritized . •Access to milling facilities in situations where whole grain cereal is provided. •Older persons should be assisted and encouraged in small scale horticultural activities to increase consumption of fresh foods.
2. Family and community support for food preparation
•Older persons, without family or community support, can be assisted through community based support programs. Assistance with tasks such as collection of rations, food preparation and collection of water may be required for older persons.

Management of food related issues

1. Temporary substitution of food items
2. Packaging of food aid commodities
3. Exchange and trade of rations
4. Quality control

Temporary substitution of food items

- Unavailable food commodities can be replaced by another food in order to maintain the energy and/or protein level of the food basket.
- These substitute should only be considered as a temporary measure and should not be implemented for longer than one month.
- Inappropriate substitutions- such as the provision of unfamiliar foods, the use of unsolicited donations of expired foods or the use of highly processed commercial foods- should be avoided.

Packaging of food aid commodities

- Proper food packaging is necessary to preserve and protect the quality of commodities.
- Proper labeling of food aid commodities provides vital information to field staff.
- Packaging should be environmentally friendly and, if possible, serve as an additional resource to the population.

Exchange and trade of rations

- The practice of exchange, bartering or resale of food aid commodities in emergency situations may facilitate diversification of food and enable access to a number of foods that are not provided in the ration.
- The sale of food in the marketplace does not necessarily indicate a food surplus.
- The rationale for trading food may simply be to diversify the diet and to improve its palatability and quality.

Quality control

- A system of quality control for all commodities must be implemented to ensure that food distributed to refugees is of good quality and safe for human consumption.
- The acceptability and consumption of food is directly influenced by the quality of the food.
- Suppliers of food commodities must be carefully scrutinized to ensure that a regular quality control check is done.
- All food received should have a minimum shelf life of six months.
- Adequate storage structures should be in place.
- Written procedures should be in place for checking the quality of food at the distribution stage.
- Fumigation and food quality control measures should be in place.

Monitoring and follow up

- First of all, a monitoring system must be established to ensure that any inadequacy in the ration are discovered in a timely manner.
- Secondly, a strategy outlining actions to be taken in response to food shortages or inadequate rations should be in place.
- Thirdly, given that access to food can change dramatically over time, and the opportunities for obtaining food through the population’s own means differs significantly between situations.
- It is essential to make strong links between food aid and the potential for food production from the outset of the emergency.

What is the proper management of food supplies?

- The objective is to ensure safety and prevent the transmission of disease through food.
  - Inspect the food received
  - Verify that transportation units
  - Good ventilation and light in warehouses
  - Distribution on a First In/First Out basis

Food and Nutrition in times of Covid-19

- Huge impact on food availability and accessibility
- Significant proportion of population involved in informal sectors, migrant workers faced maximum hardship

- Insufficient quantity and quality, irregularity in distribution, lack in variety.
- Aggravate the problem of malnutrition particularly among vulnerable groups

- Integrated Child Development Services
- Mid-Day Meal Scheme

Conclusion

- In major emergencies, most urgently needed action is to prevent death and illness caused by malnutrition
- Basic energy and protein requirements are primary concern
- When we talk about Food and Nutrition security, as a nation we can say that we are food secure with our surplus food production, providing additional grains at the time of crisis, but we are far away from becoming nutritionally secure