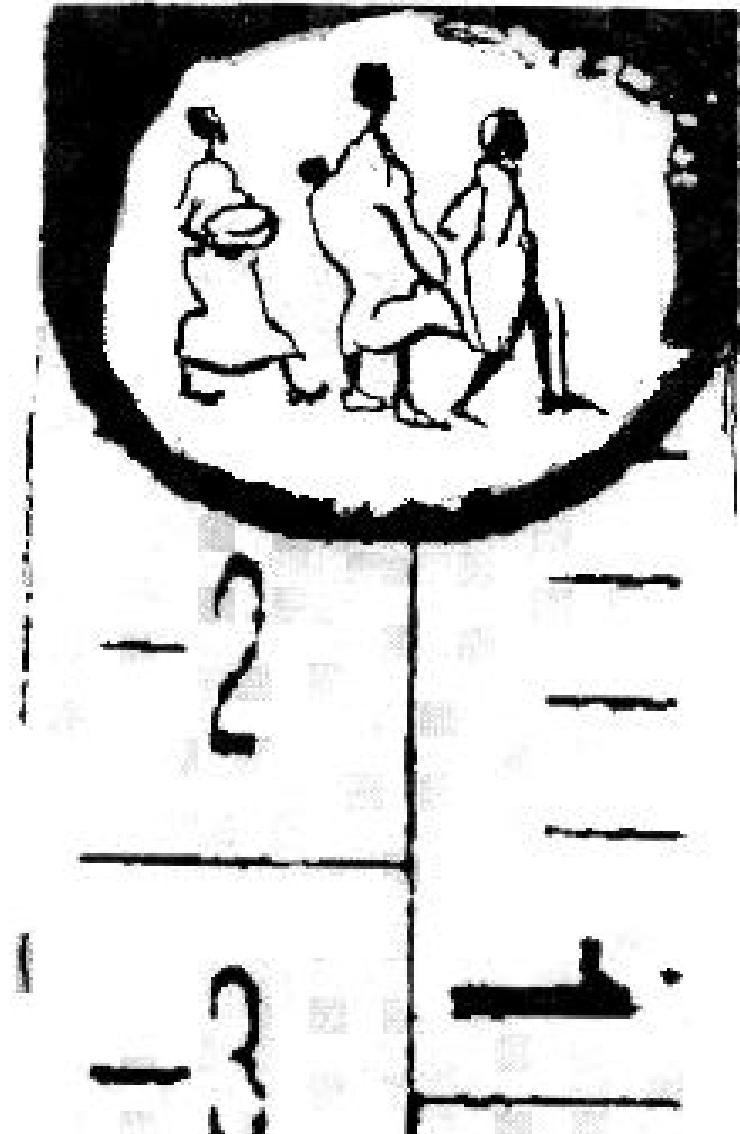


ADULTS



ASSESSMENT OF
NUTRITIONAL STATUS IN
EMERGENCY-AFFECTED
POPULATIONS

July 2000

Steve Collins, Arabella Duffield & Mark Myatt

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SUMMARY

This article describes simple techniques suitable for the assessment of the nutritional status of adults aged 20-60 years in emergency-affected populations. The BMI (Body Mass Index), MUAC (Mid-upper Arm Circumference), and clinical models are assessed for their usefulness in determining the prevalence of chronic undernutrition in adults at the population level, and also for screening severely undernourished adults for entrance to feeding clinics.

No consensus on a definitive method to assess adult undernutrition has been reached; more research is required to do this. This article makes only preliminary recommendations.

SURVEYS AND POPULATION LEVEL ASSESSMENTS OF CHRONIC UNDERNUTRITION

The BMI may be used to estimate the prevalence of chronic undernutrition in a population survey, using the classification system shown below.

The classification of categories of chronic undernutrition using the BMI

| Classification of chronic underweight categories | BMI (kg m⁻²) |
|---|------------------------------------|
| Normal | > = 18.5 |
| Grade I | 17.0-18.4 |
| Grade II | 16.0-16.9 |
| Grade III | < = 15.9 |

The BMI is known to vary with age and body shape. In order to account for changes in body shape the Cormic Index (sitting height/standing height) must be taken into account, and standardised for, when comparing the BMI of different populations.

MUAC may also be used to assess the prevalence of chronic undernutrition at the population level.

SCREENING SEVERELY UNDERNOURISHED ADULTS

No single definition or classification of acute adult undernutrition has been universally accepted, but interim techniques may be recommended until further research clarifies criteria. We suggest that the MUAC in combination with clinical signs should be used to screen adult entrance into feeding centres, using the classification shown below. The BMI is

inappropriate for this purpose as it is affected by oedema and body shape and difficult to measure. In any particular situation, workers should only use these suggested criteria as a starting point and adapt them to situation-specific factors.

Admission criteria into adult therapeutic feeding centres should be based upon the following cut-offs:

- MUAC < 160 mm irrespective of clinical signs
- MUAC 161-185 mm plus one of the following:
 - Bilateral pitting oedema (Beattie grade 3 or worse)
 - Inability to stand
 - Apparent dehydration
- Famine oedema (Beattie grade 3 or worse) alone as assessed by a clinician to exclude other causes.

Additional social factors can be included in the model. The relative weighting of these must be determined locally; for example whether you need one, two or three additional social factors to tip the balance in favour of therapeutic rather than supplementary care. Relevant social factors could include the following:

- Access to food (quantity and quality)
- Distance from centres
- Presence /absence of carers
- Shelter
- Dependants
- Cooking utensils

Admission to adult supplementary feeding centres should be based upon the following cut-off:

- MUAC 161-185 mm and no relevant signs or few relevant social criteria.

In any particular situation, workers should take these suggested standards as the starting point and adapt them according to situation-specific factors.

UNITED NATIONS Administrative Committee on Coordination
SUB-COMMITTEE ON NUTRITION
THE UN SYSTEM'S FORUM FOR NUTRITION

VISION AND MANDATE

Our long-run vision is of a world in which malnutrition is no longer a human development constraint. This is possible, but to achieve it will require decisive action at country level, supported by a coherent and co-ordinated international strategy, founded on human rights and providing a framework for action throughout the UN and international development finance system, implemented in close partnership with NGOs, bilaterals and governments. Nutrition needs to be made a key development priority, recognized as vital to the achievement of other social and economic goals. Good nutrition under normal conditions contributes to the prevention and mitigation of death and malnutrition in emergency situations. Good nutrition facilitates the prompt return to conditions favouring development following disasters.

The mandate of the ACC/SCN is to raise awareness of nutrition problems and mobilize commitment to solve them -- at global, regional and national levels; to refine the direction, increase the scale and strengthen the coherence and impact of actions against malnutrition world wide; and to promote co-operation amongst UN agencies and partner organizations in support of national efforts to end malnutrition in this generation.

Three main areas for action have been identified: (i) Promote of harmonized approaches among the UN agencies, and between the UN agencies and governmental and non-governmental partners, for greater overall impact on malnutrition. (ii) Review the UN system response to malnutrition overall, monitor resource allocation and collate information on trends and achievements reported to specific UN bodies. (iii) Advocate and mobilize to raise awareness of nutrition issues at global, regional and country levels and mobilize accelerated action against malnutrition. These three functions are all vital and of equal importance and can be seen as a triangle, one dependent on the other.

The UN members of the ACC/SCN are the FAO, IAEA, IFAD, ILO, UN, UNAIDS, UNDP, UNEP, UNESCO, UNFPA, UNHCHR, UNHCR, UNICEF, UNRISD, UNU, WFP, WHO and the World Bank. The ADB and IFPRI are also part of this group. From the outset, representatives of bilateral donor agencies and NGOs have participated actively in SCN activities. The Secretariat is hosted by WHO in Geneva.

The SCN undertakes a range of activities to meet its mandate. Annual meetings have representation from those mentioned above as well as academia -- a one-day Symposium is held during the annual meeting, focussing on a subject of current importance for policy. The SCN convenes working groups on specialized areas of nutrition; currently there are nine working groups in areas ranging from foetal and infant malnutrition, nutrition of the school aged child, and household food security to capacity building .

The SCN's reports on the world nutrition situation, published every two to three years, are authoritative sources of information to guide the international community in its nutrition work. Nutrition Policy Papers and the SCN News summarise current knowledge on selected topics. Quarterly bulletins on the nutritional status of refugees and displaced persons are also published in collaboration with a large network of NGOs.

Signalling the need for norms and standards.

The SCN will identify for the attention of technical agencies or other bodies critical areas where norms and standards are missing or out-of-date and holding programmes back. This includes (especially) identifying knowledge gaps and significant areas in dispute or controversy; as well as identifying areas requiring operational research, and facilitating this work.

Extract from the ACC/SCN's Strategic Plan, April 2000

INTRODUCTION

This supplement has been produced in response to the increasing number of reports on adult nutrition surveys received by the RNIS and the concomitant interest in the subject shown by the readership. We hope that it will help the readers of the RNIS to interpret the results of the adult nutritional surveys reported.

This article describes simple techniques suitable for the assessment of adult nutritional status in emergency-affected populations. We do not intend it as a comprehensive review of all aspects of assessing adult nutritional status, but as a guide to techniques useful in the field.

During famine-relief operations workers are increasingly recognising and treating severe adult undernutrition. There have, however, been few studies to investigate the problems associated with screening and treating severely undernourished adults during famine and consequently, little guidance is available to field workers. There is at present, no universally accepted definition or classification of acute adult undernutrition and no specific treatment guidelines for the condition. Thus the screening and selection of admissions into therapeutic feeding centres and the dietary treatment of those admitted becomes problematic. Since 1992 however, there have been several advances made in these areas and this article attempts to pull some of these together. We also make some recommendations as to the techniques suitable for the assessment of adult nutritional status under different circumstances.

All of the indicators described in this article attempt to assess adult nutritional status. It is important to realise that, to date, no consensus on a definitive method has been reached; more research is required to achieve this. None of the anthropometric indices described below can be considered to be a gold standard, although body mass index (BMI) has often, mistakenly, been treated as if it were.

This supplement focuses on the nutritional assessment of adults between twenty and sixty years of age. The assessment of older persons is a

complex task and is not described in detail here^{1, 2}. In addition, the article does not consider the assessment of obesity, micronutrient deficiencies or pregnancy.

Appendix one provides some basic definitions of terms that are employed in the discussion of adult nutritional assessment.

ACUTE AND CHRONIC UNDERNUTRITION

There are two main patterns of undernutrition found in children. These are stunting and wasting^{3, 4}. Different processes produce these two patterns and they are assessed using separate anthropometric indices. In children, acute nutritional deficit and/or disease (such as diarrhoea) produce wasting, characterised by a reduction in weight-for-height or arm circumference, or both. Prolonged nutritional deficit and/or disease result in stunting, characterised by a reduction in height-for-age⁵. Wasting and stunting are associated with different functional consequences. Weight-for-height is a powerful predictor of short-term mortality, as is the mid upper arm circumference (MUAC). Height-for-age predicts longer-term mortality^{6, 7, 8, 9, 10}.

The nutritional assessment of adults is more problematic. Despite metabolic differences between chronic and acute undernutrition^{11, 12, 13, 14}, the absence of linear growth removes the power of a height variable to discriminate between the two main patterns of undernutrition. In 1988, the International Dietary Energy Consultative Group proposed a definition of chronic adult undernutrition calling it 'chronic energy deficiency' (CED), clearly differentiating it from 'acute energy deficiency' (AED).

Chronic Energy Deficiency (CED) was defined as:

"A steady state at which a person is in an energy balance although at a cost either in terms of increased risk to health or as an impairment of functions and health"¹⁴



Acute Energy Deficiency (AED) was defined as:

"A state of negative energy balance, i.e. a progressive loss of body energy"¹⁴

The differentiation of acute and chronic adult undernutrition is important because the two conditions entail different adaptations and have different functional consequences. For example, habituation to CED has been described in Indian labourers who, with a mean BMI of 16.6kg m⁻², were able to function reasonably normally¹¹. By contrast, similar BMIs, rapidly induced in 32 previously well-nourished volunteers, resulted in extremely poor physical and psychological states¹². Differentiating between these two types of undernutrition may be difficult with a one-off measurement. They can be distinguished using a series of measurements taken over time, but in practice, this option is often not available. As acute undernutrition wastes peripheral body tissues faster than central tissues, it may be possible to compare two different body measurements in order to differentiate between these two forms of undernutrition. It may also be that adaptation below a certain threshold for each measurement is impossible and hence those falling below that threshold must have acute undernutrition. However, at present there are few data available with which to examine these problems.

We feel that the term "energy deficiency" is unhelpful when applied to undernutrition because it obscures the importance of protein catabolism, deficiencies of vitamins and minerals. For this reason, we prefer the term "undernutrition" rather than "energy deficiency".

Primary undernutrition develops when nutrient intake is insufficient to provide for normal physiological needs. In adults, primary undernutrition is invariably due to a lack of food. Secondary undernutrition occurs when an underlying disease process (for example, HIV/AIDS, TB and cancer) increases metabolic demands and/or decreases food intake or utilisation. The treatment of primary and secondary undernutrition may be quite different.

MEASURING NUTRITIONAL STATUS IN ADULTS

An ideal index of nutritional status, for any age group, should meet the following requirements:

- It must be correlated with body fat and protein stores.
- It must be correlated with health or functional outcomes.
- It must be simple to obtain and interpret in the field. It must also be accurate (close to the true value), valid (represent what it is thought to represent) and precise (repeatable).

In addition to these requirements, as adult height is largely determined by an individual's genotype and childhood nutritional experience¹⁵, it follows that if an index is to reflect current nutritional status in adults it must be independent of height.

WEIGHT

The use of weight alone to assess nutritional status should be limited to monitoring purposes because it is confounded by height. Weight is appropriate for monitoring the progress of patients suffering from long-term morbidity, recovering from disease or surgery, or during nutritional rehabilitation within a therapeutic feeding centre.

BODY MASS INDEX

The body mass index (BMI) is calculated from weight and height measurements using the formula $BMI = \text{weight (in kg)} / \text{height}^2 (\text{in m}^2)$. The BMI was first introduced by Quetlet in order to eliminate the confounding effects of height on weight. In normal adults, the ratio of the weight to the square of height is roughly constant, and a person with a low BMI is underweight for their height¹⁶. BMI reflects protein and fat reserves, which in turn reflect functional reserves including the ability to survive nutritional deficit and some diseases.

BMI may be appropriate for population-level assessments of chronic undernutrition. In 1988, researchers proposed the use of BMI to define and diagnose chronic undernutrition¹⁴. This

classification provides a useful framework for the analysis of height and weight data from chronically undernourished adult populations.

Table 1 The classification of categories of chronic undernutrition

| <i>Classification of underweight categories</i> | <i>BMI (kg m⁻²)</i> |
|---|------------------------------------|
| Normal | > = 18.5 |
| Grade I | 17.0-18.4 |
| Grade II | 16.0-16.9 |
| Grade III | < = 15.9 |

(adapted from Ferro-Luzzi et al, 1992¹⁷)

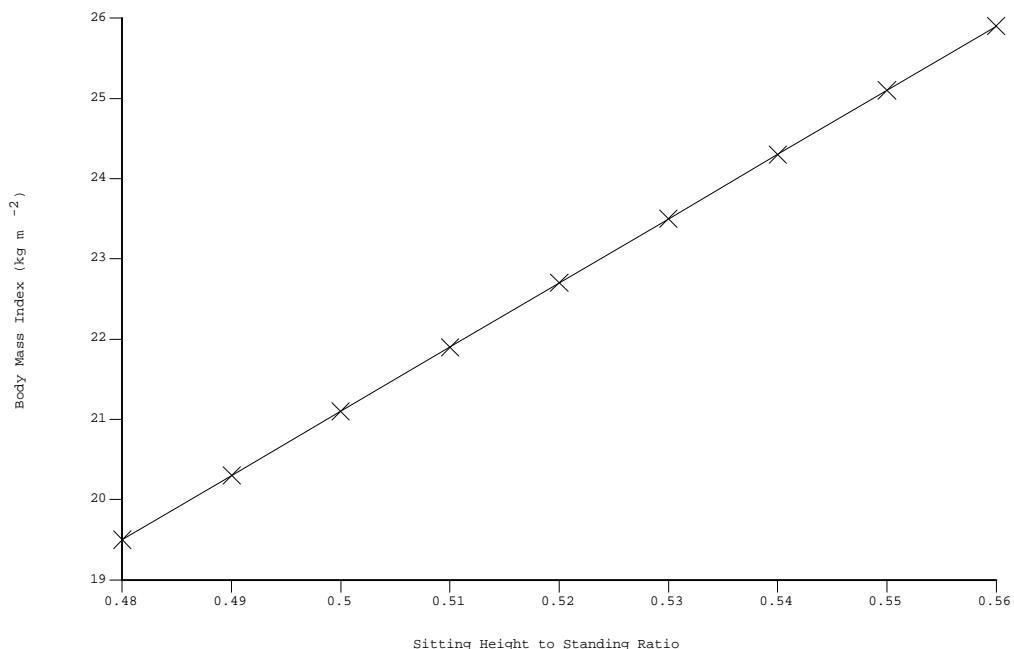
There is an increasing body of evidence that low BMI is related to both increases in morbidity and mortality^{18, 19} and, in fertile-age women, to the chances of having low birth weight babies²⁰. In addition, BMI is known to be highly correlated with both fat and fat-free mass, although these associations may vary with age, sex and ethnicity²¹.

However, there are several difficulties associated with the use of BMI as an anthropometric index. These difficulties can broadly be separated into theoretical and practical problems.

THEORETICAL PROBLEMS WITH BMI

Body shape - Many factors other than nutritional status determine BMI. Most important of these is body shape, in particular the ratio of leg-length to trunk-length, sometimes called the sitting-height to standing height ratio (SH/S) or Cormic index. This index varies both between populations and within populations. These differences result in world-wide (i.e. between populations) variation in the SH/S ratio from 0.48 in Australian aborigines^{22, 23} up to 0.55 in the Japanese²². This has a considerable influence on BMI, equivalent at the extremes of the range of SH/S ratio, to a variation of over 6 kg m⁻²

Figure 1 The effect of varying sitting height: stature ratio (SH/S) on BMI for a 70 kg, initially 1.75 metre male (from Norgan 1994²⁴)





There is also considerable within-population variation in the Cormic Index. In one aboriginal population, the within-population range for the Cormic Index was 0.41 - 0.54²³. This is greater than the world-wide variation in Cormic Index²² and equivalent to more than 10 kg m⁻² variation in BMI, dependant upon shape alone.

Sitting height can be measured by sitting the person on a straight-backed chair with a height board strapped to the back. This measurement is then used to correct BMI by applying a correction factor based on a linear regression model (see box 1)²³.

Comparisons of BMI between different populations can be made using a correction factor based upon the mean Cormic Index for each population. Such corrections should always be made when BMI is used to compare the nutritional status of different populations.

Follow-up surveys for the comparison of within-population data (for example, before and after an intervention, surveillance by repeated surveys etc) do not require the Cormic Index correction.

If BMI is being used to assess an individual for undernutrition the estimation of the individual's Cormic Index should be used as a correction factor. Without this correction the sensitivity and specificity of BMI as a screening indicator may be low^{22, 24}. During emergencies, especially at the height of a famine relief program, when there are large numbers of people competing for relatively scarce resources, there is almost never sufficient time or staff to perform this standardisation. We therefore feel that BMI is inappropriate for this role.

Age - Adult body size, shape and composition vary with age.^{25, 26, 27, 28, 29, 30, 31, 32, 33, 34}. Adults tend to loose fat free mass (FFM) and increase fat mass (FM) with age³⁵. These changes may alter the functional significance of BMI at different ages. Some NGOs use different cut-off points for older adults when admitting individuals to a feeding programme. For example, for adults aged 50y+ Action Contre La Faim (ACF) admits adults to therapeutic feeding centres and supplementary feeding centres using the cut-offs of 15kg m⁻² and 16 kgm⁻² respectively, but admits those aged less than 50 at 16kg m⁻² and 17kg m⁻².

BOX 1

THE CORRECTION OF BMI USING THE CORMIC INDEX (SH/S)

In order to standardise BMI to take into account changes in SH/S ratio we recommending using the equations below to calculate BMI standardised to the actual SH/S ratio for the population under study.

Male subjects - BMI = 0.78(SH/S)-18.43

Female subjects - BMI = 1.19(SH/S)-40.34

Note: SH/S ratios should be expressed as a percentage

The observed BMIs can then be standardised to a SH/S ratio of 0.52 by adding the differences between the observed BMI and BMI standardised for the population SH/S ratio to a BMI standardised to 0.52 using the equation below:

$$\text{BMIS}_{\text{std}} = \text{BMI}_{0.52} + (\text{BMI}_{\text{ob}} - \text{BMI}_{\text{es}}),$$

Where BMI_{std} = standardised BMI,
 $\text{BMI}_{0.52}$ = estimated BMI at SH/S of 0.52
 BMI_{ob} = actual BMI
 BMI_{es} = estimated BMI at actual SH/S

Examples

1. A Male population "A" has a mean BMI of 18.5 kg m⁻² and a mean SH/S ratio of 50%. The $\text{BMI}_{0.52} = 0.78 * 52 - 18.43 = 22.13$. The $\text{BMI}_{\text{es}} = 0.78 * 50 - 18.43 = 20.57$. Therefore the $\text{BMIS}_{\text{std}} = 22.13 + (18.5 - 20.57) = 20.06 \text{ kg m}^{-2}$
2. A Female population "A" has a mean BMI of 17.0 kg m⁻² and a mean SH/S ratio of 54%. The $\text{BMI}_{0.52} = 1.19 * 52 - 40.34 = 23.92$. The $\text{BMIS}_{\text{es}} = 1.19 * 54 - 40.34 = 21.54$. Therefore the $\text{BMIS}_{\text{std}} = 21.54 + (17.0 - 23.92) = 14.62 \text{ kg m}^{-2}$

These are *ad-hoc* modifications to the standard cut-off points for the use of BMI to assess undernutrition. As yet there are no published data that support the use of distinct cut-off points for different age groups. Many adults in the developing world do not know their exact age and it may, therefore, be difficult to differentiate the diagnosis of nutritional status according to age in an emergency situation. It may be useful, however, to

separate age groups when presenting the results of an adult nutritional survey using BMI in a non-emergency setting, where age can be ascertained using instruments such as local event diaries which would seldom be available in an emergency situation.

The increasing prevalence of kyphosis and scoliosis with age further necessitates the use of proxies for height when assessing the nutritional status of older adults².

Chronic and acute undernutrition - A great deal of research has focused on use of BMI for the assessment of chronic undernutrition in stable populations. This role is primarily that of prevalence estimation, providing information useful in planning at a population level. This is a different role to that of screening individuals who may be suffering from acute undernutrition in order to regulate admissions to feeding centres. The common assumption in contemporary NGO field manuals and recent academic articles^{36, 37, 38} that BMI is also an appropriate indicator for screening during famine, has not been tested.

BMI cut-off points for screening adult admissions to feeding centres, extrapolated directly from CED, may be inappropriate. The cut-off point of 16 kg m², that indicates severe chronic undernutrition does not necessarily reflect the degree of acute undernutrition that requires specialised treatment^{39, 40}. During a famine, there is intense competition for entry into feeding centres and it is important that screening indicators are specific, only selecting those who would die if not given specialised treatment.

As adults are usually the primary caregivers and income earners in a household, it is also important not to admit those who do not need therapeutic treatment into a centre as this may have a negative affect on the rest of the household.

In 1996, Ferro-Luzzi and James³⁶ adjusted their theoretical estimation of the lowest BMI compatible with life down from 12 kg m² in order to account for the extremely low BMIs being observed in Somalia during the famine there in 1992. They created two new BMI cut-offs of <13 kg m² and <10 kg m², denoting severe wasting and extreme wasting respectively. These values did not take into

account the Somali long-legged phenotype⁴¹, an important factor explaining the very low BMIs observed³⁹. Thus the cut-off values they propose are probably too low. In our experience a BMI of 10 kg m² after standardisation to a SH/S ratio of 0.52 is probably not compatible with life. One of 13 kg m², probably represents a degree of emaciation where peripheral stores have already been exhausted with a corresponding increase in central catabolism. This level is therefore probably inappropriately low to be used as a cut-off for admission into an adult therapeutic centre.

PRACTICAL PROBLEMS WITH BMI

Difficulties in obtaining the component measures of BMI during famine - The height and weight measurements required to assess BMI are often difficult to obtain during famine. Chair or bed-scales are usually unavailable and thus patients must be able to stand in order to be weighed. Usually, many of the most severely undernourished adults requiring admission to therapeutic feeding centres cannot stand at all and BMI cannot be estimated. In addition, many studies have reported that gross weakness^{42, 43}, flexor contractions⁴³, or scoliosis⁴⁴ are common. These prevent many patients standing straight enough for accurate height estimation. As height is a squared term, these errors are magnified in BMI calculation.

If BMI is to be used during an emergency there is a need to obtain robust, reliable and precise scales that can withstand repeated measurements under dry, dusty and hot conditions. These may be expensive.

Difficulties in the calculation of BMI - Even in non-famine situations the calculation of BMI and Cormic Index may be unfamiliar to field workers and therefore difficult. ACF have developed tables of weight-for-height that show BMI ranges (like those used for children) that may reduce this difficulty.

Difficulties in obtaining the component measures of BMI in elderly and handicapped people - As adults become older, spinal disease (predominantly osteoarthritis and osteoporosis) affects an increasing proportion of people. These conditions affect the ability to stand straight and make the accurate measurement of height impossible. BMI, based on height cannot therefore



be used in older adults⁴⁵. Recognition of this problem has prompted research into the use of proxy measures of height. Researchers have shown a good relationship between arm-span, demi-span, femur length, knee height and height^{46, 47, 48, 49, 50}. These proxies are converted to estimates of height using correction factors derived from regression equations. As the relationship between proxies and height has been shown to vary between ethnic groups and by age, different correction factors should be applied to different populations^{47, 48, 50}. Suitable population-specific correction factors to apply to proxy measures of height are usually unavailable in emergencies.

In elderly individuals, there are no viable alternatives to estimating height from arm span or demi-span. It should be recognised, however, that at the individual level, there is significant error involved in the estimation of height using correction factors based on population means. For example, the standard error of the estimate of height from arm span is reported to be between 2.5 and 3.8cm⁴⁶. The squaring of the height element in calculating BMI magnifies these differences.

Famine oedema - Adult nutritional oedema is common during famine and its presence increases weight, producing an upward bias in BMI. In adults

the frequent co-existence of pitting oedema and ascites means that oedema fluid can often account for over 10% of body weight. Famine oedema is also associated with poor prognosis (see Figure 2). Consequently, patients with severe famine oedema often have a poorer prognosis the higher their admission BMI, the opposite of the situation in marasmic patients (see Figure 3). BMI is therefore, not an appropriate indicator for people suffering from famine oedema. This may be corrected by using a modified screening criteria (i.e. BMI below a cut-off point OR the presence of oedema). However, as the presence of oedema, particularly in older adults, may not always be indicative of undernutrition, it will be necessary to train field workers to differentiate between the causes of oedema in adults. Alternatively, adults presenting with oedema will have to be referred to a clinician who is able to differentiate between the types of oedema.

As the prevalence of famine oedema is frequently high during emergencies (see Table 2), the inability of BMI to assess oedematous adults limits the usefulness of BMI as a screening tool to assess acute adult undernutrition.

Table 2 Incidence of famine oedema

| Study | Location | Year | Prevalence of famine oedema |
|----------------|-----------------|-------------|------------------------------------|
| Collins | Somalia | 1992 | 24% |
| Collins | Angola | 1993 | 90% |
| Collins | Sudan | 1993 | 0% |
| Zimmer et al. | France | 1942 | 50% |
| Mollinson | Germany | 1945 | typical finding |
| McCance et al. | Germany | 1946 | common |
| Debray | France | 1945 | 100% |
| Keys et al.* | U.S.A. | 1945 | 87% |

* In a selected population of previously well-nourished American volunteers starved under experimental conditions

Figure 2 Pitting oedema and the odds of mortality, based upon the grading system described in Table 4 (adapted from Collins 1995)³⁹

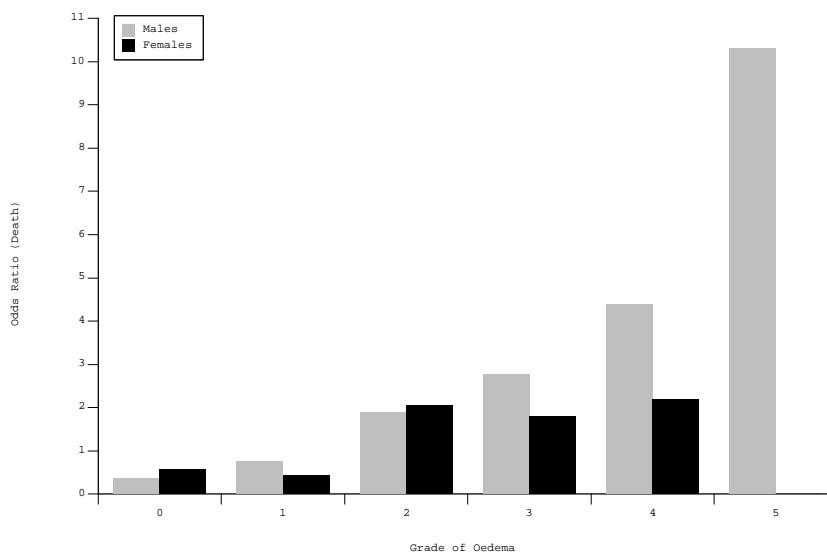
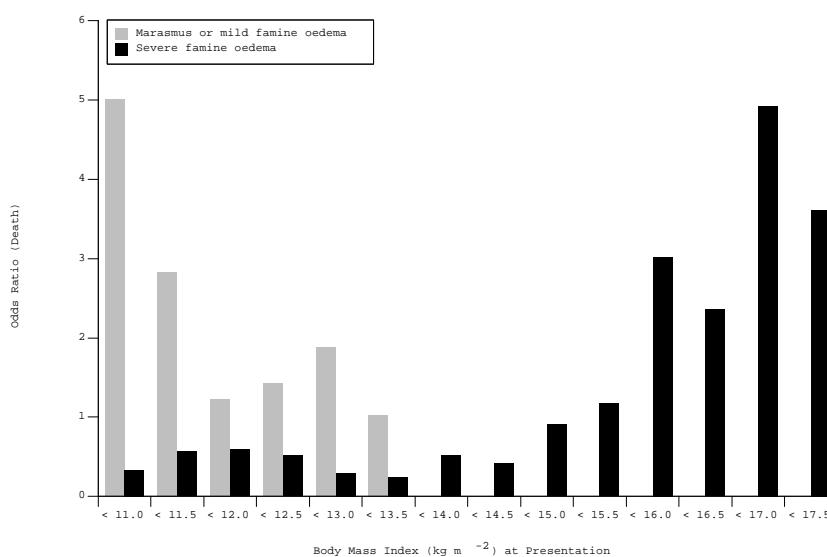


Figure 3 The odds of mortality below different thresholds of admission BMI for oedematous ($N=75$) and marasmic ($N=218$) patients admitted to a therapeutic centre in Baidoa, Somalia during 1992/3 (adapted from Collins 1995)³⁹





SUMMARY - THE USE OF BMI

In our opinion, the many problems with the use of BMI for screening acutely undernourished adults admissions to feeding programmes during famine relief programmes make the indicator inappropriate for this role.

BMI combined with an assessment of the prevalence of famine oedema is an appropriate indicator for population-level assessment of chronic undernutrition. These data can be categorised according to the classification given in Table 1 above. Such surveys should also assess MUAC.

If BMI survey data are used to compare BMIs between populations, estimates should be corrected by standardisation to a SH/S ratio of 0.52 using the mean SH/S ratio for the specific populations being studied.

Inside feeding centres it is useful to assess a standardised BMI on each patient admitted (standardised using individualised SH/S ratios).

MID-UPPER ARM

CIRCUMFERENCE (MUAC)

MUAC is the circumference of the left upper arm, measured at the mid-point between the tip of the shoulder and the tip of the elbow (olecranon process and the acromium). In children, MUAC is useful for the assessment of nutritional status^{51, 52, 53, 54, 55, 56}. It is good at predicting mortality and in some studies, MUAC alone^{57, 58, 59} or MUAC for age¹⁰, predicted death in children better than any other anthropometric indicator. This advantage of MUAC was greatest when the period of follow-up was short⁶⁰.

The MUAC measurement requires little equipment and is easy to perform even on the most debilitated individuals. Although it is important to give workers training in how to take the measurement in order to reduce inter- and intra- observer error, the technique can be readily taught to minimally trained health workers⁶¹. It is thus potentially suited to screening admissions to feeding centres during emergencies. The use of MUAC in emergencies is, however, still controversial, and disagreement over the preferential selection of younger children, the levels of cut-off points used, the efficiency of a two-

phase screening process and poor reproducibility in the measurement continue^{62, 63, 64, 65, 66}. Consequently, some humanitarian relief agencies remain sceptical about the use of MUAC in emergencies⁶⁷.

At present during emergencies, MUAC is only recommended for use with children between one and five years of age^{68, 37, 38}. It is, however, increasingly being used to assess adult undernutrition during famine^{69, 70, 71}. Measurements of adult MUAC have long been known to reflect changes in adult body weight⁷², and the major determinants of MUAC, arm muscle and sub-cutaneous fat, are both important determinants of survival in starvation^{73, 74, 42}. As MUAC is less affected than BMI by the localised accumulation of excess fluid (pedal oedema, periorbital oedema, ascites) common in famine, it is likely to prove to be a more sensitive index of tissue atrophy than low body weight. It is also relatively independent of height⁷⁰.

The use of MUAC has not been evaluated as a prognostic indicator. However, estimates of arm muscle area (AMA) or corrected arm muscle area (CAMA), corrected for humerus cross-sectional area, have been incorporated into diagnostic schemes for adult undernutrition in hospitals⁷⁵ and used as prognostic indicators in the elderly and in cancer patients^{76, 77}. However, it is unlikely that CAMA or AMA will be of use in emergency assessments as both require accurate measures of skin-fold thickness that would be hard to obtain given the rush and pressure of an emergency operation.

Ferro-Luzzi and James³⁶ have proposed MUAC cut-off points for use in screening acute adult undernutrition. They base these on extrapolation from more normally nourished populations in developing countries, without reference to data from acutely undernourished adults during famine. Although there is some evidence that the undernourished category may be associated with increased morbidity in chronically undernourished populations¹⁹, we doubt whether the criteria proposed are appropriate for screening acutely undernourished adults.

Data from famines suggest that the relationship between MUAC and BMI is not constant during acute undernutrition and that an accelerated loss of

peripheral tissue during acute undernutrition has a relatively greater depressing effect on MUAC than upon BMI⁷¹. These data also suggest that during acute undernutrition the differences in MUAC between men and women become less pronounced, a finding supported by previous observations in more normally nourished population⁷⁸.

It is likely, therefore, that in populations suffering from famine, MUAC cut-off points denoting moderate to severe undernutrition should be adjusted. Values of 185 mm denoting moderate undernutrition and 160 mm denoting severe undernutrition in both sexes have been proposed and used in famines⁷¹. Given that there are different cross-sectional humerus bone areas in men versus women⁷⁹, it is unclear whether common cut-off points for both sexes will prove appropriate.

THEORETICAL PROBLEMS WITH MUAC

Lack of data upon which to decide useful cut-off points - There are insufficient data available correlating MUAC with mortality and other functional measures in adults. Cut-off points based on risk of mortality cannot, therefore, be presented with any degree of certainty. There exists a need for more field studies during emergency famine-relief operations to evaluate the power of MUAC to predict adult mortality in different famine affected populations.

Age - The use of MUAC in adults may be affected by the redistribution of subcutaneous fat towards central areas of the body during ageing^{80, 19}. In older children and adolescents, the rapidly changing patterns of skeletal muscle and subcutaneous fat are also likely to be a problem. Age specific MUAC cut-off points may be required for older children, adolescents, and the elderly.

Ethnicity – Ethnic differences in MUAC have not been sufficiently studied to determine whether a single cut-off point for MUAC could be used for all ethnic groups.

PRACTICAL PROBLEMS WITH MUAC

Measurement error - In children, the use of MUAC is associated with two problems: the preferential selection of younger children as undernourished^{66, 81, 9} and a lack of reproducibility in MUAC measurements⁶⁵. Problems with the reproducibility of MUAC measurements are potentially a more serious obstacle to the use of MUAC in adults. As in children, both inter- and intra- observer errors in MUAC measurements may occur. The importance of these errors needs to be investigated, but it is likely that the larger dimension of the adult arm will reduce the relative importance of such errors. The development of colour-banded numeric MUAC bands reflecting threshold values of MUAC with a change of colour would further reduce these problems by removing numerical errors. Given the ease with which MUAC measurements can be performed it would be feasible to refer any patients found to have a MUAC within a few millimetres on either side of the threshold (designated on the band as a different coloured zone) to a more experienced worker for verification or for further (e.g. clinical) assessment as part of a two-stage screening process. The width of this zone should be based upon a more detailed examination of errors in the evaluation of adult MUAC by minimally trained workers. Colour-banded MUAC measurement straps are already in use with children.

The assessment of adult nutritional status using MUAC requires no equipment apart from a tape measure. As the index is the actual measurement itself, mathematical manipulation of the measurement obtained is not necessary. The ease with which MUAC can be assessed make it suitable for nutritional screening during the height of an emergency where time and skilled personnel are at a premium.

SUMMARY – THE USE OF MUAC

In our opinion, MUAC is an appropriate indicator for the assessment of acute adult undernutrition. The indicator is useful for both screening acute adult undernutrition and for estimating prevalence of undernutrition at a population level. We suggest, that until more data are available, the following cut-off points are used for both sexes for screening adult admissions to feeding centres:⁹



Table 3 Suggested MUAC cut-off points for moderate and severe acute adult undernutrition

| Level of undernutrition | MUAC (mm) |
|--------------------------------|------------------|
| Moderate | < 185 |
| Severe | < 160 |

At present there is insufficient data to assess the usefulness of MUAC as a tool with which to monitor treatment in adult feeding centres. More data is required to assess this role.

COMBINATION MEASURES

Some authors have proposed the combined use of BMI and MUAC, suggesting that such a classification might prove better able to discriminate between at-risk individuals and those who are thin but not at risk⁸². Given the relative strengths of the two indicators, it is probable that this combination will only be appropriate for the population assessment of CED. However, we see little advantage of a combination measure over the use of BMI alone.

CLINICAL SIGNS FOR SCREENING ACUTE UNDERNUTRITION

For many years, it has been recognised that undernutrition increases both susceptibility to, and the severity of, infection. Vitamin, mineral and other dietary deficiencies, depressed cell mediated and humeral immunity, gastric acidity, mucosal integrity and altered flora are all known to increase susceptibility to infection and the ability of an individual to utilise their energy and protein reserves^{83, 84}. The situation in an emergency is usually made worse by the breakdown in public health infrastructure and the congregation of displaced people in crowded and unhygienic conditions⁸⁵. This combination of poor public health environment and immunosuppression means that in famine it is usually infection combined with metabolic dysfunction rather than absolute loss of fat or fat-free mass that kills people. This is different from the situation in

industrialised countries where exhaustion of fat or fat-free mass is more often the terminal event^{86, 73}.

Therefore, the clinical signs of infection or metabolic dysfunction are likely to be useful prognostic indicators. This possibility has been investigated in children but rarely in adults^{87, 88}. Although reported as effective in identifying children at a high risk of mortality⁸⁸, these models have been criticised because the interactions between the features used, such as oedema and hypoprotinaemia, were not taken into account⁴.

FAMINE OEDEMA

In both children and adults, famine oedema has long been recognised as an important sign relating to the severity of undernutrition (see above). In adults, famine oedema is common (see Table 2) and usually (but not always) related to a poor prognosis (see Figure 2)^{89, 42, 39, 92}. For this reason the presence of famine oedema is usually used as an indicator of severe undernutrition. It is important to note, however, that the prognostic significance of adult famine oedema varies according to the context and in some occasions, the sign is of less use as an indicator of severity.

Famine oedema in adults should be diagnosed in a similar way to that in children, using firm pressure applied over a bony prominence for approximately 3 seconds and assessing whether an indentation remains after the pressure is removed. The severity of oedema should be graded using the system devised by Beattie during the Second World War (see Table 4)⁸⁹. In our experience pitting oedema of grade 3 and above are often associated with a markedly worse prognosis particularly if they occur in male patients³⁹. Lesser grades of oedema rarely appear to be clinically relevant.

It is important to note that oedema in adults may be induced by reasons other than undernutrition including cardiac, vascular, renal and hepatic disease. Differentiating between nutritional oedema and oedema secondary to other causes can be difficult and usually requires clinical expertise.

Table 4 Classification of famine oedema based on the Beattie classification⁸⁹

| Grade | Extent of oedema |
|--------------|---|
| 0 | absent |
| 1 | minimal oedema on the foot or ankle that was demonstrable but not obvious |
| 2 | obvious oedema on foot or ankle |
| 3 | oedema demonstrable up to knee |
| 4 | oedema demonstrable up to inguinal ligament |
| 5 | total body oedema (anasarca) |

Features of famine oedema not included in the Beattie classification

| | |
|----------------|--|
| Ascites | in isolation probably not a useful indicator of the severity of primary undernutrition. Prognosis relates to extent of accompanying oedema. Often occurs in secondary to disease (especially TB) |
| Peri-orbital | in isolation does not appear to reflect a poor prognosis |
| Scrotal | probably the result of ascitic fluid tracking downwards under the influence of gravity, in isolation does not appear to reflect a poor prognosis |
| hydroarthrosis | significance unknown |

CLINICAL MODELS

In adults, until recently the use of clinical models to assess nutritional status appears to have been restricted to the nutritional assessment of surgical patients⁹¹. Since 1992, similar assessments have been made amongst severely undernourished adult inpatients in several therapeutic feeding centre during different famines. A model using three clinical signs: apparent dehydration, oedema and inability to stand has proved useful in predicting prognosis among adult patients⁹². These three clinical signs were far better at predicting mortality than BMI, were easy to elicit and the model only involves counting.

To be useful in screening admissions to therapeutic feeding centres during famine rather than predicting prognosis in those already admitted, an indicator of nutritional status must be added to this

basic clinical model. This allows the model to differentiate between those with clinical illness but

no undernutrition, better treated in medical units, from those with both illness and undernutrition, best treated in specialised feeding centres. A combination model, "The Concern Health and Nutrition Evaluation Score" (CHANCES) has been used in Ajiep in South Sudan during 1998 (see Table 5). In addition to the basic signs demonstrated in Table 5, additional relevant criteria, in particularly social criteria such as presence of a carer or distance away from feeding centres can also be added to the model.

Preliminary indications are that this model performed well⁹³.

Table 5 The CHANCES screening model for acute adult undernutrition during famine

| Category | Action | MUAC (mm) | Relevant clinical signs |
|-------------------------|-----------------------|------------------|--------------------------------|
| Normal | Do not admit | > 185 | +/- |
| Moderate undernutrition | Supplementary feeding | 160 - 185 | - |
| Severe undernutrition | Therapeutic feeding | 160 - 185 | + |
| Severe undernutrition | Therapeutic feeding | < 160 | +/- |

* An adult presenting with bilateral oedema (Beattie grade 3 or more), but not low MUAC, should be referred to a clinician in order to assess whether s/he has nutritional oedema. If the oedema is nutritional s/he should be admitted to the Therapeutic Feeding Centre.



ACTIVITIES OF DAILY LIVING

Some workers have suggested that measuring functional ability rather than anthropometry may provide a useful screening tool. Functional ability is usually measured using scores derived from the answers to a set of several related questions. Such an instrument should be able to differentiate between those who can and cannot care for themselves. Valid and reliable sets of questions can, however, be time consuming to develop and test. Currently available instruments (e.g. those used for needs assessment in the elderly) may be appropriate in emergency situations but still require field testing during famine and identification of valid and reliable cut-off points. The CHANCES model creates a composite function/clinical score, with function being assessed solely by ability of an individual to stand. As in the CHANCES model, an indicator of nutritional status would need to be included to allow the instrument to differentiate between those with clinical illness but no undernutrition, best treated in medical units, and those with undernutrition, best treated in specialist feeding centres.

SUMMARY – THE USE OF CLINICAL MODELS

In our opinion, the combination of MUAC and clinical signs, based upon the CHANCES clinical model, is the method of choice for screening acutely undernourished adult admissions into feeding centres.

Admission criteria into adult therapeutic feeding centres should be based upon the following cut-offs:

- MUAC < 160 mm irrespective of clinical signs
- MUAC < 161-185 mm plus one of the following:
 - Bilateral pitting oedema (Beattie grade 3 or worse)
 - Inability to stand
 - Apparent dehydration
- Famine oedema (Beattie grade 3 or worse) alone as assessed by a clinician to exclude other causes.

Additional social factors can be included in the model. The relative weighting of these; for example whether you need one, two or three additional social factors to tip the balance in favour of therapeutic rather than supplementary care must be determined locally. Relevant social factors could include the following:

- Access to food (quantity and quality)
- Distance from centres
- Presence /absence of carers
- Shelter
- Dependants
- Cooking utensils

Admission to adult supplementary feeding centres should be based upon the following cut-off:

- MUAC < 161-185 mm and no relevant signs or few relevant social criteria.

In any particular situation, workers should take these suggested standards as the starting point and adapt them according to situation-specific factors.

It is important to note that the CHANCES model presented here screens adults in *urgent* need of nutritional support. If in a particular situation, the needs are such that workers have to make the CHANCES model more stringent in order to avoid being overwhelmed by admissions it is essential that they call for assistance and additional resources. In such situations vigorous advocacy is essential to publicise the extent of the crisis and call for help.

PRIMARY AND SECONDARY UNDERNUTRITION

An important problem in assessing adult undernutrition during famine is the inability to differentiate between primary and secondary undernutrition. At present, there are no one-off measurements that can do this. In practice admission into selective feeding programmes should be based on the CHANCES criteria, irrespective of whether the adult is suffering from primary or secondary undernutrition. Those with malnutrition secondary to infection (for example, TB or HIV) will fail to respond adequately to treatment. Adult selective feeding programmes

must therefore be designed in a way that allows for these people to be referred to other more appropriate support or treatment programmes. The design of these is beyond the scope of this article.

In future, as catabolic hormones produced in response to infection have a greater influence on peripheral energy and protein stores⁸² it might be that in secondary undernutrition resulting from infection the MUAC is more depressed than BMI. This might lead to the possibility of using a combination of the two indicators to differentiate

between primary and secondary undernutrition. To date, no work has been undertaken to investigate this possibility.

GENERAL SUMMARY – SUGGESTED INDICATORS FOR ASSESSING ADULT UNDERNUTRITION IN THE FIELD

Earlier in this report we defined the criteria of an ideal index of nutritional status. Table 6 shows how BMI, MUAC, and CHANCES meet these criteria.

Table 6 How BMI, MUAC, and CHANCES meet the criteria of an ideal index of nutritional status in famines

| Criteria | BMI | MUAC | CHANCES |
|--|--|---|--|
| Independent of height | Yes | Yes | Yes |
| Correlated with body energy stores | Yes Upwardly biased by oedema. | Yes | Yes |
| Correlated with health / functional outcomes | Yes in chronic ? acute | ? Insufficient data. | Yes |
| Simple to obtain and interpret | No Measurements difficult in patients unable to stand and those with musculo-skeletal problems. | Yes | Yes Proposes clinical signs are easy to elicit. |
| Accurate | ? Needs correction for body shape using extra measurement of SH/S and further arithmetic. | Yes | Yes |
| Valid | ? Not in the presence of oedema. | Yes | Yes |
| Precise | Yes | ? measurement errors in children. Insufficient data in adults. | See MUAC. ? |



In table 7 we present some interim recommendations for techniques that may be used, under different circumstances for the assessment of adult nutritional status. These recommendations are *preliminary* and there is a need for further research to clarify the criteria. It must also be noted that, in emergency relief programmes, the appropriate indicator cut-off point (screening level) is that which selects the number of individuals that can be treated with the resources at hand ⁹⁴. In reality, such cut-off point values often cannot be determined universally but must be tailored to suit the resources available in each particular situation ⁹⁴. The choice of underlying body measurement may also be determined by available equipment (e.g. scales may not be available to measure weight).

combined with the armed conflict that has characterised almost all famines during the last ten years, make such broad-based population studies unfeasible. Consequently, no such studies have yet been performed for any nutritional indicator in either adults or children during the height of a famine. Given these difficulties, relating indicators to mortality in a selected feeding centre population may be all that is reasonably possible. The selection bias involved in such studies must be acknowledged and results interpreted with caution.

Patterns and prevalence of adult undernutrition during famine - Data on the prevalence and patterns of adult undernutrition during famines may be useful in defining cut-offs. Data on different ethnic groups and settings would be useful.

Table 7 The applicability of BMI, MUAC, Weight, and CHANCES in different situations

| | BMI | MUAC | Weight | CHANCES |
|--|-----|------|--------|---------|
| Chronic undernutrition | + | + | | |
| Acute undernutrition | | + | | + |
| Monitoring nutritional rehabilitation (& progressive illness / post operative recovery) | + | | + | |

WHERE DO WE GO FROM HERE? FUTURE RESEARCH NEEDS:

Defining functional cut-offs - Longitudinal studies should be undertaken to determine whether individuals falling below specific cut-off points for BMI, and MUAC have elevated morbidity or mortality, poor pregnancy outcome, decreased work ability or physical performance measures. Such studies must be conducted in a variety of situations with different levels of undernutrition among adults. During emergencies, such studies are problematic. Ideally studies relating indicators to the risk of mortality in a general population are required to establish functional cut-off points that could be used for the screening of adult admissions to feeding centres. However, famines always involve massive social upheaval and large numbers of afflicted people. These factors,

Practicality of measurements and calculations

- The practicality of obtaining various measures should be explored in field situations. Survey organisers should assess the ease of training survey workers in measuring MUAC, weight, and height, as well as assessing inter- and intra-observer variability in these measurements when measuring adults.

Adjusting for differences in body shape - Surveys undertaken in a variety of populations should explore the utility of adjusting indices using weight and height for differences in body shape by using the SH/S Index or other indicators of body shape.

The use of MUAC to monitor recovery from undernutrition. The changes in MUAC and weight during recovery from undernutrition should be compared with a view to establishing whether

MUAC is useful in this role and if it is, establishing relevant MUAC discharge criteria.

More data on differentiating between secondary and primary undernutrition -
Examination of adult failure-to-thrive in centres should include attempts to identify measurements

or signs that predict failure-to-thrive in feeding centres.

The aetiology, significance and treatment of famine oedema and ascites - More information on the significance and prevalence of famine oedema and ascites is required. It is recommended that surveys assess subjects for these symptoms.



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APPENDIX 1: BASIC DEFINITIONS

WASTING

Low weight-for-height, usually defined as less than -2SDs of the NCHS/WHO reference median value, or sometimes 80% of the NCHS/WHO reference median of weight-for-height. At present, no clear definition of wasting in adults is available.

STUNTING

Low height-for-age, usually defined as less than -2SDs of the NCHS/WHO reference median value, or sometimes 80% of the NCHS/WHO reference median of height-for-age.

BMI

Body mass index (weight/height²). An index of protein and fat stores.

FAMINE OEDEMA

Bilateral dependant pitting oedema resulting from undernutrition. In both adults and children this is an important sign of severe undernutrition, carrying a high mortality risk.

MUAC

The mid upper arm circumference, measured on a straight left arm (in right handed people) mid way between the tip of the shoulder (acromium) and the tip of the elbow (olecranon). An index of peripheral protein and fat stores. This is an accepted measure of acute undernutrition.

ASCITES

The accumulation of serous fluid in the peritoneal cavity.

CORMIC INDEX

The ratio of leg-length to trunk-length, sometimes called the sitting height to standing height ratio (SH/S).

INCIDENCE

The number of new cases of undernutrition in a defined population within a specified period of time⁹⁵.

PREVALENCE

The total number of undernourished individuals in a given population at any one time⁹⁵.

INDICATOR

An indicator is a variable taking one of two possible values, one indicating the presence of a condition, the other indicating absence of the condition⁹⁵. In the context of assessing nutritional status this will usually mean whether or not an individual is above or below a pre-defined value of a particular body measurement or combination of measurements (e.g. MUAC, weight, BMI). A clear idea of the purpose of the assessment being undertaken should inform the choice of body measurement used and the cut-off points that are applied to it.

SENSITIVITY

Sensitivity is the number of people correctly identified by an indicator as being undernourished divided by the total number of undernourished people measured. A sensitive indicator will identify a large proportion of the undernourished people measured.

SPECIFICITY

Specificity is the number of people correctly identified by an indicator as non-undernourished divided by the total number of non-undernourished people measured. A specific indicator will correctly identify a large proportion of the *non-undernourished* people measured.

SURVEILLANCE

Ongoing scrutiny, generally using methods distinguished by their practicability, uniformity, and frequently their rapidity, rather than by complete accuracy. Its main purpose is to detect changes in trend or distribution in order to initiate investigative or control measures ⁹⁵. The appropriateness of a nutritional indicator for surveillance lies in its ability to reflect the true incidence of undernutrition in a population. The principal objective of a surveillance system is to provide information in order to aid decision making at a community level and there may be no immediate benefits for the individuals surveyed ⁹⁶. Surveillance normally estimates incidence rather than prevalence.

NUTRITIONAL SURVEY

A survey which examines the presence or absence of undernutrition in each member of a representative sample of a population at one particular time. A survey estimates prevalence rather than incidence ⁹⁵.

SCREENING

In the context of nutrition, the purpose of screening is to select individuals at increased risk of morbidity and mortality who are likely to respond to treatment and to treat them. The numbers selected by the indicator used are those that need treatment ⁹⁶. In emergency relief programmes, the appropriate indicator cut-off point (screening level) is that which selects the number of individuals that can be treated with the resources at hand ⁹⁴. Such cut-off point values cannot therefore be determined universally but must be tailored to suit the resources available in each particular situation ⁹⁴. The choice of underlying body measurement will often be determined by available equipment (e.g. scales may not be available to measure weight).

CLINICAL MONITORING

The performance and analysis of routine measurement aimed at detecting changes in the nutritional status of an individual.

GENERAL SUMMARY – SUGGESTED INDICATORS FOR ASSESSING ADULT UNDERNUTRITION IN THE FIELD

SURVEYS AND POPULATION LEVEL ASSESSMENTS OF CHRONIC UNDERNUTRITION

1. BMI
2. MUAC

If the survey results are used to compare BMI between populations then BMI must be standardised for the average population Cormic Index (sitting height/standing height)

SCREENING SEVERELY UNDERNOURISHED ADULTS

THERAPEUTIC FEEDING CENTRES

CHANCES model:

1. MUAC < 160 mm alone
2. MUAC < 161-185 mm plus one of the following:
 - Oedema
 - Inability to stand
 - Apparent dehydration
3. Famine oedema (Beattie grade 3 or worse) alone as assessed by a clinician to exclude other causes

Additional social factors can be included in the model. The relative weighting of these, for example whether you need one, two or three additional social factors to tip the balance in favour of therapeutic rather than supplementary care must be determined locally. Relevant social factors could include the following:

- Access to food (quality and quantity)
- Distance from centres
- Presence /absence of carers
- Shelter
- Dependants
- Cooking utensils

SUPPLEMENTARY FEEDING CENTRES

MUAC < 161-185mm and no relevant clinic signs or few relevant social criteria

In any particular situation, workers should take these suggested standards as the starting point and adapt them according to situation-specific factors.