Section 5

Conclusions and Policy Implications

GLOBAL NUTRITION CLUSTER

This section is part of a larger 208 page report titled:

Weight-for-height and MUAC for estimating the prevalence of acute undernutrition? Mark Myatt and Arabella Duffield, Save UK London 22 October 2007

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Conclusions and policy implications

The research reported here was undertaken to assess the relationships between commonly employed anthropometric measures of acute undernutrition in emergencies. Currently, the majority of agencies use W/H z-score based case-definitions to estimate the prevalence of undernutrition in surveys but use a combination of MUAC and W/H percentage of medians for admission into feeding programs. Historically, most agencies have used W/H indices calculated from the NCHS reference but the WHO has recently produced a new international reference population. The use of different indices has led to confusion at the field and HQ levels of many agencies about which is the appropriate indicator to use and how the various indicators relate to each other. Crucially, the relationships between these indicators may be different in populations living in different locations. It is important to understand these relationships because different indicators classify different children and different numbers of children as malnourished and the choice of indicator will have an impact on decisions to intervene (if these are based upon the results of prevalence surveys), program size, and may also have an effect on mortality rates within programs.

The database on which this research is based was compiled from 560 anthropometric surveys of 459,036 children aged between 6 and 59 months living in 31 countries. To the authors' knowledge it is the largest set of data with the variables of interest available at this time. A summary of the main results is shown in the *Table 5.01* and *Table 5.02.*

Table 5.01 : Effects of changing reference populations

Indicator	Context		Effect of change from NCHS to WHO reference
WHZ	Prevalence estimation	Global	Slight increase in prevalence
		Severe	Increased prevalence
WHM	Therapeutic feeding	Severe	Slightly decreased estimate need
	Supplementary feeding	Moderate	Decreased estimate of need

Table 5.02 : Effects of changing indicators

Indicator	Context		Effect of change from W/H (NCHS) to MUAC
MUAC	Prevalence estimation	Global	Overall similar Increase in children with high SSR Decrease in children with low SSR
		Severe	Overall similar Increase in children with high SSR Decrease in children with low SSR
WHM	Therapeutic feeding	Severe	Increased estimate of need Increase greater in children with high SSR
	Supplementary feeding	Moderate	Increased estimate of need Increase greater in children with high SSR

Populations where children, on average, have low SSRs (i.e. relatively long legs compared to trunk length) include Sudan, parts of Ethiopia and Kenya, and the Indian Sub-continent).

Summary of results

The results of the analysis presented demonstrates:

- The estimates of prevalences of malnutrition vary according to which indicator is employed. The difference between the prevalence estimates is not systematic (i.e. it is not always higher or lower for one indicator) and depends on whether the prevalence estimates are made for *severe* or *global* acute malnutrition and whether or not z-scores or percentage of the median is used.

- The relationships between the prevalence of either *global* or *severe* acute undernutrition measured by W/H (NCHS) or W/H (WHO) do **not** show major differences between populations living in different locations and hence both the percentage of the median and z-scores can be "transformed" using the global equations presented in the report.

- The relationships between the prevalence of global or severe acute undernutrition measured by W/H (NCHS or WHO references) and MUAC show significant differences in populations living in different locations. This means that no global "transformations" can be used to estimate the prevalence of low MUAC from estimates of low W/H or vice versa and that any transformations should use location-specific corrections.

- MUAC based case-definitions select younger children than W/H (NCHS or WHO) based case-definitions. This means that more young children will be enrolled in programs.

- The relationship between W/H and MUAC is complicated by body shape. All other things being equal, children with a lower SSR have a significantly lower WFH than those with a higher SSR. This results in children with low SSR (i.e. long legs and / or short trunk) being more likely to be classified as acutely undernourished using the W/H based case-definitions.

These results imply that it is not straightforward to switch from one anthropometric indicator to another because different estimators yield different prevalence estimates (note that the *true* prevalence of undernutrition is not known – see below).

Discussion, recommendations and policy implications

The terms *nutritional status* and *anthropometric status* are often used interchangeably. Nutritional status refers to the internal state of an individual as it relates to the availability and utilisation of nutrients at the *cellular* level. This state cannot be observed directly so *observable indicators* are used instead. There are a range of observable indicators (biochemical, clinical, and anthropometric) of nutritional status, none of which taken alone or in combination are capable of providing a full picture of an individual's nutritional status. There is, therefore, no "gold-standard" indicator of nutritional status.

Nutritional status can be usefully defined at the *individual*, as opposed to the *cellular*, level as the ratio of nutrient reserves (muscle and fat) to the nutrient requirements of organs (brain, liver, heart, kidneys, lungs, &c.). It is generally recognised that muscle plays a special role as a nutrient reserve during infection and that infection is a major etiological factor in acute undernutrition. Muscle mass is critical to survival, normal absorption and metabolism[1,2].

W/H expresses the relationship between weight and height. In children, about 4% of weight is nutrient reserves in muscle. About 96% of weight is, therefore, unrelated to important nutrient reserves. Height is almost completely unrelated to the nutrient requirements of organs. MUAC, however, is directly related to muscle mass and is, therefore, a direct measure of nutrient reserves.

The limited evidence that is currently available suggests that an index known as the *lean-mass ratio* (LMR), the ratio of the estimated mass of the limbs to the estimated mass of the trunk, is the best *anthropometric* indicator of nutritional status[3]. *Table 5.03* summarises the associations between LMR and the various anthropometric indicators that are practical to collect in developmental and emergency settings. The available evidence suggests that MUAC uncorrected for age or height is a better indicator of nutritional status than all other practical indicators and that W/H is **not** associated with LMR and the worst practical indicator of nutritional status.

1 Briend, A, Garenne, M, Maire, B, Fontaine, O and Dieng, K,*Nutritional status. Age and survival: the muscle mass hypothesis, EJCN*,1989, 43, 715-726

2 Wolfe, RR,*The under-appreciated role of muscle in health and disease*,AJCN, 2006, 84; 475-82

3 Brambilla P, et al., Lean mass of children in various nutritional states: Comparison between dual-energy X-ray absorptiometry and anthropometry,*Annals of the New York Academy of Science*,2000, 904:433-6

Table 5.03 : Correlation between different anthropometric indicators of nutritional status and lean mass ratio (adapted from Brambilla et al, 2000)

Index		***R***	**p**
MUAC	Uncorrected	0.591	< 0.0001
Weight-for-age	z-score	0.325	0.0149
	% median	0.311	0.020
Height-for-age	z-score	0.438	0.0007
	% median	0.426	0.0010
MUAC-for-age	z-score	0.382	0.0037
	% median	0.277	0.0402
MUAC-for-height	z-score	0.348	0.0088
	% median	0.323	0.0156
Weight-for-height	z-score	0.075	0.5885
	% median	0.114	0.4074

An alternative to examining the association between an anthropometric indicator and nutritional status is to examine the prognostic value (i.e. of predicting death) of various indicators. When this has been done, W/H has been consistently shown to be the least effective predictor of mortality and that, at high specificity, MUAC is superior to height-for-age and weight-for-age which are both superior to W/H[4,5,6,7,8,9,10,11,12,13]. It should be noted that these findings are based on W/H indices calculated using the NCHS reference population. It is possible, although not probable, that the predictive value of W/H will be improved by use of the WHO reference population. This issue could be resolved by the re-analysis of existing cohort study data.

In terms of indicators that are practical to collect in developmental and emergency settings, MUAC has the best claim to be a practicable "gold-standard" of nutritional status. It is also better than competing indicators in terms of age-independence, precision, accuracy, sensitivity, and specificity[14]. It is also simple, cheap, and acceptable to children and their carers.

The results of the current analysis also support using MUAC rather than W/H to detect cases of severe malnutrition because W/H is influenced more influenced by body shape than MUAC. Similar differences have been noted previously. For example, the prevalence returned by W/H (NCHS) is consistently higher than expected in children from the Indian sub-continent[15,16]. This has been explained by redefining wasting as a *chronic* condition related to a combination of poor health and nutrition. Prevalence returned by W/H (NCHS) is lower in Hispanic children from central and South America[17]. This has been explained by body-shape.

The authors of this report believe that, taken together, this body of evidence strongly suggests that MUAC is a better indicator of severe acute undernutrition than W/H (NCHS or WHO) and that, in the future, agencies should uniformly use MUAC and / or oedema to admit children into therapeutic feeding programs. In practice, this is currently happening in many programs run by international agencies, and was ratified by the WHO in an informal consultation on community-based management of severe malnutrition in children in 2005[18]. The use of MUAC is also gaining ground in admission for supplementary feeding programs, for example in the Ethiopian Enhanced Outreach Strategy (EOS) program, and its adoption would simplify programming and probably improve coverage – particularly if the case finding activities were devolved to the community.

4 Alam N, Wojtyniak B, Rahaman MM, *Anthropometric indicators and risk of death*, Am J Clin Nutr, 1989;49:884-888
5 Briend A, Zimicki S, *Validation of arm circumference as an indicator of risk of death in one to four year old children*, Nutr Res, 1986;6:249-261
6 Briend A, Dykewicz C, Graven K, Mazumder RN, Wojtyniak B, Bennish M, *Usefulness of nutritional indices and classifications in predicting death of malnourished children*, Br Med J (Clin Res Ed). 1986 Aug 9;293(6543):373-5
7 Briend A, Wojtyniak B, Rowland MGM, *Arm circumference and other factors in children at heightened risk of death in rural Bangladesh*, Lancet, 1987;26:725-727
8 Chen LC, Chowdhury MK, Huffman SL, *Anthropometric assessment of energy-protein malnutrition and subsequent risk of mortality among pre-school children*, Am J Clin Nutr, 1980;33:1836-1845
9 Myatt M, Khara T, Collins S, *A review of methods to detect cases of severely malnourished children in the community for their admission into community-based therapeutic care programs*, FNB, 2006, 27:3, S7-S23
10 Smedman L, Sterky G, Mellander L, Wall S, *Anthropometry and subsequent mortality in groups of children aged 6-59 months in Guinea-Bissau*, Am J Clin Nutr, 1987;46:396-73
11 Sommer A, Lowenstein MS, *Nutritional status and mortality: A prospective validation of the QUAC stick*, Am J Clin Nutr, 1975;28:287-292
12 Vella V, Tomkins A, Ndiku J, Marshal T, Cortinovis I, *Anthropometry as a predictor for mortality among Ugandan children allowing for socio-economic status*, Eur J Clin Nutr, 1994;48:189-197
13 Berkley J, Mwangi I, Griffiths K, Ahmed I, Mithwani S, English M, Newton C, Maitland K, *Assessment of severe malnutrition amongst hospitalized children in Rural Kenya: Comparison or weight for height and mid upper arm circumference*, JAMA, 2005;294(5):591-597
14 Myatt M, Khara T, Collins S, A review of methods to detect cases of severely malnourished children in the community for their admission into community-based therapeutic care programs. FNB, 2006, 27:3, S7-S23
15 de Onis M, et al., *The worldwide magnitude of protein-energy malnutrition: An overview from the WHO Global Database on Child Growth*, Bulletin of the World Health Organisation, 1993, 71:703-712
16 Victoria CG, *The association between wasting and stunting: An international perspective*, Journal of Nutrition, 1992, 122:1105-1110
17 Martorell R, et al., *Short and plump physique of Mexican-American children*, American Journal of Physical Anthropology, 1987, 73:475-487
18 Anon, *Community-based management of severe malnutrition. A joint statement by WHO / WFP / UN-SCN and UNICEF*, May 2007

Agencies continue to estimate the prevalence of both global and severe acute malnutrition using a mixture of W/H (NCHS) and W/H (WHO). While it is not necessary to employ the same indicator for estimating prevalence as for admission, using a mixture of indicators is confusing and, as the results of this analysis have shown, may produce very different estimates of program need in some settings. Classic W/H based surveys using either the WHO or the NCHS references may miss important information if they do not use MUAC to estimate potential patient load for therapeutic programs. Therefore MUAC must be introduced into these surveys. Whether or not W/H should be retained in emergency situations needs to be discussed but the authors of this report believe that it should eventually be dropped as it is time consuming, expensive and confusing. The use of MUAC and oedema alone in estimating prevalence and admission would greatly simplify interpretation, planning, and programming in emergencies.

Note that a change to using MUAC for estimating prevalence may have the result that many situations previously classified as *critical* or *serious* by the WHO classification scheme using a W/H (NCHS) based case-definition would be classified as *poor* or *acceptable* when using MUAC. This may result in a reduction in the number of feeding programs undertaken in emergencies or at least the use of different strategies to reach children. Agencies need to take this into consideration.

Although the evidence is strongly in favour of using MUAC for estimating prevalence and for admission to therapeutic feeding programs, more information is needed on the use of MUAC as a monitoring tool and for discharge. There is currently limited evidence to show that MUAC does respond to CTC programming[19]. More research and information is required on this topic. There may also be a need for more discussion on the choice of MUAC thresholds for admission to supplementary feeding programs. This discussion could be linked to an upcoming WHO meeting about the effectiveness of supplementary feeding programs.

19 Myatt M, Khara T, Collins S, A review of methods to detect cases of severely malnourished children in the community for their admission into community-based therapeutic care programs. FNB, 2006, 27:3, S7-S23

Recommendations

Mortality risk of excluded children

The switch to MUAC will result in a reduction in the overall estimates of the prevalence of malnutrition in short-trunked and long-legged populations. For example, there may be a drop in the prevalence of acute malnutrition from 20% to 7% in Somali region in Ethiopia despite the fact that the environment remains the same and the children's nutritional status will not actually have changed. Under the new regime, large numbers of children with < 80% W/H but a normal MUAC will be excluded from feeding programmes. We do not know what the extra risk of mortality is for these children compared to children with a W/H > 80% and a normal MUAC as the longitudinal studies assessing anthropometry and mortality did not include these types of populations. It is likely that agencies will be uncomfortable switching over to MUAC without knowing what the extra risk is for the children who are excluded from the programme.

Recommendation : Undertake a longitudinal study to assess the risk of morbidity and / or mortality in children classified as normal MUAC but low W/H in different ethnic groups.

Classification of the prevalence of malnutrition

Many emergencies previously classified as *critical* or *serious* by the WHO using the WHM (NCHS) case-definition would be re-classified as *poor* or *acceptable*. This may result in a reduction in the number of feeding programmes undertaken in emergencies or the use of different strategies to reach children.

Recommendation : Review the WHO classification of the severity of prevalence of malnutrition in a population using data from surveys with information on MUAC and mortality.

Confusion between MoH and NGO definitions of acute malnutrition

The WHO has just produced its new international standards for acute malnutrition based on W/H which it is encouraging national Governments to adopt. Confusion will arise between MoH clinics using W/H measurements and NGOs using MUAC measurements to diagnose acute malnutrition.

Recommendation : Negotiate with the WHO to replace W/H with MUAC to measure acute malnutrition in its roll-out of the new growth standards.

Historical Data

Recommendation : Whilst the work described above is undertaken, the authors of this report recommend that all agencies collect MUAC in their surveys and the SCN/NICS, CREN, UNICEF, WHO and any other agencies systematically record, report and compile data on MUAC so that trend data on MUAC can be compiled for different populations.