Global MUAC Cutoffs for Adults: A Technical Consultation

The U.S. Agency for International Development through the Food and Nutrition Technical Assistance III Project (FANTA), convened a technical consultation at FHI 360 in Washington, DC on February 12-13, 2018 to review the results of meta-analyses exploring whether standardized MUAC cutoffs can be used to identify acute undernutrition among adults, and to reach consensus on the possibility of recommending a global cutoff for identifying undernutrition in adults.

The objectives of the consultation were to:

- Review the results of the individual participant-level data meta-analysis (IPDMA) that explored the sensitivity and specificity of various MUAC cutoffs for identifying undernutrition among adults
- Achieve consensus on the possibility of recommending a single or a set of cutoffs
- Achieve consensus on the recommended settings, purpose, and use of the agreed-upon cutoff(s), or on the next steps needed to reach a recommended single or set of cutoffs.

Participants included researchers from Tufts University's School of Medicine who conducted the IPDMA, members of the Technical Advisory Group (TAG) who advised the work conducted thus far, other researchers who contributed their datasets to the analysis, stakeholders and experts from organizations with an interest and expertise in the assessment of adult nutritional status including USAID/OFDA, FHI 360's Alive & Thrive project, and Valid International. For a full list of participants, please see Appendix 1.

In 2011, recognizing that globally recognized cut-offs have not been established to classify acute malnutrition among adolescents and adults using MUAC, a group of partners that included the Food and Nutrition Technical Assistance Project (FANTA), National Institutes of Health (NIH), Tufts University, United States Agency of International (USAID) and the World Health Organization (WHO) initiated a collaborative research project. The objective of the research project was to assess and increase the evidence base for establishing standardized MUAC cut-offs for moderate and severe acute malnutrition among adolescents and adults. To achieve this objective, two main activities were undertaken: 1) a systematic review of the peer reviewed literature to compile and synthesize findings across studies that have examined the association of low MUAC with other measures of poor nutritional status or poor functional or clinical outcomes among adults and/or adolescents; and 2) a secondary data analysis to explore if standardized MUAC cut-offs can be used for identification of moderate and severe acute malnutrition among adolescents and adults.

At the February 2018 meeting, Tufts' Alice Tang, the PI for the two aforementioned activities, presented the findings of the research. She first shared the findings of the systematic review of the existing evidence on the use of MUAC as an indicator or predictor of nutrition- and health-related outcomes in adolescents, pregnant women, men and non-pregnant women, as well as in the elderly. Despite

significant associations between low MUAC (as defined by various cutoffs) and several adverse health outcomes—particularly among pregnant women—across studies there was insufficient evidence to draw firm conclusions about MUAC as an indicator of nutrition- or health-related outcomes. There were also too few diagnostic tests carried out across the studies to be able to recommend an optimum MUAC cutoff for any particular health outcome at the time of the review. Dr. Tang then presented the results of the IPDMA in the pregnant women population. This analysis found that it is difficult to recommend a single cutoff to identify pregnant women with undernutrition that would be suitable across geographic settings. Finally, Dr. Tang presented the findings of the IPDMA in the general adult population (men and non-pregnant women). In this population, the analysis found that MUAC cutoffs in the range of ≤23.0 cm to ≤25.5 cm could potentially serve as appropriate indicators for low BMI (<18.5).

The presentations were followed by a rich discussion that brought up several issues and around global MUAC cutoffs for the general adult population. These include:

- The suitability of BMI as a marker of undernutrition in adults to use as the gold standard against which to compare proposed MUAC cutoffs
- Concern about BMI and MUAC not being perfectly correlated: if there is severe infection, or in short term/acute malnutrition, MUAC decreases before BMI is affected, as peripheral tissues are catabolized while central stores and organs are protected as long as possible.
- The existence of better proposed functional indicators against which to compare MUAC such as: recent weight loss, muscle weakness, loss of muscle mass, grip strength, body composition (i.e. % fat vs lean mass), and ability to stand
- The suitability of using 18.5 as a cutoff for all settings and purposes when BMI is used as the comparator. For instance:
    - If the priority is to use MUAC as a first screening measure in order to definitely exclude those without malnutrition, a cutoff on the higher side might be desirable
    - If the priority is to be as inclusive as possible for identifying the severest cases of malnutrition, a cutoff on the lower side might be desirable
- The confounding of the relationship between MUAC and BMI by edema since the results of the IPDMA presented by the Tufts University researchers for the general adult population did not exclude participants with edema, since that information was not available in most datasets.
- The suitability of including the 18–20 year olds in an analysis of MUAC or BMI, as these young adults might still be undergoing some growth

Following the discussion, FANTA's Nutrition Research Technical Advisor, Zeina Maalouf-Manasseh, shared information on MUAC cutoffs for adult undernutrition currently used in 9 African countries for HIV care and management of malnutrition programs. The cutoffs for severe malnutrition used in non-pregnant adults range from 16.0 to 21.0 cm (the majority being in the 18.0-19.0 range) and for moderate malnutrition range from 18.0 to 23.0cm (with all but one in the 21.0-23.0 range). Countries have used various processes to choose their cutoffs, including using cutoffs recommended by neighboring countries and reviewing the literature for recommendations.

Further discussion followed regarding the pros and cons of recommending a single or a set of MUAC cutoffs for undernutrition in adults. There was a preference for a single or a set of two cutoffs (one for moderate undernutrition and the other for severe undernutrition) that would be used for all settings,

including clinical as well as epidemiological/surveillance settings. Based on the results shared by Tufts, some felt more comfortable, at this stage, to put forward a cutoff only as a proxy for BMI. After that there could be a decision tree or algorithms where additional indicators could be introduced to decide on specific services that will be offered to different groups, for example for infectious disease patients, pregnant women, etc. In addition, the issue of excluding lactating women (perhaps up to six months postpartum) was brought up.

More discussion continued on day 2 regarding the various settings in which MUAC cutoff would be used, and those included targeting adolescents, entry into urgent care, as well as diagnosis of malnutrition and monitoring of treatment. A short presentation by the Tufts researchers recapped the summary estimates from their IPDMA including the sensitivity, specificity, likelihood ratio positive and likelihood ratio negative of different MUAC cutoffs with respect to a BMI < 18.5. Some discussion of possible cutoffs to recommend raised the concerns mentioned earlier (especially the comparison with BMI, an imperfect marker of malnutrition), but also the question of whether wants to err on the conservative side, and over-identify (identify too many), or to be more restrictive and run the risk of under-identifying. In addition, the question of availability of resources for treatment was brought up. An agreement was reached to present some illustrative tables with interpretation of the presented numbers, as a guide/support to countries for a process they could use to come up with data-based cutoffs that would suit their needs (see Appendix 2).

In the closing deliberations, the group agreed to draft a viewpoint, to be submitted to a peer-reviewed journal alongside an article by the Tufts group, that outlines what there was consensus on at the consultation. The viewpoint would state that there was agreement that MUAC is an indicator for adult undernutrition. The viewpoint would also highlight that data gaps that did not allow the group to propose a cutoff. These include:

- Analysis of the predictive capability of MUAC cutoffs with regards to functional indicators of adult undernutrition. These could include: recent weight loss, muscle weakness, loss of muscle mass, grip strength, body composition (i.e. % fat vs lean mass), ability to stand
- Data for pregnant women, which is a population of interest for many programs addressing undernutrition in adults
- Data on the response to therapeutic nutrition when undernutrition was identified using MUAC

The group left encouraged by the momentum this consultation generated around global MUAC cutoffs for adults, and with the recommendation that this work move forward with the support of all involved stakeholders.

Appendix 1. Consultation Participants

First Name	Last Name	Affiliation
Kaushik	Bose	Vidyasagar University, WB, India
Jane	Badham	Consultant
Mei	Chung	Tufts University
Steve	Collins	Valid International
Jessica	Escobar-Alegria	Alive & Thrive/FHI 360
Lindy	Fenlason	USAID/GH
Zeina	Maalouf-Manasseh	FANTA/FHI 360
Erin	Milner	USAID/GH
Cecilie	Patsche	Aarhus University
Tim	Quick	USAID/OHA
Sandra	Remancus	FANTA/FHI360
Elisabeth	Sommerfelt	FANTA/FHI360
Alice	Tang	Tufts University
Mija	Ververs	CDC
Sonia	Walia	USAID/OFDA

Appendix 2. Interpretation of Measures of Diagnostic Accuracy

In considering the optimal MUAC cutoff for identifying undernutrition in adults, interested parties are encouraged to consider the sensitivity (SENS), specificity (SPEC), likelihood ratio positive (LR+), likelihood ratio negative (LR-), the rate of False Negatives (FN) and the rate of False Positives (FP) of various cutoffs with regards to the comparator, ideally, a functional outcome. In the illustrative tables below, MUAC cutoffs are compared to a BMI < 18.5. Definitions and guidelines for the optimal SENS, SPEC, LR+, LR-, FN and FP values are provided below. As noted below, in choosing the optimal cutoff, consideration should be given to the purpose/use of the cutoff, as well as the resources available for referral and treatment of identified undernutrition cases.

MUAC (cm)	SENS	SPEC	LR+	LR-
≤19.0	4.8 (2.1, 10.5)	99.8 (99.1, 99.9)	19.7 (5.0, 78.1)	0.95 (0.92, 0.99)
≤19.5	7.8 (4, 14.6)	99.7 (98.9, 99.9)	23.9 (8.5, 66.8)	0.92 (0.88, 0.97)
≤20.0	12.8 (7, 22.3)	99.6 (98.7, 99.9)	35.9 (12.1, 106.5)	0.88 (0.81, 0.95)
≤20.5	17.1 (10, 27.6)	99.4 (98.1, 99.8)	28.2 (11.1, 71.9)	0.83 (0.75, 0.92)
≤21.0	23.2 (13.7, 36.6)	99 (97.4, 99.6)	24.1 (11.6, 50.3)	0.78 (0.67, 0.89)
≤21.5	29.6 (17.8, 44.9)	98.5 (95.3, 99.5)	19.8 (8.1, 48.5)	0.72 (0.60, 0.86)
≤22.0	43.7 (26.4, 62.8)	96.6 (87.7, 99.1)	12.7 (4.8, 33.8)	0.58 (0.43, 0.79)
≤22.5	56.8 (32.5, 78.2)	95.2 (81.9, 98.9)	11.8 (4.3, 32.7)	0.45 (0.27, 0.75)
≤23.0	61.4 (41.4, 78.2)	94.3 (86.8, 97.7)	10.8 (5.8, 20.1)	0.41 (0.26, 0.64)
≤23.5	73.3 (56.8, 85.1)	90.5 (80.1, 95.8)	7.7 (4.1, 14.5)	0.30 (0.18, 0.47)
≤24.0	81.9 (73.4, 88.2)	85.6 (78.5, 90.6)	5.6 (3.2, 10.0)	0.21 (0.13, 0.33)
≤24.5	87.9 (78.6, 93.5)	80.2 (65.4, 89.6)	4.4 (2.6, 7.7)	0.15 (0.09, 0.25)
≤25.0	90.8 (84.5, 94.7)	77.4 (66.1, 85.7)	4.0 (2.7, 6.0)	0.12 (0.07, 0.19)
≤25.5	94.6 (89.7, 97.2)	71.3 (58.1, 81.7)	3.3 (2.2, 4.9)	0.08 (0.04, 0.14)
≤26.0	96.6 (92.5, 98.5)	63.5 (48.5, 76.2)	2.6 (1.8, 3.8)	0.05 (0.03, 0.11)
≤26.5	97.3 (94.1, 98.8)	56.1 (41.1, 70.1)	2.2 (1.6, 3.1)	0.05 (0.03, 0.09)

SENS is defined as the probability of having a MUAC ≤ cutoff given that BMI is <18.5.

SPEC is defined as the probability of having a MUAC > cutoff given that BMI is ≥18.5.

From the report of the IPDMA on MUAC cutoffs for adults: "For the context that is most likely to be useful for establishing a global MUAC cutoff for nonpregnant adults (screening and case detection in the community), a high SPEC (minimizing FP results) is proposed to be important; a high SPEC minimizes the number of people who are referred for further services who don't need it, which is especially prudent in settings where resources are limited. A MUAC cutoff with the highest SENS at or above a set minimum SPEC (e.g., 70%) might therefore be a reasonable starting point for selecting a MUAC cutoff."

LR+ = sensitivity / (1-specificity)

$$= \frac{\text{Probability of MUAC} \leq \text{cutoff in those with BMI} < 18.5}{\text{Probability of MUAC} \leq \text{cutoff in those with BMI} \geq 18.5}$$

LR- = (1-sensitivity) / specificity

= Probability of MUAC > cutoff in those with BMI <18.5
Probability of MUAC > cutoff in those with BMI ≥18.5

Some guidelines in choosing the optimal LR+ and LR- values:

LR+ :

- A LR > 10 indicates that the test result has a large effect on increasing the probability of disease presence
- LR 5-10 indicates the test has a moderate effect on increasing the probability of disease
- LR <5 indicates a small effect on increasing the probability of disease

Therefore, a greater LR+ is desirable

LR- :

- An LR of <0.1 indicates that the result has a large effect on decreasing the probability of disease presence
- LR 0.5-0.1 indicates that the test has a moderate effect on decreasing probability of disease
- LR >0.5 indicates a small effect on decreasing disease probability

Therefore, a lower LR- is desirable.

Also from the report of the IPDMA on MUAC cutoffs for adults: "the selection of the optimal MUAC cutoff for identifying … undernutrition in nonpregnant adults must take into consideration the tradeoff between referring too many individuals who are not in need of services to the health care system or program (higher FP rate) and not capturing the entire population in need of services (higher FN rate)". The table below presents the FN and FP values for all the studies included in the IPDMA, as well as for select subgroups, at different MUAC cutoffs.

MUAC cutoff	All studies		Low prevalence studies removed		Males		Females		HIV-negative		HIV-positive	
	FN[a]	FP[b]	FN	FP	FN	FP	FN	FP	FN	FP	FN	FP
≤ 23.0	39%	6%	31%	8%	48%	4%	30%	5%	57%	2%	30%	6%
≤ 23.5	27%	10%	21%	14%	38%	8%	20%	8%	43%	3%	---	---
≤ 24.0	18%	14%	14%	21%	27%	12%	16%	12%	32%	7%	15%	16%
≤ 24.5	12%	20%	7%	33%	19%	17%	10%	15%	24%	9%	11%	21%
≤ 25.0	9%	23%	6%	39%	14%	18%	7%	22%	19%	13%	9%	19%
≤ 25.5	5%	29%	3%	48%	8%	23%	5%	26%	5%	16%	4%	24%

FN = False negatives or proportion of individuals with low BMI that are missed using the MUAC cutoff

FP = False positives or proportion of individuals with normal to high BMI that are referred for further screening