NUTRITIONAL ASSESSMENT TECHNIQUES

M.Sc., FOODS AND NUTRITIONAL SCIENCE,
Second Year, Paper – II

Specialization-I: Clinical Nutrition and Dietetics

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FOREWORD

Acharya Nagarjuna University, since its establishment in 1976, has been moving ahead in the path of academic excellence, offering a variety of courses and research contributions. The University achieved recognition as one of the eminent universities in the country by gaining A grade from the NAAC 2016. At present Acharya Nagarjuna University is offering educational opportunities at the UG, PG levels to students of 447 affiliated colleges spread over the two districts of Guntur and Prakasam.

The University had started the Centre for Distance Education in 2003-04 with the aim to bring Higher education within the reach of all. The Centre has been extending services to those who cannot join in colleges, cannot afford the exorbitant fees as regular students, and to housewives desirous of pursuing higher studies to study B.A., B.Com, and B.Sc., Courses at the Degree level and M.A., M.Com., M.Sc, M.B.A. and LL.M. courses at the PG level.

For better understanding by students, self-instruction materials have been prepared by eminent and experienced teachers. The lessons have been prepared with care and expertise. However constructive ideas and scholarly suggestions are welcome from students and teachers. Such ideas will be incorporated for the greater efficacy of the distance mode of education. For clarification of doubts and feedback, Weekly classes and contact classes are arranged at UG and PG levels respectively.

I wish the students who pursue higher education through Centre for Distance Education will not only be personally benefited by improving their qualifications but also strive for nation's growth by being a member in Knowledge society I hope that in the years to come, the Centre for Distance Education will grow in strength by introducing new courses, catering to the needs of people. I congratulate all the Directors, Academic coordinators, Editors, Lesson - Writers, and Academic Counsellors and Non-teaching staff of the Centre who have been extending their services in these endeavours.

Prof. Raja Sekhar P.
Vice - Chancellor (FAC)
Acharya Nagarjuna University

SYLLABUS

M.Sc (Course Code-139)

Paper - II: NUTRITIONAL ASSESSEMENT TECHNIQUES

UNIT - I

- Nutritional surveillance: Need determinants, Nutritional surveillance over view of the methods of assessment of Nutritional and health status.

UNIT - II

- Methods of assessment: Direct and Indirect methods of Nutritional assessment of human groups.

UNIT - III

- Assessment of age: Using local events calendar.
- Anthropometry Assessment: Measurements used, use of equipment, standards for comparison. Classification used to categorize malnutrition, cut of points used to distinguish current and long term malnutrition.
- Indicators of nutritional status: weight/age, height/age and weight/height, mid upper arm (MUAC).
- Guidelines for interpretations of growth charts: Graphs, Sliding role, thinness graphs, Sliding role, thickness chart, wasting and stunting classifying scale, Quack stick, shakris arm band assessment of specificity and sensitivity of new devices.

UNIT - IV

- Dietary assessment: Methods and techniques for assessing dietary intakes of individual, house hold level and Institutional level, Essential features, Uses and limitations of different methods.
- Problems intake measurements, factors affecting the accuracy of dietary assessment. Interpretation of dietary data.

UNIT - V

- Clinical assessment: Study of different methods and techniques for clinical assessment of nutritional status and diagnosis of sign of relation to various nutrient deficiencies.
- Biochemical assessment: Methods and techniques for major nutritional disorders, standards for comparison, field level assessment techniques.

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UNIT—I

NUTRITIONAL SURVEILLANCE

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OBJECTIVES

After going through the unit, students will be able to :

- state the required determinants for nutritional surveillance;
- discuss the importance of nutritional surveillance;
- explain the methods of assessment of nutritional and health status.

STRUCTURE

1.1 INTRODUCTION

The concept of nutritional surveillance is derived from disease surveillance, and means "to watch over nutrition, in order to make decisions that lead to improvements in nutrition in populations". Three distinct objectives have been defined for surveillance systems, primarily in relation to problems of malnutrition in developing countries: to aid long-term planning in health and development; to provide input for programme management and evaluation; and to give timely warning of the need for intervention to prevent critical deteriorations in food consumption. Decisions affecting nutrition are made at various administrative levels, and the uses of different types of nutritional surveillance information can be related to national policies, development programmes, public health and

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nutrition programmes, and timely warning and intervention programmes. The information should answer specific questions, for example concerning the nutritional status and trends of particular population groups.

Defining the uses and users of the information is the first essential step in designing a system; this is illustrated with reference to agricultural and rural development planning, the health sector, and nutrition and social welfare programmes. The most usual data outputs are nutritional outcome indicators (*e.g.*, prevalence of malnutrition among preschool children), disaggregated by descriptive or classifying variables, of which the commonest is simply administrative area. Often, additional "status" indicators, such as quality of housing or water supply, are presented at the same time. On the other hand, timely warning requires earlier indicators of the possibility of nutritional deterioration, and agricultural indicators are often the most appropriate.

Data come from two main types of source: administrative (e.g., clinics and schools) and household sample surveys. Each source has its own advantages and disadvantages: for example, administrative data often already exist, and can be disaggregated to village level, but are of unknown representativeness and often cannot be linked with other variables of interest; sample surveys provide integrated data of more or less known representativeness, but sample sizes usually do not allow disaggregation to, for example, specific villages. A combination of these sources, with a capability for ad hoc surveys (formal or informal) is often the best solution. Finally, much depends on adequate facilities for data analysis, even though simple, comprehensible data outputs are what is required. Intersectoral cooperation is needed to provide realistic options for the decision-making process.

Goal and Objectives of Nutrition Surveillance System (NSS)

The overall goal of the nutritional surveillance system is to monitor the nutrition and health status.

- To provide timely information on the selected crucial health and nutritional data.
- To create an interactive mechanism for planning, monitoring and evaluating nutrition and health.
- To build capacity within various departments to conduct surveillance.
- To identify selected determinants of vulnerability, nutrition, behavior, and health access of specific groups and regions so that interventions can be accurately and timely targeted to optimize prevention.
- To determine short-term changes in basic indicators of mortality and patterns of cause-specific health center access including coverage rates.

A nutrition assessment is an in-depth evaluation of both objective and subjective data related to an individual's food and nutrient intake, lifestyle, and medical history.

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Once the data on an individual is collected and organized, the practitioner can assess and evaluate the nutritional status of that person. The assessment leads to a plan of care, or intervention, designed to help the individual either maintain the assessed status or attain a healthier status.

1.2 METHODS OF NUTRITION SURVEILLANCE AND ANALYSIS

Current sources of information on nutrition Nutrition surveillance undertaken by various organizations utilizes a diverse range of information sources on nutrition. These include nutrition surveys, health facility information, rapid assessments and sentinel site surveillance. Information on the wide range of factors affecting nutrition is also collected from partners in other sectors including, health, food security, water and security.

1. Nutrition surveys: Use weight for height indicator and standard survey methodologies as per nutrition survey guidelines. These methodologies are endorsed by the Nutrition Working Group of the particular organization.

2. Health facilities: Currently there are several health facilities throughout the world. Over hundreds of these health facilities collect nutrition data on a monthly basis through anthropometrical measurements of children under the age of five. Nutrition data collected from these facilities serves as an early-warning indicator in case of a crisis. The health facility data also indicates trends in malnutrition rates over a period of time. Health facility data are not representative of the entire population given that not all children are brought to the health centre. Caution should therefore be exercised when interpreting this data.

Some of the health facilities provide therapeutic and supplementary feeding services to severely and moderately malnourished children, respectively. The trend of admissions and re-admissions may be a pointer to the incidences of acute malnutrition in the facility's catchment area.

3. Rapid assessments: These are mainly carried out on an ad hoc basis and are useful when nutrition information is urgently needed or when resources for carrying out a nutrition survey are limited. A combination of methods is used to conduct rapid assessments. MUAC is one of the methods of data collection during rapid nutrition assessment.

4. Sentinel site surveillance: This involves surveillance in a limited number of sites or population for the purpose of detecting trends in the overall well being of the population. The sites may be specific population groups or villages which cover populations at risk. Trends are monitored for various indicators including nutritional status, morbidity, dietary issues, coping strategies and food security.

5. Dietary assessments: These are part of nutrition surveys and sentinel site surveillance. The general objective is to obtain information on the overall adequacy of the diet consumed by households.

The 24 hour recall method is used to determine dietary intake. Depending on the objective of the dietary assessment, actual estimates of amounts of food consumed may be determined through weighing or volume estimates

Data Collection Methodologies

Information on nutrition can be collected using either quantitative or qualitative research methodologies. ***Quantitative approaches*** provide actual statistics on nutritional status while qualitative research methodologies offer explanations into the actual causes of malnutrition. The use of both approaches is required to develop a useful understanding of the nutrition situation in any population.

Qualitative research explores, discovers; asks why, how and under what circumstances. It involves respondents as active participants rather than subjects. The investigator is an instrument of research. In qualitative research, there is the participant who contributes the information and the researcher who guides the research process and knowledge generation. These two are essentially partners and the process towards knowledge generation is based on mutual trust and understanding of a common goal.

Nutrition Survey

Standard survey methodology is used in all surveys. Anthropometric and other quantitative data are collected on individual children. Sampling procedures are used to ensure that the children are representative of the whole population. Qualitative data on nutrition and related factors are collected to enable an interpretation of the quantitative data collected.

Issues of interest in planning a survey

A nutrition survey is used to determine the nutritional status of a population when:

- No major differences are expected between the various groups in that population
- Access to all populations in the area of interest is possible to ensure that random sampling is undertaken

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Remember:

- A nutrition survey will provide one result that is relevant to the whole area surveyed; it is not possible to break down the results by cluster and to draw conclusions for use in targeting
- Nutrition surveys require a serious investment in time - around one month and in budget.
- The survey should never be attempted without the support of technical expertise during planning, implementation and analysis.

Main functions of a survey

- To establish a baseline;
- To measure impact of impending or actual food insecurity on population;
- To measure progress or impact of nutrition projects.

Steps in conducting a nutrition survey

1. Plan the survey.
2. Administer the survey.

Plan the survey

Successful planning is guided by the following principles:

(i) *Review existing information* related to the anticipated survey area. In particular, determine the nutritional and health status, socio-economic background, food security, cultural issues, geographic location, population and settlement patterns. Such information is useful in understanding the actual nutrition problem, defining appropriate objectives, selecting relevant resources, planning for adequate equipment and developing the survey schedule.

(ii) *Identify survey goals and objectives.* Set objectives for the survey to ensure effective outcome of the survey results. All nutrition surveys should be guided by clearly stated objectives. The survey coordinator needs to know:

- Why is the nutrition survey being conducted?
- What types of nutrition information are needed?
- How will the survey information be used?

(iii) *Identify survey indicators.* It is important to establish a range of variables well in advance. The survey indicators include anthropometric indicators and mortality data with the possible addition of morbidity prevalence, infant feeding, care practices and household food consumption patterns.

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(iv) *Selecting survey methodology.* Is important to determine the type of the survey design during planning. For example, is the survey focusing on all households in the project area or targeted populations only?

(v) *Select survey sample.* When dealing with large population groups it is not possible to survey the entire population due to cost and time constraints. For this reason, a portion of the population is selected. This proportion of the whole population is the sample.

Four main *sampling methods* are used

(a) Two-Stage Cluster sampling

(b) Random sampling

(c) Systematic sampling

(d) Stratified sampling

(vi) *Identify types of personnel, equipment and resources* needed for conducting the nutrition survey.

(vii) *Agree on roles and responsibilities of partners.* Ensure that partners in all sectors are involved in the survey.

(viii) Plan a detailed time and *activity schedule* to be completed within the set time frame and cost.

(ix) *Develop data collection instruments* like questionnaires, focus group discussion guides, interview schedules and observation checklists.

(x) *Pre-test* the data collection instruments.

Administer the survey

The plans are translated into actions and include:

- Logistical arrangements
- Selecting the survey team
- Training research personnel
- Supervising the survey process
- Data collection activities like anthropometric measurements
- Selecting appropriate data processing methods and ensuring quality control procedures
- Analyzing data using appropriate statistical tools
- Interpreting data
- Report writing
- Discussing findings and recommendations
- Sharing the survey findings with partners

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On completion of the survey, there is need to follow up with stakeholders on how to use nutrition data generated from survey; Implement nutrition survey recommendations continue monitoring and evaluation of the situation.

Interpreting nutrition survey data

Cut off points for indicators of malnutrition				
Description of Nutritional Status	Weight for Height Index		Oedema	MUAC
	W/H % of the Median	Z Score (SD)		
Severe Acute Malnutrition	< 70%	<-3 Z scores (less than minus 3)	Present	<11 cm
Moderate Acute Malnutrition	>70% and < 80%	Less than - 2 Z-scores BUT greater than or equal to -3 Z-score		<12.5 cm >11 cm
Global / Total Acute malnutrition (moderate plus severe)	< 80%	<-2 Z scores	Present	<12.5 cm
Normal	>80%	>-2 Z-scores (Greater than or equal to -2Z-scores)		>13.5 cm
At risk				<13.5 cm >12.5 cm
**The presence of oedema always implies severe malnutrition.*				

Classification of global acute malnutrition using Z- scores

The following classifications for malnutrition have been established by WHO as levels for interpreting weight for height Z-score in emergencies.

Global Acute Malnutrition W/H Z score	*Interpretation*
< 5%	Acceptable level
5 – 9.9%	Poor
10 – 14.9%	Serious
> 15%	Critical

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Mortality Assessment

Mortality data collection uses the same methodology except that while the nutrition data requires thirty under-five children in each cluster (which might be found in twenty households), mortality data collection will require a minimum of thirty households. The mortality questionnaire is administered to a responsible member of that household and death statistics are collected retrospectively. The recall period commonly used is three months. All households encountered in the sampling process for under-five children should be included until the desired sample size is attained regardless of whether a child below the age of five is present or not as a household with no children could indicate that a child or children had died prior to the survey.

Classification of mortality data

Indicator	*Definition*	*Interpretation*
Crude Mortality Rate (CMR)	An estimate of the rate at which members of the population die during a specified period. This is the number of deaths from all causes per 10,000 people per day.	<1/10,000/day indicates a situation that is acceptable >1 to <2/10,000/day indicates a situation of alert >2/10,000/day indicates an emergency situation
CMR=Total number of deaths over a specified time period* 10,000 Total estimated population (current)* specified time period in days		
Under Five Mortality Rate (U5MR)	The number of deaths among children between birth and their fifth birthday expressed per 10,000 live births. This is the number of deaths from all causes per 10,000 of under five year old children per day.	<2/10,000/day indicates a situation that is acceptable >2 to 4/10,000/day indicates a situation of alert e"4/10,000/day indicates an emergency situation
U5MR= Total number of under 5 deaths over a specified time period* 10,000 Total estimated under 5 population (mid/current)*specified time period in days		

Note: — Anthropometric data alone is not sufficient for analysis and interpretation. Contextual information collected during the survey or from other sources is crucial for an in-depth and broad interpretation of the results. Verification of both qualitative and quantitative data is important.

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Rapid Assessment

As the name suggests, this is a method used to gather nutrition information within the shortest time possible and is particularly useful in situations where physical access to population is limited or when the speed of the assessment is a major consideration. The results of rapid assessment provide a basis for planning during an emergency. The purpose of rapid assessment is to determine the severity and extent of the nutrition situation without embarking on a full scale survey.

In carrying out a rapid nutritional assessment, Mid Upper Arm Circumference (MUAC) is the commonly used screening tool in measuring malnutrition levels especially in emergencies. MUAC assessments are further complemented by qualitative methods to generate information on such issues as food security, health, environment, and care practices.

Rapid assessments need to involve intersectoral teams and a variety of data collection methods will be required to facilitate triangulation and verification of all information.

Steps in planning Rapid Nutritional Assessment:

- Define objectives of the assessment
- Determine target site, area or population
- Develop most appropriate methods of data collection
- Identify and train personnel to be involved in the assessment
- Assemble materials and equipment needed during the assessment
- Develop the time plan and activity schedules

Using MUAC in Rapid Nutritional Assessment

Like data collection during nutrition surveys, selection of survey children should be as representative as possible. Depending on the size of the population either total population or a sample may be assessed using MUAC. If a sample is to be used, a 30 by 30 cluster methodology will be adopted as used in surveys or in other random sampling procedure. But since MUAC assessment is rapid, an assessment of all children in selected clusters/villages is commonly used. All children aged 12-59 months in the selected villages are measured.

Data for assessing the nutritional status using MUAC is taken for all children ages 12-59 months. MUAC should be taken by the most experienced member of the team to ensure accuracy in data collection.

Use of MUAC alone is not a sufficient tool for screening during rapid nutritional assessment. Qualitative data is used to complement MUAC using semi-structured interviews with key informants and various groups in the community.

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Direct observation, seasonal calendars, transect walks, review of documents including health facility records are additional methods used.

Using the methodologies described elsewhere in this booklet, information should be collected on the issues influencing nutritional status in all sectors. These will include the following, among other issues:

- Food availability in area under assessment (Is food readily available? What foods are available?)
- Water sources (type, number and status)
- Common diseases in the area
- Accessibility to health services (What is the distance of the health facility from the village?)
- Any livestock movements (If yes, from where to where and what is the reason for that movement)
- Any population movements (If yes, from where to where and why)
- Weaning foods for children aged 6-59 months
- Feeding pattern (usual number of meals per day, current number of meals; usual and current composition of meals
- Security situation

Other methods of information collection used in the analysis of the nutrition data

- *Focus Group Discussions:* Group discussions of 6-12 people that engage in understanding the qualitative aspects of the nutritional status of a given population.
- *Direct Observation:* Involves observing visible indications of malnutrition and related issues that could influence nutritional status like poor environmental health and sanitation.
- *Key Informant Interviews:* Involves interviewing key persons with specialized information on the subject under study like nutritionists, health officers and agriculturalists.
- *Case study:* involves an in-depth and focused study on subjects with similar characteristics like less than 2-year old children with episodes of diarrhoea.
- *Transect Walks:* Observations of all aspects of life in the area of interest during a walk from one edge of the area to the other.
- *Mapping:* Supports focus of questions, identification of resources and understanding of livelihoods.

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Health Facility Data

Nutrition data is collected at health facilities and summarized at the end of each month. Data from health facilities is entered in the Health Information System (HIS) database. This database also contains components on diseases (morbidity) and immunization. Health facility personnel are encouraged to provide explanations for upward or downward trends in levels of malnutrition among children attending the health facility.

The major limitation of the health facility data is that not all children are brought to the health centre for growth monitoring. The method is therefore not representative of the entire population. Care should be taken when interpreting health facility data.

Surveyers undertakes on-the-job training and follow-up support at health facility level that covers the following areas:

- Importance of carrying out nutrition surveillance
- Methods of carrying out nutrition surveillance
- Anthropometric measurement procedures in terms of accuracy and possible errors
- Recording and reporting procedures through use of standard registers and (HIS) forms
- Interpretation of nutrition data using Z scores
- Diagnosis of the causes of malnutrition both at individual and population level
- Integrity of the equipment
- Flow of information
- Growth monitoring process

Sentinel Sites Surveillance

The sentinel sites are purposively selected in highly vulnerable areas following a predefined criterion. Selection of households in each site is then undertaken in a random manner and a household questionnaire administered in each by surveyer's staff in collaboration with key partners and community assistants on the ground. Qualitative data is collected through focus group discussions, key informants and observations. Data analysis is further undertaken using EPIINFO and Microsoft Excel. Trends observed on the key indicators especially nutritional status indicate the sites for continuation in monitoring.

Dietary Assessments

A section of the household survey comprises of a table on dietary intake data collection. The respondents are required to recall the foods consumed in the previous 24 hour.

Key issues like food frequency, types of food groups consumed and the relationships between malnutrition and dietary diversity are investigated. At the analysis stage, diversity of the diet is determined by analysing the range of food groups consumed during the recall period.

QUALITATIVE DATA

Qualitative research techniques:

A number of qualitative research techniques are used for nutrition studies. They include:

- Focus group discussions
- In-depth interviews
- Case studies
- Observational studies
- Experience survey

Focus Group Discussions

In a focus group discussion, the interviewer acts as a moderator/facilitator of the group discussion process, his/her role involves introducing the topics, probing questions and eliciting responses from the respondents. The moderator's role should be passive and should not dominate the discussion.

Focus groups are composed of people with common characteristics such as age, sex, social or economic background. Interaction is best within a small group of participants ranging from six to twelve persons. Every participant is encouraged to express views. The type of response generated from the discussions determines the quality and interpretation of results.

In-Depth Interviews

This is an exchange between the interviewer and the respondent that allows investigation at a greater level of detail. The interview probes for feelings, attitudes, opinions and views. It requires the interviewer to be skilled in the questioning technique so as to elicit the required response.

Both the interviewer and the participant work together in a relaxed setting, a conversation is created by making participants talk freely on an identified topic.

Observation

It involves watching people and events to see how something happens rather than how it is perceived. This is called direct observation. In nutrition studies, one can observe child caring practices or child feeding practices in a given household over a period of time without interviewing that family.

Direct observation can be used to confirm information that respondents may provide on the same matter. Observations are useful for overcoming contradictions provided in interviews by respondents.

In most observation sites such as the health facility, the researcher should prepare a list of things to observe. What is seen or heard will give meaning and new insights into a nutritional issue being investigated. The observation process should be discreet.

Documentary Evidence

This involves analyzing existing material for a special purpose such as the creation of a database. Content analysis can be used to determine a trends analysis in nutritional status over a period of time, examine food patterns and habits across communities, food and nutritional policy, cultural beliefs and practices concerning food consumption.

Case study

The study concentrates on the history and the 'story' of a specific individual or situation. Factors that contribute to malnutrition of an individual child in a refugee camp would constitute a case study. The case must be understood in its own context. However, by undertaking a number of such studies, some trends might be identified or further investigation might be prompted.

Basic Steps in Qualitative Data Analysis and Interpretation

- ***Data organization:*** To analyze qualitative data, the researcher should first review the research questions or objectives. The process begins by reading and fully comprehending the field notes. As the researcher reads and transcribes field notes, the researcher should watch out for emerging themes. Such themes can be disease prevalence, infant feeding habits, commonly consumed foods and foods in season.
- ***Displaying data and establishing patterns:*** The researcher should examine data layout more closely. What patterns are emerging from the relationships? Which ideas are related?
- ***Data analysis and interpretation:*** The researcher requires analytical skills. These develop with guidance and experience. Data analysis involves sieving information to establish relationships between concepts. For instance, relationships between morbidity and nutritional status in a community. Interpretation involves communicating essential ideas of the study to identify connections and links with major themes. It is processing of findings to create connections and gaps.
- ***Triangulation of the qualitative and quantitative data is done during interpretation.*** Triangulation is the integration of two methodologies to

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give data an in-depth and richer meaning. It is usually after establishing the nutritional status of a population, that linkage is made between the prevalence of malnutrition and causal factors in the community.

- *Intervention programme data:* Consideration of the supplementary and therapeutic feeding data (wherever available) is important to monitor the incidence of malnutrition. Special focus is made on the new admission and readmission rates as well as the places of origin of the malnourished cases. Details of the age categories to facilitate establishing the vulnerable population groups are needed.
- *Report Writing:* It is both a descriptive and narrative account of the nutrition situation. The report states the problem, significance of the study, objectives, methodologies, findings and consequently, recommendations.

1.3 ELEMENTS OF NUTRITIONAL SURVEILLANCE

The data for a nutritional assessment falls into four categories: anthropometric , biochemical , clinical, and dietary.

Anthropometrics

Anthropometrics are the objective measurements of body muscle and fat . They are used to compare individuals, to compare growth in the young, and to assess weight loss or gain in the mature individual. Weight and height are the most frequently used anthropometric measurements, and skinfold measurements of several areas of the body are also taken.

As early as 1836, tables had been developed to compare weight and height in order to provide a reference for an individual's health status. The Metropolitan Life Insurance Company revised height and weight tables in 1942, using data from policyholders, to relate weight to disease and mortality. There has been much discussion about the relevance (and appropriateness) of using the individuals who buy life insurance as a basis for "ideal" height and weight. There are also a number of problems with using a table to determine whether an individual is at the right weight—or even what the "ideal

In 1959, research indicated that the lowest mortality rates were associated with below-average weight, and the phrase "desirable weight" replaced "ideal weight" in the title of the height and weight table.

To further characterize an individual's height and weight, tables also include body-frame size, which can be estimated in many ways. An easy way is to wrap the thumb and forefinger of the nondominant hand around the wrist of the dominant hand. If the thumb and forefinger meet, the frame is medium; if the fingers do not meet, the frame is large; and if they overlap, the frame is small.

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Determining frame size is an attempt at attributing weight to specific body compartments. Frame size identifies an individual relative to the bone size, but does not differentiate muscle mass from body fat. Because it is the muscle mass that is metabolically active and the body fat that is associated with disease states, Body Mass Index (BMI) is used to estimate the body-fat mass. BMI is derived from an equation using weight and height.

To estimate body fat, skinfold measurements can be made using skin-fold calipers. Most frequently, tricep and subscapular (shoulder blade) skin-folds are measured. Measurements can then be compared to reference data—and to previous measurements of the individual, if available. Accurate measuring takes practice, and comparison measurements are most reliable if done by the same technician each time.

To estimate desirable body weight for amputees, and for paraplegics and quadriplegics, equations have been developed from cadaver studies, estimating desirable body weight, as well as calorie and protein needs. Calorie needs are determined by the height, weight, and age of an individual, which determine an estimate of daily needs.

The Harris-Benedict equation is frequently used, but there are quicker methods to estimate needs using just height and weight. Opinions and methods vary on how to estimate calorie needs for the obese . As previously mentioned, body fat is less metabolically active and requires fewer calories for support than muscle mass. If an individual's current body weight is more than 125 percent of the desirable weight for the individual's height and age, then using body weight to estimate calories needs usually leads to an over-estimation of those needs.

Biochemical Data

Laboratory tests based on blood and urine can be important indicators of nutritional status, but they are influenced by nonnutritional factors as well. Lab results can be altered by medications, hydration status, and disease states or other metabolic processes, such as stress . As with the other areas of nutrition assessment, biochemical data need to be viewed as a part of the whole.

Clinical Data

Clinical data provides information about the individual's medical history, including acute and chronic illness and diagnostic procedures, therapies, or treatments that may increase nutrient needs or induce malabsorption . Current medications need to be documented, and both prescription drugs and over-the-counter drugs, such as laxatives or analgesics, must be included in the analysis. Vitamins , minerals , and herbal preparations also need to be reviewed. Physical

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signs of malnutrition can be documented during the nutrition interview and are an important part of the assessment process.

DIETARY DATA

There are many ways to document dietary intake. The accuracy of the data is frequently challenged, however, since both questioning and observing can impact the actual intake. During a nutrition interview the practitioner may ask what the individual ate during the previous twenty-four hours, beginning with the last item eaten prior to the interview. Practitioners can train individuals on completing a food diary, and they can request that the record be kept for either three days or one week. Documentation should include portion sizes and how the food was prepared. Brand names or the restaurant where the food was eaten can assist in assessing the details of the intake. Estimating portion sizes is difficult, and requesting that every food be measured or weighed is time-consuming and can be impractical. Food models and photographs of foods are therefore used to assist in recalling the portion size of the food. In a metabolic study, where accuracy in the quantity of what was eaten is imperative, the researcher may ask the individual to prepare double portions of everything that is eaten—one portion to be eaten, one portion to be saved (under refrigeration, if needed) so the researcher can weigh or measure the quantity and document the method of preparation.

Food frequency questionnaires are used to gather information on how often a specific food, or category of food is eaten. The Food Guide Pyramid suggests portion sizes and the number of servings from each food group to be consumed on a daily basis, and can also be used as a reference to evaluate dietary intake.

During the nutrition interview, data collection will include questions about the individual's lifestyle—including the number of meals eaten daily, where they are eaten, and who prepared the meals. Information about allergies , food intolerances, and food avoidances, as well as caffeine and alcohol use, should be collected. Exercise frequency and occupation help to identify the need for increased calories. Asking about the economics of the individual or family, and about the use and type of kitchen equipment, can assist in the development of a plan of care. Dental and oral health also impact the nutritional assessment, as well as information about gastrointestinal health, such as problems with constipation , gas or diarrhea, vomiting, or frequent heartburn.

EVALUATION

After data are collected, the practitioner uses past experience as well as reference standards to assimilate the information into an assessment that provides an understanding of the individual's nutritional status. The practitioner uses the anthropometric data to assess ideal and desirable weight, as well as skinfold measurements to determine body fat. Height, weight, and age are plugged into the Harris-Benedict equation to determine calorie and protein needs. Using the clinical, biochemical, and dietary data, influences on the nutritional status can be determined. A nutritional intervention, which usually includes dietary guidance and exercise recommendations, is then formulated and discussed with the individual.

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STUDENT ACTIVITY

1. Point out the motive of nutrition surveillance.

2. Discuss the features of qualitative research technique of nutrition assessment.

3. Write down three most important steps of qualitative data analysis.

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1.4 METHOD OF ASSESSMENT OF NUTRITION AND HEALTH STATUS

Measuring nutritional status Nutritional assessment is the process of evaluating the nutritional status of an individual. Four methods are available that can be referred to as the 'ABCD' of nutritional assessment.

1. Anthropometric assessment
2. Biochemical or laboratory assessment
3. Clinical assessment
4. Dietary Assessment

Anthropometric Assessment

Anthropometry is the measurement of the body's physical dimensions. The physical dimensions are used to develop an understanding on an individual's nutritional status. The following measurements are commonly used.

Weight: Changes in weight among young children can be a useful indicator of the general health and wellbeing of the entire population. Under certain special circumstances however, it may be essential to measure other age groups.

Height/Length: Height or length of children changes over time and is dependent on their nutrient intake and utilization.

Mid Upper Arm Circumference (MUAC): These are rapid and effective measures that predict risks of death among children aged 12 - 59 months. MUAC is a useful screening tool for determining children at risk in emergencies.

Body Mass Index (BMI): Is a useful tool when measuring an adult's nutritional status. Weight and height measurements are taken, then used to compute the index.

Use of BMI in older people can be unreliable as accuracy in height may be impeded by age-related factors like spinal curvature. MUAC is therefore an appropriate measure since is relatively independent of aging.

Oedema: Abnormal accumulation of fluid indicating severe malnutrition.

Age as an Indicator

Age is used to develop nutritional indicators in combination with certain anthropometric measurements like height and weight. For nutritional assessment in emergencies, children less than 5 years are commonly measured since their measurements are more sensitive to factors that influence nutritional status such as illness or food shortages.

Anthropometry Related Indicators

The body measurements of weight, height and age are converted into nutritional indices. To generate the indicators, any of the two variables measured are related. That is, weight, height and age as follows:

- Weight for height
- Weight for age
- Height for age

Weight for Height/Length (W/H) *(measures 'wasting' or 'acute' malnutrition)*

- Expresses the weight of the child in relation to the height.
- In children under 5 years of age, the relationship of weight to height is almost constant regardless of their sex or race and follows a constant evolution as they grow. Internationally accepted reference values of weight-for-height for under five-year-old children are available.
- Body weight is sensitive to rapid changes in food supply or disease, while height changes very slowly.
- Low weight for height is characterized by wasting and loss of muscle fat. It is an indicator of thinness and identifies acute malnutrition.
- This is the most useful index for screening and targeting vulnerable groups in emergencies. It is a useful indicator for admissions and discharge in and out of feeding programs.
- Alongside oedema, it is the most appropriate index used to detect existing malnutrition or recent onset of malnutrition in the population.

Height for Age (H/A) *(measures "stunting" or chronic malnutrition)*

- It is a measure of chronic malnutrition. That is, long-term and persistent malnutrition normally associated with long-term factors such as poverty and frequent illness.
- A child's height is compared to the median height (length) of the reference population of the same age and sex to give H/A index. Children falling below the cut off point of –2 SD from the median of the reference population are classified as too short for their age or stunted.

Weight for Age (W/A) (measures underweight)

- It conveys the weight of a child in relation to the child's age.
- WH index is a useful index for monitoring growth and development of children.
- When used in growth monitoring at health facilities, a child's W/A is

commonly plotted on the Road to Health growth chart. This allows for better understanding of the child's positive or negative growth.

- At population level, the measurement indicates the total proportion of underweight children.

Oedema

- It is the abnormal accumulation of large amounts of body fluid in the intercellular tissues.
- It is a key clinical feature of severe malnutrition and is associated with high mortality rates in children.
- Oedema increases the child's weight. It therefore tends to hide the true picture of the nutritional status of the child.
- All cases of oedema should be separated from the rest of the respondents during analysis and treated as severe acute malnutrition.
- Oedema should always be used as a major criteria for admission into therapeutic feeding programs.

Mid Upper Arm Circumference (MUAC)

- MUAC measurements are a good predictor of immediate risk of death.
- It is an initial screening tool in feeding programs as it is simple and fast to use.
- It is useful when access to population is difficult, resources limited or when WH measurement is not possible.
- MUAC results provide indications for nutritional status and are less accurate.

Biochemical Methods

This is a measure of nutrients in blood, urine and other biological samples. Compared to other methods, biochemical methods of nutritional assessment provide the most objective and quantitative data on nutritional status. The usefulness of biochemical tests is that they provide indications of nutrient deficits long before clinical manifestations and signs appear.

Biochemical tests are also important in validation of data especially where respondents are under-reporting or over-reporting what they eat. These tests are therefore particularly useful in complementing and validating dietary intake surveys.

The major disadvantages of biochemical methods is that they are complex, expensive and require a high level of expertise.

CLINICAL ASSESSMENT

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Clinical signs in the assessment of nutritional status result from both lack of nutrients and nonnutritional causes. Signs and symptoms should be investigated and combined with anthropometrical, dietary evaluation and biochemical tests for accurate analysis and interpretation of data.

Clinical assessment involves:

(a) medical history,

(b) dietary history and

(c) physical examination by a health professional to identify signs and symptoms associated with malnutrition.

The medical history of the respondent is the first step in clinical analysis. This can be obtained by:

- Finding out the respondent's past and present health status. Many diseases such as malaria, measles, tuberculosis and HIV/ AIDS can affect the nutritional status.
- Identifying conditions such as diarrhoea and lack of appetite.
- Evaluating a child's age, or a woman's obstetric history.
- Analysing socio-economic support and access to healthcare.

Dietary history includes determining the respondent's eating habits. For instance timing and frequency of meals, tastes, allergies, ability to access food physically and economically, how food is prepared and how food is distributed at household level.

Detection of Malnutrition during Clinical Assessment

Acute malnutrition

This is a classical form of malnutrition related to low intake of energy-giving foods and proteins in the body. Acute malnutrition is the most common form of malnutrition. The term covers a range of clinical disorders that occur as a result of an inadequate intake of energy, protein and other nutrients. The most severe clinical forms of acute malnutrition are marasmus and kwashiorkor. These conditions are characterized by growth failure. Acute malnutrition has a wide range of manifestations that range from weight loss (thinness) to stunting (shortness) or a combination of both.

Marasmus: This is a very serious form of acute malnutrition characterized by severe weight loss or wasting. Marasmus is a condition commonly associated with low intake of energy-giving foods. It requires immediate treatment.

Kwashiorkor: This is a very serious form of acute malnutrition characterized by oedema, apathy and loss of appetite. It is a condition commonly associated with low intake of proteins or inadequate synthesis of proteins in the body. The condition requires immediate attention.

Oedema

This is fluid accumulation in the body as a result of severe nutritional deficiency. Bilateral oedema is an indicator of acute malnutrition and may be detected by pressing the thumb on the feet just above the ankle for three seconds. This will leave a dent.

Bilateral oedema is a manifestation of severe acute malnutrition and requires immediate treatment.

Micronutrient deficiency

This is a deficiency that results from the inadequate intake of nutrients required by the body in minute quantities for the normal function of the body. The main micronutrient deficiencies of public health concern are Iron Deficiency Anaemia (IDA), Vitamin A Deficiency (VAD), Iodine Deficiency Disorder (IDD) and Zinc deficiency. These deficiencies may cause permanent damage to health and even death.

Outbreaks of other types of micronutrient deficiencies occasionally experienced in emergencies include vitamin C (scurvy), niacin (pellagra) and thiamine (beriberi).

Signs and symptoms of malnutrition

	Clinical assessment	***Possible nutritional deficiency***
Hair	Dull, dry, brittle, wire-like Thin, wider gaps between hairs Lightening of normal hair colour Can be pulled out easily	All associated with acute malnutrition
Eyes	Bitot spots Dry greyish yellow or white foamy spots on whites of the eye.	Vitamin A deficiency
	Conjunctival Xerosis. Inner lids and white of eyes appear dull dry and pigmented.	Vitamin A deficiency
	Corneal Xerosis Cornea (coloured part of the eye) becomes dull, milky, hazy, opaque.	Vitamin A deficiency

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Teeth	Mottled Enamel White or brownish patches in tooth enamel; pitting of enamel most obvious in front teeth.	Excessive fluorine
Gums	Purplish, red, spongy and swollen. Bleed easily with slight pressure	
Glands	Enlarged Thyroid. May be visible or felt. More visible with head tipped back	Iodine deficiency
Subcutaneous	Oedema	Sodium and water retention
Tissue	Bilateral swelling usually of ankles and feet first.	associated with acute malnutrition
Bones	Knock-knees - Curve inward at knees Bowlegs - Legs are bowed outward.	Past Vitamin D and Calcium deficiency
	Osteomalacia	Calcium deficiency
	Tender and brittle bones in adults Joint pain	Possible Vitamin C deficiency
Muscles	Muscle wasting	Associated with severe acute malnutrition
	Excess folding of skin under buttocks	
Skin	Dry or Scaly skin; cracking, yellow pigmentation Pellagrous dermatitis Flaky paint dermatitis	Vitamin A, Zinc, and Vitamin C deficiencies. Niacin deficiency acute malnutrition
Other	Poor wound healing	Associated with Zinc deficiency
	Weakness and fatigue	Iron and Vitamin B1 deficiency

Dietary Methods

Dietary methods generally involve the assessment of food consumption over a period of time. In nutrition surveillance, the dietary assessment involves identifying food availability, accessibility, who consumed and at what frequency. Data on foods consumed assist in the identification of nutrient intake. Interpretation of dietary intake involves use of food consumption tables. Nutrient intake in dietary methods is used to complement anthropometry, biochemical or clinical data.

Analysis of dietary intake involves:

- grouping of foods according to a predetermined system (e.g. FAO or USDA) to determine diversity
- Determining the frequency of consumption of foods in each food group.
- In some circumstances, based on this baseline and the level of acute malnutrition, using regression analysis to project the level of acute malnutrition in foreseeable circumstances

Food Frequency Recall

This is an assessment method commonly used in nutrition assessments or surveys to determine dietary intake. It involves establishing the frequency of which certain types of foods (those of particular interest in the survey) are consumed over a specified time-frame normally a week or two. It is easier to administer than the 24-hour recall method. The frequency of consumption could be coded as:

(a) 'Frequently consumed' - food item consumed once a week to many times a day.

(b) 'Not frequently consumed' – food item consumed no more than twice a month

(c) 'Never Consumed' – food item not consumed at all.

The 24-hour Dietary Recall

In this method, the respondent is asked to remember in detail the type and quantity of foods consumed during the previous 24 hours. Asking respondents about their activities during the day can assist in recalling what they ate and provides valuable information in estimating the level of activity and energy expenditure. The values of these measurements are converted into grams or millilitres (drinks and beverages). The amounts of various nutrients are then calculated using the food composition tables and/ or nutrition computer packages designed for this particular nutritional assessment method.

The method is reasonably quick and inexpensive but respondents may withhold or alter information about what they ate due to embarrassment or to influence the research. To develop an understanding of seasonality, the assessment should be repeated at intervals throughout the year.

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ASSESSMENT OF HEALTH STATUS

In the past, attempts have been made to correlate nutritional status with postoperative outcome and complication rate. This resulted in the definition of the prognostic nutritional index (PNI), a parameter to prospectively identify the patient at risk of nutritionally based complications and to permit a quantitative estimate of this risk. Of numerous anthropometric and biochemical parameters, the serum albumin level, triceps skinfold thickness, serum transferrin level and cutaneous delayed hypersensitivity reactivity appeared to have a major influence on postoperative outcome. These factors were used to define the prognostic index, which allows quantification of the risk of complications and provides a quantitative estimate of operative risk, thereby permitting rational selection of patients to receive preoperative nutritional support.

Another index, the prognostic inflammatory and nutritional index (PINI), combining values of acute-phase reactants (orosomucoid and C-reactive protein) and visceral proteins (albumin and prealbumin) in a formula provides a scoring system for the diagnosis and prognosis of stressed patients.

In another survey of 12 parameters of nutritional status, only preoperative levels of total serum protein and total iron-binding capacity were independently related to postoperative sepsis in cancer patients. Whether these parameters are only non-specific markers of malnutrition or whether they are directly involved in host defence mechanisms remains unclear, however.

Indices such as these have been developed to prospectively quantitate the risk for postoperative infection in order to diminish this risk by taking appropriate nutritional measures.

From these indices it is clear that only a limited number of anthropometric and biochemical parameters for malnutrition show a clear correlation with postoperative outcome.

A large number of these parameters are used today for the assessment of nutritional status and quantification of the degree of malnutrition. However, because of the large interindividual variation and the dependence of these values on disease state, data have to be interpreted with caution.

Therefore, at least as important as these parameters is the clinical presentation of the patient, because it can identify the patients who are in a depleted state or are at risk of developing malnutrition.

Clinical Assessment

Clinical assessment, as presented by Jeejeebhoy (1990) may form the basis for assessment of the nutritional status of the patient. It is based on the clinical impression of the patient, without exactly defining or quantifying the degree of

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malnutrition. It combines a number of clinical parameters of the nutritional status or, more correctly, forms an index of sickness rather than of nutritional status. Clinical assessment should focus on the following points:

- past nutritional intake;
- disease process and any operation affecting future intake of nutrients;
- catabolic effect of the disease affecting the patient;
- current physical state in relation to weight loss, deterioration of functional status, body fat loss and other signs of malnutrition, such as glossitis, oedema, skin rashes and neuropathy;
- functional status of the central nervous system, namely alertness, ability to ambulate and to cough; cardiovascular and renal function.

Based on features of the clinical history and physical examination, some diseases and factors of high risk for development of malnutrition can be identified:

- chronic diseases, like malignancy, kidney and liver diseases, congestive heart failure;
- digestive and absorptive abnormalities, like inflammatory bowel disease, short-bowel syndrome, gastrointestinal fistula, pancreatic disease, chronic diarrhoea;
- social and dietary factors, like drug and alcohol abuse, poverty, poor dentation;
- other factors leading to increased requirements like burns, sepsis, surgery, chemotherapy.

Clinical assessment can identify those patients that are at risk for malnutrition. In an attempt to define the patient's risk of nutritionally related complications, the SGA (subjective global assessment) grading scale has been introduced by Detsky (1987). This assessment is based on the following features of the patient's condition: weight change, dietary intake, gastrointestinal symptoms, functional capacity, stress and physical signs. On the basis of these features, patients are scaled into SGA grade A to C, depending on their nutritional status; this grading helps to identify those patients who are at risk of nutritionally mediated complications.

Definition of Severity of Malnutrition

Since malnutrition causes variable modifications of the various body compartments, it is worthwhile to distinguish the lean body mass, which comprises the masses of the cells, extracellular fluid and skeleton, from the fatty mass, i.e. the adipose tissue. For a reference adult of 70 kg, the cellular mass is 28 kg (40%), extracellular fluid mass 17.5 kg (25%), the skeletal mass 7 kg (10%) and the adipose tissue mass 17.5 kg (25%) (Blackburn 1979).

Patients identified at risk of protein-energy malnutrition are to undergo evaluation to determine the severity and type of malnutrition present. These examinations include the following tests:

1. Assessment of body weight and (recent) weight loss.
2. Assessment of static caloric reserve (fat store).
3. Assessment of static protein reserve (muscle store).
4. Assessment of circulating protein status.
5. Assessment of immune status.
6. Body composition measurement.

Assessment of Body weight and (recent) weight loss

Optimal body weight

When interpreting body weight, allowance must be made for the clinical judgement in function of the accuracy of the history, the underlying disease, and variations in hydration or oedemas. Parameters worth recording are the weight expressed as a percentage of the ideal weight and as a percentage of the usual weight, as well as the recent percentage loss in weight in the course of the disease. A weight amounting to 80% of the ideal weight may be interpreted as minor denutrition, 70 to 80% as moderate malnutrition and less than 70% of the ideal weight as severe malnutrition. The ideal weight is defined as the weight relative to height associated with the lowest mortality. If the usual weight, i.e. the premorbid weight, differs greatly from the ideal weight, the usual weight should be used as a reference. In the case of kwashiorkor, the weight loss can be less pronounced, because of the oedemas frequently observed.

Body mass index

The body mass index provides a relation between body weight and body height and is defined as follows:

$$BMI = \text{body weight in kg}/(\text{body height in m})^2$$

The BMI is usually calculated for a clinical assessment of overweight and obesity. Limit values are dependent on the age (< or >=35 years) of the patient. The curvilinear plot of BMI and overall mortality risk results in a U-shaped curve. In general, a good weight can be defined as a BMI between 20 and 25 kg/m^2 ; overweight is a BMI > 25 kg/m^2 and a BMI > 30 kg/m^2 strongly indicates signs of obesity with increased risk (Bray, 1992). Conversely, BMI values lower than 19

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are indicative of malnutrition and thus increased mortality risk. Moderate undernutrition can be defined as a BMI between 16 and 18 kg/m^2 ; a BMI < 16 kg/m^2 indicates severe malnutrition. In critically ill patients it is often difficult to measure body height and body weight, while body weight may be influenced by fluid shifts.

Assessment of static caloric reserve

Subcutaneous fat forms a valid index for body fat. The measurement of skinfold thickness is a simple and rapid method for determining body fat stores. The triceps skinfold thickness (TST) is very informative about total body fat store. To determine body fat, the skinfold thickness is measured at the triceps, the thorax and the abdomen.

Furthermore, anthropometric measurements of the arm provide an indirect evaluation of the other body compartments. The muscle is representative of the lean mass, while the adipose tissue is an index of the energy reserves. From the measurement of the mid upper arm circumference and the triceps skinfold, the arm muscle circumference and the values of the muscle compartment and adipose compartment can be calculated. Although these measurements are not sufficiently sensitive to allow precise determination of the body composition in a particular patient, repeated measurements appear to be useful in assessing the effect of nutritional therapy.

One has to realise, however, that changes in muscle mass are changes in volume; the corresponding change in circumference is therefore more difficult to detect. Furthermore, the muscle mass is exaggerated by this method (15 - 25%). Additionally, in acute disease muscle tissue is characterized by a relative increase in water content, which makes it difficult to detect a loss in tissue. Changes in energy and nitrogen in the short term can not be detected by anthropometry, although it may detect large shifts in body compartments over months or years. Therefore, one can conclude that anthropometric measurements can only give an indication of depletion.

Assessment of static protein reserve

Creatinine

Creatinine is a metabolite of creatine; the amount of creatine in an individual is constant and creatine is only contained in the muscle tissue. Creatinine can not be reutilized and its excretion in urine is proportional to the muscle creatine content and therefore to the total body muscle mass. Creatinine excretion is practically independent of protein intake and therefore the 24 h creatinine excretion represents a parameter for the muscle tissue metabolism, as one mole of creatinine correlates to 17-20 kg of muscle tissue. In physical efforts and acute illness the creatinine excretion is enhanced and is therefore not a good index for assessment of malnutrition under these circumstances.

3-Methylhistidine is another biochemical parameter for estimating body protein mass. This amino acid is located almost exclusively in myofibrillar protein and is released when this protein is degraded; it cannot be recycled and is excreted in the urine. Collection of 3-methylhistidine in the urine therefore reflects the amount of muscle protein broken down. The interpretation of 3-methylhistidine excretion is complicated, however, by the fact that other factors than muscle mass, such as age, dietary intake and stress influence 3-methylhistidine excretion.

Creatinine/height index

As the muscle tissue is dominated by the height of the patient, the creatinine/height index has been introduced (24 h urine creatinine divided by the length) to correlate creatinine excretion to muscle tissue. The values observed have to be compared to reference values of creatinine excretion for a normal adult of the same sex and length. It is assumed that a reduction in muscle mass produces a proportional reduction in creatinine/height index.

Nitrogen Balance

Since the protein mass appears to be the limiting factor governing survival, dynamic assessment of nitrogen balance is of prime importance. There are several methods for assessing protein and nitrogen metabolism. The oldest and most widely used method for evaluating changes in body nitrogen is the nitrogen balance method. However, there are other methods, like determining arteriovenous differences in amino acids, reflecting amino acid metabolism, or methods using radioactive labelled amino acids.

As body proteins contain virtually all the nitrogen in the organism, measurement of nitrogen balance reflects protein balance. Metabolites of protein breakdown appear mainly in the urine. Protein is also lost in the stool, in the renewal of the skin and in the growth of hair and nails. In hospital, there are further losses, e.g. in wounds and fistulae.

By measuring the quantities of nitrogen given as protein and the quantities lost by various routes, one can arrive at a nitrogen balance: $N_{bal} = N_{in} - N_{out}$

However, the nitrogen balance only defines the difference between nitrogen entering and exiting the body. It should be pointed out that nitrogen losses are routinely underestimated because of incomplete collections of urine and faeces and insensible losses (e.g. through skin and sweat), while nitrogen intake can easily be overestimated because of food not consumed.

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The nitrogen balance is an indirect, but nevertheless reliable measure of protein conservation. A negative nitrogen balance, for example, shows that protein losses are greater than protein intake, indicating catabolic state.

In hospital, the measurement of an exact nitrogen balance is hardly practicable. Even the equipment for measurement of total nitrogen in urine is often not available. One may, however, make use of the following approximation:

$$N_{bal}\ (g/24h) = N_{in} - [UNN + 4 + (BUN_e - BUN_s/100 \times BW \times F)]$$

N_{in} = *nitrogen intake (g/24h)*

UUN = urinary urea nitrogen (g/24h)

BUN = blood urea nitrogen (mg/dl) (s = at start, e = at end of 24h)

BW = body weight (kg)

F = body water factor (male: F = 0.60, female: F = 0.55)

This equation takes account for the fact that the majority of the nitrogen losses in urine (80 - 90%) are in the form of urea; this fraction may rise in catabolic situations, but is never below this value. Losses in the urine other than as urea are reckoned to amount to 2 g and the skin and faecal losses also to 2 g (hence the 4 in the equation). Finally, a correction is made for urea that is produced, but does not appear immediately in urine, accumulating instead in the blood (BUN). Losses from the drainage of wounds and fistulae have to be taken into account by measurement.

To calculate nitrogen balance, a 24 h urine collection is required in order to determine urea nitrogen (1 g of nitrogen = 2.2 g of urea) or total urinary nitrogen, to which is added the undetermined nitrogen losses (skin, faeces) estimated at 2 - 4 g of nitrogen. Urinary nitrogen losses vary from an obligatory minimum of about 2 g/day to more than 30 g/day in massive protein catabolism. The nitrogen balance is negative when nutritional intake is less than the sum of urinary nitrogen and undetermined losses. The daily nitrogen losses depend on many factors. These are increased by immobility, by reduction of the caloric intake with a constant nitrogen intake, and by stress-related increases in protein oxidation. The latter can produce dramatic increases in nitrogen losses.

One must remember that nitrogen losses are tantamount to protein losses. Nitrogen losses therefore are always associated with a loss of functional capability, and lead to a higher incidence of complications, wound dehiscence, increased susceptibility to infection, decreased organ function (liver, gut, heart, lung) and in the extreme case to death from nitrogen deficiency. Nitrogen losses furthermore lead to substantial losses in body weight according to the equation:

$$1\ g\ N = 6.25\ g\ protein = 25\ g\ muscle\ tissue$$

Assessment of circulating protein status

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Plasma protein concentrations are used routinely for assessment of nutritional status and the effect of nutritional therapy, but these are not highly specific. Numerous factors may modify the serum protein levels, particularly the state of hydration or the presence of oedema.

Serum albumin is an index often used, although many factors other than energy intake influence the metabolism of albumin and its distribution in the intra- and extravascular fluids. Albumin is the main protein synthesized and secreted by the liver (15 g per day) with a half-life of approximately 18 days. Measurement of albumin will not always give a correct indication, as for example in acute illness (especially sepsis) when the extravascular distribution of albumin rises, resulting in a lowered serum albumin, without a lowered store. Overhydration is another cause of a low albumin concentration not indicative of undernutrition. Albumin may serve as a parameter of chronic protein deficiency because of its relatively long half-life, which makes it a poor indicator of acute protein-energy deficiency.

Transferrin, which has a half-life of 8-10 days, may be a more sensitive index than albumin, but possesses low specificity. Serum concentrations are influenced by lack of iron, acute hepatitis and acute and chronic disease, without the necessary implication of loss of protein.

Other proteins with an even shorter half-life have been assessed. These are the retinol-binding protein (RBP), and the thyroxin-binding prealbumin (TBPA), which have half-lives of 12 and 48 h respectively. These parameters function as an indicator of acute protein alterations. C-reactive protein (CRP) is an acute phase protein, very low in normal healthy subjects, but exponentially rising with the onset of infection and returning very rapidly to normal or near normal values after the stimulus is removed. This makes it a helpful marker in the care of patients who are at high risk for post-operative infection.

Assessment of immune status

The well-established interaction between malnutrition and infection may be due to modifications of the immunological defence observed in protein-energy malnutrition. Malnutrition decreases the synthesis of acute phase proteins that can help in the survival during stress, infection and injury. Besides that, cellular immunity is generally impaired in malnutrition (Chandra, 1983). Assessment is carried out on the total lymphocyte count in blood and by using tests for skin hypersensitivity to various antigens. From the extent of the cutaneous reaction, an immune score can be established. In general, a lowered immune score indicative of anergy is associated with an increased incidence of infectious

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complications. Interpretation of the immune response is nevertheless limited by the numerous variables which may affect it, such as certain drugs, surgical stress and the reliability of reference values. In undernourished patients, lowered, normal or raised serum immunoglobulin levels are observed, so that the effect of malnutrition on the humoral response has yet to be defined. Other major components of defence against infections are diminished in malnutrition, such as complement factors or leukocyte bactericidal capacity (Chandra, 1983).

Body composition measurement

To date, new and more precise methods for assessing changes in body composition, as occurring in protein-energy malnutrition, have been developed. Each type of protein-energy malnutrition is characterized by specific changes in body composition.

Marasmic patients have marked deficits of total body fat and protein. Marasmic kwashiorkor is also characterized by deficits in total body fat and protein and a marked relative increase in extracellular water. Patients with kwashiorkor are characterized by raised amounts of total body water, extracellular water and the proportion of extracellular water in the fat-free body.

In order to overcome the shortcomings of determining body composition by indirect anthropometric and biochemical measurements, body composition analysis by isotope dilution techniques and neutron activation analysis, bioelectrical impedance analysis and magnetic resonance spectroscopy techniques have been developed.

In isotope dilution assays, radioactive isotopes (^{22}Na and ^{3}H) are used to assess total exchangeable sodium, total exchangeable potassium and total body water. As sodium is diluted primarily in the extracelullar water compartment and potassium in the intracellular water compartment, the body cell mass, body fat mass, lean body mass, extracellular mass and the ratio of extracellular water to intracellular water can be determined. Malnutrition leads to a reduction of the body cell mass, while the extracellular mass and extracellular water rise, leading to a net change in the ratio of Na_e/K_e (e = exchangeable). This ratio appears to be a marker for malnutrition; it approximates unity in well-nourished subjects and is greater than 1.22 in malnourished subjects (Forse and Shizgal, 1980).

Isotope dilution technique allows definition of the body cell mass, which is however greatly influenced by changes in intracellular water and determination by the isotope dilution technique may therefore result in an over- or underestimation of the protein mass.

Reaction activation analysis allows direct measurement of a number of elements, including nitrogen. The patient is radiated with high energy neutrons and afterwards moved to a whole body radiation counter. The radiation emitted by radionucleides induced by the neutrons is specific for various elements in the body. The complex spectrum from the patient is measured and analysed to give counting rates due to nitrogen (protein), hydrogen, carbon, chorine and in some systems calcium, phosphorus and sodium. From these data, the total body content for these elements can be calculated.

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For this reason, neutron activation analysis is a reliable and direct method, although the equipment required is expensive. Compared to the isotope dilution technique, it is preferable in patients with fluxes in body water.

Micronutrient Status

Efficient utilisation of nitrogen-calorie substrates can only occur in the presence of physiological concentrations of a multitude of micronutrients: electrolytes, minerals, vitamins and trace elements. These nutrients are essential in minute quantities for the maintenance of normal metabolic functions. Micronutrient deficiencies may be the consequence of inadequate intake, defective absorption or utilisation, or they may supervene as a result of increased requirements. Diagnosis of micronutrient deficiencies attempts to identify the infraclinical or asymptomatic stages rather than to describe manifest organic alterations.

1.5 APPLICATIONS OF NUTRITIONAL ASSESSMENT

Measurement of nutritional status is one of the key indicators for :

- monitoring the overall welfare of a population and
- measuring the impact of change in factors that affect the welfare of a population.

Negative change in the nutritional status of a population indicates a problem. The effects of increasing malnutrition are felt in a society both in the short term and long term. In much of sub-Saharan Africa, measurement (anthropometry) of children under the age of five is the most commonly used method for estimating the nutritional status of the population as a whole, although strictly speaking, one cannot imply that because children are malnourished, that the whole population is malnourished.

The availability of good data provides a strong foundation for the more important next step -the analysis of the information. Malnutrition rates are meaningless without explanations for the levels and trends. Frameworks help in the analysis of information and facilitate a better understanding of the factors that interact to influence nutrition at both the individual and population level.

A better understanding of causes of malnutrition provides a sound basis for the design and implementation of interventions across the sectors. Understanding the roles of different actors leads to more effective strategies and efficient use of limited resources.

Use of Nutrition-Related Information

Using information on nutrition and other background information supports analysis and decisions on interventions and programs for both short and long-term projects. More specifically, nutrition information:

- Serves as a vital indicator of the overall health and welfare of populations especially where regular demographic and health surveys are lacking.
- Is critical during crises and emergencies for (i) the identification of most vulnerable or affected individuals or groups, (ii) as a screening tool to identify malnourished individuals needing special assistance, (iii) to evaluate the progress of growth amongst the nutritionally vulnerable groups and (iv) to monitor effects of nutrition interventions among vulnerable groups.
- Is invaluable for program management (planning, implementation, monitoring and evaluation) in many sectors including food security (agriculture and livestock), health, water and sanitation, education and environment.
- Nutrition information can contribute to designing of food, health and other development policies.
- Facilitates analysis of socio-economic factors, demographics, food security and cultural aspects of a population.
- Can be used in crisis mitigation especially as an early-warning indicator. This speeds up response to threats like droughts or disease outbreaks.

The principal users of nutrition information are:

- Government authorities and Non Governmental Organizations (NGOs) that support food security, health and nutritionrelated programs
- Donors
- Communities involved in the design, planning and management of nutritionrelated programs
- Health workers who produce the data

Nutrition Information in Early Warning

Populations respond to changes in their environment in many ways and these responses can ultimately be reflected in changes in food consumption and health status. These population responses vary from one situation to another with

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some populations changing their nutrition related behaviour, manifesting as increasing malnutrition quite early in a crisis and before any apparent deterioration in food security. On the other hand, other populations will use all means available to avoid any reduction in the quality or quantity of food, often sacrificing livelihoods in the process. Therefore, a deterioration in nutritional status can be an early indicator of impending hardship if interpreted together with disease and food security patterns. Continuous analysis of the nutrition situation combined with reliable measurement of outcomes can help to identify the stages of a drought process and the response of the population to events around them.

Nutrition-related information provides an authoritative basis for the formulation of an appropriate response. Once data is available, appropriate emergency preparedness and response can be undertaken well in advance. However, for nutritional surveillance to be used as an effective tool for early warning, it must incorporate both quantitative and qualitative aspects of data collection, analysis and interpretation.

Nutrition Information in Program Management

Planning and Implementation

Planning involves assessing, analyzing problems and opportunities, setting objectives and designing appropriate interventions that can achieve objectives. Nutrition-related information is used to analyze the situation in relation to factors across the sectors – in particular health, food security, care practices, livelihoods and other underlying factors. The causes of malnutrition may not be obvious. It is important to differentiate the immediate lifethreatening problems from the underlying causes and to develop appropriate interventions.

In both emergency and development, analysis of nutrition information helps to identify individuals at risk and where they are located. It facilitates the design of appropriate interventions based on the causes and effects. The analysis helps to formulate goals, objectives, strategies and activities that the project/program intends to address. The severity of malnutrition, its nature and the related health risks determine the choice of response from the problem analysis. Where lives are threatened, quick action is necessary.

Monitoring and evaluation

Nutrition information is useful for monitoring and evaluation in both emergency and development interventions. Nutrition-related information is used during project implementation for monitoring purposes. It is also used at the evaluation stage to assess the extent and impact of the project.

Monitoring and evaluation assesses the nutritional performance against set objectives. It ensures that the planned activities are conducted accordingly. Project monitoring is continuous and focuses mainly on short-term activities and results.

Evaluation on the other hand is periodic and focuses on the achievement of the project objectives and the impact of the project.

Monitoring can therefore be defined as the continuous process of collecting information and presenting data, through out the project cycle, in order to assess the impact and lead to improvements in the effectiveness of the program.

Evaluation focuses on:

- Relevance
- Appropriateness
- Effectiveness and efficiency
- Timeliness and management of the project
- Achievement of the project overall goal
- Lessons learned for future planning

Nutrition provides us with both a tool and a forum to monitor and evaluate interventions.

Concluding Remark

Assessment of the nutritional status of a patient is relatively difficult. Ideally, the identification of protein-energy malnutrition should conform to the following criteria:

1. It should specifically identify protein-calorie malnutrition and
2. be negative in patients without protein-calorie malnutrition.
3. It should be unaffected by non-nutritional factors.
4. It should demonstrate normalisation with adequate nutritional support.

From the preceding, it is clear that a number of methods and parameters are available for assessment of the nutritional status of patients and for evaluating the response to clinical nutrition. Some of these parameters are specific and sensitive, while others are not. Problems with the interpretation of anthropometric parameters are that these parameters are subject to observer errors and are influenced by changes in tissue composition induced by non-nutritional factors. For example, the administration of intravenous fluids or blood products, or the extensive loss of fluids or blood, or the excessive loss of fluid or protein through, diarrhoea, fistulae etc. may invalidate anthropometric and serum protein measurements. Disease states like hepatic disease and nephrosis may reduce serum levels of albumin and transferrin in patients undergoing nutritional assessment. Infection and trauma may interfere with delayed cutaneous hypersensitivity test. The prolonged half-lives of serum albumin and transferrin cause delayed responses in both nutritional depletion and repletion. Other tests like body composition measurements are not generally used.

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Furthermore, one must remember that these nutritional parameters have wide confidence limits and therefore are in general more suited for use in epidemiological surveys than in individual patients. The problem is that none of these parameters is suited as the sole parameter to assess nutritional status.

Therefore, clinical evaluation forms the basis in identifying those patients who are at risk of malnutrition and nutritionally related complications. On the basis of this clinical evaluation, patients that are malnourished can be further evaluated using anthropometry and biochemical markers. Further, these techniques are a helpful tool in assessment of the effect of nutritional support.

As already discussed, some investigators have tried to asses the nutritional status by combining several parameters into a prognostic index. The relative value of these scoring systems has been demonstrated in clinical studies (Vehe et al., 1991) and further trials are needed to confirm the performance of such indices as a prognostic tool.

Applying the mentioned methods and limits for assessing the nutritional status, one can arrive at the following definitions about the nutritional status of the patient:

1. Normal nutritional status exists when all parameters are within the reference range.
2. Adipositas (obesity) exists when body weight, BMI and skinfold thickness are supranormal and all other parameters are in the normal range.
3. Protein malnutrition exists when body weight, BMI and skinfold thickness are within the normal range and arm-muscle circumference and creatine excretion are diminished; plasma protein levels are depressed.
4. Protein-calorie malnutrition exists when weight, BMI, skinfold thickness (energy component), arm- muscle circumference and creatine excretion (protein component) are decreased, indicating that functional proteins are depressed.

STUDENT ACTIVITY

1. Do a practical by studying a case in your local area by using nutrition assessment methods and write your remark.

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2. Discuss the features of "Food Frequency Recall" assessment techniques.

1.6 SUMMARY

- The concept of nutritional surveillance is derived from disease surveillance, and means "to watch over nutrition, in order to make decisions that lead to improvements in nutrition in populations".
- Rapid assessment method is used to gather nutrition information within the shortest time possible and is particularly useful in situations where physical access to population is limited or when the speed of the assessment is a major consideration.
- Anthropometrics are the objective measurements of body muscle and fat. They are used to compare individuals, to compare growth in the young, and to assess weight loss or gain in the mature individual.
- Biochemical method is a measure of nutrients in blood, urine and other biological samples. Compared to other methods, biochemical methods of nutritional assessment provide the most objective and quantitative data on nutritional status.
- Clinical signs in the assessment of nutritional status result from both lack of nutrients and nonnutritional causes. Signs and symptoms should be investigated and combined with anthropometrical, dietary evaluation and biochemical tests for accurate analysis and interpretation of data.
- Dietary methods generally involve the assessment of food consumption over a period of time. In nutrition surveillance, the dietary assessment involves identifying food availability, accessibility, who consumed and at what frequency.

1.7 GLOSSARY

- **Nutritional surveillance:** To watch over nutrition, in order to make decisions that lead to improvements in nutrition in populations.
- **Anthropometrics:** It is an objective measurements of body muscle and fat .

- **Biochemical assessment:** A measure of nutrients in blood, urine and other biological samples.
- **Clinical assessment:** This method of nutrition assessment uses signs in the assessment of nutritional status result from both lack of nutrients and nonnutritional causes.
- **Dietary assessment:** It is a method of nutrition assesment which generally involve the assessment of food consumption over a period of time.

1.8 REVIEW QUESTIONS

1. What is nutrition surveillance?
2. How is nutrition surveleillance done?
3. What is qualitative research data analysis? How is it used in nutrition status assessment?
4. How is Anthropometric assessment done?
5. Differentiate between clinical and biochemical method of nutrition assessment.
6. Discuss the applications of nutrition assessment.
7. How is health status assessed?

1.9 FURTHER READINGS

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UNIT—II

METHODS OF ASSESSMENT

OBJECTIVES

After going through the unit, students will be able to :

- describe the methods of nutritional assessment;
- state the direct method of nutritional assessment;
- discuss the indirect method of nutritional assessment.

STRUCTURE

2.1 INTRODUCTION

Nutritional status is the condition of health of the individual as influenced by the utilization of the nutrients. It can be determined by correlation of information obtained through medical and dietary history, thorough physical examination and laboratory investigation.

Nutritional assessment aids in identifying

(a) Under Nutrition

(b) Over Nutrition

(c) Nutritional deficiencies

(d) Individuals at the risk of developing malnutrition

(e) Individuals at the risk of developing nutritional related diseases

(f) The resources available to assist them to overcome nutritional problems.

2.2 METHODS OF ASSESSMENT

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The nutritional status can be assessed by the following methods:

I Direct Methods

(a) Nutritional Anthropometry
(b) Clinical Examination
(c) Biochemical tests and
(d) Biophysical methods.

II Indirect Methods

(a) Vital statistics of the community
(b) Assessment of socio – economic status and
(c) Diet surveys

ANTHROPOMETRIC MEASUREMENTS AND INDICES

Nutritional Anthropometry is concerned with the measurements of the variations of physical dimensions and body composition at stages of life cycle and different planes of nutrition. It is a field-oriented method, which can be easily adopted and interpreted.

The basic measurements which should be made on all age groups are weight in kg, length / height and arm circumference in cms. In young children it should be supplemented by measurements of head and chest circumference.

Weight:

Weight gain is an indicator of growth in children. It is measured with the help of the weighing scale. Body weight should be determined after the first void and before ingestion of food.

The weight for age can be compared with the standards of ICMR and the nutritional status can be interpreted.

The standard reference body weight (kg) of Indians of different age groups is given in the table 1.

Table 1. Reference body weight (kg) of Indians of different Age groups

	Reference body weight (kg)		
	Age (years)	*Male*	*Female*
Infants	0 – ½	5.4	5.4
Children	½– 1	8.6	8.6
	1 – 3	12.61	11.81

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	4 – 6	19.20	18.69
	7 – 9	27.00	26.75
	10 – 12	35.54	37.91
Adolescents	13 –15	47.88	46.66
	16 – 18	57.28	49.92
Adults	20 – 50	60	50

Source : ICMR 2002. Nutrient Requirements and recommended dietary allowances for Indians. NIN.

Anthropometric Indices : Weight for age The Nutritional status can be interpreted using Gomez Classification as follows

Weight > 90% Weight for age. Normal.

76 – 90% Weight for age. Grade I malnutrition.

61 < 75% Weight for age. Grade II malnutrition.

< 60% Weight for age. Grade III malnutrition.

Linear Measurements

Two types of linear measurements are commonly used.

(i) height or length of the whole body

(ii) circumference of the head and the chest.

Height :

The height of the individual is the sum of four components: leg, pelvis, spine and skull as given in Table 2.

Table 2. The Standard Reference height for Indians of different age groups.

Age (years)	Height in cm	
	Boys	Girls
1+	80.07	78.09
2+	90.01	87.93
3+	98.36	96.21
4+	104.70	104.19
5+	113.51	112.24
6+	118.90	117.73
7+	123.32	122.65
8+	127.86	127.22

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9+	133.63	133.08
10+	138.45	138.90
11+	143.35	145.00
12+	148.91	150.98
13+	154.94	153.44
14+	161.70	155.04
15+	165.33	155.98
16+	168.40	156.00

Source : ICMR 2002. Nutrient Requirements and recommended dietary allowances for Indians. NIN.

The height of an individual is measured using a stadiometer. For infants and children recumbent length (crown – heel length) is measured. The measurement is compared with the standards of the ICMR as given in table 16C to assess nutritional status.

The desirable birth weight and length of an infant is 3 kg and 50 cm respectively. By the time the baby turns the first birth day, the birth weight is doubled and an increment of 25 cm in length is reached.

Head Circumference :

The measurement of head circumference is a standard procedure to detect pathological condition in children. Head circumference is related mainly to brain size. At birth the circumference of head is greater than that of the chest.

Chest Circumference :

The circumference of the head and the chest are about the same at six months of age. After this the skull grows slowly and the chest more rapidly.

Therefore between the ages of six months and five years the chest / head circumference ratio of less than one may be due to failure to develop or due to wasting of muscle and fat of chest.

In nutritional anthropomertry the chest/head circumference ratio is of value in detecting under nutrition in early childhood.

Mid Upper Arm Circumference (MUAC) :

Mid upper arm circumference at birth in a healthy child is between 10 – 11cm. over the first year the increment in MUAC is 3 to 4 cm as the muscles of the arms start to develop. In the preschool age the increase in MUAC is only one cm. Hence there is not much difference between the MUAC of a 3 year old from that of a 5 year old. So MUAC is an age independent index. The field workers in

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nutrition in our country have fixed the desirable value for MUAC as 12 cm for Indian preschool children.

The WHO has recommended 14 centimeter as a desirable value for MUAC for preschool children. Hence in screening malnourished children in a community this method is used with ease. When the value of MUAC is less than 12 cm among 1 –5 year old children, they are designated as malnourished.

In the field condition a bangle with a diameter of 4 centimeter can be used as a tool to detect malnutrition. When the bangle moves smoothly over the mid-upper arm of the child, it indicates malnutrition. The bangle test can be conducted with ease in field condition to screen malnourished children.

Clinical Signs of Nutritional Dificiency Disorders

Clinical examination is an important practical method for assessing the nutritional status of a community. Essentially, the method is based on examination for changes, believed to be related to inadequate nutrition that can be seen or felt in the superficial epithelial tissues especially the skin, eyes, hair and buccal mucosa or in organs near the surface of the body such as the parotid and thyroid glands.

Clinical assessment must always be carried out by individuals with adequate training. The following simple guide is employed to interpret the following deficiencies.

Guide for the interpretation of deficiencies and identifying the clinical signs.

Condition	*Clinical Signs*
(i) Protein Energy Malnutrition	: Odema, depigmentation, sparseness and easy pluckability of hair, moon face, enlarged liver, muscle wasting.
(ii) Vitamin A deficiency	: Night blindness, Bitot' s spots in the eye, Xerosis of skin.
(iii) Riboflavin deficiency	: Angular stomatitis, cheilosis.
(iv) Thiamine deficiency	: Oedema, sensory loss, calf muscle tenderness.
(v) Niacin deficiency	: Raw tongue, pigmentation of the skin.
(vi) Vitamin C deficiency	: Spongy and bleeding gum.
(vii) Vitamin D deficiency	: Rickets, beading of ribs, Knock – knees, bowed legs.

(viii) Iron deficiency : Pale conjunctiva, spoon –shaped nails.

(ix) Iodine deficiency : Enlargement of thyroid gland.

Source: Jelliffe, D.B., 1989, The Assessment of Nutritional Status of the community WHO Monograph Series, Geneva

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Clinical signs in the assessment of nutritional status result from both lack of nutrients and nonnutritional causes. Signs and symptoms should be investigated and combined with anthropometrical, dietary evaluation and biochemical tests for accurate analysis and interpretation of data.

Clinical assessment involves:

(a) medical history,

(b) dietary history and

(c) physical examination by a health professional to identify signs and symptoms associated with malnutrition.

The medical history of the respondent is the first step in clinical analysis. This can be obtained by:

- Finding out the respondent's past and present health status. Many diseases such as malaria, measles, tuberculosis and HIV/ AIDS can affect the nutritional status.
- Identifying conditions such as diarrhoea and lack of appetite.
- Evaluating a child's age, or a woman's obstetric history.
- Analysing socio-economic support and access to healthcare.

Dietary history includes determining the respondent's eating habits. For instance timing and frequency of meals, tastes, allergies, ability to access food physically and economically, how food is prepared and how food is distributed at household level.

Detection of Malnutrition during Clinical Assessment

Acute malnutrition

This is a classical form of malnutrition related to low intake of energy-giving foods and proteins in the body. Acute malnutrition is the most common form of malnutrition. The term covers a range of clinical disorders that occur as a result of an inadequate intake of energy, protein and other nutrients. The most severe clinical forms of acute malnutrition are marasmus and kwashiorkor. These conditions are characterized by growth failure. Acute malnutrition has a wide range of manifestations that range from weight loss (thinness) to stunting (shortness) or a combination of both.

Marasmus: This is a very serious form of acute malnutrition characterized by severe weight loss or wasting. Marasmus is a condition commonly associated with low intake of energy-giving foods. It requires immediate treatment.

Kwashiorkor: This is a very serious form of acute malnutrition characterized by oedema, apathy and loss of appetite. It is a condition commonly associated with low intake of proteins or inadequate synthesis of proteins in the body. The condition requires immediate attention.

Oedema

This is fluid accumulation in the body as a result of severe nutritional deficiency. Bilateral oedema is an indicator of acute malnutrition and may be detected by pressing the thumb on the feet just above the ankle for three seconds. This will leave a dent.

Bilateral oedema is a manifestation of severe acute malnutrition and requires immediate treatment.

Micronutrient deficiency

This is a deficiency that results from the inadequate intake of nutrients required by the body in minute quantities for the normal function of the body. The main micronutrient deficiencies of public health concern are Iron Deficiency Anaemia (IDA), Vitamin A Deficiency (VAD), Iodine Deficiency Disorder (IDD) and Zinc deficiency. These deficiencies may cause permanent damage to health and even death.

Outbreaks of other types of micronutrient deficiencies occasionally experienced in emergencies include vitamin C (scurvy), niacin (pellagra) and thiamine (beriberi).

Biophysical Methods

The biophysical methods are used to assess the alterations in functions associated with inadequate nutrition. For (eg) Dark adaptation test is used to evaluate the ability to see in the dim light.

Biochemical Test

Biochemical tests can be used to detect the deficiencies by analyzing blood, urine, stools and phlem. For (eg) Estimation of hemoglobin in blood to detect iron deficiency.

This is a measure of nutrients in blood, urine and other biological samples. Compared to other methods, biochemical methods of nutritional assessment provide the most objective and quantitative data on nutritional status. The usefulness of biochemical tests is that they provide indications of nutrient deficits long before clinical manifestations and signs appear.

Biochemical tests are also important in validation of data especially where respondents are under-reporting or over-reporting what they eat. These tests are therefore particularly useful in complementing and validating dietary intake surveys.

The major disadvantages of biochemical methods is that they are complex, expensive and require a high level of expertise.

INDIRECT METHODS

Vital Statistics

Malnutrition influences morbidity, mortality, life expectancy and other health statistics. Hence vital statistics may therefore be considered as indirect indication of the nutritional status of the community. Infant mortality rate, maternal mortality rate and morbidity rate are the vital statistics that can be used to assess the nutritional status of the community.

Assessment of Socio – Economic Status

Low food availability, increased family size, unsanitary living conditions, inadequate knowledge of nutritional needs, inappropriate weaning practices are powerful social cultural and economic factors, which influence nutritional status.

Diet Surveys

Diet surveys are helpful in studying the quality and quantity of food consumed by the family and the community. The techniques of collecting information on family food consumption include:

(1) *Food Inventory Method:* This method is usually employed in Institutions where homogenous group of people take their meals in a common kitchen eg. Hostels, orphanages. In this method the amount of food stuff issued to the kitchen as per the issue register is taken into consideration. No direct measurement or weighing is done. A study period of one week is desirable.

(2) *Food expenditure pattern method:* In this method information on the amount spent on food and non-food items during the previous month or week is collected using a questionnaire. This method avoids actual weighing of foods.

(3) *24 hour recall:* In this method a set of standardized cups suited to local conditions are used. The standard cups help the respondent to recall the quantities of the food prepared and fed to individual members on the previous day. This is usually done for three consecutive days. The advantage of this method is that the intake of each food item by the specific individual in the family such as pre-school child, adolescent, pregnant women can be assessed using the cups.

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(4) *Diet History:* This method is useful for obtaining qualitative details of diet and studying patterns of food consumption at household and industrial level. The procedure includes assessment of the frequency of consumption, different foods, daily or number of times in a week or fortnight or occasionally. This method is used to study meal pattern, dietary habits, food preferences, and avoidances during sickness.

(5) *Weighment method:* In this method, the food either raw or cooked is actually weighed using an accurate balance. It is ideal to conduct the survey for seven consecutive days. Every day food is weighed in the morning and evening before actual cooking. The age, sex, physiological status of the family members should be noted down. Nutrient intake is then calculated using the ICMR food composition tables. Though this method is accurate as the foods are directly weighed, it requires extreme cooperation of the house wives.

The information on food and nutrient consumption is compared with the recommended allowances of the ICMR and the adequacy is determined. A combination of dietary, clinical and biochemical assessment is desirable for assessment of nutrition status of individuals or communities.

Dietary methods generally involve the assessment of food consumption over a period of time. In nutrition surveillance, the dietary assessment involves identifying food availability, accessibility, who consumed and at what frequency. Data on foods consumed assist in the identification of nutrient intake. Interpretation of dietary intake involves use of food consumption tables. Nutrient intake in dietary methods is used to complement anthropometry, biochemical or clinical data.

Analysis of dietary intake involves:

- Grouping of foods according to a predetermined system (e.g. FAO or USDA) to determine diversity
- Determining the frequency of consumption of foods in each food group.
- In some circumstances, based on this baseline and the level of acute malnutrition, using regression analysis to project the level of acute malnutrition in foreseeable circumstances

Food Frequency Recall

This is an assessment method commonly used in nutrition assessments or surveys to determine dietary intake. It involves establishing the frequency of which certain types of foods (those of particular interest in the survey) are consumed over a specified time-frame normally a week or two. It is easier to administer than the 24-hour recall method. The frequency of consumption could be coded as:

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(a) 'Frequently consumed' - food item consumed once a week to many times a day.

(b) 'Not frequently consumed' – food item consumed no more than twice a month

(c) 'Never Consumed' – food item not consumed at all.

The 24-hour Dietary Recall

In this method, the respondent is asked to remember in detail the type and quantity of foods consumed during the previous 24 hours. Asking respondents about their activities during the day can assist in recalling what they ate and provides valuable information in estimating the level of activity and energy expenditure. The values of these measurements are converted into grams or millilitres (drinks and beverages). The amounts of various nutrients are then calculated using the food composition tables and/ or nutrition computer packages designed for this particular nutritional assessment method.

The method is reasonably quick and inexpensive but respondents may withhold or alter information about what they ate due to embarrassment or to influence the research. To develop an understanding of seasonality, the assessment should be repeated at intervals throughout the year.

STUDENT ACTIVITY

1. Point out the indices used in Anthropometric measurement.

2. Discuss the method of diet survey.

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2.3 SUMMARY

- Nutritional status is the condition of health of the individual as influenced by the utilization of the nutrients.
- Nutritional status can be assessed by two methods: (i) direct and (ii) indirect.
- Nutritional Anthropometry is concerned with the measurements of the variations of physical dimensions and body composition at stages of life cycle and different planes of nutrition.
- The measurement of head circumference is a standard procedure to detect pathological condition in children.
- Clinical examination is an important practical method for assessing the nutritional status of a community.
- Diet surveys are helpful in studying the quality and quantity of food consumed by the family and the community.

2.4 GLOSSARY

- **Nutritional status:** the condition of health of the individual as influenced by the utilization of the nutrients.
- **Nutritional Anthropometry:** the measurements of the variations of physical dimensions and body composition at stages of life cycle.
- **Biochemical tests:** a method to assess nutritional status which is used to detect the deficiencies by analyzing blood, urine, stools and phlem.
- **Diet surveys:** a method which is helpful in studying the quality and quantity of food consumed by the family and the community.

2.5 REVIEW QUESTIONS

1. What are the essential elements of direct method of nutrition assessment?
2. How is indirect method of nutrition assessment conducted?
3. Differentiate between biophysical and biochemical assessment.
4. What are the techniques used in dietary survey?

2.6 FURTHER READINGS

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UNIT—III

ASSESSMENT OF AGE AND ANTHROPOMETRY ASSESSMENT

OBJECTIVES

After going through the unit, students will be able to :

- discuss the method of age assessment;
- explain the anthropometry assessment;
- state the indicators of nutritional status;
- point out the guidelines for interpretations of growth charts.

STRUCTURE

3.1 INTRODUCTION

The term anthropometric refers to comparative measurements of the body. Anthropometric measurements are used in nutritional assessments. Those that are used to assess growth and development in infants, children, and adolescents include length, height, weight, weight-for-length, and head circumference (length is used in infants and toddlers, rather than height, because they are unable to

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stand). Individual measurements are usually compared to reference standards on a growth chart.

Anthropometric measurements used for adults usually include height, weight, body mass index (BMI), waist-to-hip ratio, and percentage of body fat. These measures are then compared to reference standards to assess weight status and the risk for various diseases. Anthropometric measurements require precise measuring techniques to be valid.

3.2 AGE ASSESSMENT

Assessing a person's age is often made difficult because young people arrive without identification documents. There are guidelines on handling cases where a person's age is in dispute. The following five key points will also help you make the right decisions when you are assessing the age of a young person.

If in any doubt refer to social services

Then childcare professionals can undertake an assessment of age. Age assessment is a process, not a single event. Only through direct work with a child over time and an holistic assessment of their experience, skills and needs can a judgement be made on which age band a child or young person is likely to fit into. It is recognised that age determination is an inexact science. Even when based on medical evidence, it is impossible to identify a child's exact age and the margin of error can be five years either way.

Life experience takes its toll

Young people may look and act older than they are because of their experience in their country of origin. For example, they may have worked and taken on 'adult' responsibilities from an early age. Also, the experience and trauma of war may affect the way a young person looks and acts.

Young people with facial hair

Teenage boys with beards often look older than they are. Boys in some parts of the world, notably the Indian sub-continent, grow facial hair earlier than most boys in Europe. It is a cultural norm in some countries to grow a beard as soon as it is physically possible. For example, in some parts of Afghanistan it is common to grow a beard at the age of 13 or 14.

Birth dates are not important in some countries. A young person may not know their date of birth and be vague about when they were born. This does not mean they are trying to hide their age. In 2001, UNHCR estimated that there were about 40 million unregistered births around the world. In some places date of birth is not important and birthdays are not celebrated. In some places calendars are not used and the passing of time is measured by seasons rather than calendar dates.

Different calendars are used in some countries

There is often confusion over age because of different calendars used around the world. For example, the Ethiopian calendar is currently eight years and seven days behind our calendar (this changes regularly as there are 13 months in the Ethiopian calendar). Converting from one calendar to the other can be difficult. Mistakes are made and young people or their interpreters may often give the wrong date of birth.

3.3 ANTHROPOMETRY ASSESSMENT

Changes in body dimensions reflect the overall health and welfare of individuals and populations. Anthropometry is used to assess and predict performance, health and survival of individuals and reflect the economic and social well being of populations. Anthropometry is a widely used, inexpensive and non-invasive measure of the general nutritional status of an individual or a population group. Recent studies have demonstrated the applications of anthropometry to include the prediction of who will benefit from interventions, identifying social and economic inequity and evaluating responses to interventions.

Anthropometry can be used for various purposes, depending on the anthropometric indicators selected. For example, weight-for-height (wasting) is useful for screening children at risk and for measuring short-term changes in nutritional status. However, weight-for-height is not appropriate for evaluating changes in a population over longer time periods. A clear understanding of the different uses and interpretations of each anthropometric indicator will help to determine the most appropriate indicator(s) for program evaluation.

Anthropometric Indicators

The four building blocks or measures used to undertake anthropometric assessment are:

- AGE
- SEX
- LENGTH (or height)
- WEIGHT

Each of these variables provides one piece of information about a person. When they are used together they can provide important information about a person's nutritional status. The actual measurement of age, weight and height of

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children requires specific equipment and techniques which are described later. When two of these variables are used together they are called an index. Three indices are commonly used in assessing the nutritional status of children:

- Weight-for-age;
- Length-for-age or Height-for-age;
- Weight-for-length or Weight-for-height.

There are many other anthropometric measures including mid-upper-armcircumference (MUAC), sitting height to standing height ratio (Cormic Index), and many skinfold measures. This guide will concentrate on the measurements and interpretation of weight and height in children.

What the Indices Reflect About the Nutritional Status of Infants and Children

The advantages and disadvantages of the three indices and the information they can provide is summarized below:

Weight-for-age: Low weight-for-age index identifies the condition of being underweight, for a specific age. The advantages of this index are that it may reflect both past (chronic) and/or present (acute) undernutrition (although it is unable to distinguish between the two).

Height-for-age: This index is an indicator of past undernutrition or chronic malnutrition. It cannot measure short term changes in malnutrition. For children below 2 years of age, the term is length-for-age; above 2 years of age, the index is referred to as height-for-age. Deficits in length-for-age or height-forage are signs of stunting.

Weight-for-height: This index helps to identify children suffering from current or acute undernutrition or wasting and is useful when exact ages are difficult to determine. Weight-for-length (in children under 2 years of age) or weightfor-height (in children over 2 years of age) is appropriate for examining short-term effects such as seasonal changes in food supply or short-term nutritional stress brought about by illness.

The three indices are used to identify three nutritional conditions: underweight, stunting and wasting.

Underweight: Underweight, based on weight-for-age, is a composite measure of stunting and wasting and is recommended as the indicator to assess changes in the magnitude of malnutrition over time.

Stunting: Low length-for-age, stemming from a slowing in the growth of the fetus and the child and resulting in a failure to achieve expected length as compared to a healthy, well nourished child of the same age, is a sign of stunting. Stunting is an indicator of past growth failure. It is associated with a number of long-term factors including chronic insufficient protein and energy intake, frequent infection, sustained inappro-priate feeding practices and poverty. In children over 2 years of age, the effects of these long-term factors may not be reversible. For evaluation purposes, it is preferable to use children under 2 years of age because the prevalence of stunting in children of this age is likely to be more responsive to the impact of interventions than in older children. Data on prevalence of stunting in a community may be used in problem analysis in designing interventions. Information on stunting for individual children is useful clinically as an aid to diagnosis. Stunting, based on height-for-age can be used for evaluation purposes but is not recommended for monitoring as it does not change in the short term such as 6 -12 months.

Wasting: Wasting is the result of a weight falling significantly below the weight expected of a child of the same length or height. Wasting indicates current or acute malnutrition resulting from failure to gain weight or actual weight loss. Causes include inadequate food intake, incorrect feeding practices, disease, and infection or, more frequently, a combination of these factors. Wasting in individual children and population groups can change rapidly and shows marked seasonal patterns associated with changes in food availability or disease prevalence to which it is very sensitive. Because of its response to short-term influences, wasting is not used to evaluate all kinds programs but may be used for screening or targeting purposes in emergency settings and is sometimes used for annual reporting. Weight-for-height is not advised for evaluation of change in a population since it is highly susceptible to seasonality.

- *Oedema.* Oedema is the presence of excessive amounts of fluid in the intracellular tissue. Oedema can be diagnosed by applying moderate thumb pressure to the back of the foot or ankle. The impression of the thumb will remain for some time when oedema is present. Oedema is diagnosed only if both feet show the impression for some time. As a clinical sign of severe malnutrition, the presence of oedema should be recognized when using short term indicators such as wasting. The presence of oedema in individuals should be recorded when using weight-for-height for surveillance or screening purposes. When a child has oedema, it is automatically included with children counted as severely malnourished, independently of its wasting, stunting, or underweight status. This is due to the strong association between oedema and mortality. Oedema is a rare event and its diagnosis is used only for screening and surveillance and not for evaluation purposes.
- *Mid — Upper Arm Circumference (MUAC).* MUAC is relatively easy to measure and a good predictor of immediate risk of death. It is used for rapid screening of acute malnutrition from the 6-59 month age range (MUAC overestimates rates of malnutrition in the 6-12 month age group).

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MUAC can be used for screening in emergency situations but is not typically used for evaluation purposes. (MSF, 1995) MUAC is recommended for assessing acute adult undernutrition and for estimating prevalence of undernutrition at the population level.

3.4 COLLECTING ANTHROPOMETRIC DATA THROUGH SURVEYS

The type of anthropometric data collected will depend on the reason for the survey. When the survey results will be used for long-term planning the information needed might be different than information for program management. Monitoring of growth promotion programs will require different types of information.

The collection of anthropometric data may be the main purpose of a survey or it may be part of a larger more comprehensive survey such as the KPC (Knowledge, Practice, Coverage). Information on individuals and households should be collected to interpret anthropometric data. Deciding what information will be collected, how it will be collected and from whom it will be collected is all part of planning the survey. The steps that should be taken to conduct a survey are outlined below.

Steps for Conducting a Survey

The following checklist outlines the steps necessary for conducting a survey. All of these steps should be clearly thought out before the survey begins.

- **Define survey objectives.** The first step is to determine the specific purpose of the survey. Make a detailed list of what is expected to be achieved and what information is needed.
- **Budget for the survey.** Develop a detailed item-by-item budget for all the costs and expenses of the survey, including personnel, supplies, materials, transportation, accommodation and meals. Determine the costs associated with data entry, cleaning, analysis, reporting and testing of all steps to ensure smooth implementation.
- **Choose the survey design.** Depending on the goal of the survey, the survey planning team should review different design possibilities such as a case-control or reflexive design before choosing the final design. Having a clear idea of the survey goals will help to determine which people or which groups of people to include in the survey and the best method for collecting the information.
- **Plan for personnel, facilities, and equipment.** Conducting a survey within a limited time-frame (usually less than six months) requires early

planning for materials and staff. During this stage the survey planning team decides how many field staff and how many office personnel they will need and how they will recruit them. Any advance work needed to find and hire staff is planned at this point. Other needs such as office space and equipment are also considered and planned. Specific equipment is needed to do anthropometric assessments as part of a survey and is discussed in the coming section.

- **Select the sample.** Once the survey goals and methods of collecting the information have been decided, the groups and numbers of people to be interviewed are selected. A sample is a small part of the group being studied that has been chosen to represent the whole group. There are special considerations when choosing a sample for anthropometric assessment.
- **Develop the questionnaire.** The list of essential information needed to meet the survey objectives forms the basis of the survey questionnaire. A standard, printed questionnaire ensures that all the respondents are asked the same questions and enables the survey responses to be tabulated easily and quickly. The questionnaire may need to be translated into local languages. Translated questionnaires should be translated back to the original language by another translator and compared to the original questionnaire. Enumerators need to be trained in the appropriate use of the translation.
- **Pre-test the questionnaire.** Before the questionnaire is finalized it should be tested for content and length; the questions should gather the needed information and should be easily understood by both interviewers and respondents. In the pre-test a small number of interviews are conducted and the questionnaire is revised on the basis of these results and comments from the interviewers.
- **Train personnel.** Training of field staff is a vital step in the survey process; accurate, meaningful information can be collected only if interviewers thoroughly understand all their field instructions and procedures. When all the field materials have been prepared and finalized, and the field staff has been hired, all interviewers and supervisors should be brought to a central location to be taught survey procedures, how to collect the data and how to use the questionnaire. When anthropometric assessment will be part of the survey, correct methods for taking measurements should also be part of the training schedule. If the actual survey is delayed for more than three weeks following training, it will be necessary to retrain personnel.
- **Standardize the anthropometric technique.** The training of personnel

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on specific measurement and recording techniques should include not only theoretical explanations and demonstrations, but also provide an opportunity for participants to practice the measurement techniques, as well as reading and recording the results. Once all personnel have adequately practiced the measurement and recording techniques, and feel comfortable with their performance, standardization exercises should be carried out to ensure that all interviewers acquire the skills necessary to collect high quality data.

- **Interview.** The success of a survey depends on the quality of the field procedures, supervision and interviewing. Interviewers should follow sampling and interviewing instructions precisely and accurately. They need to keep in touch with their field supervisor and bring any problems or difficulties to their attention.
- **Supervise the data collection.** Once the interviewing begins, field supervisors should be present to assist interviewers with problems that may arise in finding the correct households, conducting the interviews or completing the work on time. Field supervisors, in addition to solving field problems, are responsible for distributing materials, reviewing and checking completed questionnaires and making progress reports to the central office.
- **Edit and code the interviews.** Completed interviews should be reviewed to make sure all the questions have been asked and the answers have been recorded clearly. Someone from the survey planning team should check all numerical codes on the questionnaire and assign codes to any responses written in respondents' own words. Some surveys directly enter data into the computer at the time of the measurement. This improves quality and speed but requires functioning equipment in often difficult conditions.
- **Tabulate the data.** Whether the survey results are to be compiled by hand or by computer, the responses for each questionnaire will have to be assigned numerical codes. This process is usually simplified by including numerical codes for each of the response categories on to the printed questionnaire form. When the interviews are completed, these codes are then transferred by hand to tabulation sheets or the codes can be entered into a computer. Both of these methods allow the survey results to be read and interpreted by means of statistical tables and percentages. As field computers and satellite communication become more common, it will be possible to enter data directly by the interviewer with immediate feedback for possible errors in measurement and recording.

- **Analyze and report the survey results.** On the basis of the tables prepared, the survey data are studied and interpreted and conclusions are drawn about the nutritional and socio-economic conditions of the households in the project area. The report on the survey contains the most important findings and conclusions, statistical tables and a description of the procedures used in conducting the survey. The survey results should be presented in a clear and straightforward manner.

3.5 WEIGHING AND MEASURING EQUIPMENTS

Equipment is required to do anthropometric assessment. The most common types of equipment used are scales and measuring boards. Sources for obtaining equipment and tips on what to look for in equipment are listed below. Whatever equipment is chosen, staff need training to ensure its proper use and care. Check with the local UNICEF office for their specifications and availability.

Scales

Scales used in the field should be portable, durable and capable of reading up to 25 kg for children and have 100 gram increments. There are several different attachments that can be used to help weigh children with spring scales. The size of the child will determine which attachment should be used. For weighing infants, a sling or basket is usually attached to the spring scale. For children, weighing trousers are used to suspend them. These are small pants with straps that the child steps into. The trousers are then hung from the scale by the straps. There are other alternatives than the trousers, but they can be difficult to use for infants and small children. For infants, a cloth folded to hang from the scale with the infant is preferred. For children who are old enough to grasp firmly onto something, a handle is sometimes attached to the scale and the child hangs from it by their hands until their weight is read. Whatever is used to suspend the child, the scale should be zeroed to ensure that the weight of the trousers, sling or basket is not added to the child's weight.

Electronic Scales: UNICEF and others have found electronic scales to be durable and flexible especially given the option of weighing the mother with the child. The mother can be weighed with the child. The mother is then weighed without the child. The difference between the two measures is the child's weight. This technique is useful in situations where the child struggles and use of a sling or weighing pants causes stress for the child. An additional advantage is that the weight of the mother is also available.

Each member of the field staff should have their own scale if possible, otherwise it might take longer to do measurements and complete the survey. Several scales that are available for purchase are listed below:

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UNICEF Electronic Scale:— The scale is manufactured by SECA and is a floor scale for weighing children as well as adults (capacity 150 kg). Weighing capacity from 1 kg to 150 kg in 100 g divisions, accuracy +/- 100 g. Weight of adult on scale can be stored (tared) in memory, allowing weight of baby or small child held by adult to show on scale indicator. Solar cell on-switch (light sensitivity 15 lux). Powered by long-life lithium battery, good for one million weighing cycles. Portable, weight 4 kg. Instructions in English, French and Spanish.

The major advantage of this scale is the micro-computer chip so that it can adjust to zero and weigh people quickly and accurately. The child may be weighed directly. If a child is frightened, the mother can first be weighed alone and then weighed while holding the child in her arms, and the scale will automatically compute the child's weight by subtraction. Recent experience in surveys suggests that the scale is appropriate for Cooperating Sponsor use although there have been some difficulties with heat adversely affecting the scale.

UNICEF Hanging Scale: This is a Salter type spring scale with a capacity of 25 kg and 100 gram increments. Using this scale requires that the child be dressed in a set of plastic or nylon trousers before being weighed. The interviewers will need several pairs of these special trousers if they are going to use hanging scales. A hook for hanging the scale from a door or a ceiling beam may also be necessary. The scale should be checked periodically with standard 5 or 10 kg weights. Beam-and-spring or dial type scale, with two suspension hooks. With adjustment screw on top. The scale weighs about 1 kg. For weight monitoring. Practical to use, easy to transport. Suspend the scale from a solid support.

TALC Weighing Scale: The TALC scale can be used like any other hanging scale, with the advantage that a growth chart can be put in it, and the child's weight is marked directly from the pointer on the spring. The TALC scale can be made locally from a TALC starter kit. This includes three springs, instructions and three specimen growth charts. The scale can also be made from local materials with the purchase of the TALC scale spring and instructions. A TALC sample pack includes spring, hook, nylon cord, wood pieces, screws and instructions.

Suspended Infant Weighing Pack: This scale was developed in conjunction with the US Centers for Disease Control. It is a dial scale made of durable plastic with an easy to read face. It is capable of weighing up to 25 kg in 100 gram increments. The pack includes a sling, weighing trousers, a detachable handle for weighing larger children and a vinyl shoulder bag.

Chasmors Ltd. Model MP25: This is a lightweight scale with a stainless steel case and an unbreakable plastic cover. It is easy to read and can weigh up to 25kg in 100 gram gradations. The scale comes with two weighing trousers and one sling (for newborns).

Salter Model 235-6S: This is a lightweight scale in a durable non-rust metal case with an unbreakable plastic face. Its capacity is 25 kgs with 100g increments.

Length/Height Boards

Length/height boards should be designed to measure children under 2 years of age lying down (recumbent), and older children standing up. The board should measure up to 120 cm (1.2 meters) for children and be readable to 0.1 of a centimeter. A measuring board should be lightweight, durable and have few moving parts. The metal part on the boards absorbs heat easily so care must be taken in field conditions. Another concern with length/height boards is that they resemble coffins and this can be disconcerting to the caregiver. Check with the survey personnel and adjust the design. Provide adequate training both in using the equipment and in providing appropriate information for the caregiver. Ideally, each field staff should have their own board. This makes the survey process more efficient than when boards have to be shared. Several types of length and height boards are available and are listed below. The Dutch infant-child-adult measuring board is recommended but local adaptations are possible to reduce the cost.

UNICEF Model (Infant length/height measuring board): An infant/child height measuring board measuring both recumbent length and standing height. This board is made of wood, smooth-finish, all parts glued and screwed; height is 130 cm (collapses to 75 cm); and width 30 cm. Supplied with a shoulder strap. Illustrated instructions for assembly and use are included, also guidelines and plans for local construction. Estimated weight: 10 kg.

Infant/Child Height/Length Measuring Board: This board has 130 cm capacity (collapses to 75cm) and has 0.1 cm increments. The board weighs 6 kg, is portable, water-resistant and has an adjustable, removable nylon shoulder strap. It is easy to assemble and dismantle, with the sliding head-footpiece stored in the base of the board for transport or storage.

Infant Recumbent Length Board: This board is lightweight, durable and capable of measuring recumbent length up to 100 cm.

Infant Measuring Board: This measuring board is designed to be especially lightweight and extremely portable. It can measure up to 100 cm, is collapsible and comes with a vinyl plastic tote bag.

Portable Adult/Infant Measuring Board: This is an adjustable measuring board which has been extensively used by WHO and CDC, with a vertical aluminum post. It can measure the height of adults and then by taking off its vertical extension it can be adapted to measuring infants. When collapsed it is approximately the length of two briefcases laid end to end. It also has an optional vinyl carrying case.

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Infant/Child/Adult Height/Length Measuring Board: This measuring board has a 200 cm capacity (collapses to 85 cm) and has 0.1 cm increments. The board weighs 6 kg, is portable, water-resistant and has an adjustable, removable nylon shoulder strap. It is easy to assemble and dismantle.

Adult Measuring Device (Microtoise): This lightweight portable tape is wall mounted and fits easily into the package needed for field measurements. Made of plastic, the Microtoise measures up to 2 meters.

Adult Measuring Device (Harpenden Pocket Stadiometer): An inexpensive height measuring device useful for children over 24 months and adults (range 0-2000mm).

Local Construction Various plans exist for the local construction of foldable height/length boards. It is important that the materials are durable, lightweight and the wood should be well seasoned to guard against warping. Sealing the wood with water repellant and ensuring the measuring tape is protected from wear will improve the durability of the board. The tape measure should be durable with 0.1 cm increments and the numbers of the tape measure must be next to the markings on the board when the measure is glued to the side of the board. The boards should be long enough to measure children up to 5 years and a "correction" factor is needed to convert recumbent length to standing height for children over 24 months in order to use the WHO/NCHS growth reference standards.

Mid-Upper Arm Circumference Measure

MUAC Tape: Arm circumference insertion tape: to measure mid-upper arm circumference of children, up to 25 cm. Colour-coded in red/yellow/green, non-tear, stretchresistant plasticized paper. Supplied in pack of tapes together with written and pictorial instructions for use.

3.6 TAKING MEASUREMENTS

Accurate anthropometric measurement is a skill requiring specific training Training requires step-by-step procedures to follow when taking measurements Standardizing methods helps ensure that the measurements will be correct and makes comparisons possible. Comparisons may be done between data collected from different areas of a country, between different surveys or betweer measurements and the reference standards.

None of these comparisons will be possible without a standard method fo taking measurements. This section will cover the necessary field equipment an(methods for taking measurements.

Interviewer Field Materials

The checklist below includes the equipment and materials interviewers should have with them in the field. All of these items may not be necessary for every survey.

- Equipment bag
- List of assigned households and their addresses (or location)
- Map of the area
- Log book
- Pre-numbered questionnaires for assigned households
- Spare questionnaires
- Waterproof envelopes for blank and completed questionnaires
- Weighing scale
- Scale hooks
- Weighing pants or hanging swing
- Storage bag for pants
- Piece of rope for scales
- Storage box for scales
- Height/length measuring board
- Sliding head/foot pieces
- Clipboard
- Stapler and box of staples
- Pencils and pencil sharpener
- Eraser
- Pens
- Spare paper

Procedures Before Measuring

There are a few preparatory procedures and decisions that should be addressed prior to obtaining measurements. Guidelines to make the field experience easier are:

- **Initial preparation.** Ensure that the mother or caretaker understands what is happening to the child. The measurement of weight and length can be traumatic. Participants need to be comfortable with the process. The equipment should be cool, clean and safely secured. Work out of direct sunlight since it can interfere with reading scales and other equipment and it is more comfortable for the measurer and child.

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- **Two trained people required.** When possible, two trained people should measure a child's height and length. The measurer holds the child and takes the measurements. The assistant helps hold the child and records the measurements on the questionnaire. If only one trained person is available to take the measurements, then the child's mother can help. The measurer would also record the measurements on the questionnaire.
- **Measuring board and scale placement.** There will usually be several choices on where to place the measuring board or scale, but the choice should be made carefully. Be sure that you have a sturdy, flat surface for measuring boards, a strong place to hang scales from and adequate light so the measurements can be read with precision.
- **When to weigh and measure.** Weighing and measuring should not be the first thing you do when you start an interview. It is better to begin with questions that need to be answered. This helps make the mother and child feel more comfortable before the measurements begin.
- **Weigh and measure one child at a time.** You should complete the questions and measurements for one child at a time. This avoids potential problems with mixups that might occur if you have several children to measure.
- **Control the child.** When you are taking weight and length/height measurements the child needs to be as calm as possible. A child who is excited or scared can make it difficult to get an accurate measurement.
- **Recording measurements.** All measurements should be recorded in pencil. If a mistake is made when recording a measurement, it can be corrected.

How to Measure Age, Height, Length, Weight and MUAC

The following suggestions are adapted from How to Weigh and Measure Children: Assessing the Nutritional Status of Young Children in Household Surveys, UN Department of Technical Cooperation for Development and Statistical Office, 1986.

Age

The child's accurate age is required for sampling, deciding on whether the child is measured standing or reclining for height or length, and for converting height and weight into the standard indices. At the time of measurement, an age estimate is needed for decisions on sampling and for the position on the measuring board. It is recommended the enumerators use simple methods to approximate the age and that the data analyst calculates the age using a computer program which will require the date of birth and date of measurement.

To complete the determination, the enumerator needs to examine documentary evidence of the birth date (such as birth, baptismal certificate, clinic care or horoscope). Cross checking is necessary even if the mother knows the birth date or age of the child as errors in recall are common. Where there is a general registration of births and where ages are generally known, the recording of age is a straightforward procedure, with age measured to the nearest month or year as the case may be. For example, an infant whose date of birth is 13 July, 1996 could be recorded as being 6 months if seen between 13 December, 1996 and 12 January, 1997 (both dates inclusive). Similarly, a child born on 13 July, 1995 could be recorded as 6 years old if seen between 13 July 2001 and 12 July, 2002 (both dates inclusive). If dates cannot be recalled, use of a local calendar will assist mothers in recalling the date of birth. Construction of the local calendar should be done prior to the survey and tested using the enumerators.

Height for children 24 months and older (Figure 1)

1. ***Measurer or assistant:*** Place the measuring board on a hard flat surface against a wall, table, tree, staircase, etc. Make sure the board is not moving.
2. ***Measurer or assistant:*** Ask the mother to remove the child's shoes and unbraid any hair that would interfere with the height measurement. Ask her to walk the child to the board and to kneel in front of the child. If a Microtoise measure is used, stand the child vertically in the middle of the platform.
3. ***Assistant:*** Place the questionnaire and pencil on the ground (Arrow 1). Kneel with both knees on the right side of the child (Arrow 2).
4. ***Measurer:*** Kneel on your right knee on the child's left side (Arrow 3). This will give you maximum mobility.
5. ***Assistant:*** Place the child's feet flat and together in the center of and against the back and base of the board/wall. Place your right hand just above the child's ankles on the shins (Arrow 4), your left hand on the child's knees (Arrow 5) and push against the board/wall. Make sure the child's legs are straight and the heels and calves are against the board/wall (Arrows 6 and 7). Tell the measurer when you have completed positioning the feet and legs.
6. ***Measurer:*** Tell the child to look straight ahead at the mother who should stand in front of the child. Make sure the child's line of sight is level with the ground (Arrow 8). Place your open left hand under the child's chin. Gradually close your hand (Arrow 9). Do not cover the child's mouth or ears. Make sure the shoulders are level (Arrow 10), the hands are at the child's side (Arrow 11), and the head, shoulder blades and buttocks are against the board/wall (Arrows 12,13, and 14). With your right hand, lower

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the headpiece on top of the child's head. Make sure you push through the child's hair (Arrow 15).

7. *Measurer and assistant:* Check the child's position (Arrows 1-15). Repeat any steps as necessary.
8. *Measurer:* When the child's position is correct, read and call out the measurement to the nearest 0.1 cm. Remove the headpiece from the child's head and your left hand from the child's chin.
9. *Assistant:* Immediately record the measurement and show it to the measurer.
10. *Measurer:* Check the recorded measurement on the questionnaire for accuracy and legibility. Instruct the assistant to erase and correct any errors.

Length for infants and children 0-23 months (Figure 2)

1. *Measurer or assistant:* Place the measuring board on a hard flat surface, i.e., ground, floor, or steady table.
2. *Assistant:* Place the questionnaire and pencil on the ground, floor, or table (Arrow 1). Kneel with both knees behind the base of the board if it is on the ground or floor (Arrow 2).
3. *Measurer:* Kneel on the right side of the child so that you can hold the foot piece with your right hand (Arrow 3).
4. *Measurer and assistant:* With the mother's help, lay the child on the board by supporting the back of the child's head with one hand and the trunk of the body with the other hand. Gradually lower the child onto the board.
5. *Measurer or assistant:* Ask the mother to kneel close on the opposite side of the board facing the measurer as this will help to keep the child calm.
6. *Assistant:* Cup your hands over the child's ears (Arrow 4). With your arms comfortably straight (Arrow 5), place the child's head against the base of the board so that the child is looking straight up. The child's line of sight should be perpendicular to the ground (Arrow 6). Your head should be straight over the child's head. Look directly into the child's eyes.
7. *Measurer:* Make sure the child is lying flat and in the center of the board (Arrows 7). Place your left hand on the child's shins (above the ankles) or on the knees (Arrow 8). Press them firmly against the board. With your right hand, place the foot piece firmly against the child's heels (Arrow 9).
8. *Measurer and assistant:* Check the child's position (Arrows 1-9). Repeat any steps as necessary.
9. *Measurer:* When the child's position is correct, read and call out the measurement to the nearest 0.1 cm. Remove the foot piece and release your left hand from the child's shins or knees.

10. ***Assistant:*** Immediately release the child's head, record the measurement, and show it to the measurer.

11. ***Measurer:*** Check the recorded measurement on the questionnaire for accuracy and legibility. Instruct the assistant to erase and correct any errors.

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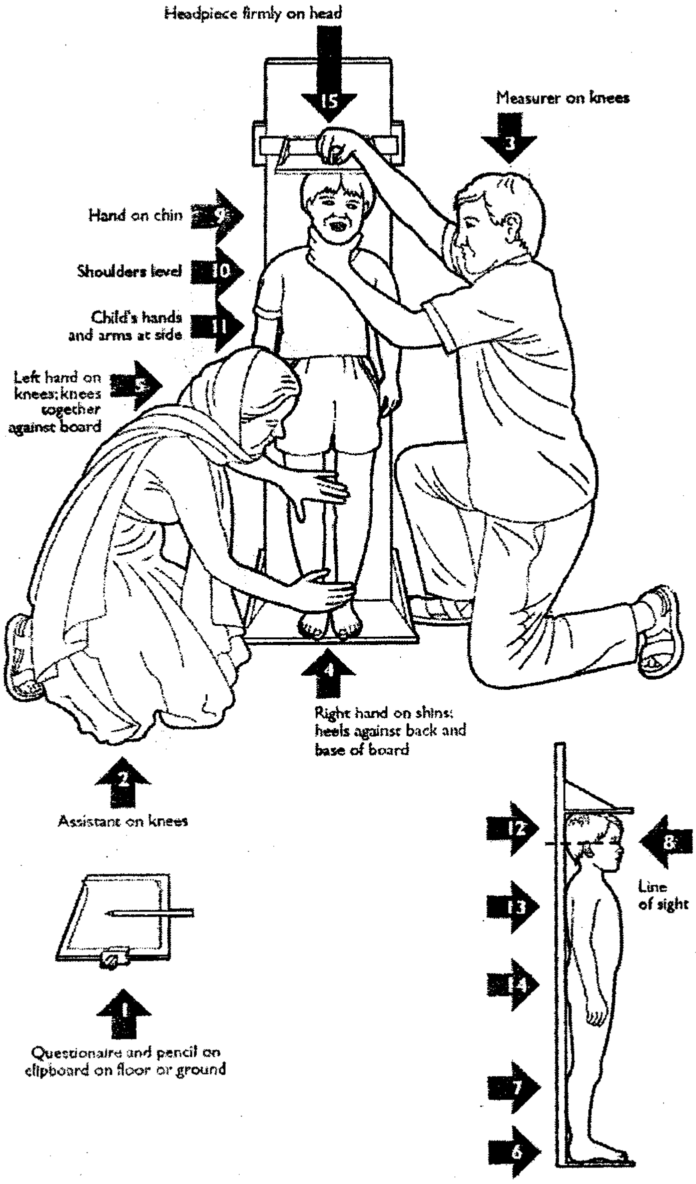

Figure 1. Child Height Measurement - Height for Children 24 Months and Older

Source: How to Weigh and Measure Children: Assessing the Nutritional Status of Young Children, UN 1986.

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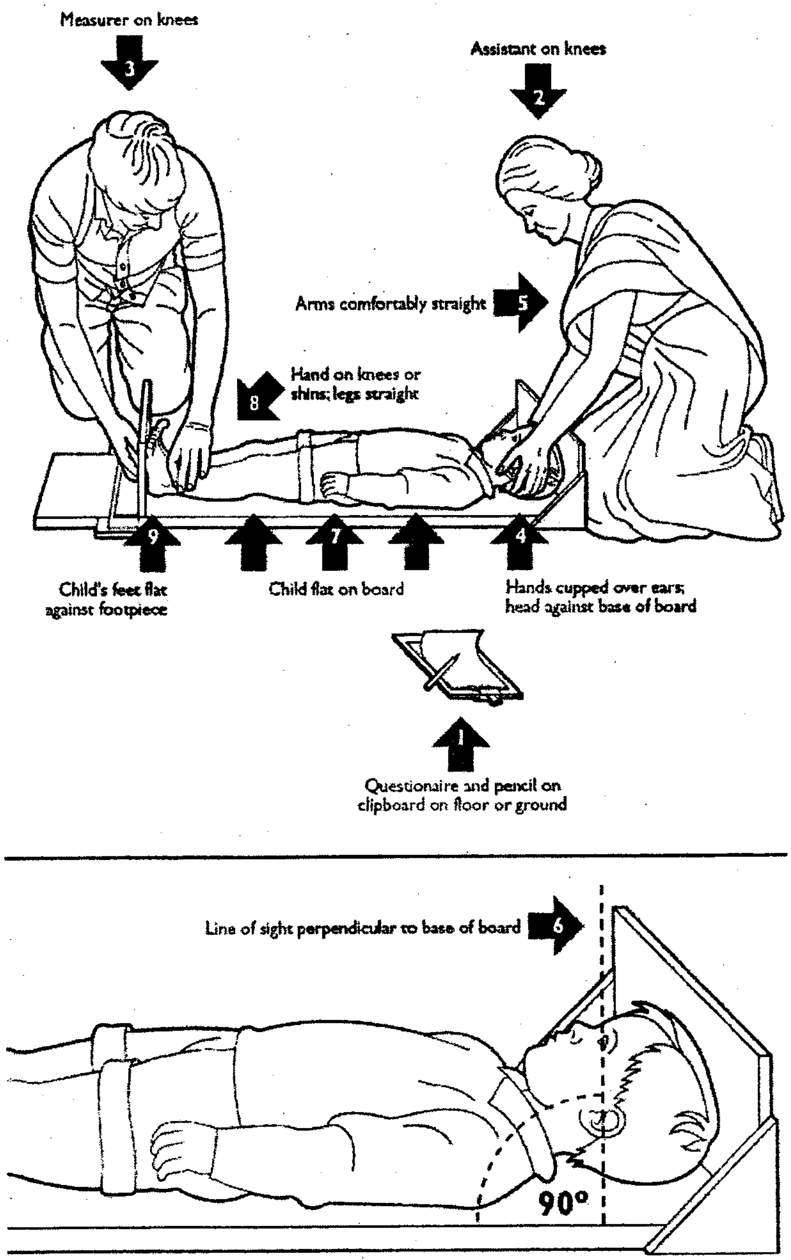

Figure 2. Child length measurement - length for infants andchildren 0-23 months

Source: How to Weigh and Measure Children: Assessing the Nutritional Status of Young Children, UN 1986.

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Weight Using Salter-like Hanging Scale (Figure 3)

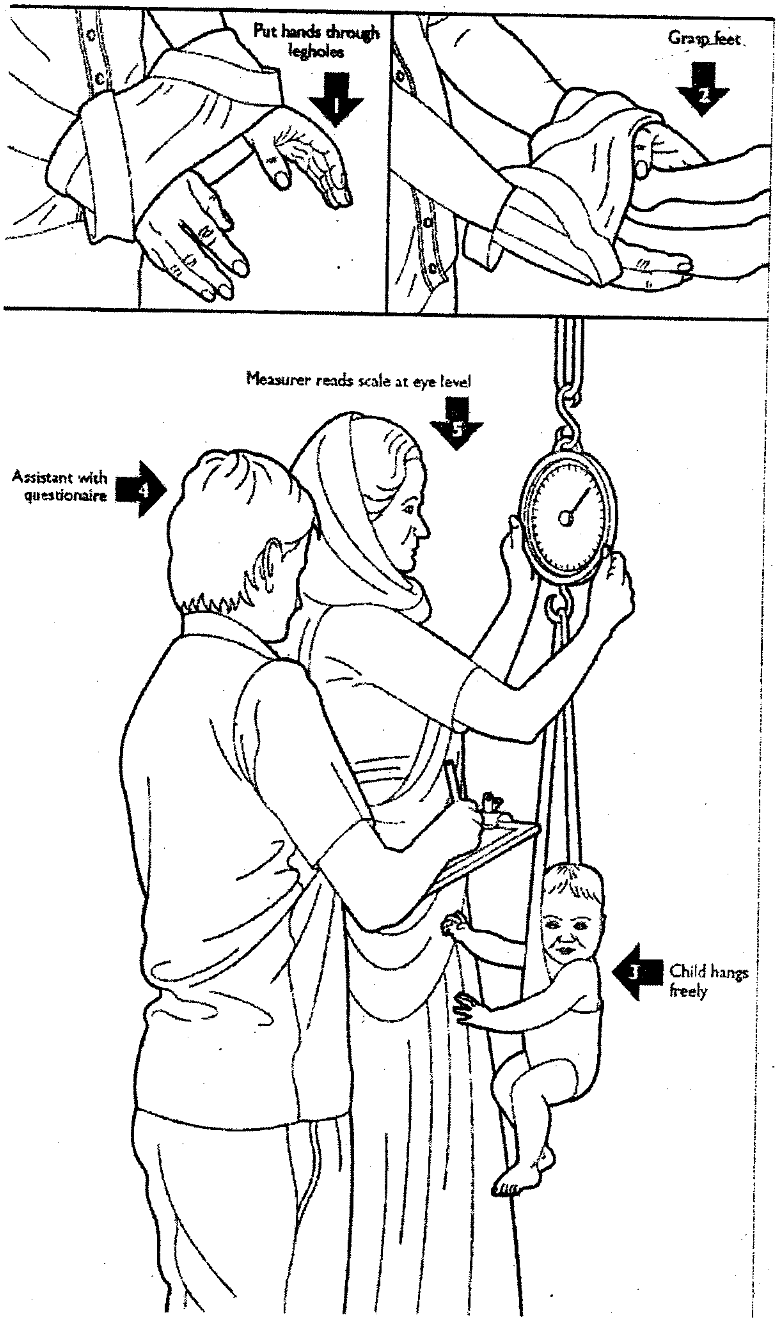

Figure 3. Child Weight

Source: How to Weigh and Measure Children: Assessing the Nutritional Status of Young Children, UN 1986.

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1. ***Measurer or assistant:*** Hang the scale from a secure place like the ceiling beam. You may need a piece of rope to hang the scale at eye level. Ask the mother to undress the child as much as possible.
2. M easurer: Attach a pair of the empty weighing pants to the hook of the scale and adjust the scale to zero, then remove from the scale.
3. *Measurer:* Have the mother hold the child. Put your arms through the leg holes of the pants (Arrow 1). Grasp the child's feet and pull the legs through the leg holes (Arrow 2). Make certain the strap of the pants is in front of the child.
4. *Measurer:* Attach the strap of the pants to the hook of the scale. DO NOT CARRY THE CHILD BY THE STRAP ONLY. Gently lower the child and allow the child to hang freely (Arrow 3).
5. ***Assistant:*** Stand behind and to one side of the measurer ready to record the measurement. Have the questionnaire ready (Arrow 4).
6. ***Measurer and assistant:*** Check the child's position. Make sure the child is hanging freely and not touching anything. Repeat any steps as necessary.
7. *Measurer:* Hold the scale and read the weight to the nearest 0.1 kg. (Arrow 5). Call out the measurement when the child is still and the scale needle is stationary. Even children who are very active, which causes the needle to wobble greatly, will become still long enough to take a reading. WAIT FOR THE NEEDLE TO STOP MOVING.
8. ***Assistant:*** Immediately record the measurement and show it to the measurer.
9. ***Measurer:*** As the assistant records the measurement, gently lift the child by the body. DO NOT LIFT THE CHILD BY THE STRAP OF THE WEIGHING PANTS. Release the strap from the hook of the scale.
10. ***Measurer:*** Check the recorded measurement on the questionnaire for accuracy and legibility. Instruct the assistant to erase and correct any errors.

Child Mid-Upper Arm Circumference (MUAC) Procedure (Figure 4)

1. ***Measurer:*** Keep your work at eye level. Sit down when possible. Very young children can be held by their mother during this procedure. Ask the mother to remove clothing that may cover the child's left arm.
2. ***Measurer:*** Calculate the midpoint of the child's left upper arm by first locating the tip of the child's shoulder (Arrows 1 and 2) with your finger tips. Bend the child's elbow to make a right angle (Arrow 3). Place the tape at zero, which is indicated by two arrows, on the tip of the shoulder (Arrow 4) and pull the tape straight down past the tip of the elbow (Arrow 5). Read the number at the tip of the elbow to the nearest centimeter. Divide this number by two to estimate the midpoint. As an alternative, bend the tape up to the middle length to estimate the midpoint. A piece of

string can also be used for this purpose. Either you or an assistant can mark the midpoint with a pen on the arm (Arrow 6).

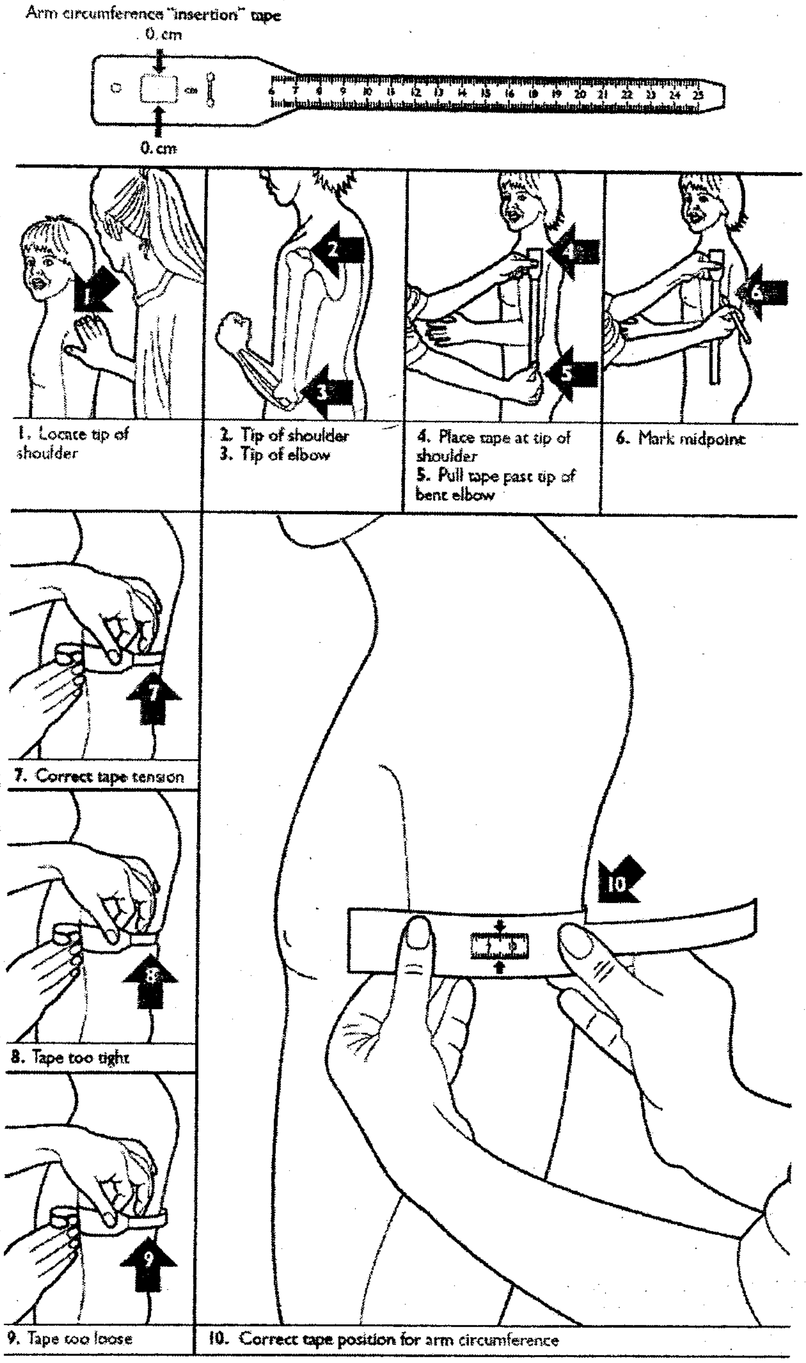

Figure 4. Child Mid-Upper Arm Circumference Measurement

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3. ***Measurer:*** Straighten the child's arm and wrap the tape around the arm at midpoint. Make sure the numbers are right side up. Make sure the tape is flat around the skin (Arrow7).
4. ***Measurer and assistant:*** Inspect the tension of the tape on the child's arm. Make sure the tape has the proper tension (Arrow 7) and is not too tight or too loose (Arrows 8-9). Repeat any steps as necessary.
5. ***Assistant:*** Have the questionnaire ready.
6. ***Measurer:*** When the tape is in the correct position on the arm with the correct tension, read and call out the measurement to the nearest 0.1cm. (Arrow 10).
7. ***Assistant:*** Immediately record the measurement on the questionnaire and show it to the measurer.
8. ***Measurer:*** While the assistant records the measurement, loosen the tape on the child's arm.
9. ***Measurer:*** Check the recorded measurement on the questionnaire for accuracy and legibility. Instruct the assistant to erase and correct any errors.
10. ***Measurer:*** Remove the tape from the child's arm.

ASSESSING THE ACCURACY OF MEASUREMENTS

Accuracy is achieved through good training and supervision. There are techniques for measuring the accuracy of the measurements. When taking more than one height or weight measurement on the same person, the two measurements can be averaged. If they are vastly different from each other, the measurements should be disregarded and the measuring should start again (Table1 provides specific parameters).

Table 1. Largest acceptable differences between repeated measurements

Anthropometric measurement	*Largest acceptable difference*
Weight	0.5kg
Height	1.0cm
MUAC	0.5cm

The field supervisor is usually responsible the field. for assessing the accuracy of measurements. There are a few practices a supervisor should employ to make sure that the data collected is of high quality.

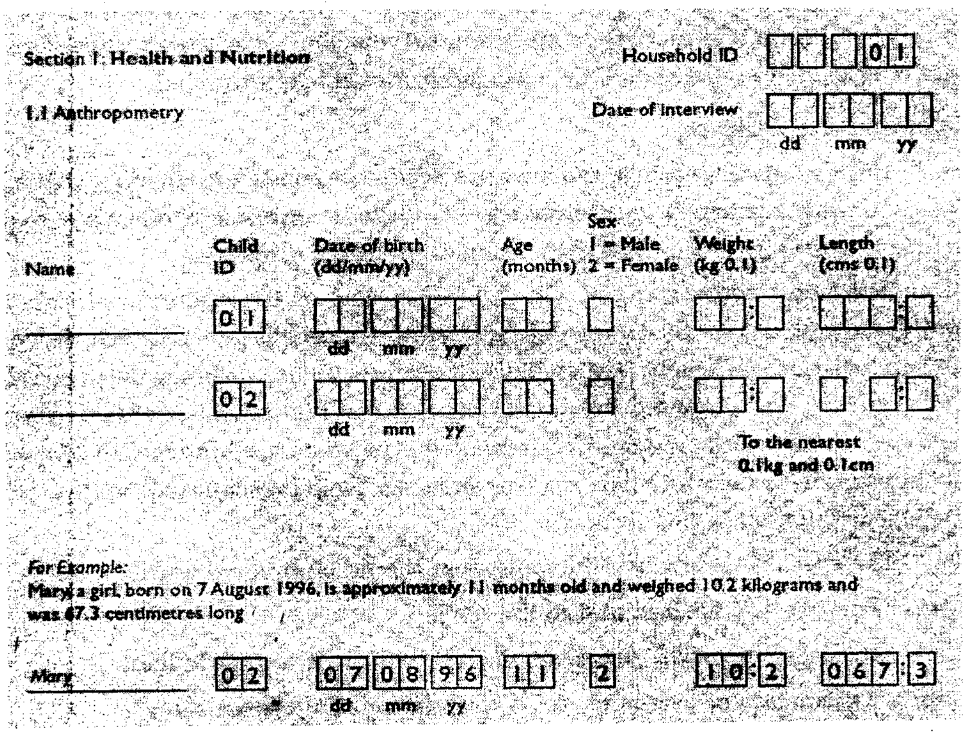
These are:

- Checking the measurements recorded and submitted by field staff, to see whether they look reasonable.

- Accompanying field staff on interviews to watch how measurements are taken.
- Conducting repeat visits to some households that have already been interviewed by the field staff. Measurements should be repeated to determine if the previous measurements are supported by the repeat measurements.

Entering the Data

A survey questionnaire usually contains a wide range of information to be collected. A questionnaire should be adapted to the needs for measuring anthropometry.Some information will carry over from one module or section to another. The following is an example of one format used for survey work for children under five years of age.


Section 1: Health and Nutrition — Household ID [ ][ ][ ][0][1]

1.1 Anthropometry — Date of Interview [ ][ ] [ ][ ] [ ][ ] (dd mm yy)

Name	Child ID	Date of birth (dd/mm/yy)	Age (months)	Sex 1 = Male 2 = Female	Weight (kg 0.1)	Length (cms 0.1)
________	01	dd mm yy				
________	02	dd mm yy				

To the nearest 0.1kg and 0.1cm

For Example:
Mary, a girl, born on 7 August 1996, is approximately 11 months old and weighed 10.2 kilograms and was 67.3 centimetres long

Mary	02	07 08 96 (dd mm yy)	11	2	10.2	067.3

Figure 5. Child anthropometry questionnaire (partial)

Anthropometry - basic information: Enter the children's names and identification code numbers, enter the sex and their ages (see Figure 5). Be careful not to mix up children when moving from one section of a questionnaire to another.

Child weight: Record the child's weight in kilograms to one decimal. Read the supporting notes carefully as they should be known to all interviewers and supervisors. In the example of Mary (Figure 5), her weight was 10.2 kilograms. Had her weight been 9.5 kgs, the entry would be |0|9:5|. Always note the zeros and the decimals.

Child length: Record the child's length in centimeters to one decimal. In the example of Mary (Figure 5), her length was 67.3 centimeters. The entry is made as |0|6|7:3|. Always note the zeros and the decimals. Make sure the information is entered accurately and fully on each child.

Training Field Staff

Training field staff to collect anthropometric data through surveys usually involves learning: to take anthropometric measurements; and other skills such as household selection, interviewing techniques and recording requirements. All of these skills are important for conducting surveys that yield valid results. This section will cover what should be expected from field staff training.

Planning the Training

It is recommended that you always select more candidates than you need. This will allow you to pick the candidates with the best performance when training is over and will give you some extra trainees in case of dropouts.

The length of the training will vary depending on the resources available and the complexity of the survey. As a guideline, training is generally scheduled for two to five days. Usually, the first day of training is spent explaining the purpose of the survey and outlining the survey procedures; the second and third days focus more closely on survey procedures and the questionnaire; and the last couple of days should be used for field exercises and tests. Field exercises will be covered in more detail later in this section.

The checklist below lists the topics that should be covered during training:

- Purpose and background of the survey
- Organization of the survey team and division of responsibilities
- Explanation of sampling and household selection procedures
- Question-by-question review of the questionnaire
- Instruction in techniques of interviewing, recording answers and checking out questionnaires
- Explanation of specific nutrition indicators
- Instructions on how to take and record anthropometric measurements and standardization tests
- Administrative details (timetable, logbook, supplies, reports).

Field Exercises and Standardization

Survey staff should have ample opportunity to practice the skills taught during training. This is especially true with training on taking anthropometric measurements. Trainees practical skills need to be developed. During practice sessions a supervisor can determine who needs more training. Practice sessions might begin by taking trainees to a school, maternal and child health clinic, hospital or orphanage and letting them practice taking children's measurements.

By the end of training, all trainees should also have had a chance to practice what they have learned. Choose a village that is close to the training center. The trainees should go through an entire survey with a few households and the supervisor should watch how each trainee performs. This will provide trainees with hands-on experience, make them feel more confident when they go into the field and will give the supervisor a chance to correct any mistakes.

Survey Training Manual

A training manual should give an overview of the purpose of the survey, an outline of the whole survey process and clearly define what is expected of the field staff. It can also include useful tips and answers to common questions that come up in the field. All field staff should be provided with their own copy of the training manual.

3.7 COMPARISON OF ANTHROPOMETRIC DATA TO REFERENCE STANDARDS

Comparing the measurements of children to reference standards is an easy procedure because of readily available public-domain computer software. This section describes some underlying principles for efficient use of the available software beginning with how individual measurements are compared to the reference standard.

WHO Reference Standards

The reference standards most commonly used to standardize measurements were developed by the US National Center for Health Statistics (NCHS) and are recommended for international use by the World Health Organization. The reference population chosen by NCHS was a statistically valid random population of healthy infants and children. Questions have frequently been raised about the validity of the US-based NCHS reference standards for populations from other ethnic backgrounds. Available evidence suggests that until the age of approximately 10 years, children from well-nourished and healthy families throughout the world grow at approximately the same rate and attain the same height and weight as children from industrialized countries.

The NCHS/WHO reference standards are available for children up to 18 years old but are most accurate when limited to use with children up to the age of 10 years. The international reference standards can be used for standardizing anthropometric data from around the world.

Comparisons to the Reference Standard

References are used to standardize a child's measurement by comparing the child's measurement with the median or average measure for children at the same age and sex. For example, if the length of a 3 month old boy is 57 cm, it would be difficult to know if that was reflective of a healthy 3 month old boy without comparison to a reference standard. The reference or median length for a population of 3 month old boys is 61.1 cm and the simple comparison of lengths would conclude that the child was almost 4 cm shorter than could be expected.

When describing the differences from the reference, a numeric value can be standardized to enable children of different ages and sexes to be compared. Using the example above, the boy is 4 cm shorter than the reference child but this does not take the age or the sex of the child into consideration. Comparing a 4 cm difference from the reference for a child 3 months old is not the same as a 4 cm difference from the reference for a 9 year old child, because of their relatively different body sizes.

Taking age and sex into consideration, differences in measurements can be expressed a number of ways:

- standard deviation units, or Z-scores
- percentage of the median
- percentiles.

Standard Deviation Units or Z-Scores

Z-scores are more commonly used by the international nutrition community because they offer two major advantages. First, using Z-scores allows us to identify a fixed point in the distributions of different indices and across different ages, i.e., for all indices for all ages, 2.28% of the reference population lie below a cut-off of -2 Zscores. The percent of the median does not have this characteristic. For example, because weight and height have different distributions (variances), -2 Z-scores on the weight-for-age distribution is about 80% of the median, and -2 Z-scores on the height-for-age distribution is about 90% of the median. Further, the proportion of the population identified by a particular percentage of the median varies at different ages on the same index.

The second major advantage of using Zscores is that useful summary statistics can be calculated from them. The approach allows the mean and standard deviation to be calculated for the Z-scores for a group of children. This can not be done with percentages of the median or centiles. Thus, the Z-score application is considered the simplest way of describing the reference population and making comparisons to it. It is the statistic recommended for use when reporting results of nutritional assessments.

The Z-score or standard deviation unit (SD) is defined as the difference between the value for an individual and the median value of the reference population for the same age or height, divided by the standard deviation of the reference population. This can be written in equation form as:

Z-score (or SD-score) = (observed value — median reference value)/standard deviation of reference population

Percentage of the Median and Percentiles

The percentage of the median is defined as the ratio of a measured or observed value in the individual to the median value of the reference data for the same age or height for the specific sex, expressed as a percentage. This can be written in equation form as:

Percent of median = (observed value)/(median value of reference population)

The median is the value at exactly the mid-point between the largest and smallest. If a child's measurements are exactly the same as the median of the reference population we say that they are "100% of the median".

The percentile is the rank position of an individual on a given reference distribution, stated in terms of what percentage of the group the individual equals or exceeds. Percentiles will not be presented in this guide. The distribution of Z-scores follows a normal (bell-shaped or Gaussian) distribution. The commonly used -3, -2, and -1 Z-scores are, respectively the 0.13th, 2.28th, and 15.8th percentiles. The percentiles can be thought of as the percentage of children in the reference population below the equivalent cut-off. Approximately 0.13 percent of children would be expected to be below -3 Z-score in a normally distributed population.

Z-score	*Percentile*
-3	0.13
-2	2.28
-1 1	5.8

Cut-offs

The use of a cut-off enables the different individual measurements to be converted into prevalence statistics. Cut-offs are also used for identifying those children suffering from or at a higher risk of adverse outcomes. The children screened under such circumstances may be identified as eligible for special care.

The most commonly-used cut-off with Z-scores is -2 standard deviations, irrespective of the indicator used. This means children with a Z-score for underweight, stunting or wasting, below -2 SD are considered moderately or severely malnourished. For example, a child with a Z-score for height-for-age of -2.56 is considered stunted, whereas a child with a Z-score of -1.78 is not classified as stunted.

In the reference population, by definition, 2.28% of the children would be below -2 SD and 0.13% would be below -3 SD (a cut-off reflective of a severe condition). In some cases, the cut-off for defining malnutrition used is -1 SD (e.g. in Latin America). In the reference or healthy population, 15.8% would be below a cut-off of -1 SD. The use of -1 SD is generally discouraged as a cut-off due to the large percentage of healthy children normally falling below this cut-off. For example, the 1995 DHS survey using a –2 SD cut-off for stunting in Uganda found a 36% prevalence of stunting in under-three year olds. This level of stunting is about 16 times the level of the reference population.

A comparison of cutoffs for percent of median and Z-scores illustrates the following

90% = -1 Z-score
80% = -2 Z-score
70% = -3 Z-score (approx.)
60% = -4 Z-score (approx.)

Cut-off Points for MUAC for the 6 - 59 Month Age Group

MUAC cut-offs are somewhat arbitrary due to its lack of precision as a measure of malnutrition. A cut-off of 11.0cm can be used for screening severely malnourished children. Those children with MUAC below 13.5cm should be selected to have their weight-for-height measured.

Global Malnutrition is a term generally used in emergency settings. The global malnutrition rate refers to the percent of children with weight-for-height below -2 Zscores and/or edema. This refers to all moderate and severe malnutrition combined. The combination of a low weight-for-height and any child with edema contributes to those children counted as in the global malnutrition statistic.

Malnutrition Classification Systems

The cut-off points for different malnutrition classification systems are listed below. The most widely used system is WHO classification (Z-scores). The Road-to-Health (RTH) system is typically seen in clinic-based growth-monitoring systems. The Gomez system was widely used in the 1960s and 1970s, but is only used in a few countries now. An analysis of prevalence elicits different results from different systems. These results would not be directly comparable. The difference is especially broad at the severe malnutrition cut-off between the WHO method (Zscores) and percent of median methods. At 60% of the median the closest corresponding Z-score is –4. The WHO method is recommended for analysis and presentation of data.

Mild, moderate and severe are different in each of the classification systems listed below. It is important to use the same system to analyze and present data. The RTH and Gomez classification systems typically use weight-for-age.

System	Cut-off	Malnutrition classification
WHO	< -1 Z-score	mild
	< -2 Z-score	moderate
	< -3 Z-score	severe
RTH	> 80% of median	normal
	60% - < 80% of median	mild-to-moderate
	< 60% of median	severe
Gomez	> 90% of median	normal
	75% - < 90% of median	mild
	60% - < 75% of median	moderate
	< 60% of median	severe

3.8 INDICATORS OF NUTRITIONAL STATUS

Approximately 790 million people in the developing world subsist on diets that are deficient in energy. About 200 million children suffer from malnutrition and 2 billion people suffer from a variety of micronutrient deficiencies. The vast majority of the food-insecure, whether their malnutrition is due to deficiencies in energy or in micronutrients, live in low-income developing countries and mainly in the poorest areas of those. These numbers are only estimates, since no direct data are actually available to assess the magnitude of these problems, identify the causal factors thereof, or describe the nutritional status of the poor.

At the World Food Summit (WFS) in 1996, governments and heads of state committed themselves to reducing the number of undernourished people to half its current level (then estimated at 840 million) by the year 2015. In order to monitor progress towards this goal, the WFS called for better information to identify the food-insecure and vulnerable groups, assess the extent of low food intake and undernutrition, and ascertain the main causes contributing to food

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insecurity and vulnerability to malnutrition. Better information is expected to facilitate the identification of appropriate policy and programme responses and the targeting of interventions to improve food security and nutrition.

With this objective, governments undertook to define, develop and periodically update a Food Insecurity and Vulnerability Information and Mapping System (FIVIMS), regrouping data on food-insecure and vulnerable people - what socio-economic categories they belong to, where they are located, and what degree of food deficiency and undernutrition prevails among them. National data will be integrated into international databases collaborating in this exercise. The latter will be linked through a common, decentralized system for posting and disseminating information, allowing to better monitor food security and nutrition trends at the global level.

At the national level, the WFS called for close attention to monitoring the availability and nutritional adequacy of food supplies, particularly in areas at high risk of chronic or seasonal food insecurity and among nutritionally vulnerable groups. It also called for mechanisms to be established for collecting information on the nutritional status of the poor and on members of vulnerable and disadvantaged groups at sub-national levels. This note presents relevant methods in this context and their population dimensions.

Possible Causes of Low Food Consumption and Poor Nutritional Status

Low or inadequate food consumption - and consequent poor nutritional status - may be the result of a variety of causes, often operating in combination. Figure 1 illustrates the array of relevant factors. It shows that key determinants of food consumption are food availability (whether from local production or other sources) and people's access to that food (i.e. their capacity to produce or purchase). In addition, aspects related to the stability of supplies over time (obtaining a steady flow of food from an inherently irregular production) are essential. The stability of access to food (e.g. stable income) is important in terms of food security.

The above determinants are in turn affected by the socio-economic and political environment at large, in particular by economic conditions at the macro and micro levels (importance and characteristics of the agricultural sector; trade relations; livelihood systems; etc.). Educational levels and cultural values also play a role in shaping food habits, consumption patterns and food supply systems in general.

At the individual level, the degree of efficiency with which the body utilizes the food consumed is a key determinant of nutritional status. That efficiency is generally affected by poor health conditions and reduced significantly by specific diseases (infections, intestinal parasites, diarrhoea etc.).

Assessing Nutritional Status in a Population

A variety of methods are commonly used for assessing the nutritional status of populations based on anthropometric, clinical and biochemical measurements. Although methods based on dietary characteristics do not directly measure nutritional status, they are very often used by nutritionists in the field to assess it. These methods are described below and the main indicators recommended in the context of FIVIMS are presented in Table 2.

Table 2. Core indicators for nutritional status

Anthropometry:—

- Children under 5 years: W/A, W/H, H/A (to assess the satisfactory character, or otherwise, of corporal growth)
- Children 5-10 years: W/A, W/H, H/A (idem)
- Adults (>20 years): BMI (to assess underweight and overweight)
- Birth weight: percent under 2.5 kg at birth (to assess the nutritional situation of new-borns and of mothers during pregnancy)

Micronutrient deficiencies:—

- Prevalence of night blindness (hemeralopy) in children (to assess the vitamin A nutritional status)
- Prevalence of goitre [total goitre rate, TGR] (to assess the iodine nutritional status)
- Prevalence of nutritional anaemia among women and pre-school children (to assess the iron and/or folates nutritional status)

Anthropometric measurements (body dimensions and composition) are often used as proxies for assessing the eventual extent and severity of malnutrition. The classical indicators in this respect have to do with the growth of children and body composition of adults. The most commonly used measurements are the body weight, height, age and sex of each individual, which allow to calculate the following indicators:

Weight-for-Age (W/A) reflects body mass relative to chronological age

Low W/A is influenced by both the height of the child (height-for-age) and his or her weight (weight-for-height). Its composite nature makes interpretation complex. For example, weight-for-age fails to distinguish between short children of adequate body weight and tall, thin children. However, in the absence of significant wasting (see next paragraph) in a community, similar information is provided by weight-for-age and height-for-age as both reflect the long-term health

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and nutritional experience of the individual or population. In general terms, the world-wide variations and age distribution of low W/A are similar to those of low height-for-age.

Weight-for-Height (W/H) reflects body mass relative to height

Low W/H (wasting or thinness) indicates in most cases a recent and severe process of weight loss, which is often associated with acute starvation and/or severe disease. However, wasting may also be the result of a chronic unfavourable condition. Provided there is no severe food shortage, the prevalence of wasting is usually below 5 percent, even in poor countries. The Indian subcontinent, where higher prevalence rates are found, is an important exception. A prevalence exceeding 5 percent is alarming given a parallel increase in mortality that soon becomes apparent. On the severity index, prevalence rates between 10-14 percent are regarded as serious, and above or equal 15 percent as critical. Typically, the prevalence of low weight-for-height shows a peak in the second year of life. Lack of evidence of wasting in a population does not imply the absence of current nutritional problems: stunting and other deficits may be present.

Overweight is the preferred term for describing high W/H. Even though there is a strong correlation between high W/H and obesity as measured by adiposity, greater lean body mass can also contribute to high weight-for-height. On a population-wide basis, high W/H can be considered as an adequate indicator of obesity, because the majority of individuals with high W/H are obese. Strictly speaking, the term obesity should be used only in the context of adiposity measurements, for example skinfold thickness.

Height-for-Age (H/A) reflects height relative to chronological age

Low H/A is called stunting. Stunted growth reflects failure to reach linear growth potential as a result of sub-optimal health and/or nutritional conditions. On a population-wide basis, high levels of stunting are associated with poor socio-economic conditions and increased risk of frequent and early exposure to adverse conditions such as illness and/or inappropriate feeding practices. Similarly, a decrease in the national stunting rate is usually indicative of improvements in overall socio-economic conditions of a country.

The world-wide variation of the prevalence of low H/A is considerable, ranging from 5 percent to 65 percent among the less developed countries. In many such settings, prevalence starts to rise at the age of about three months; the process of stunting slows down at around three years of age, after which mean heights run parallel to the reference curve. Therefore, the age of the child modifies the interpretation of the findings: for children below 2-3 years, low H/A probably reflects a continuing process of "failing to grow" or "stunting"; for older children, it reflects a state of "having failed to grow" or "being stunted". It is important to distinguish between the two related terms, length and stature: length refers to the measurement in recumbent position, the recommended way to measure children below 2 years of age or less than 85 cm tall; whereas stature refers to standing height measurement. For simplification, the term height is used to cover both measurements.

Body Mass Index

(BMI)= weight (in kg). [height (in m) squared] reflects also body mass relative to height and is mainly used for adults and adolescents. High BMI permits to assess degrees of overweight and obese people and low BMI to assess different levels of thinness (and of chronic energy deficiency).

At the level of an entire population, the information gathered through the above indices provides a basis for assessing the prevalence of unsatisfactory conditions under one or the other of the relevant criteria. In practice, the indicators will then be:

a. For children under age five, the Z-score classification system is used for population-wide assessments including surveys and nutrition surveillance [2]. For consistency with clinical screening, prevalence-based data are commonly reported using cut-off values, usually at minus two and plus two Z-scores from the median in the reference population. This implies that slightly more than 2 percent of the reference population will be classified as "malnourished" even if they are truly "healthy" individuals with no growth impairment.

   o Prevalence of underweight children is the percentage of children with a weight that is more than two Z-scores below the referenced weight-for-age.

   o Prevalence of stunted children is the percentage of children with a height that is more than two Z-scores below the referenced height-for-age.

   o Prevalence of wasted children is the percentage of children with a weight that is more than two Z-scores below the referenced weight-for-height.

b. For adults (active, usually 20-49 years), although reference data are less validated than for children, recommendations for threshold to be used are:

   o For thinness:—

   grade 1: BMI 17.0 - 18.49 (mild thinness)

   grade 2: BMI 16.0 - 16.99 (moderate thinness)

   grade 3: BMI <16.0 (severe thinness)

- For overweight: –

  grade 1: BMI 25.0 - 29.9 (mild overweight)

  grade 2: BMI 30.0 - 39.99 (moderate overweight)

  grade 3: BMI > 40 (severe overweight)

3.9 GUIDELINES FOR INTERPRETATIONS OF GROWTH CHARTS

This guide instructs health care providers on how to use and interpret the CDC Growth Charts to assess physical growth in children and adolescents. Using these charts, health care providers can compare growth in infants, children, and adolescents with a nationally representative reference based on children of all ages and racial or ethnic groups. Comparing body measurements with the appropriate age- and gender-specific growth chart enables health care providers to monitor growth and identify potential health- or nutrition-related problems.

During routine screening, health care providers assess physical growth using the child's weight, stature, length, and head circumference. Although one measurement plotted on a growth chart can be used to screen children for nutritional risk, it does not provide adequate information to determine the child's growth pattern. When plotted correctly, a series of accurate weights and measurements of stature or length offer important information about a child's growth pattern, which may be influenced by such factors as gestational age, birth weight, and parental stature. Parental stature, for example, is considered before assuming there is a health or nutrition concern. Other factors, such as the presence of a chronic illness or special health care need, must be considered, and further evaluation may be necessary.

Steps

1. Obtain accurate weights and measures. When weighing and measuring children, follow procedures that yield accurate measurements and use equipment that is well maintained. See the Anthropometry: Accurately Weighing and Measuring Infants, Children and Adolescents module for information about accurate weighing and measuring procedures.

2. Select the appropriate growth chart. Select the growth chart to use based on the age and gender of the child being weighed and measured.

Enter the child's name and the record number, if appropriate.

Use the charts listed below when measuring boys and girls in the recumbent of position (should be limited to those lessthan 36 months

Use the charts listed below when determining the stature (standing height) of boys and girls aged 2 to 20 years:

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old):

- Length-for-age
- Weight-for-age
- Head circumference-for-age
- Weight-for-length

- Weight-for-age
- Stature-for-age
- BMI-for-age

3. **Record data.** After selecting the appropriate chart and entering the patient's name and record number, if appropriate, complete the data entry table.

First, record information about factors obtained at the initial visit that influence growth.

- Enter mother's and father's stature as reported.
- Enter the gestational age in weeks.

The next line is reserved for recording the child's birth data. (Omit this step when using growth charts for children aged 2 to 20 years.)

- Enter the date of birth.
- Enter birth weight, length, and head circumference.
- Add notable comments (e.g., breastfeeding).

Record information obtained during the current visit.

- Enter today's date.

Determine age to the nearest month for infants and 1/4-year for children 2 to 20 years.

- Enter the child's age.

Example of how to calculate the child's age: To calculate Sam's age, subtract his birth date from the date of the visit or measurement. To subtract, it will be necessary to convert months to days and years to months if either the month or day in the birth data is larger than in the date of measurements. When converting one month to days, subtract 1 from the number of months in the date of measurement, then add 28, 30, or 31, as appropriate, to the number of days. When converting one year to months, subtract 1 from the number of years in the date of measurement, then add 12 to the number of months.

	Year	*Month*	*Day*
Date of Measurement	1998	4	4
Convert one month to days		(-1)	(+30)
		3	34
Convert one year to months	(-1)	(+12)	
	1997	15	34
Birth Date	1994	9	15

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Child's Age	3	6	19

Sam is aged 3 years, 6 months and 19 days.

Days	Month	Months	Year
0–15	0	0–1	0
16–31	1	2–4	1/4
		5–7	1/2
		8–10	3/4
		11–12	1

Using the guide above, 3 years, 6 months, and 19 days is rounded to 3 years and 7 months. Because age for children over 2 is rounded to the nearest 1/4 year, Sam is aged 3 years, 6 months, and 19 days. Sam's age is rounded to 3 1/2 years.

- Enter weight, stature, and head circumference (if appropriate) immediately after taking the measurement.
- Add any notable comments (*e.g.*, was not cooperative).

4.Calculate BMI. BMI is calculated using weight and stature measurements, then used to compare a child's weight relative to stature with other children of the same age and gender.

With a calculator, determine BMI using the calculation below.

BMI = {Weight (kg)/Stature (cm)/Stature (cm)} × *100*

5. Plot measurements. On the appropriate growth chart, plot the measurements recorded in the data entry table for the current visit.

- Find the child's age on the horizontal axis. When plotting weight-for-length, find the length on the horizontal axis. Use a straight edge or right-angle ruler to draw a vertical line up from that point.
- Find the appropriate measurement (weight, length, stature, head circumference, or BMI) on the vertical axis. Use a straight edge or right-angle ruler to draw a horizontal line across from that point until it intersects the vertical line.
- Make a small dot where the two lines intersect.

6. Interpret the plotted measurements. The curved lines on the growth chart show selected percentiles that indicate the rank of the child's measurement. For example, when the dot is plotted on the 95^{th} percentile line for BMI-for-Age, it means that only 5 of 100 children (5%) of the same age and gender in the reference population have a higher BMI-for-Age. Interpret the plotted measurements based on the percentile ranking and the percentile cutoff corresponding to the nutrition indicator shown in the table below. If the percentile rank indicates a nutrition-related health concern, additional monitoring and assessment are recommended.

- Determine the percentile rank.
- Determine if the percentile rank suggests that the anthropometric index is indicative of nutritional risk based on the percentile cutoff value.

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- Compare today's percentile rank with the rank from previous visits to identify any major shifts in the child's growth pattern and the need for further assessment.

Anthropometric	*Index Percentile Cut-off Value*	*Nutritional Status Indicator*
BMI-for-Age	Greater than or equal to 95^{th}	Overweight
Weight-for-Length	$> 95^{th}$	
BMI-for-Age	Greater than or equal to 85^{th} and $< 95^{th}$	At Risk of Overweight
BMI-for-Age		
Weight-for-Length	$< 5^{th}$	Underweight
Stature/Length-for-Age	$< 5^{th}$	Short Stature
Head Circumference	$< 5^{th}$ and $> 95^{th}$	Developmental for-Age Problems

Student Activity

1. Point out the anthropometric indices used for infants.

2. Discuss the methods of child weight measurement.

3. Prepare an anthropometric data comparison chart.

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3.10 SUMMARY

- The term anthropometric refers to comparative measurements of the body. Anthropometric measurements are used in nutritional assessments.
- Anthropometry is used to assess and predict performance, health and survival of individuals and reflect the economic and social well being of populations.
- Low weight-for-age index identifies the condition of being underweight, for a specific age.
- Underweight, based on weight-for-age, is a composite measure of stunting and wasting and is recommended as the indicator to assess changes in the magnitude of malnutrition over time.
- Wasting is the result of a weight falling significantly below the weight expected of a child of the same length or height. Wasting indicates current or acute malnutrition resulting from failure to gain weight or actual weight loss.
- The most common types of equipment used are scales and measuring boards in anthropometric assessment.
- The reference standards most commonly used to standardize measurements were developed by the US National Center for Health Statistics (NCHS) and are recommended for international use by the World Health Organization.

3.11 GLOSSARY

- **Anthropometry:** it refers to comparative measurements of the body.
- **Oedema:** the presence of excessive amounts of fluid in the intracellular tissue.
- **Wasting:** it indicates current or acute malnutrition resulting from failure to gain weight or actual weight loss.
- **Z-score (Standard deviation value):** the difference between the value for an individual and the median value of the reference population for the same age or height, divided by the standard deviation of the reference population.
- **Cut-off:** it is an anthropometric standard for comparison which enables the different individual measurements to be converted into prevalence statistics. Cut-offs are also used for identifying those children suffering from or at a higher risk of adverse outcomes.

3.12 REVIEW QUESTIONS

1. Which are the indicators used in anthropometry?
2. What are the important steps followed while conducting survey?
3. Prepare a chart of materials used in anthropometric survey.
4. How is age, height and length measured?
5. How is accuracy of measurement assessed?
6. What is *Z-score*? Point out its uses.
7. Discuss any two indicators of nutritional status.

3.13 FURTHER READINGS

- Mahtab S.Bamji, textbook of Human Nutrition, Oxford &IBH publishing Co., pvt. Ltd., 1999.
- Maurice E.Shills, Vernon R.Young Modern Nutrition in healath and disease K.M. Varghese com., 1988.
- Park and A, Text of preventive and social medicine, M\s Banrasidas bhanot publishers 1983.

UNIT—IV

DIETARY ASSESSMENT

OBJECTIVES

After going through the unit, students will be able to :

- understand the method and techniques used to assess dietary intakes of individual and household;
- discuss the factors affecting the accuracy of dietary assessment;
- describe the method of interpretation of dietary data.

STRUCTURE

4.1 INTRODUCTION

Dietary intake is generally considered to include all foods and beverages (hereafter referred to as food) consumed by the oral route. Items that are not considered as foods such as dietary supplements and condiments, which contain energy and/or nutrients, should be, but are not always, included as part of dietary intake. When such items are omitted from assessments of dietary intake it is usually because of difficulties with identification, quantification or lack of information about their composition.

4.2 MEASUREMENT OF DIETARY INTAKE

In many, but not all, instances the underlying purpose in measuring dietary intake, whether for an individual or for a group, is to obtain quantitative information on the amounts of energy and nutrients available for metabolism. This objective is indirectly met by measuring dietary intake.

This is because dietary intake is measured in terms of food intake and not in terms of energy and nutrient intake and because the amounts of energy and nutrients derived from measurements of food intake, at best, are the amounts of energy and nutrients found in food and not necessarily the amounts available to the individual for metabolism. Dietary intake measurements, therefore, only provide a guide to, and not a direct measure of, the amounts of energy and nutrients available for metabolism. They do, however, provide the best way of describing the actual food intake of both individuals and groups.

Day-to-day Variation

The food intake of individuals is not a static quantity. It varies both in type and amount from day to day, from week to week and from year to year. In general quantitative measurements of dietary intake can only be made over very short periods of time. This means that such measurements are unlikely to reflect the long-term habitual intake of individuals that for most purposes is the timeframe of interest.

When dietary intake data are used in order to assess the adequacy of energy or nutrient intake in relation to requirements it is important that short-term measurements are always adjusted for within-person variation in intake. This is possible, for group data, when at least 2 days of information are obtained from the same individuals. For assessment of relationships between nutrient intake and health status in individuals' long-term data on intake are always necessary. Methods designed to obtain a 'history' of intake over a longer period of time may relate to intake over the past month or the past year and can usually only provide semi-quantitative information on food and beverage intake.

One Measurement – or Many?

Even a short-termmeasurement of dietary intake (24 hours) usually involves the collection of data for between 10 and 40 different food items each of which has to be described and its quantity measured or estimated. In effect a measurement of dietary intake represents not one but many related but essentially independent measurements.

A consequence of this situation is that different aspects of dietary intake are estimated with varying levels of precision and accuracy. Similarly, the precision and accuracy of estimates of energy and nutrient intake, obtained from a measurement of dietary intake, can also be expected to vary.

Measurement Error

'There is not, and probably never will be, a method that can estimate dietary intake without error (Beaton 1994)'.

The Nature of Error

The fact that there is error in dietary measurements does not mean that dietary data should not be collected but simply that dietary data need independent validation and that it is important to determine the nature of the errors associated with dietary data in order that these can be taken into account in evaluating the data. Basically errors are of two types: Random errors and Systematic errors.

Random error increases the variance of the dietary estimates and consequently reduces their precision. The effects of random errors can always be reduced by increasing the number of observations. For example, the effect of day-to-day variation in food intake can be reduced by increasing either the number of days of observation on each individual or the number of individuals for whom data are collected.

In contrast the effects of systematic error cannot be reduced by increasing the number of observations. Systematic error arises from errors that are non-randomly distributed in a group or in the data from a given individual. For example, use of inappropriate nutrient composition data for some food items but not others will affect the food intake data for different individuals in different ways. Systematic errors lead to bias in the estimates of intake obtained.

Precision/Repeatability

In the laboratory the precision of a method is given by the coefficient of variation of repeated determinations on the same sample made under the same conditions. In the context of dietary studies we determine whether the same method gives the same answer when repeated in the same individuals. The terms repeatability and reproducibility are commonly used to describe the precision of a method.

It is important to note that it is possible for a method to have high precision (good repeatability) but yet not to provide an accurate (valid) estimate of intake.

Accuracy/Validity

An accurate method is one that measures what the method intends to measure, *i.e.*, the 'truth'. In the context of dietary studies 'the truth' represents the actual intake over the period of the study. For example, a valid dietary record is a complete and accurate record of all the food consumed over the period of the record. To be a valid record of habitual intake it also needs to reflect what would have been consumed if the individual had not been keeping a record. If the process of recording influenced what was eaten then the record is not a valid record of habitual intake over the period although it may be a true record of actual intake over the period.

Except for short-term dietary assessments that can be validated against direct observations of intake (made unknown to the respondent) it is not possible to determine the validity of a dietary method without the use of an independent (non-dietary) measure of intake.

4.3 LABORATORY METHODS OF ASSESSING DIETARY INTAKE

Eating is an integral part of everyday life and consequently it is not possible to assess what people eat habitually under controlled or laboratory conditions. It is possible to measure accurately and precisely what people eat under such conditions but not what they would choose to eat if they were not placed in a laboratory situation.

Laboratory-Based Dietary Studies

In a laboratory study of dietary intake the individuals whose food intake is being assessed have access only to foods that have been prepared under known conditions and for which the energy or nutrient composition has been determined by chemical or other appropriate analytical methods. In such studies the individuals may 'live' in a metabolic facility for the period of the study or they may live at home and take their meals in the metabolic laboratory. In either case the amount of all foods provided to each individual is carefully measured and recorded prior to consumption and any food that is not eaten is also carefully measured and recorded.

This approach in assessing dietary intake enables precise estimation of the amounts of energy and nutrients that are ingested by an individual over a fixed period of time. Additional measurements are needed to determine the proportion of the ingested nutrients that is available for metabolism.

Analysis of Foods Consumed

Determination in the laboratory, by chemical or other methods, of the energy and nutrient content of the food and beverages that have been consumed by an individual, can also be considered under the heading of laboratory methods. This approach allows accurate determination of the energy and nutrient content of the actual foods consumed by individuals eating their habitual diets. The accuracy of the food intake information on which the analysis is based is, however, not assessed by this approach.

There are three ways in which foods that have been consumed may be sampled for analysis. The first approach is to collect a duplicate portion of all foods consumed during the period of the dietary record. The second approach is to collect only samples of the food consumed for analysis. The third approach is not to sample the foods that have actually been eaten but to reconstruct a composite from the record of the foods that have been consumed during the period of the dietary record and to analyse this. For the latter approach to be effective the dietary record must provide adequate detail not only of the types of foods consumed but also details of the way in which they were prepared for consumption.

Markers of Energy and Nutrient Intake

It is now widely recognised that in order to assess the validity of any dietary assessment, including weighed records, it is necessary to compare the dietary data with one or more objective measures that reflect but are independent of food intake. For groups such measures may include food supply and/or expenditure data but at the individual level the measures are biochemical or physiological markers that reflect energy or nutrient intake. Measures that have been used for this purpose include energy expenditure, urinary breakdown products of protein, urinary sodium and potassium, plasma levels of vitamins and tissue levels of minerals and fatty acids.

The three measures most widely used as independent assessments of dietary intake are urinary nitrogen as a marker of protein intake, energy expenditure as measured by doubly labelled water to compare with energy intake (EI) in weight stable individuals and the ratio of EI to basal metabolic rate (BMR) to identify 'plausible' records of food intake. The EI/BMR ratio is not strictly a laboratory assessment of 'intake' but provides a way of comparing an estimate of intake with an independent but related measure, i.e. an estimate of BMR.

Urinary Nitrogen

Similar to the 24-hour recall, a single 24-hour urine collection does not necessarily reflect what is habitual. However, urinary nitrogen excretion is less variable from day to day than dietary protein intake; and while around 2 weeks of food intake are needed to assess habitual protein intake, only eight 24-hour urine collections are needed to assess nitrogen excretion with the same level of confidence.

Although fewer 24-hour urine collections may be needed urine collections are, in general, no more acceptable to respondents than 24-hour food records, may be incomplete and require access to laboratory facilities. Nevertheless they can provide, subject to appropriate checks, a practical and independent assessment, of protein, potassium and sodium intake.

Correlations between urinary N and dietary N measured by food record are better (0.65–0.79) than between urinary N and dietary N measured by food-frequency questionnaire (0.15–0.24).

Doubly Labelled Water Method

The doubly labelled water method (DLW) is described elsewhere in this analysis. Its use in the field of dietary assessment is based on the following relationship:

Energy expenditure (EE)= Energy intake(EI) + or — change in body energy reserve

Over periods when there is no, or only minimal, change in the body energy reserve the DLW method allows, for the first time, assessment of energy expenditure (and by equivalence energy intake) in free-living subjects over a period of one or more weeks. The method involves minimal inconvenience to the subject and has a high level of accuracy and precision. Under controlled conditions the DLW method gives a small overestimate of 2–3% when compared with whole body calorimetry and under field conditions the bias is not expected to exceed 5%.

A number of investigators have compared self-reported dietary EI with energy expenditure determined by DLW. In these studies, differences between the measured EI and expenditure have varied from −44% to +28% in different population groups. This large range of variation confirms the need to include an independent assessment of EI in all dietary studies to ascertain the level of bias applicable to the particular group under study since it is not readily predicted on the basis of gender, age and body mass index.

The main advantage of the DLW method is that it makes minimal demands on the respondents and does not in any way interfere with their normal daily activities and therefore with the habitual level of energy expenditure. Its main disadvantage, at this time, is its cost and the need for access to sophisticated laboratory equipment for mass spectrometric analysis. The method is, therefore, not yet available for use on a routine basis for validation of dietary intake data in respect of EI.

EI/BMR Ratio

Because of the current cost limitations of the DLW method the EI/BMR ratio has been used as an alternative approach in comparing EI from dietary studies with an independent estimate of 'expected' energy requirements. The relevant relationship in this case is:

EI:BMR = EE:BMR (physical activity level or PAL)

EI/BMR is used to determine whether a reported level of EI is a 'plausible' estimate of the actual diet during the measurement period (i.e. likely to represent habitual diet) based on an equation developed by Goldberg and colleagues. This

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equation calculates the 95% confidence limits of agreement between EI:BMR and PAL allowing for variation in EI, BMR, and PAL and also for the length of the dietary assessment period and the number of observations.

For a group, if the mean reported EI:BMR is below the lower 95% confidence limit for the specific study period and sample size, then this is an indication of bias towards under-estimation of EI. Identification of individual underreporters is much more difficult since reported EI can deviate quite markedly from energy expenditure before it falls outside the limitations of the methods. To improve the identification of individual under-reporters it is necessary to have additional information to enable subjects to be classified into different levels of activity.

4.4 FIELD METHODS FOR ASSESSING DIETARY INTAKE

Most methods used to measure dietary intake are field methods in the sense that the information is obtained either at the home of the individual concerned or from an individual who is free-living and not subject to laboratory restrictions. It is possible to classify the most commonly used field methods for measuring dietary intake in a number of different ways. For the purpose of this report the methods are classified into those that record intake as it occurs (records) and those that recall intake after it has occurred (recalls).

Irrespective of the specific method used to obtain the information on food and beverage intake all dietary assessments involve the five basic steps illustrated in *Fig. 1*. The figure also illustrates the main variations possible for each method and the sources of error that may operate at each step.

Records

Dietary records can be of several types:

- Records can be descriptive or quantitative.
- If quantitative the amounts can be estimated in household measures, by photographic means or by actual weighing of all the foods consumed over the period of the record.
- The person who records the intake may be the person whose intake is being recorded or it may be an external observer.
- The information on food intake can be converted to nutrient intake by means of food composition tables, by analysis of samples of the foods consumed or by laboratory analysis of a duplicate diet.

Menu Record

The simplest form of dietary record is a menu record. This type of record only records the types of food consumed and the frequency with which they are consumed but not the quantities in which they are consumed. Since it requires relatively little input from the respondent it is possible for such a record to be kept for a longer period of time than one that requires quantities to be measured or estimated. Menu records are mainly useful for determining food intake patterns over time and for assessing compliance with dietary advice. Their principal disadvantage is that it is not possible to use them to derive an estimate of nutrient intake without additional information on portion size.

Estimated Record

Estimated records require the respondent (or another person) to record all food consumed over a specified period of time, generally for between 1 and 7 days. Unless the record involves analysis of a duplicate portion, the foods consumed must be described in sufficient detail to allow the investigator to select an appropriate food from tables of food composition or for laboratory analysis.

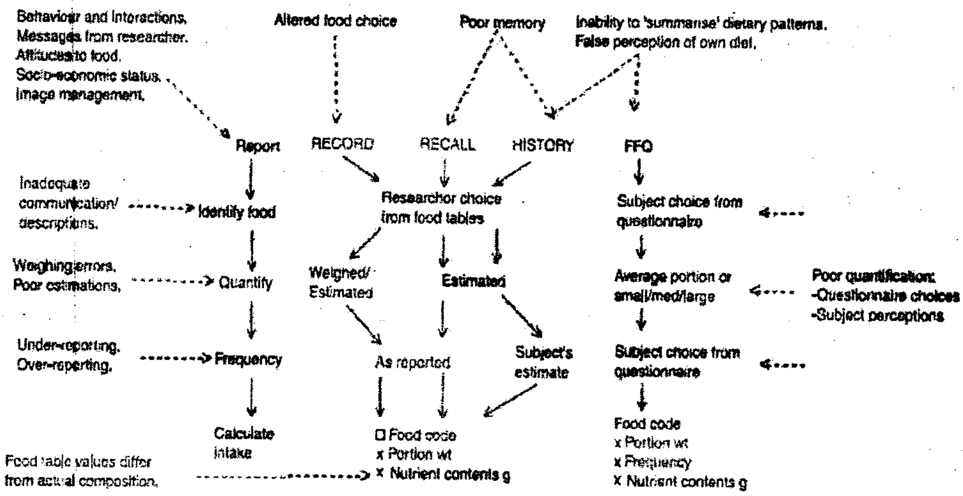

Fig. 1 The process of dietary assessment (Source: Black, 1999)

The record must also provide information on the amounts of the foods that have been consumed. This may be done in terms of the measures usually used in the household (jugs, cups, bowls, spoons) in which the data are being collected or by means of a set of standard measures. If the former approach is used the household measures need to be calibrated by the investigator. In addition to household measures two-dimensional representations of different shapes may also be used to assist the investigator to convert area and volume descriptions to estimates of mass.

An alternative approach to quantitation is for respondents to photograph the food to be consumed, prior to consumption. A reference plate of known size or other reference object is included in the photograph to allow subsequent estimation of portion size from the photographic record.

The principal advantage of records estimated in household measures is that they involve less disruption to normal eating patterns than the weighing of food and as a result have less effect on usual food habits. Estimating rather than weighing the foods consumed leads to a loss of precision but the magnitude of this effect is not well documented.

Weighed Record

A weighed record can be either a record of food as it is consumed (weighed inventory) or a much more detailed record of the weights of ingredients, final cooked weights of prepared foods, the weights of foods eaten and any plate waste (precise weighing method). The latter approach is used when tables of food composition contain little information on mixed dishes and when it is possible for the information to be collected by the investigator. Weighed records kept by the respondent usually use the weighed inventory method and are kept for periods of only 1–4 days because of the high respondent burden involved.

Weighed records have the potential to provide the most accurate description of the types and amounts of the foods actually consumed over a specified period of time. However, weighing all food is time-consuming and the method requires a high level of cooperation from respondents. In most individuals the method probably affects the amounts and kinds of food eaten. While the method may accurately reflect actual intake during the record-keeping period, this intake may not reflect habitual intake.

Recalls

Dietary recalls can be of several types:

- Recalls can be quantitative, semi-quantitative or in terms of frequency.
- If quantitative the amounts consumed can be described in household measures, by reference to photographs or three-dimensional food models, or simply in terms of small, medium or large portions.
- Recalls can relate to specified (yesterday) or to indefinite periods of time.
- Recalls can refer to short (e.g. 24 hours) or to extended periods of time such as the previous year or longer.
- The information on food intake may or may not be converted to nutrient intake. If converted to nutrient intake it may be presented in terms of categories (e.g. high, medium or low) rather than as absolute estimates of intake.

24-hour Recall

The 24-hour recall is the most widely used method for obtaining quantitative recall data. The period of recall can be longer than 24 hours but is usually restricted to this length of time because of the difficulties that individuals have in being able to recall, in sufficient detail, what and how much food was eaten over longer periods of time.

A 24-hour recall is usually conducted by means of an interview during which the respondent is asked to provide a recall of all food eaten, most often, over the previous 24 hours. Traditionally, food intake has been reviewed chronologically but more recently a 'multiple pass' technique has been described which is considered to provide better cues for respondents' cognitive processes than chronological cues. First the respondent provides a list of all foods eaten on the previous day using any recall strategy they desire, i.e. not necessarily in chronological order. The interviewer then obtains a more detailed list by probing for additions to these foods and by giving respondents an opportunity to recall food items initially omitted from the list. Finally, the interviewer reviews the list of foods to allow yet further reports of foods and eating occasions to be added if appropriate.

Recalls conducted by means of a face-to-face interview usually use aids such as food photographs or models to help the respondent with the task of describing the amount consumed. In telephone interviews respondents may be provided with photographs of food portions and two-dimensional pictures of areas and volumes to assist with quantitation.

The main advantages of the 24-hour recall are that it generally has a higher response rate than recording methods, can provide detailed information on food intake and is suitable for use in face-to-face, telephone and computer assisted interviews. The principal disadvantages are that the method cannot provide information on habitual intake, unless it is repeated on multiple occasions, and it may not be suitable for some groups who are unable to describe food eaten from memory.

Diet History

The diet history method does not involve recall over a specific period of time, rather it attempts to obtain a semi-quantitative picture of typical or habitual intake as reflected by intake in the immediate past. As first proposed by Burke in the 1940s, the method had several components:

- An interview to obtain usual diet.
- A cross-check of this information by food group.
- A 3-day record of food intake in household measures.

The 3-day record is now seldom used as a regular component of a diet history. During the interview the investigator attempts to construct the respondent's pattern of intake over a period such as a typical week or fortnight and if appropriate any seasonal variations. Often a recall of intake on the previous day is used as the starting point for elaborating the usual variations in meal pattern and food intake. A diet history interview generally takes at least an hour and requires an interviewer with the skills to help respondents recall their intake freely and fully in a nonjudgemental atmosphere. Information on the usual size of food proportions is obtained with the aid of food models or photographs in the same way as for a 24-hour recall.

The dependence of the diet history on both respondent and interviewer skills may make the results less comparable between individuals than those obtained from other methods and for this reason it is often considered more appropriate to categorise diet history data (e.g. as high, medium, low) than to present them as absolute intakes.

The main advantage of the diet history method is that, if successfully carried out, it can provide an estimate of habitual intake for individuals. Its principal disadvantages are the time and skills required by both interviewers and respondents and the semi-quantitative nature of the data obtained.

Food-Frequency Questionnaire

A food-frequency questionnaire is basically a list of foods with a selection of options for reporting how often each food is consumed. Typical options include: daily; 3–4 times per week, 1–2 times per week, 1–2 times per month, < 1 per month and never.

Respondents indicate the most appropriate frequency option for each of the foods on the list by marking the appropriate column in the questionnaire. The food list may contain only a few items or it may contain up to 200 items. The length of the list depends largely on the focus of the questionnaire. A questionnaire designed to capture a high proportion of total EI will necessitate a much longer list than a questionnaire designed to capture the same proportion of total calcium intake.

Food-frequency questionnaires are almost always designed for self-completion. This is because they were developed primarily as a practical and cost-effective way of collecting long-term dietary intake data from large numbers of respondents. When appropriately designed such questionnaires can be optically scanned to save time both on data entry and checking procedures.

Some food-frequency questionnaires attempt to quantify the frequency information by obtaining additional data on portion size. This information may be obtained by asking respondents to indicate if their usual portions are large, medium or small relative to those eaten by others; by asking them to describe their usual portion size in terms of a standard portion described on the questionnaire or by reference to a picture atlas of food portions.

Food frequency questionnaires provide a relatively inexpensive and standardised way of collecting information from a large number of individuals. Their main disadvantages lie in the lack of detail that can be obtained about foods, the semi-quantitative nature of the data, and the large random errors. The latter most likely reflect the complex nature of the task that respondents completing a food frequency questionnaire are asked to perform.

4.5 WHICH METHOD OF DIETARY ASSESSMENT?

It is not possible to decide which method of dietary assessment to use until the purpose of a study has been clearly defined. The purpose for which the data are being collected governs both the kind of information that is needed and the time for which it needs to be collected from each individual. The purpose of the study also determines the level of precision that is needed in order to meet the study objectives and therefore the size of the sample. Both the method and sample size have major implications for the human and economic resources required for the study.

Group Comparisons

When dietary data are collected in order to describe the diet of a group for comparison with another group or groups, it is possible to use either a short-term method such as a 24-hour recall or record, or a long-term method such as food records obtained over several days, a diet history or a food frequency questionnaire. The choice of method in this situation will depend on the importance of obtaining a representative sample, the level of precision required and the resources, both human and economic, that are available. Usually the most efficient approach is to measure the diet of as many individuals as possible for a single day. This is the approach usually adopted for national surveys. In such surveys both high response rates and detailed quantitative information are important because the dietary information is used for a wide variety of purposes.

Prevalence

If the purpose of the dietary study is to determine the proportion of individuals in a population or population sub-group who are 'at risk' of dietary inadequacy or excess, then a single day of information on each individual is no longer adequate because what is required is a reliable estimate of the distribution of habitual intake for the group. In order to determine the distribution of habitual

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intake for a group at least 2 (preferably not consecutive) days of information are required from each individual. Alternatively if several days of information are available from each individual they can be used to derive a mean intake for each individual and from this the distribution of average intakes for the group.

In large surveys, e.g. national dietary surveys, where it may not be possible to obtain more than 1 day of intake from most of the population, the data necessary for statistical adjustment for within-person variation can be obtained from representative sub-sample(s) of the population and applied to the 1-day intake data for the groups represented by the sub-samples.

While the use of statistical techniques, to remove the effect of day-to-day variation in intake can greatly improve estimates of the proportion of individuals above/below cut-off levels of interest, it is important to note that this type of adjustment does not enable the actual 'at risk' individuals to be identified.

Individual Diets

When the purpose of a study is to assess the diet of specific individuals it is necessary to obtain dietary information over at least a week and preferably longer. In studies or situations where information on the usual pattern of food intake rather than precise quantitative information on nutrient intake is required, e.g. in clinical practice the diet history is often used for this purpose. Because a diet history requires time, a skilled interviewer and respondents with the ability to describe their habitual diet from memory it is not a method that is readily applied to large randomly selected samples of the population.

Long-term information about an individual can also be obtained using multiple 24-hour recalls, or 24-hour food records, over an appropriate period of time, e.g. to allow for seasonal variation. The minimum number of days needed to obtain an estimate of energy or nutrient intake, with a specified level of confidence, differs for different nutrients. A reliable estimate of EI, which tends to show less day-to-day variation than other nutrients, can be obtained over a shorter period of time (a few days) than an equally reliable estimate of vitamin A intake (several weeks), for which intake is much more variable from day to day. For this reason dietary assessment alone is usually not adequate to provide reliable estimates of habitual intake, in individuals, for nutrients with high day-to- day variability in intake.

Epidemiological Studies

Epidemiological studies that include dietary assessments are generally concerned with establishing whether specific dietary components or types of foods contribute to the occurrence, development or prevention of specific conditions. The conditions may be short-term, e.g. food poisoning or chronic conditions, e.g. cardiovascular disease that develop over an extended period of time. In the case of short-term conditions such as food poisoning the focus of the dietary assessment is also short-term, *e.g.*, foods eaten in the preceding 12–48 hours and presents no particular problems with recall.

In the case of chronic conditions the information on diet also needs to be long-term. Moreover the studies usually involve large numbers of individuals who are often widely distributed geographically. Food-frequency questionnaires were specifically developed to address these needs in a practical way since they can be delivered by mail, completed in less time than a diet history, processed electronically and repeated at regular intervals. They can also be readily modified to obtain information on intake for varying periods of time.

The accuracy of the information obtained from food frequency questionnaires clearly depends very largely on the ability of respondents to answer the questions accurately, but is not easy to assess. Comparisons of nutrient intake data from food-frequency questionnaires with similar data obtained by other dietary methods often show only limited agreement at the individual level and lower precision than multiple short-term recalls or records. For this reason it may be preferable to restrict the use of food-frequency questionnaires to providing information on the long-term intake of a limited number of foods/food groups rather than to use them to derive quantitative estimates of nutrient intake for individuals.

4.6 LIMITATIONS OF DIFFERENT METHODS

Dietary assessment is an integral part of community nutrition survey. It involves collection of information concerning food habits, food supply and procurement, preparation and distribution of food. Besides this, information on food wastage, adequacy and inadequacy of diet is also collected. These studies provide only baseline information, and cannot be used as absolute indicators to adequate nutrition.

Accurate and reliable methods for assessing dietary intake of a free living population are needed to answer important questions regarding association between dietary factors and physiological processes involved in the etiology of disease.

Although various dietary assessment tools are available, none is universally appropriate for all research purposes. Inappropriate selection of dietary methodology and failure to recognize limitations in data collected by various methods contribute to possible misrepresentation of findings from dietary studies.

The selection of dietary assessment methodology depends primarily on the objectives of the study, alongwith the sample size, availability of trained personnel and resource constraints.

DIETARY DATA COLLECTION METHODS

Various classifications have been devised and suggested for collection of dietary data. However, these are two major categories of methods. The first method involves recording of food intake of families of groups, based on estimates of food purchases and disposal. The second method is based on dietary intake of individuals.

This is determined by record or recall of all foods consumed over a specified period of time.

Group Methods

Food balance sheet

On the basis of food availability 'Food balance sheet' for the entire population is prepared. The mean annual amount per person is obtained by dividing the total amount of different foods with the total population of the area. Calculations of the mean intake of different nutrients is an essential part of 'Food balance sheets'.

Advantages

(i) The food balance sheet gives a view of the total food supplies of a country. It indicates whether food consumed by the population is inadequate, adequate or large.

(ii) It serves as a basis for formulation of food programmes and for emergency rationing of food.

(iii) Valuable in inferring general food habits of the people.

Disadvantages

(i) The reliability of such data depends on the statistics used for calculation and level of development of the country.

(ii) The data shows the total amount of food available and not the actual amounts consumed.

(iii) Individual differences in food consumption are not reflected from mean total consumption data of the whole population.

Food Accounts

This method of dietary assessment is commonly used for subjects living in institutions, families or groups. This method involves detailed recording of the amount of food consumed over a period of time. This is accompanied by an inventory of food supplies both at the start and end of the survey. All the food stuffs purchased for the whole family, produced at home or elsewhere are recorded on weight basis or as gross weights or 'as purchased' weight. Additional information on the amount of different foods consumed, number of meals eaten at home or outside, helps to obtain actual mean daily food consumption per person during the survey period.

This method provides accurate information on food consumption.

Advantages

(i) Larger samples can be obtained and food consumption data for a longer period of time can be collected.

(ii) As seasonal variations are taken into account, the method provides excellent information on the annual mean food consumption.

(iii) This method is relatively cheap and does not alter the diets of the subjects to a great extent.

Disadvantages

(i) Families or households are not always representative of the whole population.

(ii) It can be used only with a literate population.

(iii) Precision may decrease after few days.

(iv) The records may not always reveal how much food was actually consumed or thrown away due to spoilage or plate wastage.

(v) Food distribution within the family is not known.

Individual Dietary Intakes

Dietary data on individuals is collected to obtain a more precise measurement of the average nutrient intake and to determine dietary inadequacies, if any. Assessment of food intake of individuals range from a qualitative type of inquiry to those of a more quantitative nature.

Weighing Method

It is one of the most accurate methods available and is also referred to as 'Precise and Weighed Individual Inventory Method'. An inventory of the food supply both at the beginning and end of the survey is made. As more food is acquired it is weighed and recorded. Weights and records of food consumption at home as well as outside and food wastage are maintained. By using the standard food tables nutritive value of dishes are calculated. At the end of the study, the amount of food wasted is added to the amount of left over food to obtain total wastage.

If all the family members are adults, dividing the total food consumed by the number of adults gives the average daily food weight consumption per person.

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Additional information like weighing the portions of food served to each member of the family before consumption can also be gathered.

Food item consumed can be calculated as:

(Initial inventory + issues or purchase) — (Final inventory and waste)

Food item consumed per person per day can be calculated as:

Total weight of food item consumed ÷ (Days of surveys × number of persons feed daily).

Advantages

(i) This method can be carried out by the subjects themselves with minimal supervision by the investigators.

(ii) The amounts consumed can be recorded accurately.

Disadvantages

(i) The sample size is often not representative, as the volunteers are selected and thus results cannot be generalized.

(ii) It is a relatively costly method and requires trained personnel.

(iii) This method has been claimed to change the diet of the respondents so much that it does not represent normal consumption pattern.

Interview Method

Food consumption data can also be collected by 'Interview Method'. This method has two techniques: *(i)* Diet recall and *(ii)* Diet history.

(i) Diet Recall

This is a frequently used method to obtain current dietary intake information from individuals. This is based on the principle that, food consumption for a specified period of time prior to the survey can be recalled as accurately as possible. It is often referred to as the '24 hours recall' method. The respondent recalls what and how much food was consumed and when it was consumed.

The ingredients recalled are recorded in household standardized volumetric measures. The volume of cooked food is also recorded. Standardized vessels are used mainly to aid in recapitulating the amount of food stuffs used and distribution of food to family members. From the raw weight of foodstuffs, their nutritive value is calculated.

(Individual intake (in volume)/Total cooked quantity) x raw amounts = x

Advantages

(i) Useful method in quick recapitulation of one's habitual diet.

(ii) It is helpful in revealing extreme daily variations in the diet.

Disadvantages

(i) A day's intake may not be representative of usual intake.

(ii) Estimation becomes difficult when diet has a lot of variety.

(iii) Subjects reporting may not be entirely truthful.

Diet History

In epidemiological studies it is often more important to obtain information on the general dietary patterns of individual rather than their current diet. The normal daily dietaries are first recorded along with the timings of each meal, their composition, snacking etc. Quality and quantity of food stuffs are calculated from the number of servings and their portion size. Seasonal variation is taken into account by conducting a year round survey.

Diet history provides a more comprehensive assessment of diet and it permits investigation of lesser known or unidentified dietary factors that can be retrieved for future examination.

Advantages

(i) The representative and large sample size permits random sampling for collection of data.

(ii) The technique is relatively inexpensive and is convenient to use.

Disadvantages

(i) This technique demands greater requirement on personal characteristics of the investigator.

(ii) Does not give precise data on individual food consumption.

(iii) Diet histories obtained are subject to problems of recall.

(iv) By this technique nutrient intake tends to be overestimated especially for trace elements.

Diet history along with food records is generally satisfactory and quantitative diet history gives reasonably accurate estimate of the usual dietary intake.

Food Frequency Method

Usual intake in terms of frequency with which various food items are consumed is recorded. When estimation of calories and other nutrients are to be made it is essential to record the amounts of foods that are eaten. The frequency data may be of a higher order of accuracy, although more limited than quantitative data obtained by other methods. There is a current trend of using abbreviated food frequencies, as they can be altered to suit specific needs of the study population.

Advantages

(i) Useful when specific information about food patterns is needed.

(ii) This method can provide information where evidence is sought of an association with diet in general rather than specific nutrients.

Questionnaire Method

In principle, this method is identical to diet history. The difference is that no interviewer is needed. Questionnaires are sent to the respondents who fill in and return them. The respondents record their usual food intake for a period of time. Frequency of most commonly consumed foods is estimated.

Advantage

(i) it is possible to collect data on large samples within a small budget.

Disadvantages

(i) Information generated need not be authentic.

(ii) Random sampling cannot be used as this requires cooperation from subjects.

4.7 ANALYSIS AND INTERPRETATION OF DIETARY DATA

Situation analysis and interpretation of nutrition data is carried out in a systematic manner in order to develop an understanding of such questions as:

- What is the population's nutritional status?
- Is the current nutritional status acceptable or not?
- Is the situation improving or deteriorating?
- What are the key factors influencing the current nutritional status?
- Which interventions are most appropriate in protecting or promoting better nutrition?
- Under the prevailing circumstances how is the nutritional status expected to evolve over the coming months?
- What is the likely situation in the neighbouring areas (*i.e.*, extrapolation)?

NOTES

(a) Collect relevant data.

(b) Establish links and associations among the various variables and the nutritional status, considering all data collected.

(c) Identify areas requiring interventions.

(d) Prepare study findings/results.

(e) Discuss findings with study population and partners.

A. Collect Relevant Data

Gather the historical data for the area or population. This includes baseline information and previous surveys or assessments data. Past relevant background information including morbidity data, food security information and trends in malnutrition as reported in health facilities. This information helps identify trends and whether the nutrition situation is improving or deteriorating.

B. Establish links and associations of the various variables and the nutritional status.

Analyze and interpret both qualitative and quantitative data. The causes of malnutrition vary from one population to another hence the need to define the specific factors that contribute to nutritional status in each population. Statistical analysis of nutrition survey data can be used to determine the links/associations while this is not possible for rapid assessments and health facility data. Further links between qualitative data and the resulting nutritional status can also be established guided by the conceptual framework.

Socio-economic and political environment.

- What is the estimated population size and how is this distributed among the various livelihood or food economy groups? Is there a particular group that is more affected than any other?
- How do the macroeconomic factors like inflation rates, money supply and employment levels affect food security?
- How does the current situation affect trade and food marketing activities (locally, nationally, regionally) for instance sanctions, ban on exports, restrictions on movements of traders?
- How do the cultural attitudes influence what people eat, own or the social institutions?
- What is the security situation in the area?

Food security situation. (Food availability and access) Type, quality and quantity of food available.

- The food economy group of the population plays a vital role in guiding this process. For instance in the case of an urban population that mainly relies on purchases to obtain food, determining the prices and availability of food in the markets is important. In the case of an agro pastoral population that mainly relies on its own production for food, determining whether there was good harvest over the seasons and if sufficient food stocks were available at the time of the survey is important.
- Weather conditions determine if good harvests will be realized, if pasture and water supply is good hence influencing animal production.
- Interpretation should take into account availability of food stocks and an estimation of how long these would last the families.
- Seeds availability and pests, rodents and disease infestation on crops influence food availability.

Access to food

- Food access is influenced by purchasing power. Definition of income availability and the proportion spent on food items is crucial especially for urban populations. In the case of agro pastoral and pastoral populations that also need to purchase certain foodstuffs to supplement their production, it is important to establish the selling prices of their products or their terms of trade.
- Availability of foods in markets at unaffordable prices can limit food access.
- Logistical or geographical obstacles to markets and insecurity can limit access to food
- If families harvest or obtain food but they sell or use the bulk of it to settle past debts there is need to analyse if the balance is sufficient to meet their needs over a given period.
- Estimating the quantities of food eaten by family members can help define if members are meeting daily food requirements or not. In the case of children, frequency of meals per day is important and more than three nutritionally balanced meals per day are recommended.
- Coping strategies in times of stress contribute to food access in Somalia. The normal means of accessing food for a given population may be constrained at a given time but since the people have viable coping strategies, their access to food may not be limited.
- Establish if there is a change in coping strategies from the normal

- The prevailing food security situation could guide in predicting future nutritional status for instance if low malnutrition rates are reported in times of relatively poor food security, the nutritional status is expected to deteriorate in the future.
- The analysis may coincide with a season characterized as a hunger gap and with a possibility of improvement if the seasonal variables get better.

Health and sanitation.

- Nutritional status and diseases are closely linked. A high incidence of important childhood illnesses (those that have strong associations with nutritional status like measles, diarrhoea, ARI and malaria) prior to or around the period of analysis will influence nutritional status.
- A disease outbreak or high disease incidences in a given area will compromise nutritional status.
- Understanding seasonal trends in disease contributes to the analysis.
- Does the community have access to quality health services and is the health services seeking behaviour positive?
- Immunization is the safest way to protect children from immunizable diseases like measles and poliomyelitis. Once immunized, bodies are more able to fight diseases. If the immunization coverage is low, the population is more vulnerable to outbreaks of communicable disease. Understanding the factors that contribute to a high or low immunization coverage rate guides in defining possible interventions; it is indicative of the level of contact with the formal health services, the quality of those health services and ultimately the extent to which the population chooses to use the health services.
- Supplementation of certain micronutrients is usually undertaken among certain population when deficiency is suspected and when foods rich in these micronutrients are not readily available.

Food consumption

- Both quantity and quality of food consumed are important in determining the well being of an individual. The body requires certain amounts of the various nutrients on a daily basis for proper growth. A limitation in any of these will have negative consequences on an individual's nutritional status.
- In most cases, people will consume the foods that are readily available to them for instance among the pastoral communities, the quantities of milk consumed during the good seasons is high unlike in the lean seasons.

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Livelihood Assets

These define the context, options and constraints available to households and individuals in their livelihood strategies. Analysis is undertaken at the zonal and/or household level, with consideration made to privately and public owned assets (or capitals).

- *Physical Capital:*This defines the basic infrastructure and producer goods needed to support livelihoods. (e.g. transportation, shelter, water supply and communications)
- *Financial Capital:* This refers to the financial resources people use to achieve their livelihood objectives; and flows and stocks that contribute to consumption and production. (e.g. flows of cash income, livestock holdings, credit)
- *Human Capital:* These are the skills, knowledge, ability to labour and good health that together enable people to pursue different livelihood strategies. (e.g. the amount and quality of labour available, skills and health status.)
- *Social Capital are the social resources* from which people draw, in pursuit of their livelihood objectives. (e.g. networks and connectedness, relationships of trust)
- *Natural Capital* are the natural resource stock from which resource flows and services useful for livelihoods are derived. (e.g. land, trees, pasture).

C. Identify Areas Requiring Interventions

- Interventions that contribute positively to the nutritional status include adequate health services; availability of clean and reliable water sources; income generating projects; education facilities; seed distribution programmes and veterinary services. If present, are they accessible to all and sustainable?
- Are certain factors contributing negatively to the nutritional status for example low knowledge on nutrition-related issues, lack of sanitation facilities; inadequate health services; low immunisation rates, low vitamin A supplementation coverage and insufficient food. Have these been addressed at all? If yes is it sufficiently so?
- Which interventions require immediate or long term response.
- Recommendations on interventions need to be guided by the analysis and ideally not by the focus of particular organizations.

D. Prepare Study Findings

- Prepare study results highlighting the important findings.

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E. Discuss Study Findings with Study Population

- Share the main study findings with the study population and partners.
- This discussion will provide an opening for more comprehensive and longer term community based analysis of issues that can be addressed more efficiently and effectively by the community themselves.

STUDENT ACTIVITY

1. Discuss the laboratory-based dietary studies.

2. State the limitations of dietary assessment methods.

3. Give the description of the steps involved in dietary data collection.

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4.8 SUMMARY

- Random error increases the variance of the dietary estimates and consequently reduces their precision. The effects of random errors can always be reduced by increasing the number of observations.
- In a laboratory study of dietary intake the individuals whose food intake is being assessed have access only to foods that have been prepared under known conditions and for which the energy or nutrient composition has been determined by chemical or other appropriate analytical methods.
- Most methods used to measure dietary intake are field methods in the sense that the information is obtained either at the home of the individual concerned or from an individual who is free-living and not subject to laboratory restrictions.
- The diet history method does not involve recall over a specific period of time, rather it attempts to obtain a semi-quantitative picture of typical or habitual intake as reflected by intake in the immediate past.

4.9 GLOSSARY

- **Food-frequency questionnaire :** A list of foods with a selection of options for reporting how often each food is consumed.
- **Food accounts :** A method of dietary assessment, commonly used for subjects living in institutions, families or groups.
- **24-hour recall :** Method for obtaining quantitative recall data.

4.10 REVIEW QUESTIONS

1. How is dietary intake measured? Explain.
2. What are the principal steps involved in field methods for assessing dietary intake?
3. State the limitations of dietary assessment methods.
4. Discuss the methods of analysis and interpretation of dietary data.
5. What should be the important components of diet history?

4.11 FURTHER READINGS

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UNIT—V

CLINICAL AND BIOCHEMICAL ASSESSMENT

NOTES

OBJECTIVES

After going through the unit, students will be able to :

- discuss the methods and techniques for clinical assessment of nutritional status;
- explain the methods and techniques of biochemical assessment;
- state the stages of nutrient deficiencies.

STRUCTURE

5.1 INTRODUCTION

Nutritional status is the balance between the intake of nutrients by an organism and the expenditure of these in the processes of growth, reproduction, and health maintenance. Because this process is highly complex and quite individualized, nutritional status assessment can be directed at a wide variety of aspects of nutriture. These range from nutrient levels in the body, to the products of their metabolism, and to the functional processes they regulate. Nutritional status can be measured for individuals as well as for populations. Accurate measurement of individual nutritional status is required in clinical practice. Population measures are more important in research. They can be used to describe nutritional status of the group, to identify populations or population segments at risk for nutrition-related health consequences, and to evaluate interventions.

The choice of nutritional status assessment method must be made mindful of the level at which one wants information, as well as of the validity and reliability of the method. All methods have error. All methods produce imperfect measures that are indirect approximations of the process. Whatever method is chosen for assessment of nutritional status, the data obtained must be compared with reference data to produce an indicator of nutritional status. The quality of the available reference data is, therefore, another factor that affects the assessment data.

Ideal methods are sensitive and specific. Unfortunately, it is difficult to achieve both in the assessment of nutritional status. Sensitivity refers to the ability of a technique to correctly identify those affected by a condition (for example, undernutrition) as having that condition. Specificity refers to the ability of a technique to correctly classify normal individuals as having normal nutritional status. Body mass index $\{wt/(ht)^2\}$ is a global measure of nutritional status that illustrates the difference between these two constructs. Most persons who consume insufficient energy have low body mass index, so the measure is sensitive. However, there are other causes of low body mass index, including genetics and disease, so body mass index is not specific to nutritional status.

The assessment of nutritional status is commonly summarized by the mnemonic "ABCD," which stands for anthropometric measurement, biochemical or laboratory tests, clinical indicators, and dietary assessment. This review will focus on anthropometric and dietary techniques.

Anthropometric Approaches to Nutritional Status Assessment

Anthropometric approaches are, for the most part, relatively noninvasive methods that assess the size or body composition of an individual. For adults, body weight and height are used to evaluate overall nutritional status and to classify individuals as at healthy or nonhealthy weights. In the United States of America and other industrialized countries, the emphasis for unhealthy weight is over-weight and obesity. The standards for these have changed over time. The most recent classification is to use body mass index *(BMI, in kg/m²)*. BMI, regardless of age or population, is normal at 18.5 to 25.0 kg/m^2, overweight at 25.0 to 29.9 kg/m^2, and obese at over 30.0 kg/m^2. In general BMI greater than 30 is assumed to be due to excessive adiposity.

In children, growth charts have been developed to allow researchers and clinicians to assess weight-and height-for-age, as well as weight-for-height. For children, low height-for-age is considered stunting, while low weight-for-height indicates wasting. In addition to weight and height, measures of mid-arm circumference and skinfold measured over the triceps muscle at the mid-arm are used to estimate fat and muscle mass. Anthropometric measures of nutritional status can be compromised by other health conditions. For example, oedema characteristic of some forms of malnutrition and other disease states can conceal wasting by increasing body weight. Head circumference can be used in children 36 months and younger to monitor brain growth in the presence of malnutrition. Brain growth is better spared than either height or weight during malnutrition.

To interpret anthropometric data, they must be compared with reference data. The choice of the appropriate reference has been discussed by Johnston and Ouyang. Because well-nourished children in all populations follow similar patterns of growth, reference data need not come from the same population as the children of interest. It is of greater importance that reference data be based on well-defined, large samples, collected in populations that are healthy and adequately nourished. Reference growth charts (Kuczmarski et al., 2002) have been compiled from cross-sectional data collected from population surveys of U.S. children. These have been adopted as international standards by the World Health Organization.

Choosing a Dietary Approach to Nutritional Status Assessment

Several techniques exist for collecting dietary data with which to estimate nutritional status. Because these techniques vary in cost for data collection, burden on the respondent, and which aspects of diet they are designed to measure, it is important to clearly articulate the goals of dietary assessment of nutritional status before choosing an assessment strategy.

The primary consideration in choosing a dietary assessment method is the specific type of data needed. Is the research intended to document intake of "foods" or of "nutrients"? If the answer is foods, the method must take account of the population's foodways. These include variability in food intake patterns (for example, day-today, seasonal, ritual cycles); differences in food consumption by sex, age, and ethnicity; and what items the population considers to be legitimate "food." If the objective is to measure nutrient intake, the method must take into account several additional factors: food preparation techniques, including the addition of condiments and the effects of the technique on nutrient composition of the food; sources of error in the determination of amounts of foods consumed; differentiation distribution of nutrients among foods; and the contribution of "non-food" consumption (such as betel nut, laundry starch, and vitamin and mineral supplements) to total nutrient consumption.

Another important consideration is the time period the data are intended to represent. If the period is a relatively discrete one, it may be possible to document diet quite precisely. However, if the interest is in measuring "usual" diet, the methods must allow this abstract concept to be estimated statistically.

Population measures of dietary status can be derived either from data describing the entire population or population sub-group, or from data describing samples of individuals. Population-wide data include food availability figures, which allow the assessment of food balance—the amount of food produced or imported by a population less that exported or used as nonhuman food. Such measures are necessarily crude, as they do not measure consumption directly. Another approach to measuring dietary status of groups has been to focus on the household. Indirect data on household food intake can be derived from records of foods brought into the household or from pantry inventories. Because of variations in intrahouse-hold distribution of foods, such techniques cannot be used to estimate individual intakes.

By far the most precise way of measuring dietary intake is to gather data on individuals. These methods depend on identifying a period of time for which data are needed, measuring food quantities consumed, and then translating these into nutrient amounts, either through direct chemical analysis or (more commonly) using food composition tables.

5.2 CLINICAL ASSESSMENT

Clinical assessment, as presented by Jeejeebhoy (1990) may form the basis for assessment of the nutritional status of the patient. It is based on the clinical impression of the patient, without exactly defining or quantifying the degree of malnutrition. It combines a number of clinical parameters of the nutritional status or, more correctly, forms an index of sickness rather than of nutritional status. Clinical assessment should focus on the following points:

- past nutritional intake;
- disease process and any operation affecting future intake of nutrients;
- catabolic effect of the disease affecting the patient;
- current physical state in relation to weight loss, deterioration of functional status, body fat loss and other signs of malnutrition, such as glossitis, oedema, skin rashes and neuropathy;
- functional status of the central nervous system, namely alertness, ability to ambulate and to cough; cardiovascular and renal function.

Based on features of the clinical history and physical examination, some diseases and factors of high risk for development of malnutrition can be identified:

- chronic diseases, like malignancy, kidney and liver diseases, congestive heart failure;
- digestive and absorptive abnormalities, like inflammatory bowel disease, short-bowel syndrome, gastrointestinal fistula, pancreatic disease, chronic diarrhoea;
- social and dietary factors, like drug and alcohol abuse, poverty, poor dentation;
- other factors leading to increased requirements like burns, sepsis, surgery, chemotherapy.

Clinical assessment can identify those patients that are at risk for malnutrition. In an attempt to define the patient's risk of nutritionally related complications, the SGA (subjective global assessment) grading scale has been introduced by Detsky (1987). This assessment is based on the following features of the patient's condition: weight change, dietary intake, gastrointestinal symptoms, functional capacity, stress and physical signs. On the basis of these features, patients are scaled into SGA grade A to C, depending on their nutritional status; this grading helps to identify those patients who are at risk of nutritionally mediated complications.

Definition of Severity of Malnutrition

Since malnutrition causes variable modifications of the various body compartments, it is worthwhile to distinguish the lean body mass, which comprises the masses of the cells, extracellular fluid and skeleton, from the fatty mass, i.e. the adipose tissue. For a reference adult of 70 kg, the cellular mass is 28 kg (40%), extracellular fluid mass 17.5 kg (25%), the skeletal mass 7 kg (10%) and the adipose tissue mass 17.5 kg (25%) (Blackburn 1979).

Patients identified at risk of protein-energy malnutrition are to undergo evaluation to determine the severity and type of malnutrition present. These examinations include the following tests:

1. Assessment of body weight and (recent) weight loss.
2. Assessment of static caloric reserve (fat store).
3. Assessment of static protein reserve (muscle store).
4. Assessment of circulating protein status.
5. Assessment of immune status.
6. Body composition measurement.

Assessment of Body Weight and (Recent) Weight Loss

Optimal Body Weight

When interpreting body weight, allowance must be made for the clinical judgement in function of the accuracy of the history, the underlying disease, and variations in hydration or oedemas. Parameters worth recording are the weight expressed as a percentage of the ideal weight and as a percentage of the usual weight, as well as the recent percentage loss in weight in the course of the disease. A weight amounting to 80% of the ideal weight may be interpreted as minor denutrition, 70 to 80% as moderate malnutrition and less than 70% of the ideal weight as severe malnutrition. The ideal weight is defined as the weight relative to height associated with the lowest mortality. If the usual weight, i.e. the

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premorbid weight, differs greatly from the ideal weight, the usual weight should be used as a reference. In the case of kwashiorkor, the weight loss can be less pronounced, because of the oedemas frequently observed.

Body Mass Index

The body mass index provides a relation between body weight and body height and is defined as follows:

$$BMI = body\ weight\ in\ kg/(body\ height\ in\ m)^2$$

The BMI is usually calculated for a clinical assessment of overweight and obesity. Limit values are dependent on the age (< or >=35 years) of the patient. The curvilinear plot of BMI and overall mortality risk results in a U-shaped curve. In general, a good weight can be defined as a BMI between 20 and 25 kg/m^2 ; overweight is a BMI > 25 kg/m^2 and a BMI > 30 kg/m^2 strongly indicates signs of obesity with increased risk (Bray, 1992). Conversely, BMI values lower than 19 are indicative of malnutrition and thus increased mortality risk. Moderate undernutrition can be defined as a BMI between 16 and 18 kg/m^2 ; a BMI < 16 kg/m^2 indicates severe malnutrition. In critically ill patients it is often difficult to measure body height and body weight, while body weight may be influenced by fluid shifts.

Assessment of Static Caloric Reserve

Subcutaneous fat forms a valid index for body fat. The measurement of skinfold thickness is a simple and rapid method for determining body fat stores. The triceps skinfold thickness (TST) is very informative about total body fat store. To determine body fat, the skinfold thickness is measured at the triceps, the thorax and the abdomen.

Furthermore, anthropometric measurements of the arm provide an indirect evaluation of the other body compartments. The muscle is representative of the lean mass, while the adipose tissue is an index of the energy reserves. From the measurement of the mid upper arm circumference and the triceps skinfold, the arm muscle circumference and the values of the muscle compartment and adipose compartment can be calculated. Although these measurements are not sufficiently sensitive to allow precise determination of the body composition in a particular patient, repeated measurements appear to be useful in assessing the effect of nutritional therapy.

One has to realise, however, that changes in muscle mass are changes in volume; the corresponding change in circumference is therefore more difficult to detect. Furthermore, the muscle mass is exaggerated by this method (15 - 25%). Additionally, in acute disease muscle tissue is characterized by a relative increase in water content, which makes it difficult to detect a loss in tissue. Changes in energy and nitrogen in the short term can not be detected by anthropometry, although it may detect large shifts in body compartments over months or years. Therefore, one can conclude that anthropometric measurements can only give an indication of depletion.

Assessment of Static Protein Reserve

Creatinine

Creatinine is a metabolite of creatine; the amount of creatine in an individual is constant and creatine is only contained in the muscle tissue. Creatinine can not be reutilized and its excretion in urine is proportional to the muscle creatine content and therefore to the total body muscle mass. Creatinine excretion is practically independent of protein intake and therefore the 24 h creatinine excretion represents a parameter for the muscle tissue metabolism, as one mole of creatinine correlates to 17-20 kg of muscle tissue. In physical efforts and acute illness the creatinine excretion is enhanced and is therefore not a good index for assessment of malnutrition under these circumstances.

3-Methylhistidine is another biochemical parameter for estimating body protein mass. This amino acid is located almost exclusively in myofibrillar protein and is released when this protein is degraded; it cannot be recycled and is excreted in the urine. Collection of 3-methylhistidine in the urine therefore reflects the amount of muscle protein broken down. The interpretation of 3-methylhistidine excretion is complicated, however, by the fact that other factors than muscle mass, such as age, dietary intake and stress influence 3-methylhistidine excretion.

Creatinine/Height Index

As the muscle tissue is dominated by the height of the patient, the creatinine/height index has been introduced (24 h urine creatinine divided by the length) to correlate creatinine excretion to muscle tissue. The values observed have to be compared to reference values of creatinine excretion for a normal adult of the same sex and length. It is assumed that a reduction in muscle mass produces a proportional reduction in creatinine/height index.

Nitrogen Balance

Since the protein mass appears to be the limiting factor governing survival, dynamic assessment of nitrogen balance is of prime importance. There are several methods for assessing protein and nitrogen metabolism. The oldest and most widely used method for evaluating changes in body nitrogen is the nitrogen balance method. However, there are other methods, like determining arteriovenous differences in amino acids, reflecting amino acid metabolism, or methods using radioactive labelled amino acids.

As body proteins contain virtually all the nitrogen in the organism, measurement of nitrogen balance reflects protein balance. Metabolites of protein breakdown appear mainly in the urine. Protein is also lost in the stool, in the renewal of the skin and in the growth of hair and nails. In hospital, there are further losses, *e.g.*, in wounds and fistulae.

By measuring the quantities of nitrogen given as protein and the quantities lost by various routes, one can arrive at a nitrogen balance: $N_{bal} = N_{in} - N_{out}$

However, the nitrogen balance only defines the difference between nitrogen entering and exiting the body. It should be pointed out that nitrogen losses are routinely underestimated because of incomplete collections of urine and faeces and insensible losses (*e.g.*, through skin and sweat), while nitrogen intake can easily be overestimated because of food not consumed.

The nitrogen balance is an indirect, but nevertheless reliable measure of protein conservation. A negative nitrogen balance, for example, shows that protein losses are greater than protein intake, indicating catabolic state.

In hospital, the measurement of an exact nitrogen balance is hardly practicable. Even the equipment for measurement of total nitrogen in urine is often not available. One may, however, make use of the following approximation:

$$N_{bal}\ (g/24h) = N_{in} - [UNN + 4 + (BUN_e - BUN_s/100 \times BW \times F)]$$

N_{in} = *nitrogen intake (g/24h)*

UUN = urinary urea nitrogen (g/24h)

BUN = blood urea nitrogen (mg/dl) (s = at start, e = at end of 24h)

BW = body weight (kg)

F = body water factor (male: F = 0.60, female: F = 0.55)

This equation takes account for the fact that the majority of the nitrogen losses in urine (80 - 90%) are in the form of urea; this fraction may rise in catabolic situations, but is never below this value. Losses in the urine other than as urea are reckoned to amount to 2 g and the skin and faecal losses also to 2 g (hence the 4 in the equation). Finally, a correction is made for urea that is produced, but does not appear immediately in urine, accumulating instead in the blood (BUN). Losses from the drainage of wounds and fistulae have to be taken into account by measurement.

To calculate nitrogen balance, a 24 h urine collection is required in order to determine urea nitrogen (1 g of nitrogen = 2.2 g of urea) or total urinary nitrogen, to which is added the undetermined nitrogen losses (skin, faeces) estimated at 2 - 4 g of nitrogen. Urinary nitrogen losses vary from an obligatory minimum of about 2 g/day to more than 30 g/day in massive protein catabolism. The nitrogen balance is negative when nutritional intake is less than the sum of urinary nitrogen and undetermined losses. The daily nitrogen losses depend on many factors. These are increased by immobility, by reduction of the caloric intake with a constant nitrogen intake, and by stress-related increases in protein oxidation. The latter can produce dramatic increases in nitrogen losses.

One must remember that nitrogen losses are tantamount to protein losses. Nitrogen losses therefore are always associated with a loss of functional capability, and lead to a higher incidence of complications, wound dehiscence, increased susceptibility to infection, decreased organ function (liver, gut, heart, lung) and in the extreme case to death from nitrogen deficiency. Nitrogen losses furthermore lead to substantial losses in body weight according to the equation:

$$1\ g\ N = 6.25\ g\ protein = 25\ g\ muscle\ tissue$$

Assessment of Circulating Protein Status

Plasma protein concentrations are used routinely for assessment of nutritional status and the effect of nutritional therapy, but these are not highly specific. Numerous factors may modify the serum protein levels, particularly the state of hydration or the presence of oedema.

Serum albumin is an index often used, although many factors other than energy intake influence the metabolism of albumin and its distribution in the intra- and extravascular fluids. Albumin is the main protein synthesized and secreted by the liver (15 g per day) with a half-life of approximately 18 days. Measurement of albumin will not always give a correct indication, as for example in acute illness (especially sepsis) when the extravascular distribution of albumin rises, resulting in a lowered serum albumin, without a lowered store. Overhydration is another cause of a low albumin concentration not indicative of undernutrition. Albumin may serve as a parameter of chronic protein deficiency because of its relatively long half-life, which makes it a poor indicator of acute protein-energy deficiency.

Transferrin, which has a half-life of 8-10 days, may be a more sensitive index than albumin, but possesses low specificity. Serum concentrations are influenced by lack of iron, acute hepatitis and acute and chronic disease, without the necessary implication of loss of protein.

Other proteins with an even shorter half-life have been assessed. These are the retinol-binding protein (RBP), and the thyroxin-binding prealbumin (TBPA), which have half-lives of 12 and 48 h respectively. These parameters function as an indicator of acute protein alterations. C-reactive protein (CRP) is an acute phase protein, very low in normal healthy subjects, but exponentially rising with the onset of infection and returning very rapidly to normal or near normal values after the stimulus is removed. This makes it a helpful marker in the care of patients who are at high risk for post-operative infection.

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Assessment of Immune Status

The well-established interaction between malnutrition and infection may be due to modifications of the immunological defence observed in protein-energy malnutrition. Malnutrition decreases the synthesis of acute phase proteins that can help in the survival during stress, infection and injury. Besides that, cellular immunity is generally impaired in malnutrition *(Chandra, 1983)*. Assessment is carried out on the total lymphocyte count in blood and by using tests for skin hypersensitivity to various antigens. From the extent of the cutaneous reaction, an immune score can be established. In general, a lowered immune score indicative of anergy is associated with an increased incidence of infectious complications. Interpretation of the immune response is nevertheless limited by the numerous variables which may affect it, such as certain drugs, surgical stress and the reliability of reference values. In undernourished patients, lowered, normal or raised serum immunoglobulin levels are observed, so that the effect of malnutrition on the humoral response has yet to be defined. Other major components of defence against infections are diminished in malnutrition, such as complement factors or leukocyte bactericidal capacity *(Chandra, 1983)*.

Body Composition Measurement

To date, new and more precise methods for assessing changes in body composition, as occurring in protein-energy malnutrition, have been developed. Each type of protein-energy malnutrition is characterized by specific changes in body composition.

Marasmic patients have marked deficits of total body fat and protein. Marasmic kwashiorkor is also characterized by deficits in total body fat and protein and a marked relative increase in extracellular water. Patients with kwashiorkor are characterized by raised amounts of total body water, extracellular water and the proportion of extracellular water in the fat-free body.

In order to overcome the shortcomings of determining body composition by indirect anthropometric and biochemical measurements, body composition analysis by isotope dilution techniques and neutron activation analysis, bioelectrical impedance analysis and magnetic resonance spectroscopy techniques have been developed.

In isotope dilution assays, radioactive isotopes (^{22}Na and ^{3}H) are used to assess total exchangeable sodium, total exchangeable potassium and total body water. As sodium is diluted primarily in the extracelullar water compartment and potassium in the intracellular water compartment, the body cell mass, body fat mass, lean body mass, extracellular mass and the ratio of extracellular water to intracellular water can be determined. Malnutrition leads to a reduction of the body cell mass, while the extracellular mass and extracellular water rise, leading to a net change in the ratio of Na_e/K_e (e = exchangeable). This ratio appears to be a marker for malnutrition; it approximates unity in well-nourished subjects and is greater than 1.22 in malnourished subjects (Forse and Shizgal, 1980).

Isotope dilution technique allows definition of the body cell mass, which is however greatly influenced by changes in intracellular water and determination by the isotope dilution technique may therefore result in an over- or underestimation of the protein mass.

Reaction activation analysis allows direct measurement of a number of elements, including nitrogen. The patient is radiated with high energy neutrons and afterwards moved to a whole body radiation counter. The radiation emitted by radionucleides induced by the neutrons is specific for various elements in the body. The complex spectrum from the patient is measured and analysed to give counting rates due to nitrogen (protein), hydrogen, carbon, chorine and in some systems calcium, phosphorus and sodium. From these data, the total body content for these elements can be calculated.

For this reason, neutron activation analysis is a reliable and direct method, although the equipment required is expensive. Compared to the isotope dilution technique, it is preferable in patients with fluxes in body water.

Micronutrient Status

Efficient utilisation of nitrogen-calorie substrates can only occur in the presence of physiological concentrations of a multitude of micronutrients: electrolytes, minerals, vitamins and trace elements. These nutrients are essential in minute quantities for the maintenance of normal metabolic functions. Micronutrient deficiencies may be the consequence of inadequate intake, defective absorption or utilisation, or they may supervene as a result of increased requirements. Diagnosis of micronutrient deficiencies attempts to identify the infraclinical or asymptomatic stages rather than to describe manifest organic alterations.

Concluding Remark

Assessment of the nutritional status of a patient is relatively difficult. Ideally, the identification of protein-energy malnutrition should conform to the following criteria :

1. It should specifically identify protein-calorie malnutrition and
2. Be negative in patients without protein-calorie malnutrition.

3. It should be unaffected by non-nutritional factors.
4. It should demonstrate normalisation with adequate nutritional support.

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From the preceding, it is clear that a number of methods and parameters are available for assessment of the nutritional status of patients and for evaluating the response to clinical nutrition. Some of these parameters are specific and sensitive, while others are not. Problems with the interpretation of anthropometric parameters are that these parameters are subject to observer errors and are influenced by changes in tissue composition induced by non-nutritional factors. For example, the administration of intravenous fluids or blood products, or the extensive loss of fluids or blood, or the excessive loss of fluid or protein through diarrhoea, fistulae etc. may invalidate anthropometric and serum protein measurements. Disease states like hepatic disease and nephrosis may reduce serum levels of albumin and transferrin in patients undergoing nutritional assessment. Infection and trauma may interfere with delayed cutaneous hypersensitivity test. The prolonged half-lives of serum albumin and transferrin cause delayed responses in both nutritional depletion and repletion. Other tests like body composition measurements are not generally used.

Furthermore, one must remember that these nutritional parameters have wide confidence limits and therefore are in general more suited for use in epidemiological surveys than in individual patients. The problem is that none of these parameters is suited as the sole parameter to assess nutritional status.

Therefore, clinical evaluation forms the basis in identifying those patients who are at risk of malnutrition and nutritionally related complications. On the basis of this clinical evaluation, patients that are malnourished can be further evaluated using anthropometry and biochemical markers. Further, these techniques are a helpful tool in assessment of the effect of nutritional support.

As already discussed, some investigators have tried to asses the nutritional status by combining several parameters into a prognostic index. The relative value of these scoring systems has been demonstrated in clinical studies and further trials are needed to confirm the performance of such indices as a prognostic tool.

Applying the mentioned methods and limits for assessing the nutritional status, one can arrive at the following definitions about the nutritional status of the patient :

1. Normal nutritional status exists when all parameters are within the reference range.
2. Adipositas (obesity) exists when body weight, BMI and skinfold thickness are supranormal and all other parameters are in the normal range.
3. Protein malnutrition exists when body weight, BMI and skinfold thickness are within the normal range and arm-muscle circumference and creatine excretion are diminished; plasma protein levels are depressed.

4. Protein-calorie malnutrition exists when weight, BMI, skinfold thickness (energy component), arm- muscle circumference and creatine excretion (protein component) are decreased, indicating that functional proteins are depressed.

5.3 BIOCHEMICAL ASSESSMENT

A person may be ill from an inadequate diet and yet their body measurements can be within normal limits. The right biochemical test would show the deficiency. Anthropometry mostly reflects undernutrition or overnutrition, too little or too much food energy. Biochemical tests are needed to demonstrate micronutrient status. On the other hand, there is no biochemical test on a body fluid that gives a measure of carbohydrate or fat intake. Biochemical methods are an essential part of nutritional assessment. There are many more biochemical tests than anthropometric measurements. Each test costs money, for collecting the blood or urine, for the equipment and chemicals, and the skilled laboratory worker's time, and for reporting and interpreting the test. So tests have to be selected, based on the situation and the subject, that are likely to yield useful results.

Biochemical (Laboratory) tests based on blood and urine can be important indicators of nutritional status, but they are influenced by nonnutritional factors as well. Lab results can be altered by medications, hydration status, and disease states or other metabolic processes, such as stress . As with the other areas of nutrition assessment, biochemical data need to be viewed as a part of the whole.

This is a measure of nutrients in blood, urine and other biological samples. Compared to other methods, biochemical methods of nutritional assessment provide the most objective and quantitative data on nutritional status. The usefulness of biochemical tests is that they provide indications of nutrient deficits long before clinical manifestations and signs appear.

Biochemical tests are also important in validation of data especially where respondents are under-reporting or over-reporting what they eat. These tests are therefore particularly useful in complementing and validating dietary intake surveys.

The major disadvantages of biochemical methods is that they are complex, expensive and require a high level of expertise.

Some of the biochemical tests are shown below together with their discriminatory power. These results show that those measurements which are good indicators of increased morbidity and mortality are not necessarily those which give the clinician a reliable way of allotting a patient to a 'feed' or 'none feed' group.

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Types of chemical techniques used in nutritional assessment

1. Measurement of nutrient concentration in the blood.
2. Measurement of the urinary excretion of a nutrient.
3. Measurement of the urinary metabolites of a nutrient.
4. Detection of abnormal metabolites in urine or blood resulting from a nutrient deficiency.
5. Measurement of changes in blood constituents or enzyme activities which are dependent upon the nutrient intake.
6. Measurement of 'tissue specific' chemical markers.
7. Saturation, loading and isotope tests.

Different Situations for Laboratory Tests

Biochemical methods for nutritional assessment are used for several different purposes :

- To recognize acute malnutrition for which the clinical signs are non-specific, *e.g.*, potassium deficiency.
- To confirm the clinical diagnosis of a deficiency disease, *e.g.*, xerophthalmia, scurvy, beri-beri, rickets, Wernicke's encephalopathy, kwashiorkor.
- For monitoring nutritional management in intensive care, with parenteral nutrition and/or tube feeding.
- In haematological diagnosis, *e.g.*, iron, folate and vitamin B12 estimations.
- In community nutrition surveys, to detect subclinical micronutrient deficiency, *e.g.*, iodine deficiency, iron deficiency.
- For checking validity of food intake measurement: 24-hour urinary nitrogen indicates protein intake in people with stable dietary pattern; carotenoids reflect fruit and vegetable intake.
- For reliability and convenience: biomarkers, for some nutrients, are more reliable and convenient than food intake estimations (*e.g.*, 24-hour urinary sodium is better than trying to work out dietary salt).
- To demonstrate objectively the response to a nutrition education programme, *e.g.*, reduction of plasma cholesterol or of urinary sodium.
- For biochemical confirmation of alcoholism.
- To diagnose nutritional supplement overdosing (*e.g.*, with vitamin A, pyridoxine).

Stages of Nutrient Deficiency

When absorbed intake of a nutrient is less than the requirement, *i.e.*, less than losses from metabolism and excretion, the depletion goes through four stages:

1. Reduced excretion of the nutrient, *e.g.*, reduced urinary excretion but body pool maintained.

2. Body pool smaller but no disturbance of function.
3. Biochemical signs of impaired function: reduced activity of an enzyme or cell depletion.
4. Morphological changes and clinical signs of deficiency disease.

Obviously many more people are found at stage 1 than are found with obvious classic deficiency disease. In other words. biochemical tests usually show subclinical nutritional deficiency; the subject may or may not be ill and the illness may or may not be due to the nutritional depletion.

Some Problems with Biochemical Tests

Instability of the nutrient in vitro **:** Vitamin C is the outstanding example. Plasma should be acidified with metaphosphoric or trichloracetic acid and analysed the same day or kept for a few days at "80°C.

Chemical specificity of the method **:** Older methods were often not specific for the nutrient, *e.g.*, DCIP or DNPH methods for vitamin C.

Other influences **:** Non-nutritional influences can significantly raise or lower plasma concentrations of most, if not all, nutrients. Plasma albumin goes down (without protein deficiency) with inflammatory disease or trauma. The liver switches to synthesis of 'acute-phase' plasma proteins and albumin may move to the extravascular space.

The relation between intake and plasma concentration **:** This shows important differences among nutrients. Plasma selenium increases in the expected linear fashion but serum calcium is homeostatically maintained the same over the range of usual calcium intakes. Plasma retinol also stays the same over most vitamin A intakes but it does go down at very low intakes, so this test is useful in low-income communities. Vitamin C concentration plateaus at intakes of about 150 mg/day so it is no higher in people who take megadoses than in those who eat a moderate amount of fruit.

Blood and urine tests cannot show calcium status **:** This requires measurements of bone mineral. Biochemical tests for zinc are also unreliable. Serum zinc is affected by age, gender, acute inflammation, time of day, fasting status, oral contraceptives, storage, haemolysis, zinc contamination of collecting tube or anticoagulant. It therefore needs careful technique and interpretation.

The Interpretation of Biochemical Tests

The uses of biochemical tests outlined here assume that such tests are informative in terms of an individual's nutritional state and are reliable from a technical standpoint.

Biochemical (chemical) measurements usually reflect the immediate past intake of nutrients or the changes produced by a long-standing deficient intake

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of a nutrient and not its current intake. They may be helpful in indicating the presence of inadequate dietary intake before the development of a biochemical lesion or a later clinical lesion which results from functional impairment of a tissue or organ.

The tests can be of several types but to be of clinical use a test must be widely available, simple to perform with accuracy and inexpensive. Many of the biochemical methods mentioned in the literature are clearly not applicable to clinical practice.

Concluding Remark

The application of nutritional assessment to hospital patients is at an early stage of development when compared to the established methods for the nutritional survey of populations. Biochemical methods are an important part of the types of assessment currently being investigated and such methods may, when they have been further developed, enable the clinician to select individual patients for nutritional therapy.

Student Activity

1. State the important points clinical assessment focus upon.

2. Explain the different situations of laboratory test.

5.4 SUMMARY

- Nutritional status is the balance between the intake of nutrients by an organism and the expenditure of these in the processes of growth, reproduction, and health maintenance.
- Clinical assessment, as presented by Jeejeebhoy (1990) may form the basis for assessment of the nutritional status of the patient. It is based on the clinical impression of the patient, without exactly defining or quantifying the degree of malnutrition.
- The BMI is usually calculated for a clinical assessment of overweight and obesity. Limit values are dependent on the age (< or >=35 years) of the patient.
- The oldest and most widely used method for evaluating changes in body nitrogen is the nitrogen balance method.
- Efficient utilisation of nitrogen-calorie substrates can only occur in the presence of physiological concentrations of a multitude of micronutrients: electrolytes, minerals, vitamins and trace elements.
- Biochemical (Laboratory) tests based on blood and urine can be important indicators of nutritional status, but they are influenced by nonnutritional factors as well.
- Biochemical (chemical) measurements usually reflect the immediate past intake of nutrients or the changes produced by a long-standing deficient intake of a nutrient and not its current intake. They may be helpful in indicating the presence of inadequate dietary intake before the development of a biochemical lesion or a later clinical lesion which results from functional impairment of a tissue or organ.

5.5 GLOSSARY

- **Body mass index :** It provides a relation between body weight and body height.
- **Biochemical tests :** A nutritional status assessment technique which is based on blood and urine.
- **Nitrogen balance :** A method for assessing protein and nitrogen metabolism in the body.

5.6 REVIEW QUESTIONS

1. How is clinical assessment of nutritional status conducted?
2. What do you understand by nitrogen balance?
3. How is body composition measured?
4. Discuss the different situations of laboratory test.

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5. What are the major problems in biochemical test?
6. How is biochemical test interpretated?

5.7 FURTHER READINGS

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(కత్తిరించి పంపవలెను)

అధ్యాపకుల, విద్యార్థుల సలహాలు, సూచనలు :

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