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Determining a Global Mid-Upper Arm Circumference Cutoff to Assess Underweight in Adults (Men and Nonpregnant Women)

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THE SCIENCE OF IMPROVING LIVES

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Contents

Abbreviations and Acronyms

AIDS	acquired immunodeficiency syndrome
ART	antiretroviral therapy
AUROCC	area under the receiver operating characteristic curve
BMI	body mass index
CBO	community-based organization
CI	confidence interval
cm	centimeter(s)
CS-RUTF	chickpea sesame-based ready-to-use therapeutic food
FANTA	Food and Nutrition Technical Assistance III Project
FN	false negative
FP	false positive
HIV	human immunodeficiency virus
IDU	injection drug user
IMAI	Integrated Management of Adult Illness
IMCI	Integrated Management of Childhood Illness
IPDMA	individual participant data meta-analysis
kg	kilogram(s)
km	kilometer(s)
LBW	low birth weight
LMIC	low- and middle-income country
mg	milligram(s)
ml	milliliter(s)
MUAC	mid-upper arm circumference
NFHL	Nutrition for Healthy Living
NHTD	National Hospital of Tropical Diseases
NIH	National Institutes of Health

NPV	negative predictive value
PEPFAR	United States President's Emergency Plan for AIDS Relief
PPV	positive predictive value
PTB	pulmonary tuberculosis
ROC	receiver operating characteristic
SD	standard deviation
SENS	sensitivity
SPEC	specificity
TAG	technical advisory group
TB	tuberculosis
TN	true negative
TP	true positive
USAID	U.S. Agency for International Development
WFP	World Food Programme
WHO	World Health Organization

Executive Summary

Background. Numerous studies have shown that mid-upper arm circumference (MUAC) correlates well with body mass index (BMI) in adult populations. However, globally applicable MUAC cutoffs have not been established to classify undernutrition among adults. Increasingly, MUAC is being used to assess nutritional status and to determine eligibility for services among adults, especially in people living with HIV and/or tuberculosis. Many countries and programs have established their own MUAC cutoffs to determine eligibility for program services, but there is limited evidence supporting these cutoffs and it is not known whether the cutoffs are optimal.

Methods. Tufts University, a partner on the Food and Nutrition Technical Assistance III Project (FANTA) funded by the U.S. Agency for International Development (USAID), undertook an individual participant data meta-analysis (IPDMA) to explore the sensitivity (SENS) and specificity (SPEC) of various MUAC cutoffs for identifying undernutrition among adults (men and nonpregnant women), as defined by the primary outcome of low BMI (<18.5). Data were compiled from 17 studies of adults: 7 from Africa, 5 from South Asia (India), 2 from Southeast Asia (Vietnam), 2 from North America (USA), and 1 from South America (Argentina). For the dataset for each individual study, as well as for the combined dataset from all studies, measures of diagnostic accuracy (SENS, SPEC, positive predictive value [PPV], negative predictive value [NPV], area under the receiver operating characteristic curve [AUROCC], and the receiver operating characteristic [ROC] curve) were determined for every 0.5 cm across a range of MUAC values from 19.0 cm to 26.5 cm. The summary statistics used a bivariate random effects model to jointly estimate SENS and SPEC while accounting for the heterogeneity between studies. The models included MUAC as the only independent variable predicting low BMI. Various subgroup analyses we performed to determine how MUAC cutoffs might differ in different settings and subpopulations.

Results.[1] The number of participants in each study ranged from 182 (ZAM) to 4,926 (VIE-FEM). The mean age for all studies combined was 32.4±12.0 years, with ages ranging from 18 years to 91 years. More than two-thirds of participants in the combined dataset were female (69%). Five studies included HIV-positive participants only, five studies included both HIV-positive and HIV-negative participants, and HIV status was not ascertained in seven of the studies. The mean MUAC measurement varied between studies, ranging from 19.7 cm in MAL-HWW to 32.7 cm in SAF. Slightly more than a quarter (27%) of the participants had low BMI (<18.5). Prevalence of low BMI ranged from approximately 5% or less in six studies to almost 90% in two studies.

Measures of SENS, SPEC, PPV, and NPV for all MUAC cutoffs varied between individual studies, but MUAC was highly discriminatory in its ability to distinguish nonpregnant adults with BMI <18.5 from those with BMI ≥18.5. The AUROCCs ranged from 0.61 (ZAM) to 0.98 (USA-HIV), with the majority of values being greater than 0.90. The AUROCC for all of the datasets combined was 0.92, which is considered to be in the "excellent" range based on general interpretations for the AUROCC. Results of the meta-analysis showed that MUAC cutoffs in the range of ≤23.0 cm to ≤25.5 cm could potentially serve as appropriate indicators for low BMI, with acceptable levels of SENS and SPEC at each of these cutoffs for the purposes of screening for undernutrition in communities or clinics. Based on our analysis, we propose that a MUAC ≤24.0 cm meets the criteria for optimizing SENS and SPEC across various subpopulations when assessed against low BMI.

[1] See Table 1 for the full names of the individual studies.

Conclusions. The recommendation for a MUAC cutoff (or range of cutoffs) based on this IPDMA is only a first step toward determining a standardized and global MUAC cutoff for nonpregnant adults. Validation studies are needed to determine whether the proposed MUAC cutoff can be efficiently and effectively used as a screening tool for adult undernutrition. If found to be a valid and reliable nutrition screening tool, the use of MUAC in place of BMI in communities and clinics will reduce the amount of time and technical skill required for nutrition screening, resulting in a higher yield of individuals who would benefit from further nutrition assessment and intervention.

1. Background

Low body mass index (BMI), calculated as weight in kilograms divided by the square of height in meters, is often used as a tool for detecting undernutrition and predicting increased morbidity and mortality in clinics, programs, and communities worldwide. Low BMI has been associated with increased morbidity and mortality in clinical settings and recently in several large epidemiological studies (Aune et al. 2016, Global BMI Mortality Collaboration 2016, Whitlock et al. 2009, Sun et al. 2016, Roh et al. 2014, Kelly et al. 2010, World Health Organization [WHO] 2009). While height and weight appear to be simple, straightforward measures, the procurement and proper maintenance and calibration of stadiometers and weight scales is necessary, and the calculation of BMI requires literacy and numeracy skills. In many settings, it can be difficult to obtain any, much less accurate, height and weight measurements, particularly where resources are scarce and demands are high.

Mid-upper arm circumference (MUAC) is a measure of the circumference of the upper arm at the midpoint between the olecranon and acromion processes (Gibson 2005). Since the arm contains both subcutaneous fat and muscle, changes in MUAC can reflect a change in muscle mass, a change in subcutaneous fat, or both. In undernourished individuals who tend to have smaller amounts of subcutaneous fat, changes in MUAC are more likely to reflect changes in muscle mass (Gibson 2005). In these individuals, MUAC measurements can be useful as an indicator of protein-energy malnutrition or starvation, particularly when measurement of weight or height is not feasible (Gibson 2005, Ververs et al. 2013). The measurement of MUAC offers several advantages. It can be taken with a simple tape measure and does not require any calculations, tables, charts, or graphs. It also does not require highly trained personnel, nor does it require costly or delicate equipment. If cutoffs are used to indicate presence or risk of undernutrition, paper tape measures can be developed using color coding so assessments can be performed without the need for any numbers or calculations.

Numerous studies have shown that MUAC correlates well with BMI in adult populations and that people with low MUAC are significantly more likely to have low BMI (Ferro-Luzzi and James 1996, Bose et al. 2007, Chakraborty et al. 2009, Collins 1996). Yet globally recognized MUAC cutoffs have not been established to classify undernutrition among adults. Increasingly, MUAC is being used to assess nutritional status and to determine eligibility for services in people living with HIV and/or tuberculosis (Ververs et al. 2013, Bahwere et al. 2011, Tumilowicz 2010). Many countries and programs have established their own MUAC cutoffs to determine eligibility for program services (Republic of Namibia Ministry of Health and Social Services 2010, Federal Democratic Republic of Ethiopia Ministry of Health 2008, Republic of Zambia Ministry of Health 2011), but there is limited evidence supporting these cutoffs and it is not known whether the cutoffs are optimal.

Patient monitoring guidelines provided by WHO for country adaptation to support the Integrated Management of Adult Illness (IMAI) do not include MUAC, in part because there is no guidance about what MUAC cutoff should trigger further action. In contrast, monitoring forms for Integrated Management of Childhood Illness (IMCI) do include MUAC because WHO has recommended a MUAC cutoff of <11.5 cm as a screening tool for acute malnutrition for children 6–60 months of age (WHO/UNICEF 2009). This cutoff has become a globally accepted standard and is often used to determine eligibility for both facility- and community-based therapeutic feeding programs. Lack of a single, universally accepted, and widely accessible approach to diagnosing and documenting adult undernutrition has impeded accurate estimations of the human and financial burdens associated with the prevention and treatment of adult malnutrition (White et al. 2012). The establishment of standardized MUAC cutoffs as a screening tool for undernutrition among adults could help expand the reach of

community and treatment programs to identify those who are at increased risk of morbidity and mortality due to acute or chronic undernutrition. Global MUAC cutoffs for adults could also serve to strengthen and harmonize programming in IMAI, HIV, and broader community health and nutrition.

Tufts University, a partner on the Food and Nutrition Technical Assistance III Project (FANTA), funded by the U.S. Agency for International Development (USAID), embarked on a series of projects to explore the potential for developing global MUAC cutoffs for detecting undernutrition in adolescents and adults. The first step consisted of a systematic review assessing the associations between low MUAC and adverse health outcomes among pregnant and nonpregnant adolescents and adults. The systematic review found that, despite significant associations between low MUAC (as defined by various cutoffs) and several adverse health outcomes, there was insufficient evidence to recommend MUAC cutoffs based on the published literature (Tang et al. 2013). We then undertook individual participant data meta-analyses (IPDMAs) to explore the diagnostic accuracy of various MUAC cutoffs for identifying pregnant women at risk of undernutrition, defined as giving birth to a low birth weight (LBW) baby, and for identifying nonpregnant adults at risk of undernutrition, defined as BMI <18.5. In the pregnant women IPDMA, we found that MUAC did not discriminate well between pregnant women who were and who were not at risk of delivering a LBW baby and it was difficult to recommend a MUAC cutoff that would be suitable for use across all settings (Tang et al. 2016). Instead, it was recommended that countries and programs conduct a cost-benefit analysis before adopting a specific MUAC cutoff.

The current report presents the results of the IPDMA exploring the diagnostic accuracy of various MUAC cutoffs for identifying undernutrition among males and nonpregnant females, henceforth referred to as "nonpregnant adults." The four studies from our systematic review that examined the association between low MUAC and low BMI among nonpregnant adults uniformly found strong associations between the two measures, with statistically significant odds ratios ranging from 13.9 to 28.8. All four studies used a MUAC cutoff of 23 cm, although two studies included 23 cm in the low category (i.e., MUAC ≤23 cm) (Chakraborty et al. 2009, Bisai and Bose 2009), while the other two did not (i.e., MUAC <23 cm) (Ferro-Luzzi and James 1996, Gartner et al. 2001). In addition, Ferro-Luzzi and James (1996) analyzed a lower cutoff for women (<22 cm) and found an equally strong association with BMI <18.5 (odds ratio=21.2). Low MUAC was also associated with increased risks of adverse clinical outcomes, including mortality in HIV-infected patients (Liu et al. 2011, Oliveira et al. 2012, Gustafson et al. 2007) and the elderly (Wijnhoven et al. 2012, Allard et al. 2004), and morbidity in other populations (Chakraborty et al. 2009, Singla et al. 2010, Lemmer et al. 2011).

The decision to conduct meta-analyses using individual-level data rather than study-level (published) data was primarily dictated by the fact that most of the published studies did not examine or provide data on the sensitivity (SENS) or specificity (SPEC) of various MUAC cutoffs. These data could be easily obtained from any study that measured MUAC and BMI on a continuous scale. Therefore, conducting an IPDMA allowed us to fully explore the diagnostic accuracy of MUAC as an indicator of low BMI across a variety of studies and settings.

2. Methods

2.1 Technical Advisory Group

At the beginning of the IPDMA process, a technical advisory group (TAG) was assembled to provide us with expertise, guidance, and feedback at key milestones during the IPDMA process. The TAG members consisted of the researchers who contributed their datasets, as well as world-renowned experts in the fields of nutrition and health from USAID, WHO, the National Institutes of Health (NIH), and the World Food Programme (WFP). Members of the TAG provided us with feedback at the following milestones: during formation of the collaborative, during development of the data analysis plan, and during review of the draft report.

2.2 Data Ascertainment

To be eligible for the IPDMA, datasets had to include nonpregnant adults over the age of 18. In addition, investigators had to be willing to share participant-level data, the data had to be collected on or after the year 2000, and the datasets had to have a minimum sample size of 100. The following minimal set of variables was requested:

1. MUAC measurement *[continuous]*
2. Height and weight (or BMI) *[continuous]*
3. Sex
4. Age
5. If dataset included HIV-positive participants, HIV status *[positive/negative]*

We included six eligible datasets from our own research team (ARG, IND-IDU, NAM, USA-IDU, USA-HIV, and VIE-IDU[2]) and also contacted researchers from eligible studies involving nonpregnant adults that were included in our systematic review. Of the 13 studies conducted among unique datasets of nonpregnant adults that were included in our systematic review, three were not eligible for this IPDMA: one because it was conducted prior to 2000 (Ferro-Luzzi and James 1996) and two because their sample sizes were fewer than 100 (Lemmer et al. 2011, Gourlay et al. 2012). We attempted to contact researchers from the remaining 10 studies and ultimately received datasets from three of them (Chakraborty et al. 2009, Bisai and Bose 2009, Oliveira et al. 2012). One of these researchers provided two eligible datasets (GUI-HIV and GUI-TBC) and the other provided four eligible datasets (IND-FSD, IND-MSD, IND-ORA, and IND-UNI) from his research group. We then put out a call for datasets through our TAG and searched the literature for articles that included measures of MUAC and BMI as continuous variables (our systematic review included only studies that examined MUAC as a binary variable) or were published after the date of our systematic review. Through these methods, we were able to obtain five additional datasets (MAL-HNW, MAL-HWW, SAF, VIE-FEM, and ZAM). The first three of these datasets were from the same research group. Thus, the present report includes data from 17 unique datasets that included MUAC and BMI measurements among nonpregnant adults. **Table 1** provides a summary of the studies included in this IPDMA. Data from four studies (IND-UNI, MAL-HNW, NAM, and ZAM) were unpublished at the time this report was written.

[2] See Table 1 for the full names of the individual studies.

Table 1. Studies Included in the IPDMA

Study Abbreviation	Country	Year(s) of Study	Investigator (Reference)	Brief Study Description[a]	Sample Size[b]
ARG	Argentina	2005–2006	Tang (Sheehan et al. 2011)	HIV-positive and HIV-negative drug users in Buenos Aires, Argentina	205
GUI-HIV	Guinea-Bissau	2007–2009	Oliveira (Oliveira et al. 2012)	Antiretroviral therapy (ART)-naïve, HIV-infected patients in Guinea-Bissau	1,055
GUI-TBC	Guinea-Bissau	2014	Patsche (Patsche et al. 2017)	Healthy controls and household contacts of tuberculosis (TB) patients in Guinea-Bissau	769
IND-FSD	India	2006	Bose (Bose et al. 2007)	Female slum dwellers in Midnapore Town, West Bengal, India	333
IND-IDU	India	2007	Tang (Tang et al. 2011)	Current and former male injection drug users (IDUs) in Chennai, Tamil Nadu, India	374
IND-MSD	India	2003–2004	Chakraborty (Chakraborty et al. 2009)	Male slum dwellers in Kolkata, India	474
IND-ORA	India	2007	Chakraborty (Chakraborty et al. 2011)	Oraon men of Gumla District, Jharkhand, India	205
IND-UNI	India	2013–2014	Chakraborty[c]	University students in Midnapore Town, West Bengal, India	599
MAL-HNW	Malawi	2008–2010	Bahwere[c]	ART-naïve, HIV-infected adults without wasting in three districts of Malawi (Lilongwe,Mzuzu, and Kasungu)	329
MAL-HWW	Malawi	2006–2007	Bahwere (Save the Children and Valid International 2007)	ART-naïve, HIV-infected adults with wasting and MUAC <22.0 cm in Mangochi, Malawi	186
NAM	Namibia	2014	Hong[c]	Adults recruited from bar district in Windhoek, Namibia	407
SAF	South Africa	2002	Charlton (Charlton et al. 2005)	Free-living and institutionalized elderly black South Africans in Cape Town, South Africa	283
USA-HIV	USA	2001–2013	Wanke (Jacobson et al. 2010, Mangili et al. 2006)	HIV-infected adults in the Greater Boston area, United States	553
USA-IDU	USA	2005–2007	Tang (Tang et al. 2010)	Current and former IDUs in the United States in Boston, MA; Baltimore, MD; and Providence, RI	520
VIE-FEM	Vietnam	2011–2012	Nguyen (Nguyen et al. 2014)	Nonpregnant females of reproductive age in Thai Nguyen Province, Vietnam	4,926
VIE-IDU	Vietnam	2006–2008	Tang (Tang et al. 2011)	Current and former male IDUs in Hanoi, Vietnam	297
ZAM	Zambia	2009–2010	Bahwere[c]	HIV-infected adults with wasting in Lusaka, Zambia	182

[a] See Annex A for full study descriptions.
[b] This refers to the total number of observations with MUAC measurements. Missing values on individual variables (e.g., BMI) may slightly reduce the numbers for analysis. Total N=11,697.
[c] Study has not been published yet.

2.3 Statistical Analyses

2.3.1 Descriptive Statistics

All datasets were converted and analyzed using the Stata statistical software (StataCorp, College Station, TX, USA). Each dataset was assessed against published manuscripts or original research protocols to create an overview of the included patients and study procedures (**Annex A**). For each dataset, we performed data checks of all variables received. All variables were checked to ensure that units, categories, coding, and labels were consistent across studies, and equivalent variables were assigned the same variable names and labels across datasets. Individual investigators were contacted to confirm missing data, to check extreme or invalid values, and to obtain clarification of the study variables and procedures. For all studies, the primary outcome, low BMI, was defined as BMI <18.5.

To better understand the data from each individual study and the degree of potential heterogeneity between studies, basic descriptive statistics were calculated for each study. These variables included age, sex, level of education, HIV status, MUAC, height, weight, and BMI. The collection of information on level of education was not consistent across studies. Some studies asked for the number of years of schooling, while others collected the data in predetermined categories, which were not equivalent between studies. For the purposes of summarizing and comparing education levels across studies, we created three general categories: no education, education at or up to the primary school level (grades 1 to 8, 1–8 years of schooling, or less than high school), and education at or above the secondary school level (grades 9 to ≥12, ≥9 years of schooling, completion of high school or beyond).

Histograms of MUAC and BMI were constructed to determine the distribution of these measurements for each study separately and for all datasets combined. Scatterplots of BMI by MUAC were examined to determine the association between the two variables, for each study separately and for all datasets combined.

2.3.2 Measures of Diagnostic Accuracy

We examined MUAC cutoffs at every 0.5 cm, ranging from 19.0 cm to 26.5 cm. For each cutoff, we calculated a 2x2 table showing the cross-tabulation of BMI category (BMI <18.5 vs. BMI ≥18.5) and MUAC measurement (above or below a specified cutoff), as shown in **Table 2**.

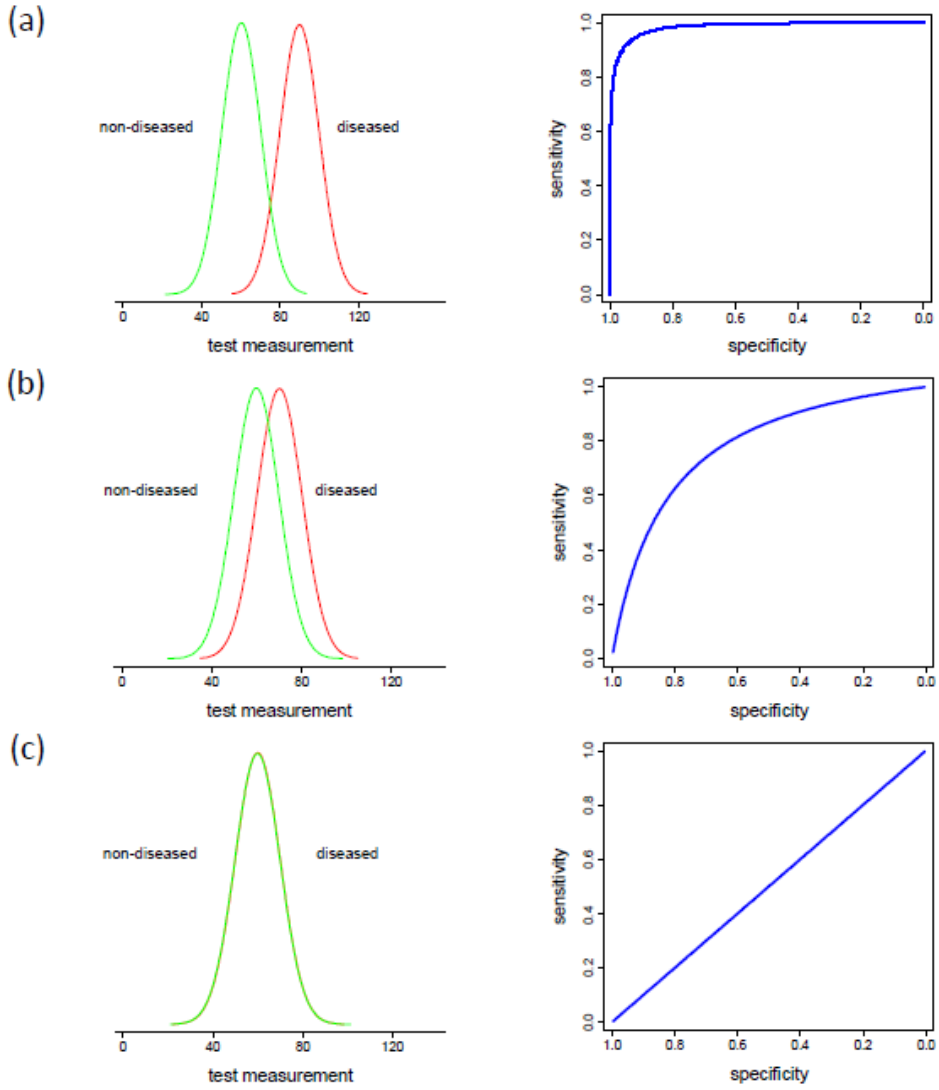
Table 2. 2x2 Cross-Tabulation of MUAC Measurement and Outcome Status

	Undernutrition (measured by BMI)		
Test Status (MUAC)	BMI <18.5	BMI ≥18.5	Total
MUAC ≤ cutoff	True positive (TP)	False positive (FP)	Total ≤ cutoff (TP + FP)
MUAC > cutoff	False negative (FN)	True negative (TN)	Total > cutoff (FN + TN)
	Total BMI <18.5 (TP + FN)	Total BMI ≥18.5 (FP + TN)	

From these data, the following measures were obtained (Macaskill et al. 2010):

- **SENS:** SENS is defined as the probability of having a MUAC ≤ cutoff given that BMI is <18.5. SENS is estimated using the numbers from Table 2 as TP ÷ (TP + FN).
- **SPEC:** SPEC is defined as the probability of having a MUAC > cutoff given that BMI is ≥18.5. SPEC is estimated using the numbers from Table 2 as TN ÷ (FP + TN).
- **Positive predictive value (PPV):** PPV is defined as the probability that an individual with MUAC ≤ cutoff will have a BMI that is <18.5. PPV is estimated using the numbers from Table 2 as TP ÷ (TP + FP). PPV depends on the prevalence of low BMI in the population. As the prevalence increases, PPV increases.
- **Negative predictive value (NPV):** NPV is defined as the probability that an individual with MUAC > cutoff will have a BMI ≥18.5. NPV is estimated using the numbers from Table 2 as TN ÷ (FN + TN). NPV also depends on the prevalence of low BMI in the population. As the prevalence increases, NPV decreases.
- **Receiver operating characteristic (ROC) curve:** The ROC curve is a graph of the values of SENS and SPEC that are obtained by varying the cutoff point across all possible values of MUAC. The graph plots SENS against (1 – SPEC). When a cutoff clearly discriminates between the distributions of MUAC among those with low BMI and those with normal to high BMI such that there is little or no overlap between the two (**Figure 1(a)**), the ROC curve will indicate that high SENS is achieved with a high SPEC and the curve approaches the upper left-hand corner of the graph where SENS is 1 and SPEC is 1. As the amount of overlap between the distributions increases, the curve approaches the straight upward diagonal of the square (**Figure 1(b)**). If the distribution of MUAC measurements among those with low BMI vs. normal to high BMI completely coincides, then MUAC would be completely uninformative and the ROC curve would be the upward diagonal of the square (**Figure 1(c)**).

Figure 1. Examples of ROC Curves (Macaskill et al. 2010)



- **Area under the receiver operating characteristic curve (AUROCC):** AUROCC is a single summary statistic that is used to compare cutoffs on the basis of their ROC curves. The AUROCC equals 1 for a perfect cutoff and 0.5 for a completely uninformative cutoff. The AUROCC can also be interpreted as an average SENS for the cutoff, taken over all SPEC values (or equally as the average SPEC over all SENS values).

We computed SENS, SPEC, PPV, NPV, ROC curves, and AUROCC over the range of MUAC cutoffs for each of the 17 datasets included in this IPDMA.

Next, we pooled together the data from all studies and created a unique participant ID number and a study identifier variable to identify participants within studies. We calculated an ROC curve and the AUROCC from the pooled dataset. We then estimated SENS and SPEC for the pooled dataset using a two-staged approach, where measures are estimated within each study in the first stage, and then the study-level data were combined across studies in the second stage. In this manner, summary measures of SENS and SPEC were obtained accounting for the clustering within studies. We used the user-written *`metandi`* command in Stata to obtain summary point estimates and 95% confidence intervals (CIs) of SENS and SPEC for each

MUAC cutoff value. This command performs a multivariate (or joint) meta-analysis of SENS and SPEC using a two-level mixed-effect logistic regression model. Within-study variability is accounted for at the first level when the counts of the 2x2 tables within each study are modeled. At the second level, the between-study variability (heterogeneity) is accounted for, allowing for the non-independence of SENS and SPEC across studies. For some instances when models would not converge in *metandi*, we used the newer user-written *midas* command. The *midas* command uses the same statistical methods as *metandi* to estimate SENS and SPEC, with a few additional options that allowed the models to converge.

2.4 Deciding on a MUAC Cutoff

We based our selection of an appropriate MUAC cutoff on the key properties proposed by Myatt et al. (2006) (shown in **Table 3**) that the selection of an appropriate indicator for case detection depends on the context in which the case detection is taking place (i.e., epidemiologic survey/surveillance, screening, and case detection in the community; case-finding in clinical contexts; and diagnosis in clinical contexts). The measurement of MUAC meets the criteria for several of these properties, including simplicity, acceptability, low cost, objectivity, and quantitativeness, all of which are important or critical for epidemiologic surveillance and community screening. 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 false positive [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.

Table 3. Relative Importance of Key Properties of Case Detection in Different Contexts[a]

	Context			
Property	Epidemiologic survey/surveillance	Screening and case detection in the community	Case-finding in clinical contexts	Diagnosis in clinical contexts
Simplicity	++++	++++	–	–
Acceptability	++++	+++	+	–
Cost	++++	++	–	–
Objectivity	++++	++++	++++	++++
Quantitativeness	++++	++++	–	–
Independence of age	++++	++++	–	–
Precision (reliability)	+ (individual) ++++ (group)	++	++++	++++
Accuracy	+ (individual) ++++ (group)	++	++++	++++
Sensitivity	+	++	+++	+++
Specificity	+	++++	++++	++++
Predictive value	+	++	++++	++++

[a] Scoring of importance: – irrelevant, + minor, ++ moderate, +++ major, ++++ crucial.
Source: Myatt et al. 2006. The table reproduces the original analysis of Sackett and Holland (1975), modified to include the properties identified by Beaton and Bengoa (1976) and Jelliffe and Jelliffe (1969).

3. Results

3.1 Descriptive Statistics

Table 4 presents participant characteristics by study. The number of participants in each study ranged from 182 (ZAM) to 4,926 (VIE-FEM). The VIE-FEM dataset was by far the largest, with nearly five times the number of participants as the second largest dataset (GUI-HIV, with n=1,055).

Overall, the mean age for all studies combined was 32.4±12.0 years, with ages ranging from 18 years to 91 years. The average age (in years) for each study was generally in the 30s, with a few exceptions. Two studies targeted slightly younger populations (mean age=22.1±1.6 years for IND-UNI [university students] and 26.4±4.5 years for VIE-FEM [women of childbearing age]), and two studies included slightly older participants (mean age=43.8±7.5 years for USA-IDU and 46.1±7.9 years for USA-HIV). One study (SAF) specifically targeted an elderly population and thus had a mean age of 71.5±7.9 years. Age distributions were approximately normally distributed, with slight left truncation in some studies (**Figure 2**).

More than two-thirds of participants in the pooled dataset were female (69%). Two studies (IND-FSD and VIE-FEM) included only female participants and four studies (IND-MSD, IND-ORA, IND-IDU, and VIE-IDU) included only male participants.

Six of the 17 studies did not collect data on education levels. Of the remaining 11 studies, education level differed widely between studies. Only one study (IND-FSD) included a majority of participants that had no schooling. Three studies (ARG, IND-IDU, and VIE-FEM) included a majority of participants with primary school education, and four studies (IND-UNI, NAM, USA-HIV, and VIE-IDU) included a majority with secondary school education or above.

HIV status was not ascertained in seven of the studies, as HIV was not the primary focus of these studies. Five studies (GUI-HIV, MAL-HNW, MAL-HWW, USA-HIV, and ZAM) included HIV-positive participants only. The remaining five studies (ARG, IND-IDU, NAM, USA-IDU, and VIE-IDU) included both HIV-positive and HIV-negative participants. One of these studies (NAM) did not offer HIV testing but included HIV status data based on participant self-report.

Table 4. Participant Characteristics, by Study and for All Studies Combined

Characteristic	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
N	205	1,055	769	599
Age (years)				
Mean±SD	31.0±7.1	37.5±10.9	33.1±13.8	22.1±1.6
(Min–Max)	(18.0–50.6)	(18.0–76.0)	(18.0–90.0)	(18.0–28.0)
Median (25th, 75th)	30.7 (25.5, 35.7)	36.0 (29.0, 45.0)	29.0 (22.0, 40.0)	22.0 (21.0, 23.0)
Sex				
Male	180 (87.8%)	313 (29.7%)	335 (43.6%)	228 (38.1%)
Female	25 (12.2%)	742 (70.3%)	434 (56.4%)	371 (61.9%)
Education				
None	8 (3.9%)	No data	101 (13.1%)	0 (0.0%)
Primary	160 (78.1%)		240 (31.2%)	0 (0.0%)
≥Secondary	37 (17.9%)		428 (55.7%)	599 (100.0%)
HIV-status				
HIV-positive	69 (33.7%)	1,055 (100.0%)	Not tested	Not tested
HIV-negative	136 (66.3%)	0 (0.0%)		
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
N	333	474	205	374
Age (years)				
Mean±SD	34.2±14.0	37.5±14.2	38.0±13.4	38.7±7.2
(Min–Max)	(18.0–80.0)	(18.0–84.0)	(18.0–70.0)	(22.0–61.0)
Median (25th, 75th)	30.0 (24.0, 40.0)	35.0 (26.0, 46.0)	37.0 (26.0, 46.0)	38.0 (33.0, 43.0)
Sex				
Male	0 (0.0%)	474 (100.0%)	205 (100.0%)	374 (100.0%)
Female	333 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Education				
None	196 (58.9%)	136 (28.7%)	No data	85 (22.7%)
Primary	128 (38.4%)	148 (31.2%)		222 (59.4%)
≥Secondary	9 (2.7%)	190 (40.1%)		67 (17.9%)
HIV-status				
HIV-positive	Not tested	Not tested	Not tested	178 (47.6%)
HIV-negative				196 (52.4%)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
N	186	329	407	283
Age (years)				
Mean±SD	34.1±9.0[a]	33.9±8.1[a]	29.9±9.7	71.5±7.9[a]
(Min–Max)	(18.0–58.0)	(18.0–57.0)	(18.0–74.0)	(60.0–91.0)
Median (25th, 75th)	33.0 (28.0, 38.0)	33.0 (28.0, 38.0)	27.0 (23.0, 35.0)	70.0 (65.0, 77.0)
Sex				
Male	56 (30.1%)	122 (37.2%)[b]	236 (58.0%)	53 (18.7%)
Female	130 (69.9%)	206 (62.8%)	171 (42.0%)	230 (81.3%)
Education				
None	No data	No data	36 (8.8%)[c]	No data
Primary			39 (9.6%)	
≥Secondary			331 (81.5%)	
HIV-status				
HIV-positive	186 (100.0%)	329 (100.0%)	73 (17.9%)[e]	Not tested
HIV-negative	0 (0.0%)	0 (0.0%)	334 (82.1%)	

Characteristic	Study			
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
N	520	553	4,926	297
Age (years)				
Mean±SD	43.8±7.5[a]	46.1±7.9	26.4±4.5[a]	31.3±5.2[a]
(Min–Max)	(22.0–67.8)	(24.1–75.4)	(18.0–44.7)	(18.5–47.9)
Median (25th, 75th)	44.2 (39.0, 49.1)	45.5 (40.5, 50.9)	25.9 (22.9, 29.2)	31.0 (27.8, 34.3)
Sex				
Male	335 (64.4%)	372 (67.3%)	0 (0.0%)	297 (100.0%)
Female	185 (35.6%)	181 (32.7%)	4,926 (100.0%)	0 (0.0%)
Education				
None	187 (36.2%)[c,d]	0 (0.0%)	404 (8.2%)[c]	1 (0.3%)[c]
Primary	206 (39.9%)	6 (1.1%)	2,685 (54.7%)	3 (1.0%)
≥Secondary	123 (23.8%)	547 (98.9%)	1,239 (37.1%)	293 (98.7%)
HIV-status				
HIV-positive	284 (54.6%)	553 (100.0%)	Not tested	201 (68%)[e]
HIV-negative	236 (45.4%)	0 (0.0%)		96 (32%)
	ZAM	**Combined[f]**		
N	182	11,697		
Age (years)				
Mean±SD	33.2±7.7	32.4±12.0		
(Min–Max)	(20.0–49.0)	(18.0–91.0)		
Median (25th, 75th)	33.0 (27.0, 38.0)	28.8 (24.0, 38.0)		
Sex				
Male	91 (50.0%)	3,671 (31.4%)		
Female	91 (50.0%)	8,025 (68.6%)		
Education				
None	No data	1,154 (13.0%)		
Primary		3,837 (43.3%)		
≥Secondary		3,863 (43.6%)		
HIV-status				
HIV-positive	182 (100.0%)	3,110 (75.7%)		
HIV-negative	0 (0.0%)	998 (24.3%)		

[a] Number of participants missing data on age: MAL-HWW (n=1), MAL-HNW (n=4), SAF (n=5), USA-IDU (n=9), VIE-FEM (n=23), VIE-IDU (n=1).
[b] Number of participants missing data on sex: MAL-HNW (n=1).
[c] Number of participants missing data on education: NAM (n=1), USA-IDU (n=4), VIE-FEM (n=2), VIE-IDU (n=1).
[d] For USA-IDA, categories are < High School, Some High School, >High School.
[e] For NAM, HIV status based on self-report; for VIE-IDU, n=1 missing data on HIV status.
[f] Statistics for the combined datasets for the education and HIV-status characteristics exclude studies that did not collect data on these variables.

Figure 2. Age Distributions, by Study and for All Studies Combined

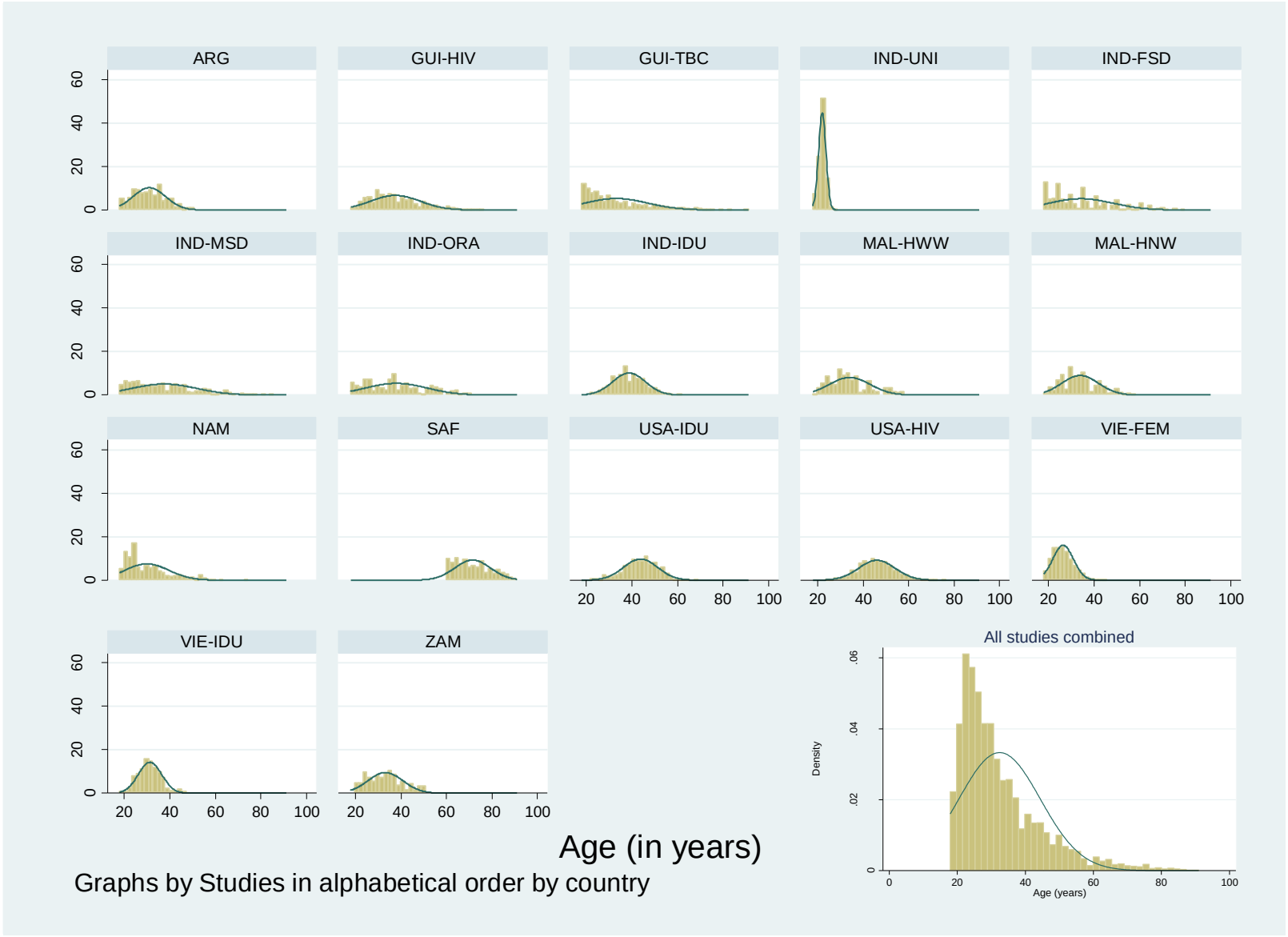


Table 5 shows MUAC measures by study. MUAC measurements ranged from a low of 11.6 cm in GUI-HIV to a high of 57.0 cm in USA-HIV. The mean MUAC measurement varied between studies, ranging from 19.7 cm in MAL-HWW to 32.7 cm in SAF. In all studies, MUAC measurements were approximately normally distributed, as displayed in **Figure 3.** When data from all studies were combined (**Figure 3 inset**), there was a predominance of MUAC values in the 22.0–26.0 cm range. MUAC was measured to the nearest tenth of a centimeter in all studies, with the exception of GUI-TBC where MUAC was measured to the nearest 0.2 cm.

Table 5. MUAC Measurements (in cm), by Study and for All Studies Combined

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
N	205	1,055	769	599
Min–Max	21.3–48.0	11.6–42.2	20.2–47.2	14.3–43.7
Mean (SD)	28.7 (3.6)	26.0 (4.4)	29.9 (4.3)	25.2 (3.3)
Median (25th, 75th)	28.0 (26.5, 31.0)	25.6 (23.2, 28.6)	29.0 (27.0, 32.2)	24.8 (23.0, 26.6)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
N	333	474	205	374
Min–Max	14.5–37.1	13.6–39.4	14.4–27.6	13.1–39.8
Mean (SD)	22.7 (3.2)	25.0 (2.9)	23.5 (2.0)	24.4 (3.3)
Median (25th, 75th)	22.1 (20.5, 24.4)	25.0 (23.2, 26.6)	23.5 (22.5, 24.7)	24.0 (22.2, 26.2)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
N	186	329	407	283
Min–Max	14.0–23.0	22.4–36.6	17.0–42.0	18.4–55.6
Mean (SD)	19.7 (1.8)	26.9 (2.6)	27.8 (3.6)	32.7 (6.4)
Median (25th, 75th)	20.2 (18.8, 21.0)	26.4 (25.0, 28.0)	27.4 (25.3, 29.7)	32.0 (28.3, 37.1)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
N	520	553	4,926	297
Min–Max	17.6–50.0	20.3–57.0	16.0–40.0	17.5–34.7
Mean (SD)	31.5 (4.9)	31.8 (5.1)	24.5 (2.3)	25.6 (2.6)
Median (25th, 75th)	31.4 (28.0, 34.5)	31.5 (28.8, 34.5)	24.3 (23.0, 25.8)	25.4 (23.8, 27.0)
	ZAM	**Combined**		
N	182	11,697		
Min–Max	13.3–25.0	11.6–57.0		
Mean (SD)	20.6 (1.5)	26.0 (4.4)		
Median (25th, 75th)	21.0 (20.0, 21.7)	25.1 (23.2, 27.9)		

Figure 3. Histograms of MUAC Measurements, by Study and for All Studies Combined

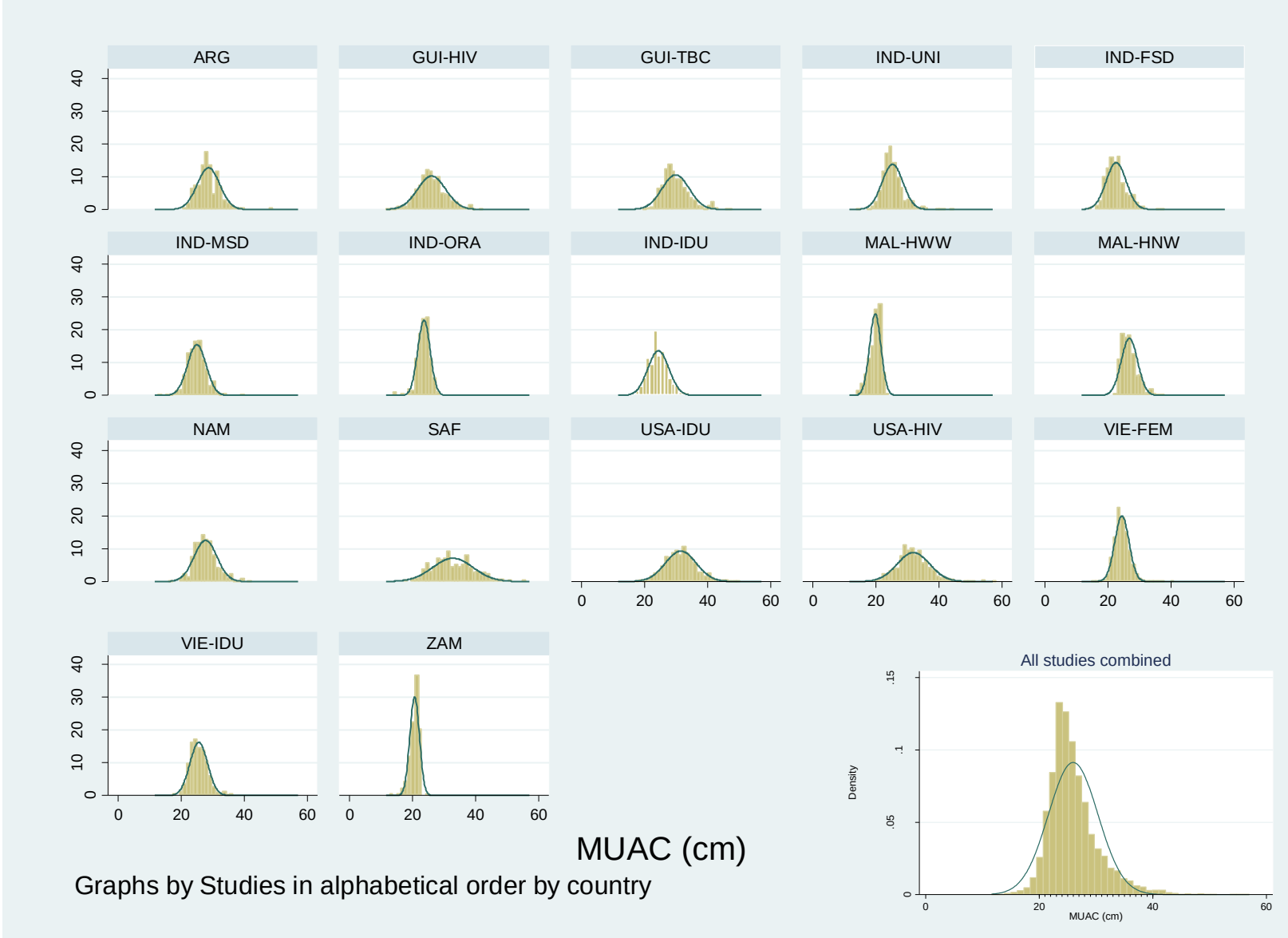


Table 6 presents height, weight, and BMI measurements for each study separately and for the combined dataset. The average height for all studies combined was 158.9±9.7 cm, with mean heights in individual studies ranging from a low of 148.2±6.3 cm (IND-FSD) to a high of 170.9±7.8 cm (ARG). The average weight for all studies combined was 53.6±14.8 kg, with mean weights in individual studies ranging from 41.3±6.3 kg (MAL-HWW) to 79.8±18.9 kg (USA-IDU).

Overall, slightly more than a quarter (27.3%) of the participants had low BMI (<18.5). Prevalence of low BMI ranged from approximately 5% or less in six studies (ARG, GUI-TBC, MAL-HNW, SAF, USA-IDU, and USA-HIV) to almost 90% in two studies (MAL-HWW and ZAM). The majority of studies included participants with BMI measurements in the normal range (18.5 to <25.0). Some studies (SAF, USA-IDU, and USA-HIV) included a majority of participants in the overweight or obese range (BMI ≥25), while several others (IND-ORA, IND-IDU, MAL-HWW, VIE-FEM, VIE-IDU, and ZAM) included few to no participants in these two categories. The distribution of BMI appeared to be approximately normal in the individual studies (**Figure 4**), but slightly right skewed in the combined dataset, with a predominance of values in the normal BMI range (**Figure 4 inset**).

Figure 5 shows the scatterplots of BMI by MUAC for each study separately and combined (**Figure 5 inset**). Correlations between BMI and MUAC were strong and statistically significant for all studies, ranging from 0.45 (IND-ORA) to 0.89 (SAF). Twelve of the 17 studies had correlation coefficients above 0.80. For the pooled dataset, the correlation coefficient was 0.87 (p<.00001).

Table 6. Height, Weight, and BMI Measurements, by Study and for All Studies Combined

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
N	205	1,055	769	599
Height (cm)				
Mean±SD	170.9±7.8	163.4±8.4[a]	165.1±9.3	158.7±8.0
Range	142.5–187.5	112.0–196.0	143.0–192.0	128.5–185.9
Median (25th, 75th)	171.0 (166.0, 176.4)	162.0 (158.0, 168.0)	164.0 (158.0, 172.0)	157.6 (152.7, 164.5)
Weight (kg)				
Mean±SD	70.3±12.9	54.1±12.1[b]	67.2±13.4	55.4±10.5
Range	46.5–146.0	27.3–117.0	35.0–137.0	21.0–93.0
Median (25th, 75th)	69.0 (61.5, 76.5)	52.7 (45.5, 60.4)	66.0 (58.0, 75.0)	54.0 (48.0, 62.0)
BMI (kg/m^2)				
Mean±SD	24.0±3.8	20.3±4.3	24.7±4.8	22.0±3.7
Range	17.6–45.8	11.3–45.7	16.2–50.9	8.5–38.6
Median (25th, 75th)	23.5 (21.3, 25.4)	19.7 (17.4, 22.4)	23.6 (21.5, 27.2)	21.5 (19.5, 23.8)
BMI categories				
<18.5	3 (1.5%)	391 (37.4%)	31 (4.0%)	90 (15.0%)
18.5 to <25.0	141 (68.8%)	532 (50.8%)	444 (58.0%)	406 (67.8%)
25.0 to <30.0	45 (22.0%)	91 (8.7%)	188 (24.5%)	78 (13.0%)
≥30.0	16 (7.8%)	32 (3.1%)	103 (13.4%)	25 (4.2%)

	Study			
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
N	333	474	205	374
Height (cm)				
Mean±SD	148.2±6.3	161.5±6.2	161.8±6.3	163.7±6.3
Range	132.0–171.0	142.8–189.3	140.3–180.6	133.2–183.2
Median (25th, 75th)	148.0 (144.3, 152.0)	161.4 (157.4, 165.2)	161.4 (158.1, 165.8)	163.4 (159.7, 167.9)
Weight (kg)				
Mean±SD	43.2±8.8	53.0±9.5	47.3±5.3	50.3±9.2[b]
Range	25.5–75.0	30.1–92.0	34.9–65.0	30.8–85.4
Median (25th, 75th)	41.5 (37.0, 48.0)	51.9 (46.4, 58.5)	46.2 (43.8, 50.4)	49.3 (43.7, 54.9)
BMI (kg/m^2)				
Mean±SD	19.6±3.7	20.3±3.3	18.0±1.6	18.7±3.0
Range	12.7–32.9	11.6–33.5	15.3–25.0	12.8–31.3
Median (25th, 75th)	18.8 (16.9, 21.8)	19.7 (17.9, 22.2)	17.8 (17.0, 19.0)	18.4 (16.7, 20.2)
BMI categories				
<18.5	153 (45.9%)	156 (32.9%)	133 (64.9%)	198 (53.2%)
18.5 to <25.0	154 (46.2%)	280 (59.1%)	72 (35.1%)	157 (42.2%)
25.0 to <30.0	21 (6.3%)	33 (7%)	0 (0.0%)	16 (4.3%)
≥30.0	5 (1.5%)	5 (1.1%)	0 (0.0%)	1 (0.3%)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
N	186	329	407	283
Height (cm)				
Mean±SD	158.6±7.6[a]	160.0±8.3	167.8±8.3	Not in dataset
Range	139.0–181.0	135.2–185.5	141.4–195.3	
Median (25th, 75th)	158.0 (152.0, 163.0)	159.0 (155.0, 166.0)	167.8 (162.7, 172.5)	
Weight (kg)				
Mean±SD	41.3±6.3[b]	58.4±9.7	65.0±15.4	Not in dataset
Range	27.0–62.0	39.0–102.0	40.0–167.0	
Median (25th, 75th)	40.0 (37.0, 45.0)	57.1 (52.1, 62.9)	62.5 (55.4, 70.1)	
BMI (kg/m^2)				
Mean±SD	16.4±1.9	22.7±3.3	23.0±5.1	31.4±8.2
Range	11.1–23.1	18.1–41.4	13.8–62.2	14.1–59.4
Median (25th, 75th)	16.4 (15.2, 17.6)	22.0 (20.5, 23.8)	22.0 (20.2, 24.8)	30.8 (25.5, 36.6)
BMI categories				
<18.5	161 (89.0%)	1 (0.3%)	35 (8.7%)	15 (5.4%)
18.5 to <25.0	20 (11.0%)	268 (81.5%)	279 (69.1%)	50 (17.9%)
25.0 to <30.0	0 (0.0%)	52 (15.8%)	63 (15.6%)	60 (21.5%)
≥30.0	0 (0.0%)	8 (2.4%)	27 (6.7%)	154 (55.2%)

	Study			
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
N	520	553	4,926	297
Height (cm)				
Mean±SD	169.9±8.7[a]	170.6±9.2[a]	152.5±5.2[a]	166.6±5.6
Range	144.1–196.0	142.3–191.0	132.8–173.0	150.5–196.2
Median (25th, 75th)	170.2 (163.9, 176.1)	171.5 (164.6, 177.3)	152.4 (149.0, 155.9)	166.8 (163.0, 170.0)
Weight (kg)				
Mean±SD	79.8±18.9	772. ±16.9	45.6±5.5	56.2±7.7
Range	35.4–156.5	36.6–169.5	29.9–74.1	39.2–87.5
Median (25th, 75th)	771. (66.3, 90.9)	75.6 (66.0, 86.6)	45.0 (41.8, 48.8)	55.6 (51.0, 60.5)
BMI (kg/m^2)				
Mean±SD	27.7±6.5	26.5±5.7	19.6±2.0	20.2±2.4
Range	15.2–61.5	15.3–57.1	14.5–32.6	13.5–29.5
Median (25th, 75th)	26.4 (23.3, 30.7)	25.5 (22.7, 29.3)	19.4 (18.2, 20.7)	20.0 (18.4, 21.4)
BMI categories				
<18.5	18 (3.5%)	17 (3.1%)	1,546 (31.4%)	78 (26.3%)
18.5 to <25.0	176 (33.9%)	233 (42.1%)	3,296 (67.0%)	206 (69.4%)
25.0 to <30.0	177 (34.1%)	185 (33.5%)	79 (1.6%)	13 (4.4%)
≥30.0	148 (28.5%)	118 (21.3%)	3 (0.1%)	0 (0.0%)

	ZAM	**Combined[f]**
N	182	11,697
Height (cm)		
Mean±SD	164.4±8.6	158.9±9.7
Range	140.0–189.0	112.0–196.2
Median (25th, 75th)	163.0 (158.0, 170.0)	157.2 (151.8, 165.0)
Weight (kg)		
Mean±SD	45.6±5.9	53.6±14.8
Range	30.7–60.6	21.0–169.5
Median (25th, 75th)	45.0 (41.1, 50.0)	49.5 (43.7, 59.5)
BMI (kg/m^2)		
Mean±SD	16.9±1.6	21.3±4.8
Range	10.7–22.2	8.5–62.2
Median (25th, 75th)	16.9 (16.0, 17.7)	20.1 (18.3, 22.8)
BMI categories		
<18.5	162 (89.0%)	3,188 (27.3%)
18.5 to <25.0	20 (11.0%)	6,733 (57.7%)
25.0 to <30.0	0 (0.0%)	1,101 (9.4%)
≥30.0	0 (0.0%)	645 (5.5%)

[a] Number of participants missing data on height: GUI-HIV (n=8), GUI-TBC (n=2), MAL-HWW (n=5), NAM (n=2), USA-IDU (n=1), USA-HIV (n=1), VIE-FEM (n=2).

[b] Number of participants missing data on weight: GUI-HIV (n=2), GUI-TBC (n=2), IND-IDU (n=2), MAL-HWW (n=2), VIE-FEM (n=2).

Figure 4. Histograms of BMI Measurements, by Study and for All Studies Combined

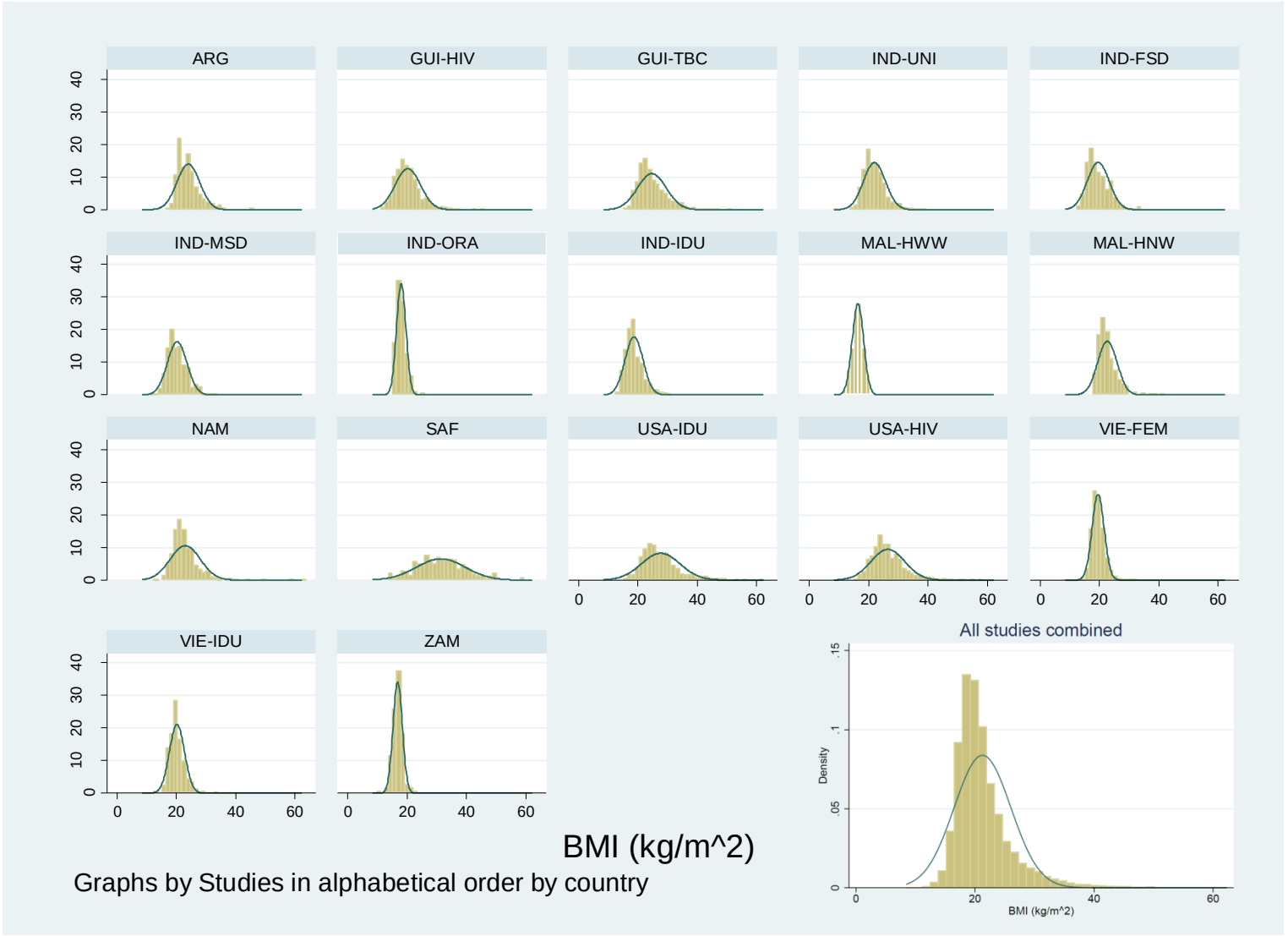
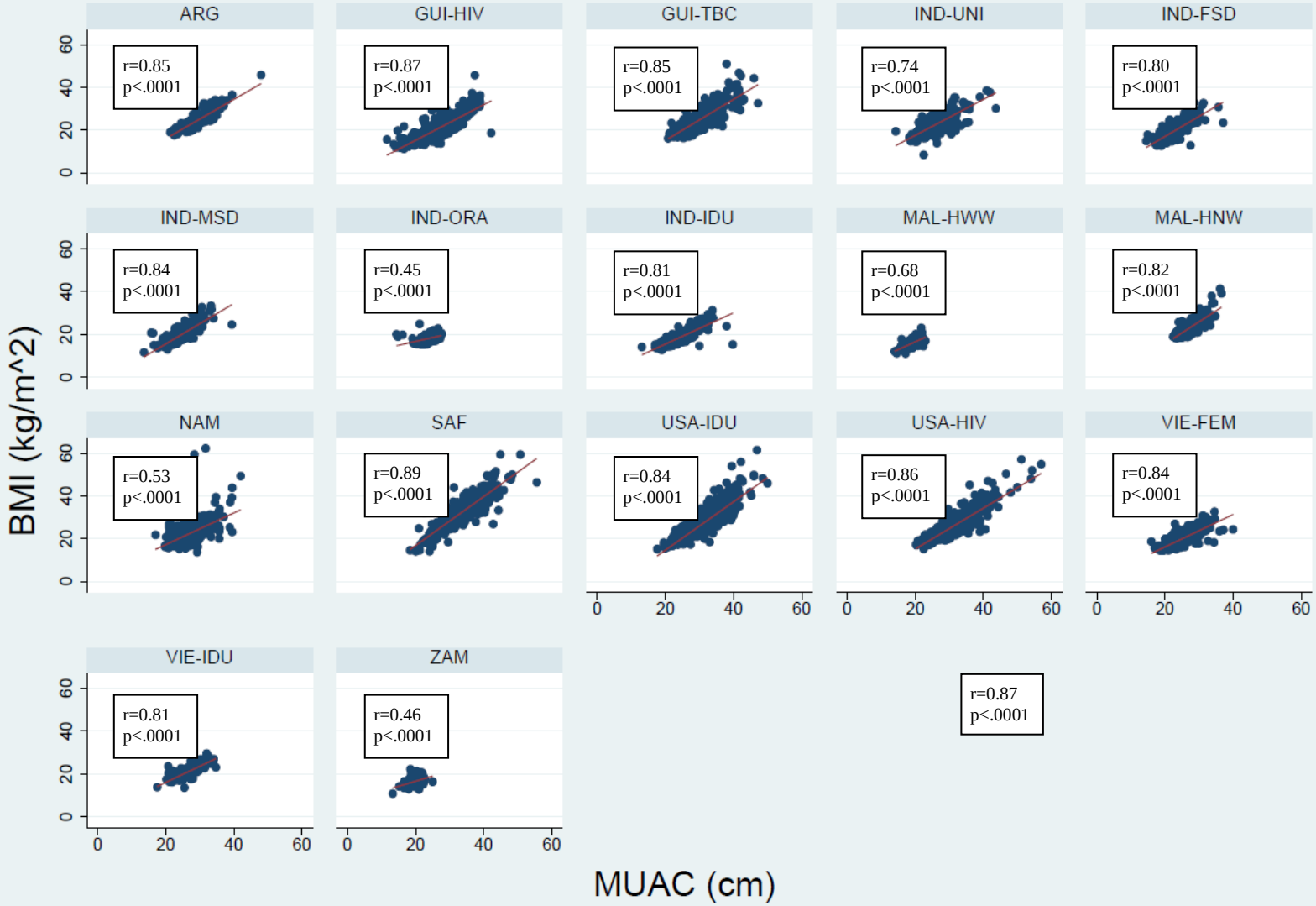


Figure 5. Scatterplots of BMI by MUAC, by Study and for All Studies Combined



3.2 Measures of Diagnostic Accuracy

Figure 6 shows the ROC curves and AUROCCs separately by study, and for all studies combined. **Tables 7–22** compare SENS, SPEC, PPV, and NPV across studies for each MUAC cutoff from 19.0 cm to 26.0 cm, in increments of 0.5 cm. **Annex B** shows the corresponding forest plots for SENS and SPEC across the range of MUAC cutoffs. **Annex C** then presents tables of SENS, SPEC, PPV, and NPV over the range of cutoffs for each individual study separately. In the tables, MUAC cutoffs with fewer than 10 individuals in any cell of the 2x2 table (cross-tabulation of MUAC cutoff by low BMI outcome) are grayed out due to reduced reliability of the estimate.

With the exception of one study (ZAM), the ROC curves show clear discrimination between the distributions of MUAC measurements among those with low BMI compared to those with normal to high BMI. The ROC curves all approach the upper left-hand corner of the graph, indicating high SENS is achieved with high SPEC. The AUROCCs range from 0.61 (ZAM) to 0.98 (ARG and USA-HIV), with the majority of values being greater than 0.90. The AUROCC for all of the data combined is 0.92, again indicating that, overall, MUAC is able to successfully discriminate between those with BMI <18.5 and those with BMI ≥18.5. Stated another way, if two adults were selected at random—one with low BMI and the other with BMI ≥18.5—there would be a 92% probability that the person with low BMI would have a lower MUAC than the person with a BMI that is not low.

As shown in the tables, values of SENS, SPEC, PPV, and NPV at each MUAC cutoff varied widely between studies. For example, at a MUAC cutoff of ≤22.5 cm, SENS varied from 0.0% (MAL-HNW) to 98.8% (ZAM), SPEC varied from 0.0% (MAL-HWW) to 99.7% (MAL-HNW), PPV varied from 0.0% (MAL-HNW) to 96.6% (GUI-HIV), and NPV varied from 0.0% (MAL-HWW and ZAM) to 99.0% (ARG).

Figure 6. ROC Curves and AUROCC, by Study and for All Studies Combined

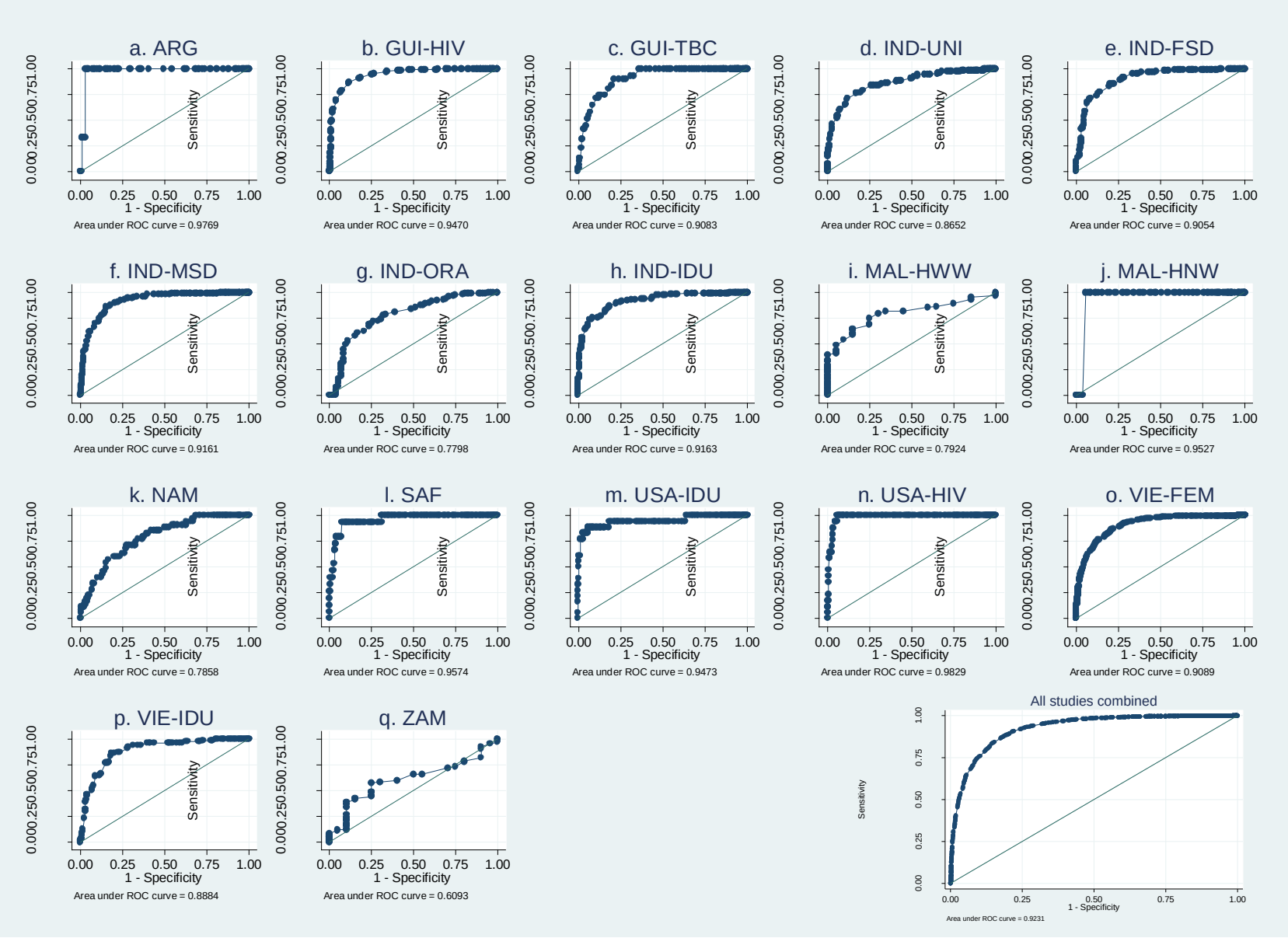


Table 7. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 19.0 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	--- (---, ---)[a]	13.0 (9.9, 16.8)	2.1 (0.1, 11.1)	4.4 (1.2, 11.0)
SPEC	--- (---, ---)	99.7 (98.9, 100.0)	100.0 (99.6, 100.0)	99.8 (98.9, 100.0)
PPV	--- (---, ---)	96.2 (87.0, 99.5)	100.0 (2.5, 100.0)	80 (28.4, 99.5)
NPV	--- (---, ---)	65.7 (62.7, 68.7)	94.6 (92.9, 96.0)	85.5 (82.4, 88.3)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	20.9 (14.8, 28.2)	5.8 (2.7, 10.7)	0.0 (0.0, 2.7)	7.1 (3.9, 11.6)
SPEC	98.3 (95.2, 99.7)	99.4 (97.7, 99.9)	95.8 (88.3, 99.1)	100.0 (97.9, 100.0)
PPV	91.4 (76.9, 98.2)	81.8 (48.2, 97.7)	0.0 (0.0, 70.8)	100.0 (76.8, 100.0)
NPV	59.4 (53.6, 65.0)	68.3 (63.8, 72.5)	34.2 (27.6, 41.1)	48.6 (43.3, 53.9)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	32.9 (25.7, 40.8)	--- (---, ---)	0.0 (0.0, 10.0)	6.7 (0.2, 31.9)
SPEC	100.0 (83.2, 100.0)	--- (---, ---)	99.7 (98.5, 100.0)	100.0 (98.6, 100.0)
PPV	100.0 (93.3, 100.0)	--- (---, ---)	0.0 (0.0, 97.5)	100.0 (2.5, 100.0)
NPV	15.6 (9.8, 23.1)	--- (---, ---)	91.3 (88.1, 93.9)	95 (91.7, 97.2)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	5.6 (0.1, 27.3)	--- (---, ---)	0.8 (0.4, 1.3)	1.3 (0, 6.9)
SPEC	100.0 (99.3, 100.0	--- (---, ---)	100.0 (99.8, 100.0)	100.0 (98.3, 100.0)
PPV	100.0 (2.5, 100.0)	--- (---, ---)	92.3 (64.0, 99.8)	100.0 (2.5, 100.0)
NPV	96.7 (94.8, 98.1)	--- (---, ---)	68.8 (67.4, 70.1)	74.0 (68.6, 78.9)
	ZAM			
SENS	16.0 (10.8, 22.6)			
SPEC	90.0 (68.3, 98.8)			
PPV	92.9 (76.5, 99.1)			
NPV	11.7 (7.1, 17.8)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 8. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 19.5 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	--- (---, ---)[a]	14.1 (10.8, 17.9)	2.1 (0.1, 11.1)	7.8 (3.2, 15.4)
SPEC	--- (---, ---)	99.7 (98.9, 100.0)	100.0 (99.6, 100.0)	99.8 (98.9, 100.0)
PPV	--- (---, ---)	96.5 (87.9, 99.6)	100.0 (2.5, 100.0)	87.5 (47.3, 99.7)
NPV	--- (---, ---)	66.0 (62.9, 68.9)	94.6 (92.9, 96.0)	86.0 (82.9, 88.7)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	28.1 (21.1, 35.9)	7.7 (4.0, 13.1)	3.0 (0.8, 7.5)	9.1 (5.5, 14.0)
SPEC	97.2 (93.6, 99.1)	99.4 (97.7, 99.9)	95.8 (88.3, 99.1)	100.0 (97.9, 100.0)
PPV	89.6 (77.3, 96.5)	85.7 (57.2, 98.2)	57.1 (18.4, 90.1)	100.0 (81.5, 100.0)
NPV	61.4 (55.5, 67.1)	68.7 (64.2, 72.9)	34.8 (28.2, 41.9)	49.2 (43.8, 54.5)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	41.6 (33.9, 49.6)	--- (---, ---)	0.0 (0.0, 10.0)	6.7 (0.2, 31.9)
SPEC	95.0 (75.1, 99.9)	--- (---, ---)	99.7 (98.5, 100.0)	100.0 (98.6, 100.0)
PPV	98.5 (92.1, 100.0)	--- (---, ---)	0.0 (0.0, 97.5)	100.0 (2.5, 100.0)
NPV	16.8 (10.4, 25.0)	--- (---, ---)	91.3 (88.1, 93.9)	95.0 (91.7, 97.2)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	16.7 (3.6, 41.4)	--- (---, ---)	1.5 (0.9, 2.2)	1.3 (0.0, 6.9)
SPEC	100.0 (99.3, 100.0)	--- (---, ---)	100.0 (99.8, 100.0)	100.0 (98.3, 100.0)
PPV	100.0 (29.2, 100.0)	--- (---, ---)	95.8 (78.9, 99.9)	100.0 (2.5, 100.0)
NPV	97.1 (95.3, 98.4)	--- (---, ---)	68.9 (67.6, 70.2)	74.0 (68.6, 78.9)
	ZAM			
SENS	21.0 (15.0, 28.1)			
SPEC	90.0 (68.3, 98.8)			
PPV	94.4 (81.3, 99.3)			
NPV	12.3 (7.5, 18.8)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 9. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 20.0 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	--- (---, ---)[a]	18.4 (14.7, 22.6)	2.1 (0.1, 11.1)	14.4 (7.9, 23.4)
SPEC	--- (---, ---)	99.5 (98.7, 99.9)	100.0 (99.6, 100.0)	99.8 (98.9, 100.0)
PPV	--- (---, ---)	96.0 (88.8, 99.2)	100.0 (2.5, 100.0)	92.9 (66.1, 99.8)
NPV	--- (---, ---)	67.1 (64.1, 70.1)	94.6 (92.9, 96.0)	86.8 (83.8, 89.5)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	41.8 (33.9, 50.1)	9.0 (5.0, 14.6)	3.0 (0.8, 7.5)	15.7 (10.9, 21.5)
SPEC	97.2 (93.6, 99.1)	99.4 (97.7, 99.9)	95.8 (88.3, 99.1)	100.0 (97.9, 100.0)
PPV	92.8 (83.9, 97.6)	87.5 (61.7, 98.4)	57.1 (18.4, 90.1)	100.0 (88.8, 100.0)
NPV	66.3 (60.2, 72.0)	69.0 (64.5, 73.2)	34.8 (28.2, 41.9)	51.0 (45.6, 56.4)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	53.4 (45.4, 61.3)	--- (---, ---)	5.7 (0.7, 19.2)	13.3 (1.7, 40.5)
SPEC	90.0 (68.3, 98.8)	--- (---, ---)	99.7 (98.5, 100.0)	100.0 (98.6, 100.0)
PPV	97.7 (92.0, 99.7)	--- (---, ---)	66.7 (9.4, 99.2)	100.0 (15.8, 100.0)
NPV	19.4 (11.9, 28.9)	--- (---, ---)	91.8 (88.6, 94.3)	95.3 (92.1, 97.5)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	22.2 (6.4, 47.6)	--- (---, ---)	3.6 (2.7, 4.7)	1.3 (0.0, 6.9)
SPEC	100.0 (99.3, 100.0)	--- (---, ---)	100.0 (99.8, 100.0)	100.0 (98.3, 100.0)
PPV	100.0 (39.8, 100.0)	--- (---, ---)	98.2 (90.6, 100.0)	100.0 (2.5, 100.0)
NPV	97.3 (95.5, 98.5)	--- (---, ---)	69.4 (68.1, 70.7)	74.0 (68.6, 78.9)
	ZAM			
SENS	33.3 (26.1, 41.2)			
SPEC	90.0 (68.3, 98.8)			
PPV	96.4 (87.7, 99.6)			
NPV	14.3 (8.7, 21.6)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 10. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 20.5 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	--- (---, ---)[a]	23.5 (19.4, 28.1)	2.1 (0.1, 11.1)	20.0 (12.3, 29.8)
SPEC	--- (---, ---)	99.4 (98.4, 99.8)	99.9 (99.3, 100.0)	99.4 (98.3, 99.9)
PPV	--- (---, ---)	95.8 (89.7, 98.9)	50.0 (1.3, 98.7)	85.7 (63.7, 97.0)
NPV	--- (---, ---)	68.5 (65.4, 71.4)	94.6 (92.9, 96.0)	87.5 (84.6, 90.1)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	50.3 (42.1, 58.5)	12.2 (7.5, 18.4)	4.5 (1.7, 9.6)	18.2 (13.1, 24.3)
SPEC	95.6 (91.4, 98.1)	99.1 (97.3, 99.8)	95.8 (88.3, 99.1)	99.4 (96.8, 100.0)
PPV	90.6 (82.3, 95.8)	86.4 (65.1, 97.1)	66.7 (29.9, 92.5)	97.3 (85.8, 99.9)
NPV	69.4 (63.2, 75.0)	69.7 (65.2, 73.9)	35.2 (28.5, 42.3)	51.6 (46.1, 57.1)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	64.0 (56.0, 71.4)	--- (---, ---)	8.6 (1.8, 23.1)	26.7 (7.8, 55.1)
SPEC	85.0 (62.1, 96.8)	--- (---, ---)	99.5 (98.1, 99.9)	100.0 (98.6, 100.0)
PPV	97.2 (92.0, 99.4)	--- (---, ---)	60.0 (14.7, 94.7)	100.0 (39.8, 100.0)
NPV	22.7 (13.8, 33.8)	--- (---, ---)	92.0 (88.9, 94.4)	96.0 (93.0, 98.0)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	22.2 (6.4, 47.6)	11.8 (1.5, 36.4)	7.1 (5.8, 8.4)	2.6 (0.3, 9.0)
SPEC	100.0 (99.3, 100.0)	100.0 (99.3, 100.0)	99.9 (99.7, 100.0)	100.0 (98.3, 100.0)
PPV	100.0 (39.8, 100.0)	100.0 (15.8, 100.0)	95.6 (90.1, 98.6)	100.0 (15.8, 100.0)
NPV	97.3 (95.5, 98.5)	97.3 (95.5, 98.5)	70.1 (68.8, 71.4)	74.2 (68.8, 79.1)
	ZAM			
SENS	43.8 (36.1, 51.8)			
SPEC	75.0 (50.9, 91.3)			
PPV	93.4 (85.3, 97.8)			
NPV	14.2 (8.1, 22.3)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 11. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 21.0 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	--- (---, ---)[a]	32.0 (27.4, 36.8)	3.2 (0.1, 16.7)	32.2 (22.8, 42.9)
SPEC	--- (---, ---)	99.4 (98.4, 99.8)	100.0 (99.5, 100.0)	98.4 (96.9, 99.3)
PPV	--- (---, ---)	96.9 (92.3, 99.1)	100.0 (2.5, 100.0)	78.4 (61.8, 90.2)
NPV	--- (---, ---)	71.0 (67.9, 73.9)	96.1 (94.4, 97.3)	89.1 (86.3, 91.6)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	66.0 (57.9, 73.5)	16.7 (11.2, 23.5)	7.5 (3.7, 13.4)	26.8 (20.7, 33.5)
SPEC	93.3 (88.6, 96.5)	99.1 (97.3, 99.8)	95.8 (88.3, 99.1)	99.4 (96.8, 100.0)
PPV	89.4 (82.2, 94.4)	89.7 (72.6, 97.8)	76.9 (46.2, 95.0)	98.1 (90.1, 100.0)
NPV	76.4 (70.2, 81.8)	70.8 (66.3, 75.0)	35.9 (29.2, 43.2)	54.4 (48.8, 60.0)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	79.5 (72.4, 85.5)	--- (---, ---)	11.4 (3.2, 26.7)	26.7 (7.8, 55.1)
SPEC	70.0 (45.7, 88.1)	--- (---, ---)	98.4 (96.5, 99.4)	99.6 (97.9, 100.0)
PPV	95.5 (90.5, 98.3)	--- (---, ---)	40.0 (12.2, 73.8)	80.0 (28.4, 99.5)
NPV	29.8 (17.3, 44.9)	--- (---, ---)	92.1 (89.0, 94.6)	96.0 (92.9, 98.0)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	27.8 (9.7, 53.5)	17.6 (3.8, 43.4)	12.7 (11.1, 14.4)	6.4 (2.1, 14.3)
SPEC	100.0 (99.3, 100.0)	99.8 (99.0, 100.0)	99.8 (99.5, 99.9)	99.1 (96.7, 99.9)
PPV	100.0 (47.8, 100.0)	75.0 (19.4, 99.4)	96.1 (92.4, 98.3)	71.4 (29.0, 96.3)
NPV	97.5 (95.7, 98.6)	97.4 (95.8, 98.6)	71.4 (70.1, 72.7)	74.8 (69.4, 79.7)
	ZAM			
SENS	57.4 (49.4, 65.1)			
SPEC	75.0 (50.9, 91.3)			
PPV	94.9 (88.5, 98.3)			
NPV	17.9 (10.4, 27.7)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 12. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 21.5 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	0.0 (0.0, 70.8)	39.1 (34.3, 44.2)	3.2 (0.1, 16.7)	41.1 (30.8, 52.0)
SPEC	99.5 (97.3, 100.0)	99.4 (98.4, 99.8)	99.9 (99.2, 100.0)	97.2 (95.4, 98.5)
PPV	0.0 (0.0, 97.5)	97.5 (93.6, 99.3)	50.0 (1.3, 98.7)	72.5 (58.3, 84.1)
NPV	98.5 (95.8, 99.7)	73.2 (70.2, 76.1)	96.1 (94.4, 97.3)	90.3 (87.5, 92.7)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	73.9 (66.1, 80.6)	22.4 (16.2, 29.8)	13.5 (8.2, 20.5)	35.9 (29.2, 43.0)
SPEC	87.8 (82.1, 92.2)	98.7 (96.8, 99.7)	94.4 (86.4, 98.5)	99.4 (96.8, 100.0)
PPV	83.7 (76.4, 89.5)	89.7 (75.8, 97.1)	81.8 (59.7, 94.8)	98.6 (92.5, 100.0)
NPV	79.8 (73.5, 85.2)	72.2 (67.7, 76.3)	37.2 (30.1, 44.6)	57.7 (51.9, 63.3)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	86.3 (80.0, 91.2)	--- (---, ---)[a]	11.4 (3.2, 26.7)	40.0 (16.3, 67.7)
SPEC	35.0 (15.4, 59.2)	--- (---, ---)	97.8 (95.8, 99.1)	99.6 (97.9, 100.0)
PPV	91.4 (85.8, 95.4)	--- (---, ---)	33.3 (9.9, 65.1)	85.7 (42.1, 99.6)
NPV	24.1 (10.3, 43.5)	--- (---, ---)	92.1 (89.0, 94.6)	96.7 (93.8, 98.5)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	33.3 (13.3, 59.0)	17.6 (3.8, 43.4)	23.2 (21.1, 25.3)	9.0 (3.7, 17.6)
SPEC	100.0 (99.3, 100.0)	99.8 (99.0, 100.0)	993. (98.9, 99.5)	99.1 (96.7, 99.9)
PPV	100.0 (54.1, 100.0)	75.0 (19.4, 99.4)	93.5 (90.5, 95.7)	77.8 (40.0, 97.2)
NPV	97.7 (95.9, 98.8)	97.4 (95.8, 98.6)	73.8 (72.5, 75.1)	75.3 (69.9, 80.2)
	ZAM			
SENS	71.6 (64.0, 78.4)			
SPEC	30.0 (11.9, 54.3)			
PPV	89.2 (82.6, 94.0)			
NPV	11.5 (4.4, 23.4)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 13. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 22.0 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	0.0 (0.0, 70.8)	48.3 (43.3, 53.4)	3.2 (0.1, 16.7)	52.2 (41.4, 62.9)
SPEC	99.0 (96.5, 99.9)	99.1 (98.0, 99.7)	99.6 (98.8, 99.9)	94.3 (91.9, 96.2)
PPV	0.0 (0.0, 84.2)	96.9 (93.4, 98.9)	25.0 (0.6, 80.6)	61.8 (50.0, 72.8)
NPV	98.5 (95.7, 99.7)	76.2 (73.2, 79.1)	96.1 (94.4, 97.3)	91.8 (89.1, 94.0)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	83.0 (76.1, 88.6)	34.6 (27.2, 42.6)	25.6 (18.4, 33.8)	44.4 (37.4, 51.7)
SPEC	80.6 (74.0, 86.1)	98.1 (95.9, 99.3)	93.1 (84.5, 97.7)	98.9 (95.9, 99.9)
PPV	78.4 (71.3, 84.5)	90.0 (79.5, 96.2)	87.2 (72.6, 95.7)	97.8 (92.2, 99.7)
NPV	84.8 (78.5, 89.8)	75.4 (70.9, 79.4)	40.4 (32.8, 48.2)	61.0 (55.0, 66.7)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	96.9 (92.9, 99.0)	--- (---, ---)[a]	14.3 (4.8, 30.3)	40.0 (16.3, 67.7)
SPEC	0.0 (0.0, 16.8)	--- (---, ---)	97.3 (95.1, 98.7)	99.6 (97.9, 100.0)
PPV	88.6 (83.0, 92.9)	--- (---, ---)	33.3 (11.8, 61.6)	85.7 (42.1, 99.6)
NPV	0.0 (0.0, 52.2)	--- (---, ---)	92.3 (89.2, 94.7)	96.7 (93.8, 98.5)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	38.9 (17.3, 64.3)	35.3 (14.2, 61.7)	36.4 (34.0, 38.9)	23.1 (14.3, 34.0)
SPEC	99.8 (98.9, 100.0)	99.3 (98.1, 99.8)	98.3 (97.8, 98.7)	97.7 (94.8, 99.3)
PPV	87.5 (47.3, 99.7)	60.0 (26.2, 87.8)	90.7 (88.1, 92.8)	78.3 (56.3, 92.5)
NPV	97.8 (96.2, 98.9)	98.0 (96.4, 99.0)	77.2 (75.9, 78.4)	78.1 (72.7, 82.9)
	ZAM			
SENS	90.1 (84.5, 94.2)			
SPEC	10.0 (1.2, 31.7)			
PPV	89.0 (83.2, 93.4)			
NPV	11.1 (1.4, 14.7)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 14. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 22.5 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	33.3 (0.8, 90.6)	50.1 (45.1, 55.2)	6.5 (0.8, 21.4)	64.4 (53.7, 74.3)
SPEC	99.0 (96.5, 99.9)	98.9 (97.8, 99.6)	99.3 (98.4, 99.8)	89.4 (86.4, 91.9)
PPV	33.3 (0.8, 90.6)	96.6 (93.0, 98.6)	28.6 (3.7, 71.0)	51.8 (42.1, 61.3)
NPV	99.0 (96.5, 99.9)	76.8 (73.8, 79.7)	96.2 (94.6, 97.4)	93.4 (90.9, 95.5)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	89.5 (83.6, 93.9)	47.4 (39.4, 55.6)	35.3 (27.3, 44.1)	51.5 (44.3, 58.7)
SPEC	73.9 (66.8, 80.1)	96.9 (94.3, 98.5)	91.7 (82.7, 96.9)	97.7 (94.2, 99.4)
PPV	74.5 (67.5, 80.6)	88.1 (79.2, 91.4)	88.7 (77.0, 95.7)	96.2 (90.6, 99.0)
NPV	89.3 (83.1, 93.7)	79.0 (74.6, 82.9)	43.4 (35.4, 51.7)	63.9 (57.8, 69.7)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	99.4 (96.6, 100.0)	0.0 (0.0, 97.5)	17.1 (6.6, 33.6)	40.0 (16.3, 67.7)
SPEC	0.0 (0.0, 16.8)	99.7 (98.3, 100.0)	97.0 (94.7, 98.5)	98.9 (96.7, 99.8)
PPV	88.9 (83.4, 93.1)	0.0 (0.0, 97.5)	35.3 (14.2, 61.7)	66.7 (29.9, 92.5)
NPV	0.0 (0.0, 97.5)	99.7 (98.3, 100.0)	92.5 (89.4, 94.9)	96.7 (93.8, 98.5)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	61.1 (35.7, 82.7)	58.8 (32.9, 81.6)	51.7 (49.2, 54.2)	38.5 (27.7, 50.2)
SPEC	99.6 (98.6, 100.0)	99.1 (97.8, 99.7)	95.5 (94.7, 96.1)	97.3 (94.1, 99.0)
PPV	84.6 (54.6, 98.1)	66.7 (38.4, 88.2)	83.9 (81.4, 86.2)	83.3 (67.2, 93.6)
NPV	98.6 (7.2, 99.4)	98.7 (97.3, 99.5)	81.2 (79.9, 82.4)	81.6 (76.4, 86.1)
	ZAM			
SENS	98.8 (95.6, 99.9)			
SPEC	0.0 (0.0, 16.8)			
PPV	88.9 (83.4, 93.1)			
NPV	0.0 (0.0, 84.2)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 15. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 23.0 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	33.3 (0.8, 90.6)	60.9 (55.8, 65.7)	12.9 (3.6, 29.8)	75.6 (65.4, 84.0)
SPEC	97.0 (93.6, 98.9)	97.9 (96.4, 98.8)	99.2 (98.2, 99.7)	82.9 (79.4, 86.1)
PPV	14.3 (0.4, 57.9)	94.4 (90.9, 96.9)	40.0 (12.2, 73.8)	43.9 (35.9, 52.1)
NPV	99.0 (96.4, 99.9)	80.7 (77.8, 83.4)	96.4 (94.8, 97.6)	95.0 (92.6, 96.9)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	95.4 (90.8, 98.1)	61.5 (53.4, 69.2)	51.1 (42.3, 59.9)	63.6 (56.5, 70.3)
SPEC	66.7 (59.3, 73.5)	94.3 (91.2, 96.6)	88.9 (79.3, 95.1)	96.0 (91.9, 98.4)
PPV	70.9 (64.2, 77.0)	84.2 (76.2, 90.4)	89.5 (80.3, 95.3)	94.7 (89.5, 97.9
NPV	94.5 (89.0, 97.8)	83.3 (79.1, 87.0)	49.6 (40.7, 58.5)	69.9 (63.6, 75.6)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	--- (---, ---)[a]	0.0 (0.0, 97.5)	20.0 (8.4, 36.9)	46.7 (21.3, 73.4)
SPEC	--- (---, ---)	98.8 (96.9, 99.7)	95.9 (93.4, 97.7)	98.1 (95.6, 99.4)
PPV	--- (---, ---)	0.0 (0.0, 60.2)	31.8 (13.9, 54.9)	58.3 (27.7, 84.8)
NPV	--- (---, ---)	99.7 (98.3, 100.0)	92.7 (89.6, 95.1)	97.0 (94.2, 98.7)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	61.1 (35.7, 82.7)	64.7 (38.3, 85.8)	66.2 (63.8, 68.6)	50.0 (38.5, 61.5)
SPEC	99.0 (97.7, 99.7)	97.9 (96.4, 99.0)	91.5 (90.5, 92.4)	93.2 (89.0, 96.1)
PPV	68.8 (41.3, 89.0)	50.0 (28.2, 71.8)	78.0 (75.7, 80.3)	72.2 (58.4, 83.5)
NPV	98.6 (97.2, 99.4)	98.9 (97.6, 99.6)	85.5 (84.4, 86.7)	84.0 (78.7, 88.3)
	ZAM			
SENS	99.4 (96.6, 100.0)			
SPEC	0.0 (0.0, 16.8)			
PPV	89.0 (83.5, 93.1)			
NPV	0.0 (0.0, 97.5)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 16. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 23.5 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	100.0 (29.2, 100.0)	69.3 (64.5, 73.8)	22.6 (9.6, 41.1)	84.4 (75.3, 91.2)
SPEC	97.0 (93.6, 98.9)	96.2 (94.4, 97.5)	98.4 (97.2, 99.2)	74.1 (70.0, 77.8)
PPV	33.3 (7.5, 70.1)	91.6 (87.8, 94.5)	36.8 (16.3, 61.6)	36.5 (30.0, 43.5)
NPV	100.0 (98.1, 100.0)	84.0 (81.2, 86.5)	96.8 (95.3, 97.9)	96.4 (94.1, 98.0)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	97.4 (93.4, 99.3)	75.0 (67.4, 81.6)	66.2 (57.5, 74.1)	73.2 (66.5, 79.3)
SPEC	57.2 (49.6, 64.6)	88.7 (84.7, 91.9)	76.4 (64.9, 85.6)	93.1 (88.3, 96.4)
PPV	65.9 (59.4, 72.1)	76.5 (68.9, 82.9)	83.8 (75.3, 90.3)	92.4 (87.0, 96.0)
NPV	96.3 (90.7, 99.0)	87.9 (83.8, 91.2)	55.0 (44.7, 65.0)	75.3 (69.0, 81.0)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	--- (---, ---)[a]	100.0 (2.5, 100.0)	28.6 (14.6, 46.3)	53.3 (26.6, 78.7)
SPEC	--- (---, ---)	93.9 (90.7, 96.2)	93.2 (90.2, 95.6)	97.3 (94.6, 98.9)
PPV	--- (---, ---)	4.8 (0.1, 23.8)	28.6 (14.6, 46.3)	53.3 (26.6, 78.7)
NPV	--- (---, ---)	100.0 (98.8, 100.0)	93.2 (90.2, 95.6)	97.3 (94.6, 98.9)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	61.1 (35.7, 82.7)	64.7 (38.3, 85.8)	80.0 (77.9, 82.0)	64.1 (52.4, 74.7)
SPEC	98.8 (97.4, 99.6)	97.2 (95.4, 98.4)	83.5 (82.2, 84.7)	91.3 (86.8, 94.7)
PPV	64.7 (38.3, 85.8)	42.3 (23.4, 63.1)	69.0 (66.8, 71.1)	72.5 (60.4, 82.5)
NPV	98.6 (97.1, 99.4)	98.9 (97.5, 99.6)	90.1 (89.0, 91.2)	87.7 (82.7, 91.7)
	ZAM			
SENS	99.4 (96.6, 100.0)			
SPEC	0.0 (0.0, 16.8)			
PPV	89.0 (83.5, 93.1)			
NPV	0.0 (0.0, 97.5)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 17. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 24.0 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	100.0 (29.2, 100.0)	78.0 (73.6, 82.0)	41.9 (24.5, 60.9)	84.4 (75.3, 91.2)
SPEC	92.6 (88.0, 95.8)	93.0 (90.7, 94.8)	97.0 (95.5, 98.1)	70.1 (66.0, 74.1)
PPV	16.7 (3.6, 41.4)	86.9 (82.9, 90.2)	37.1 (21.5, 55.1)	33.3 (27.2, 39.9)
NPV	100.0 (98.0, 100.0)	87.6 (84.9, 90.0)	97.5 (96.1, 98.5)	96.2 (93.7, 97.9)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	98.7 (95.4, 99.8)	84.6 (78.0, 89.9)	73.7 (65.3, 80.9)	80.8 (74.6, 86.0)
SPEC	47.8 (40.3, 55.3)	84.9 (80.5, 88.7)	69.4 (57.5, 79.8)	83.9 (77.6, 89.0)
PPV	61.6 (55.2, 67.8)	73.3 (66.2, 79.6)	81.7 (73.6, 88.1)	85.1 (79.2, 89.9)
NPV	97.7 (92.0, 99.7)	91.8 (88.1, 94.7)	58.8 (47.6, 69.4)	79.3 (72.8, 85.0)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	--- (---, ---)[a]	100.0 (2.5, 100.0)	40.0 (23.9, 57.9)	73.3 (44.9, 92.2)
SPEC	--- (---, ---)	88.7 (84.8, 91.9)	90.0 (86.4, 92.8)	96.2 (93.1, 98.2)
PPV	--- (---, ---)	2.6 (0.1, 13.8)	27.5 (15.9, 41.7)	52.4 (29.8, 74.3)
NPV	--- (---, ---)	100.0 (98.7, 100.0)	94.1 (91.0, 96.3)	98.4 (96.1, 99.6)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	77.8 (52.4, 93.6)	76.5 (50.1, 93.2)	89.4 (87.7, 90.9)	76.9 (66.0, 85.7)
SPEC	97.4 (95.6, 98.6)	96.8 (95.0, 98.1)	74.5 (73.0, 76.0)	85.4 (80.0, 89.8)
PPV	51.9 (31.9, 71.3)	43.3 (25.5, 62.6)	61.6 (59.6, 63.6)	65.2 (54.6, 74.9)
NPV	99.2 (97.9, 99.8)	99.2 (98.1, 99.8)	93.9 (92.9, 94.8)	91.2 (86.5, 94.7)
	ZAM			
SENS	99.4 (96.6, 100.0)			
SPEC	0.0 (0.0, 16.8)			
PPV	89.0 (83.5, 93.1)			
NPV	0.0 (0.0, 97.5)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 18. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 24.5 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	100.0 (29.2, 100.0)	86.4 (82.6, 89.7)	45.2 (27.3, 64.0)	87.8 (79.2, 93.7)
SPEC	89.6 (84.5, 93.4)	88.7 (86.0, 91.0)	95.6 (93.9, 97.0)	59.1 (54.7, 63.4)
PPV	12.5 (2.7, 32.4)	82.0 (78.0, 85.6)	30.4 (17.7, 45.8)	27.5 (22.4, 33.1)
NPV	100.0 (98.0, 100.0)	91.6 (89.2, 93.7)	97.6 (96.2, 98.6)	96.5 (93.8, 98.2)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	99.3 (96.4, 100.0)	91.0 (85.4, 95.0)	84.2 (76.9, 90.0)	85.4 (79.6, 90.0)
SPEC	41.7 (34.4, 49.2)	78.0 (73.0, 82.4)	51.4 (39.3, 63.3)	82.2 (75.7, 87.6)
PPV	59.1 (52.9, 65.2)	67.0 (60.2, 73.3)	76.2 (68.5, 82.8)	84.5 (78.7, 89.2)
NPV	98.7 (92.9, 100.0)	94.7 (91.2, 97.0)	63.8 (50.1, 76.0)	83.1 (76.7, 88.4)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	--- (---, ---)[a]	100.0 (2.5, 100.0)	48.6 (31.4, 66.0)	80.0 (51.9, 95.7)
SPEC	--- (---, ---)	84.1 (79.7, 87.9)	84.8 (80.7, 88.3)	94.7 (91.3, 97.1)
PPV	--- (---, ---)	1.9 (0.0, 10.1)	23.3 (14.2, 34.6)	46.2 (26.6, 66.6)
NPV	--- (---, ---)	100.0 (98.7, 100.0)	94.6 (91.5, 96.7)	98.8 (96.6, 99.8)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	83.3 (58.6, 96.4)	88.2 (63.6, 98.5)	95.4 (94.2, 96.4)	83.3 (73.2, 90.8)
SPEC	96.4 (94.4, 97.9)	96.1 (94.1, 97.6)	63.4 (61.8, 65.0)	82.2 (76.5, 87.0)
PPV	45.5 (28.1, 63.6)	41.7 (25.5, 59.2)	54.4 (52.5, 56.3)	62.5 (52.5, 71.8)
NPV	99.4 (98.2, 99.9)	99.6 (98.6, 100.0)	96.8 (96.0, 97.5)	93.3 (88.8, 96.4)
	ZAM			
SENS	99.4 (96.6, 100.0)			
SPEC	0.0 (0.0, 16.8)			
PPV	89.0 (83.5, 93.1)			
NPV	0.0 (0.0, 97.5)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 19. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 25.0 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	100.0 (29.2, 100.0)	91.3 (88.1, 93.9)	58.1 (39.1, 75.5)	91.1 (83.2, 96.1)
SPEC	85.1 (79.5, 89.8)	82.4 (79.3, 85.3)	92.9 (90.8, 94.7)	50.5 (46.1, 54.9)
PPV	9.1 (1.9, 24.3)	75.6 (71.5, 79.4)	25.7 (16.0, 37.6)	24.6 (20.0, 29.5)
NPV	100.0 (97.9, 100.0)	94.1 (91.8, 95.9)	98.1 (96.8, 99.0)	97.0 (94.1, 98.7)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	99.3 (96.4, 100.0)	94.2 (89.3, 97.3)	90.2 (83.9, 94.7)	90.4 (85.4, 94.1)
SPEC	33.3 (26.5, 40.7)	69.5 (64.1, 74.5)	40.3 (28.9, 52.5)	74.7 (67.6, 81.0)
PPV	55.9 (49.8, 61.9)	60.2 (53.8, 66.4)	73.6 (66.2, 80.2)	80.3 (74.4, 85.3)
NPV	98.4 (91.2, 100.0)	96.1 (92.7, 98.2)	69.0 (52.9, 82.4)	87.2 (80.8, 92.1)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	--- (---, ---)[a]	100.0 (2.5, 100.0)	60.0 (42.1, 76.1)	93.3 (68.1, 99.8)
SPEC	--- (---, ---)	72.6 (67.4, 77.3)	80.2 (75.8, 84.2)	92.8 (89.0, 95.6)
PPV	--- (---, ---)	1.1 (0.0, 6.0)	22.3 (14.4, 32.1)	42.4 (25.5, 60.8)
NPV	--- (---, ---)	100.0 (98.5, 100.0)	95.5 (92.5, 97.5)	99.6 (97.8, 100.0)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	83.3 (58.6, 96.4)	94.1 (71.3, 99.9)	97.7 (96.9, 98.4)	91.0 (82.4, 96.3)
SPEC	94.6 (92.3, 96.4)	94.6 (92.3, 96.3)	52.5 (50.8, 54.2)	72.1 (65.7, 78.0)
PPV	35.7 (21.6, 52.0)	35.6 (21.9, 51.2)	48.5 (46.8, 50.3)	53.8 (44.9, 62.5)
NPV	99.4 (98.2, 99.9)	99.8 (98.9, 100.0)	98.1 (97.3, 98.6)	95.8 (91.5, 98.3)
	ZAM			
SENS	--- (---, ---)[a]			
SPEC	--- (---, ---)			
PPV	--- (---, ---)			
NPV	--- (---, ---)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 20. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 25.5 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	100.0 (29.2, 100.0)	91.6 (88.4, 94.1)	71.0 (52.0, 85.8)	94.4 (87.5, 98.2)
SPEC	83.7 (77.8, 88.5)	81.2 (78.0, 84.1)	89.7 (87.2, 91.8)	42.0 (37.7, 46.5)
PPV	8.3 (1.8, 22.5)	74.4 (70.3, 78.3)	22.4 (14.6, 32.0)	22.4 (18.3, 26.9)
NPV	100.0 (97.8, 100.0)	94.1 (91.9, 95.9)	98.7 (97.5, 99.4)	97.7 (94.8, 99.3)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	99.3 (96.4, 100.0)	98.1 (94.5, 99.6)	96.2 (91.4, 98.8)	93.4 (89.0, 96.5)
SPEC	32.2 (25.5, 39.6)	60.1 (54.4, 65.5)	29.2 (19.0, 41.1)	62.6 (55.0, 69.8)
PPV	55.5 (49.4, 61.5)	54.6 (48.6, 60.6)	71.5 (64.3, 78.0)	74.0 (68.1, 79.3)
NPV	98.3 (90.9, 100.0)	98.5 (95.5, 99.7)	80.8 (60.6, 93.4)	89.3 (82.5, 94.2)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	--- (---, ---)[a]	100.0 (2.5, 100.0)	62.9 (44.9, 78.5)	93.3 (68.1, 99.8)
SPEC	--- (---, ---)	65.5 (60.1, 70.7)	75.1 (70.3, 79.4)	90.5 (86.3, 93.8)
PPV	--- (---, ---)	0.9 (0.0, 4.8)	19.3 (12.5, 27.7)	35.9 (21.2, 52.8)
NPV	--- (---, ---)	100.0 (98.3, 100.0)	95.5 (92.5, 97.6)	99.6 (97.7, 100.0)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	88.9 (65.3, 98.6)	100.0 (80.5, 100.0)	99.1 (98.5, 99.5)	96.2 (89.2, 99.2)
SPEC	93.4 (90.9, 95.4)	93.3 (90.8, 95.3)	41.4 (39.7, 43.1)	60.3 (53.5, 66.8)
PPV	32.7 (19.9, 47.5)	32.1 (19.9, 46.3)	43.6 (42.0, 45.3)	46.3 (38.4, 54.3)
NPV	99.6 (98.5, 99.9)	100.0 (99.3, 100.0)	99.0 (98.3, 99.5)	97.8 (93.6, 99.5)
	ZAM			
SENS	--- (---, ---)[a]			
SPEC	--- (---, ---)			
PPV	--- (---, ---)			
NPV	--- (---, ---)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 21. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 26.0 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	100.0 (29.2, 100.0)	95.4 (92.8, 97.2)	74.2 (55.4, 88.1)	95.6 (89.0, 98.8)
SPEC	80.2 (74.0, 85.5)	73.4 (69.8, 76.7)	86.1 (83.4, 88.5)	34.6 (30.4, 38.9)
PPV	7.0 (1.5, 19.1)	68.2 (64.1, 72.1)	18.4 (12.0, 26.3)	20.5 (16.8, 24.7)
NPV	100.0 (97.7, 100.0)	96.4 (94.3, 97.8)	98.8 (97.6, 99.5)	97.8 (94.4, 99.4)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	99.3 (96.4, 100.0)	98.1 (94.5, 99.6)	99.2 (95.9, 100.0)	97.5 (94.2, 99.2)
SPEC	26.1 (19.9, 33.2)	47.5 (41.9, 53.1)	19.4 (11.1, 30.5)	53.4 (45.7, 61.0)
PPV	53.3 (47.4, 59.2)	47.8 (42.2, 53.4)	69.5 (62.4, 75.9)	70.4 (64.7, 75.8)
NPV	97.9 (88.9, 99.9)	98.1 (94.4, 99.6)	93.3 (68.1, 99.8)	94.9 (88.5, 98.3)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	--- (---, ---)[a]	100.0 (2.5, 100.0)	71.4 (53.7, 85.4)	93.3 (68.1, 99.8)
SPEC	--- (---, ---)	56.4 (50.8, 61.8)	69.4 (64.4, 74.0)	89.0 (84.6, 92.5)
PPV	--- (---, ---)	0.7 (0.0, 3.8)	18.1 (12.1, 25.6)	32.6 (19.1, 48.5)
NPV	--- (---, ---)	100.0 (98.0, 100.0)	96.2 (93.2, 98.2)	99.6 (97.7, 100.0)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	88.9 (65.3, 98.6)	100.0 (80.5, 100.0)	99.8 (99.4, 100.0)	96.2 (89.2, 99.2)
SPEC	91.0 (88.2, 93.4)	91.2 (88.5, 93.5)	32.2 (30.7, 33.8)	48.4 (41.6, 55.2)
PPV	26.2 (15.8, 39.1)	26.6 (16.3, 39.1)	40.3 (38.7, 41.8)	39.9 (32.8, 47.3)
NPV	99.6 (98.4, 99.9)	100.0 (99.2, 100.0)	99.7 (99.2, 99.9)	97.2 (92.2, 99.4)
	ZAM			
SENS	--- (---, ---)[a]			
SPEC	--- (---, ---)			
PPV	--- (---, ---)			
NPV	--- (---, ---)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 22. Comparison of SENS, SPEC, PPV, and NPV Values for a MUAC cutoff of 26.5 cm across Studies

	Study			
	ARG	**GUI-HIV**	**GUI-TBC**	**IND-UNI**
SENS	100.0 (29.2, 100.0)	97.7 (95.7, 98.9)	80.6 (62.5, 92.5)	97.8 (92.2, 99.7)
SPEC	70.8 (64.0, 77.0)	66.1 (62.3, 69.7)	82.2 (79.2, 84.9)	29.1 (25.2, 33.2)
PPV	4.8 (1.0, 13.5)	63.2 (59.3, 67.1)	16.0 (10.5, 22.7)	19.6 (16.0, 23.6)
NPV	100.0 (97.5, 100.0)	98.0 (96.2, 99.1)	99.0 (97.9, 99.6)	98.7 (95.3, 99.8)
	IND-FSD	**IND-MSD**	**IND-ORA**	**IND-IDU**
SENS	99.3 (96.4, 100.0)	98.7 (95.4, 99.8)	99.2 (95.9, 100.0)	98>0 (94.9, 99.4)
SPEC	22.2 (16.4, 29.0)	38.4 (33.0, 44.0)	15.3 (7.9, 25.7)	45.4 (37.9, 53.4)
PPV	52.1 (46.2, 57.9)	44.0 (38.7, 49.4)	68.4 (61.3, 74.9)	67.1 (61.4, 72.5)
NPV	97.6 (87.1, 99.9)	98.4 (94.3, 99.8)	91.7 (61.5, 99.8)	95.2 (88.1, 98.7)
	MAL-HWW	**MAL-HNW**	**NAM**	**SAF**
SENS	--- (---, ---)[a]	100.0 (2.5, 100.0)	77.1 (59.9, 89.6)	93.3 (68.1, 99.8)
SPEC	--- (---, ---)	49.7 (44.2, 55.2)	63.4 (58.3, 68.3)	86.7 (82.0, 90.6)
PPV	--- (---, ---)	0.6 (0.0, 3.3)	16.7 (11.3, 23.3)	28.6 (16.6, 43.3)
NPV	--- (---, ---)	100.0 (97.8, 100.0)	96.7 (93.6, 98.6)	99.6 (97.6, 100.0)
	USA-IDU	**USA-HIV**	**VIE-FEM**	**VIE-IDU**
SENS	88.9 (65.3, 98.6)	100>0 (80.5, 100.0)	99.8 (99.4, 100>0)	96.2 (89.2, 99.2)
SPEC	88.0 (84.9, 90.7)	88.4 (85.4, 91.0)	24.3 (22.8, 25.8)	42.5 (35.8, 49.3)
PPV	21.1 (12.5, 31.9)	21.5 (13.1, 32.2)	37.6 (36.1, 39.1)	37.3 (30.6, 44.4)
NPV	99.5 (98.4, 99.9)	100.0 (99.2, 100.0)	99.6 (98.9, 99.9)	96.9 (91.1, 99.4)
	ZAM			
SENS	--- (---, ---)[a]			
SPEC	--- (---, ---)			
PPV	--- (---, ---)			
NPV	--- (---, ---)			

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size fewer than 10 observations are grayed out due to reduced reliability of the estimate.

Table 23 shows the summary estimates of SENS and SPEC derived from the bivariate random effects model. SENS and SPEC ranged from 4.8% and 99.8%, respectively, at a MUAC cutoff of 19.0 cm to a SENS and SPEC of 97.3% and 56.1%, respectively, at a MUAC cutoff of 26.5 cm. The MUAC cutoff with the highest SENS at or above a SPEC of 70% would be 25.5 cm. However, cutoffs with lower, but still acceptable, SENS values and higher SPEC values could extend down to 23.0.

For example, a cutoff of 23.0 cm would misclassify 39% of those with BMI <18.5 as being adequately nourished and 6% of individuals with BMI ≥18.5 as being undernourished. A cutoff of 23.5 cm would misclassify 27% of those with low BMI as being adequately nourished and approximately 10% of those with BMI in the normal to high range as being undernourished. A higher cutoff of 25.5 cm would correctly classify approximately 95% of individuals with low BMI as being undernourished, but would misclassify approximately 29% of those with BMIs in the normal to high range as being undernourished.

Table 23. Summary Estimates of SENS and SPEC at Selected MUAC Cutoffs, All Studies Combined

MUAC Cutoff (cm)	SENS	SPEC	Number of Studies Contributing Data
19.0	4.8 (2.1, 10.5)	99.8 (99.1, 99.9)	13
19.5	7.8 (4.0, 14.6)	99.7 (98.9, 99.9)	13
20.0	12.8 (7.0, 22.3)	99.6 (98.7, 99.9)	13
20.5	17.1 (10.0, 27.6)	99.4 (98.1, 99.8)	14
21.0	23.2 (13.7, 36.6)	99 (97.4, 99.6)	15
21.5	29.6 (17.8, 44.9)	98.5 (95.3, 99.5)	16
22.0	43.7 (26.4, 62.8)	96.6 (87.7, 99.1)	16
22.5	56.8 (32.5, 78.2)	95.2 (81.9, 98.9)	17
23.0	61.4 (41.4, 78.2)	94.3 (86.8, 97.7)	16
23.5	73.3 (56.8, 85.1)	90.5 (80.1, 95.8)	16
24.0	81.9 (73.4, 88.2)	85.6 (78.5, 90.6)	16
24.5	87.9 (78.6, 93.5)	80.2 (65.4, 89.6)	16
25.0	90.8 (84.5, 94.7)	77.4 (66.1, 85.7)	15
25.5	94.6 (89.7, 97.2)	71.3 (58.1, 81.7)	15
26.0	96.6 (92.5, 98.5)	63.5 (48.5, 76.2)	15
26.5	97.3 (94.1, 98.8)	56.1 (41.1, 70.1)	15

4. Discussion

Nutrition assessment is a process used to identify individuals who are at risk of malnutrition and who would benefit from nutrition and/or clinical intervention. WHO defines malnutrition as "deficiencies, excesses or imbalances in a person's intake of energy and/or nutrients" (WHO 2016). Others have defined malnutrition as "a subacute or chronic state of nutrition in which a combination of varying degrees of over- or undernutrition and inflammatory activity have led to a change in body composition and diminished function" (Soeters et al. 2008). While these definitions encompass both undernutrition and overnutrition, we focused solely on undernutrition in this report.

A full nutrition assessment requires evaluation of an individual's history and a clinical diagnosis; a physical exam for signs of malnutrition (e.g., edema or specific nutrient deficiencies) and/or clinical indicators of inflammation (fever, hypothermia, tachycardia); anthropometric data, such as weight, BMI, skinfolds, or circumferences; dietary intake; laboratory indicators if available (e.g., C-reactive protein, white blood cell count, glucose); and functional outcomes, such as strength and mobility (Jensen et al. 2012). As it is not feasible to conduct a full nutrition assessment on every individual in a community, or even on every individual who enters a health care facility, valid screening tools that are simple, quick, acceptable, and inexpensive (requiring minimal equipment and training of personnel) are needed. Ideally, these screening tools would be able to accurately identify individuals who are at high risk of malnutrition, leading to impaired function and poor clinical outcomes, and for whom intervention would improve their nutritional status and clinical outcomes and would restore function. It is important to keep in mind that no one screening tool is optimal for all individuals in all situations. Each has its strengths and limitations in different contexts and each can be affected by an individual's clinical status. Therefore, screening tools should be used only as an initial step that triggers further and more detailed nutrition assessment, followed by intervention if appropriate.

The purpose of this IPDMA was to determine whether a global MUAC cutoff could be recommended as a screening tool to assess undernutrition in nonpregnant adults. Currently, the screening tool most commonly used to determine undernutrition is BMI <18.5, which is an indicator of underweight. However, as stated earlier, the measurement of BMI requires equipment that needs to be maintained and skilled individuals to take the measurements. In settings where obtaining accurate measurements of BMI is not possible, we hypothesized that a low MUAC measurement could serve as a surrogate measure of low BMI. We compiled data from 17 datasets of nonpregnant adults: 7 from Africa, 5 from South Asia (India), 2 from Southeast Asia (Vietnam), 2 from North America (USA), and 1 from South America (Argentina). For each dataset individually, and then for the combined dataset, we determined measures of diagnostic accuracy (SENS, SPEC, PPV, NPV, AUROCC, and the ROC curve) for every 0.5 cm across a range of MUAC values from 19.0 cm to 26.5 cm. The summary statistics used a bivariate random effects model to jointly estimate SENS and SPEC while accounting for the heterogeneity between studies. The models included MUAC as the only independent variable predicting low BMI defined as BMI <18.5.

We found that, although individual measures of SENS and SPEC at each of the MUAC cutoffs varied between studies, the diagnostic accuracy of MUAC for identifying adults with low BMI was consistently high. AUROCCs ranged from 0.61 to 0.98 for individual studies, with the majority of studies (11 of the 17) having values greater than 0.90. The AUROCC was 0.92 for all studies combined, which is considered to be in the "excellent" range based on general interpretations for the AUROCC (Carter et al. 2016). Results of the meta-analysis (Table 23) showed that MUAC cutoffs in the range of 23.0 cm to 25.5 cm could potentially serve as appropriate indicators for low BMI, with acceptable levels of SENS and

SPEC at each of these cutoffs for the purposes of initial screening for undernutrition in the community or in a clinical setting.

Several studies had either a low prevalence (<10%) of individuals with BMI <18.5 (ARG, GUI-TBC, MAL-HNW, NAM, SAF, USA-HIV, and USA-IDU) or a low prevalence (<11%) of individuals with normal to high BMI (MAL-HWW, ZAM), resulting in a wide variability in SENS and SPEC at each MUAC cutoff. We conducted a sensitivity analysis where we excluded these nine studies (**Annex D**). The resulting AUROCC was still in the high range at 0.90. Results of the meta-analysis showed that MUAC cutoffs in the range of 22.5 cm to 24.5 cm provided the optimal levels of SENS and SPEC. At a MUAC cutoff of 23.0 cm, SENS was 69% and SPEC was 92%. At this cutoff, 31% of individuals with low BMI would be missed, and 8% of those with normal to high BMIs would be referred for further screening. At a MUAC cutoff of 24.0 cm, SENS increased to 86% (i.e., 14% of individuals with low BMI would be missed) and SPEC decreased to 79% (i.e., 21% of those with normal to high BMIs would be referred for further screening). At a MUAC cutoff of 24.5 cm, only 7% of those with low BMI would be missed (SENS=93%), but 33% of those with normal to high BMIs would be referred for further screening (SPEC=67%).

We hypothesized that the diagnostic accuracy of MUAC for identifying nonpregnant adults with low BMI might vary by sex or by HIV status. We therefore repeated our analyses in these subgroups. **Annex E** shows the results stratified by sex. The scatterplot shows equally strong and significant correlations between BMI and MUAC for both men and women (r=0.85 for men and r=0.89 for women). The AUROCCs were also similarly high for both sexes (0.93 for men and 0.92 for women). The MUAC cutoff with the highest SENS (91.7% for males and 95.3% for females) at or above a SPEC of 70% was 25.5 cm for both males and females.

The results of the HIV subgroup analyses are shown in **Annex F**. The correlations between BMI and MUAC were strong in both subgroups, but higher in the HIV-positive group (r=0.90 for HIV-positives and 0.80 for HIV-negatives). The AUROCC was also slightly higher in the HIV-positive subgroup (0.96) compared to the HIV-negative subgroup (0.91). The MUAC cutoff with the highest SENS at or above a SPEC of 70% was 26.5 cm in the HIV-negative subgroup (SENS=87%) and 25.5 cm in the HIV-positive subgroup (SENS=96%).

There were 325 participants (2.8%) who were over the age of 65 years, including 203 participants from one study (SAF). We conducted a sensitivity analysis removing these older participants (**Annex G**). There were no substantive differences in results between those ≥18 years of age and the 18- to 65-year-olds only. Therefore, we decided to keep the >65-year-old participants in our analyses.

We further hypothesized that MUAC cutoffs might differ between those living in low- and middle-income countries (LMICs) compared to those living in upper-middle- to high-income countries (**Annex H**). We therefore conducted an analysis whereby we excluded the studies from upper-middle- to high-income countries (ARG, NAM, SAF, USA-HIV, USA-IDU) and compared these results to the results from all studies. We found that when we excluded these five studies, SENS did not change much across the range of MUAC cutoffs, but SPEC decreased at a faster rate with increasing MUAC cutoff. Therefore, the MUAC cutoff with the highest SENS (91%) at or above a SPEC of 70% would be 24.5 cm, compared to 25.5 cm when all studies are included (SENS=95%, SPEC=71%).

Our results revealed that MUAC has an excellent ability to discriminate between those with low BMI (<18.5) and those with normal to high BMI (≥18.5). However, the selection of the optimal MUAC cutoff for identifying moderate and severe 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). We found that for the combined dataset and for most of the subgroups we examined, a MUAC cutoff of 25.5 cm satisfied our suggested criterion of selecting the cutoff with the highest SENS at or above a set minimum SPEC of 70%. This criterion resulted in very high SENS (≥91%) for the combined dataset and all subgroups. However, this criterion would also result in approximately 30% of individuals with normal to high BMI being referred for additional services when they might not need it. **Table 24** below compares the FP and FN rates for MUAC values between 23.0 cm and 25.5 cm. As shown, MUAC cutoffs lower than 25.5 cm may still provide acceptable rates of FNs, but with lower rates of FPs. For example, a cutoff of 24.5 cm would capture 88% of those with low BMI and would refer only 20% of those with normal to high BMI for further screening. The argument could be made that there were several studies with few data points in either the low BMI range or the normal to high BMI range, resulting in unstable estimates of SENS and SPEC. In this case, we would place more emphasis on the results after removing those nine low prevalence studies. Referring to Table 24, a cutoff of 23.5 cm or 24.0 cm might offer a more appropriate balance of FN and FP rates in these settings.

Table 24. Comparing FN and FP Rates between Various Subgroups of Participants and Studies

MUAC cutoff (cm)	All Studies		Low Prevalence Studies Removed		Males		Females		HIV-Negative		HIV-Positive		LMICs	
	FN[a]	FP[b]	FN	FP	FN	FP	FN	FP	FN	FP	FN	FP	FN	FP
23.0	39%	6%	31%	8%	48%	4%	30%	5%	57%	2%	30%	6%	31%	9%
23.5	27%	10%	21%	14%	38%	8%	20%	8%	43%	3%	---[c]	---[c]	20%	16%
24.0	18%	14%	14%	21%	27%	12%	16%	12%	32%	7%	15%	16%	13%	23%
24.5	12%	20%	7%	33%	19%	17%	10%	15%	24%	9%	11%	21%	9%	30%
25.0	9%	23%	6%	39%	14%	18%	7%	22%	19%	13%	9%	19%	7%	33%
25.5	5%	29%	3%	48%	8%	23%	5%	26%	5%	16%	4%	24%	4%	41%

[a] FN = percentage of individuals with low BMI who are missed using the MUAC cutoff.
[b] FP = percentage of individuals with normal to high BMI who are referred for further screening.
[c] Bivariate random effects model unable to converge.

This study had some limitations. Our initial systematic review identified 10 potentially eligible datasets, of which we were able to obtain only 2 for the IPDMA. The remaining 15 datasets in this analysis included 6 of our own datasets and 9 that were obtained through further solicitation of studies in the literature that included MUAC and BMI as continuous measures. Therefore, in the end, we were not able to use a formal systematic process for identifying all the datasets included in this analysis. In addition, although a large variety of geographical regions and settings were represented in this analysis, the datasets we obtained may not be representative of those regions or settings.

The recommendation for a MUAC cutoff (or a range of cutoffs) based on this IPDMA is only a first step toward determining a standardized and global MUAC cutoff for nonpregnant adults. While many countries and programs currently use low MUAC as a tool for assessing nutritional status and determining eligibility for limited nutrition interventions, the lack of a standardized cutoff makes it difficult to compare studies internationally and to evaluate the effect of nutritional interventions in larger contexts. The widespread collection and reporting of outcomes based on a single standardized MUAC cutoff would

facilitate better understanding of the effectiveness of MUAC as a screening tool for adult undernutrition. Based on our analysis, we propose that a MUAC cutoff of 24.0 cm meets the criterion for optimizing SENS and SPEC across various subpopulations when assessed against low BMI. However, a meaningful MUAC cutoff would be one below which function and clinical outcomes deteriorate. Whether a MUAC cutoff of 24.0 cm fits this criterion needs to be tested and validated in future studies. If found to be a valid and reliable nutrition screening tool, the use of MUAC in place of BMI in community settings would reduce the amount of time and technical skill required for nutrition screening, resulting in a higher yield of individuals who would benefit from further nutrition assessment and intervention. We stress that the proposed MUAC cutoff is intended for use as a screening tool in the community that triggers referral to a health clinic for further assessment; it is not intended to be used for diagnosis or as an entry criterion into food or nutrition supplementation programs until further validation studies have been conducted.

Finally, although the focus of this report is on adult undernutrition, we do acknowledge the growing burden of the effects of overweight and obesity on both personal and national health and the need for screening tools to help prioritize the limited services that are available to treat the health consequences in low-resource settings. Future studies should explore MUAC as a potential screening tool for overweight and obesity.

Annex A. Descriptions of Included Studies

ARG

Reference: Sheehan, H.B.; Benetucci, J.; Muzzio, E., et al. 2011. "High rates of serum selenium deficiency among HIV- and HCV-infected and uninfected drug users in Buenos Aires, Argentina." Public Health Nutrition. 15(3): 538–545.

This was a cross-sectional study examining the nutritional status of 205 current and former drug users living in Buenos Aires, Argentina. Sixty-nine participants (34%) were HIV-positive. Men and women were recruited from two sites: a government-run drug rehabilitation center (Centro Nacional de Reeducación Social) and an HIV/AIDS clinic located within the Muñiz Hospital for infectious diseases (Fundación de Ayuda al Inmunodeficiente). Participants were eligible if they were between18 and 65 years of age and reported injecting, smoking, or snorting cocaine or coca paste anytime in the past 5 years. Women who were pregnant at the time of the study visit were excluded. All participants in this study were eligible for the current IPDMA.

Body composition measurements, including weight, height, and MUAC were obtained from all participants. Height and weight were measured on each participant wearing light clothing and with shoes removed. Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer and weight was measured to the nearest 0.1 kg using a balance beam scale. MUAC was measured to the nearest 0.1 cm on the right arm at the midpoint between the acromion process of the scapula and the olecranon process of the ulna using a Gulick II tape with a tension device.

GUI-HIV

Reference: Oliveira, I.; Andersen, A.; Furtado, A.; et al. 2012. "Assessment of simple risk markers for early mortality among HIV-infected patients in Guinea-Bissau: a cohort study." BMJ Open. 2(6): e001587. doi:10.1136/bmjopen-2012-001587.

The primary objective of this longitudinal study was to evaluate anthropometric measurements (other than weight loss) and other biomarkers as potential risk factors for early mortality in patients living with HIV-1, HIV-2, or both. Participants were recruited from the outpatient ART center of the National Simão Mendes Hospital, located in the capital city of Bissau. This is the largest ART center in Guinea-Bissau, where approximately one-third of patients on ART in the country are cared for. Participants were all HIV-infected, ART-naïve patients, aged 15 years and older, who were included in the Bissau-HIV cohort between July 2007 and December 2009 and followed for at least one visit after recruitment. In addition, patients had to have a CD4+ cell count available at inclusion. To be eligible for this IPDMA, participants had to have both MUAC and BMI measurements available at the baseline visit.

Height (to the nearest 1.0 cm) and weight (to the nearest 0.1 kg) were measured on all participants who were able to stand. MUAC was measured to the nearest 0.1 cm on the left arm at the mid-point between the tip of the shoulder and the tip of the elbow using a TALC insertion tape (Teaching Aids at Low Cost, St. Albans, England).

GUI-TBC

Reference: Patsche, C.B.; Rudolf, F.; Mogensen, S.W.; et al. 2017. "Low prevalence of malnourishment among household contacts of patients with tuberculosis in Guinea-Bissau." Int J Tuberc Lung Dis. 21(6): 664–669.

The purpose of this study was to determine if patients with pulmonary TB (PTB) came from households with worse nutritional status than randomly selected control households. PTB patients were recruited for this cross-sectional study in 2014 from the study site of the Bandim Health Project in the capital city of Bissau, Guinea-Bissau. The project conducts research based on routine demographic surveillance among a population of approximately 102,000 individuals living in 37 geographically defined neighborhoods. PTB patients who were recently (<30 days) started on anti-TB treatment at the national TB hospital or one of the three regional health centers were eligible. PTB patients were included if they were ≥15 years of age, lived within the study area, not pregnant, and did not have extra-pulmonary TB. Household contacts of the index patients were invited to participate in the study if they were nonpregnant, ≥15 years of age, present at the time of the visit by a fieldworker, and screened negative for PTB. Healthy controls were recruited from the Bandim Health Project's census register, matched by neighborhood to the PTB household and using the same eligibility criteria as the household contacts. Only household contacts and healthy neighborhood controls were eligible for this IPDMA.

Height and weight measurements were obtained on each participant barefooted and wearing minimal clothing. Height was measured to the nearest 0.5 cm using a roll-up tape. Weight was measured to the nearest 0.5 kg using an analogue bathroom scale. MUAC was measured to the nearest 0.2 cm at the midpoint between the acromion and olecranon on the non-dominant arm, with the arm hanging loosely, using a non-stretchable tape (TALC, Herts, UK).

IND-UNI

Unpublished

This cross-sectional study was conducted among male and female college and university students in the West Midnapore district of West Bengal. Data collection took place between March 2013 and June 2014. The primary objectives of the study were to examine the associations between various anthropometric measures and nutritional status and to examine differences in anthropometric measures by sex. In addition, the study examined the associations between anthropometric measures, nutritional status, age at menarche, and menstrual characteristics among the female students. Participants were recruited through opportunity sampling by visiting the post-graduate departments in Vidyasagar University, the university's student housing, and a number of students' private houses in the town of Midnapore. All the students/ residents (aged 18–28 years) who were present at the time of visit were invited to participate in the study and the purpose of the study was explained to them. Students had to be reportedly and apparently fit without any current or very recent episode of infirmity and not physically or mentally challenged. Those who agreed to participate and gave verbal consent were included. Data were collected using a pretested questionnaire administered by trained research assistants.

Height, weight, and MUAC were measured on all participants using standard techniques (Lohman et al. 1988). Height was measured to the nearest 0.1 cm, weight to the nearest 0.1 kg, and MUAC to the nearest 0.1 cm.

IND-FSD

Reference: Bose, K.; Bisai, S.; Das, P.; et al. 2007. "Relationship of income with anthropometric indicators of chronic energy deficiency among adult female slum dwellers of Midnapore Town." J Hum Ecol. 22(2): 171–176.

This cross-sectional study was undertaken to examine the association between monthly per capita income and BMI, MUAC, and chronic energy deficiency among female slum dwellers in an urban setting in West Bengal, India. The study took place in a slum named "Mazdoor Nagar," which is situated in Ward 13 of Midnapore town, located approximately 130 km from Kolkata. All females ≥18 years of age residing within the study area were invited to participate in the study. The response rate was approximately 78%. All participants in this study were eligible for the current IPDMA.

Height, weight, and MUAC were measured on all participants using standard techniques (Lohman et al. 1988). Height was measured to the nearest 0.1 cm using a locally made and standardized Martin anthropometer. Weight was measured to the nearest 0.1 kg using a bathroom weight scale (Libra Weighting and Engineering, Singapore). MUAC was measured on the left arm to the nearest 0.1 cm using a non-stretchable plastic measuring tape.

IND-MSD

Reference: Chakraborty, R.; Bose, K.; and Bisai, S. 2009. "Use of mid-upper arm circumference as a measure of nutritional status and its relationship with self reported morbidity among adult Bengalee male slum dwellers of Kolkata, India." In: Ellsworth, S.J. and Schuster, R.C. (eds.), Appetite and Nutritional Assessment. New York: NOVA Science Pub Inc.

The objectives of this cross-sectional study were twofold: 1) to establish an efficient MUAC cutoff point to evaluate nutritional status and 2) to investigate the relationship between MUAC and self-reported morbidity among adult Bengalee male urban slum dwellers living in Kolkata, India. This study took place in a slum area named "Bidhan Colony" situated approximately 15 km from Kolkata town center. This refugee colony was formed by migrants from Bangladesh during the 1970–1971 civil wars. Adult males (≥18 years of age) residing within the refugee colony were eligible to participate. A total of 474 male Bengalee Hindu individuals were enrolled. All participants were eligible for this IPDMA.

Height, weight, and MUAC were measured on all participants using standard techniques (Lohman et al. 1988). Height was measured to the nearest 0.1 cm, weight to the nearest 0.1 kg, and MUAC to the nearest 0.1 cm.

IND-ORA

Reference: Chakraborty, R.; Bose, K.; and Koziel, S. 2011. "Use of mid-upper arm circumference in determining undernutrition and illness in rural adult Oraon men of Gumla District, Jharkhand, India." Rural & Remote Health. 11(3): 1754.

The purpose of this study was to evaluate the use of MUAC as an indicator of chronic energy deficiency and self-reported morbidity among rural adult men belonging to the Oraon tribal group of Jkarkand, India. Data were collected for this cross-sectional study in 2007 from the region of Bishunpur in Gumla District. Five villages in the district, accessible by road, were selected to participate without regard to any socioeconomic parameters. The villages are located approximately 130 km from the state capital, Ranchi. Surveys were conducted over a period of 3–4 days in each of the selected villages. Families were informed about the time and date of the survey in advance, and all males ≥18 years of age who were healthy enough to perform their daily work were invited to participate in the study. The participation rate was approximately 75%. All 205 participants in this study were included in the current IPDMA.

Height, weight, and MUAC were measured on all participants using standard techniques (Lohman et al. 1988). Height was measured to the nearest 0.1 cm, weight to the nearest 0.1 kg, and MUAC to the nearest 0.1 cm.

IND-IDU

Reference: Tang, A.M.; Bhatnagar, T.; Ramachandran, R.; et al. 2011. "Malnutrition in a population of HIV-positive and HIV-negative drug users living in Chennai, South India." Drug and Alcohol Dependence. 118(1): 73–77.

The purpose of this study was to determine the prevalence of poor nutrition and metabolic status in a population of HIV-positive and HIV-negative current and former injection drug users (IDUs) living in Chennai, India. Participants were recruited in 2007 from the Hopers Foundation community-based drop-in center, which provided a multitude of services to IDUs, including drug use counseling, accompanied referrals for voluntary HIV testing and counseling, counseling for partners of IDUs, condom distribution and needle exchange, opioid substitution therapy, and basic medical services. Individuals were eligible for this longitudinal study if they were between 18 and 65 years of age and had a history if IDU in the past 5 years. Given that there were very few female clients served by Hopers at the time of the study, the study was restricted to males only. Up to six study visits were recorded on each participant. However, only one study visit per participant, selected at random, was included in this IPDMA.

Height and weight were measured on each participant wearing light clothing and with shoes removed. Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer, and weight was measured to the nearest 0.1 kg using a balance beam scale. MUAC was measured to the nearest 0.1 cm on the right arm at the midpoint between the acromion process of the scapula and the olecranon process of the ulna using a Gulick II tape with a tension device.

MAL-HWW

Reference: Save the Children and Valid International. 2007. Mangochi Research on the Nutrition Care of Chronically Sick Adults using Chickpea Sesame based Ready-to-Use Therapeutic Food. Lilongwe: Save the Children and Valid International.

The objectives of this observational study were to determine the effectiveness of the use of chickpea sesame-based ready-to-use therapeutic food (CS-RUTF) in the treatment of malnutrition in chronically sick adults, to identify factors affecting that effectiveness, and to describe the short- and long-term benefits resulting from nutritional care with CS-RUTF. The study was conducted in the catchment areas of the 10 community-based organizations (CBOs) operating in Mangochi Health District in southern Malawi. All CBOs were rural nongovernmental organizations. The patients were recruited among clients of the participating CBOs. Patients were recruited at their home and follow-up visits were conducted at home. All wasted chronically sick adults were eligible for the program, with special emphasis on those with known or presumptive clinical diagnosis of HIV, living in the catchment area of CBO partners and meeting at least one of the following criteria: MUAC <22 cm or BMI <17, bilateral pitting edema, bedridden and/or inability to stand, and objective weight loss >10% (when documented).

Standard WHO guidelines were used for the measurements of height, weight, and MUAC. Height was measured to the nearest 0.1 cm using a newly procured UNICEF wooden height board, readable on both sides. Height was measured in duplicate and, in case of discrepancy, a third measurement was carried out by the supervisor. Weight was measured to the nearest 0.1 kg using a Tanita digital scale (Arlington Heights, IL, USA) with a capacity of 150 kg. Weight was measured early in the morning, between 7 am and 10 am, ideally before any food or water intake. Weight was measured twice to increase precision. Reliability of the scales was assessed every morning by measuring three metals with known weight (standard weights) of 10 kg, 20 kg, 30 kg, 40 kg, and 50 kg. The patient was measured with the same scale from admission to discharge. Participants had clothes of approximately the same weight at different weight measurement. Scale batteries were replaced as soon as power started to diminish, following the

recommendation from the scale manufacturer. MUAC was measured to the nearest 0.1 cm using an adult flexible non-extensible tape measure. MUAC was always measured in duplicate on left arm. MUAC tapes showing some folds due to wear and tear were not used. Before each MUAC measurement, the measurer checked that all the figures and graduations were still decipherable.

MAL-HNW

Unpublished

This was an unblinded randomized trial to determine the impact of nutrition education and counseling plus 2 weeks of a RUTF intervention after each episode of a mild or severe common or opportunistic infection, compared to nutrition education and counseling alone, on nutritional status among people living with HIV. Eligibility criteria included the following: confirmed HIV-positive status; WHO stages I or II; CD4 count ≥500 cells/ml; good nutritional status as determined by absence of edema; MUAC >22.0 cm for women and >23.0 cm for men; BMI >18.5 and no history of weight loss above 5% of usual weight; no clinical signs of wasting; physically active; permanent resident of the catchment area of the facility; and willingness to participate. (Note that five participants with BMI ≤18.5 were enrolled into the study in error: four with BMI=18.5 and one with BMI=18.1; however, these five participants were kept in the dataset for the current analysis as the association between MUAC and BMI in these participants would still be relevant.) Participants were recruited from two urban (Lilongwe and Mzuzu) and one rural (Kasungu) voluntary counseling and testing centers run by MACRO in central and northern Malawi. A voluntary counseling and testing center based at Likhuni Hospital, a rural hospital of the Lilongwe Health District, was later added.

Height, weight, and MUAC measurement were obtained using the same guidelines as stated above for MAL-HWW.

NAM

Unpublished

The objective of this cross-sectional study was to determine the nutritional, mental, and behavioral effects of heavy alcohol use among a population at high risk for HIV in Windhoek, Namibia. Participants were recruited from Eveline Street in the Katutura district, an area where bar and shebeen density is high. The study took place on the street outside of bars in study tents. Participants were recruited through street outreach and word of mouth. Individuals were eligible if they were ≥18 years of age; able to communicate in English, Oshiwmbo, or Afrikaans; and not intoxicated. All participants in this study were eligible for this IPDMA.

Height and weight were measured on each participant wearing light clothing and with shoes removed. Height was measured to the nearest 0.1 cm using a portable, free-standing stadiometer, and weight was measured to the nearest 0.1 kg using a digital scale. MUAC was measured to the nearest 0.1 cm on the right arm at the midpoint between the acromion process of the scapula and the olecranon process of the ulna using a Gulick II tape with a tension device.

SAF

Reference: Charlton, K.E.; Kolbe-Alexander, T.L.; and Nel, J.H. 2005. "Development of a novel nutrition screening tool for use in elderly South Africans." Public Health Nutrition. 8(5): 468–479.

The purpose of this study was to develop a nutrition screening tool for use with older South Africans. This cross-sectional study was conducted in the peri-urban areas of Cape Town, South Africa. Participants were free-living or institutionalized black men and women, ≥60 years of age. Free-living participants were recruited from church groups, luncheon clubs, and community health centers, while frail

participants were recruited from state-subsidized homes for the aging, day care centers for the elderly, and lists of applicants for homes requiring maximum care. Study visits took place in the subjects' homes. All participants in the study were eligible for this IPDMA.

MUAC was measured to the nearest 0.1 cm. The dataset included BMI, but not height and weight.

USA-IDU

Reference: Tang, A.M.; Forrester, J.E.; Spiegelman, D.; et al. 2010. "Heavy injection drug use is associated with lower percent body fat in a multi-ethnic cohort of HIV-positive and HIV-negative drug users from three U.S. cities." Am J Drug Alcoh Abuse. 36(1): 78–86.

The purpose of this study was to determine the effects of type, mode, and frequency of illicit drug use on underlying body composition after accounting for underlying differences in body shape and size. This cross-sectional study included an ethnically diverse group of drug users (with and without HIV infection) living in three U.S. cities (Baltimore, MD; Boston, MA; and Providence, RI). Individuals were eligible if they were >18 years of age, not pregnant, and not reporting any illicit drug use within the past 5 years. In Boston, Hispanic drug users were recruited from an ongoing parent study (the BIENESTAR study). In Providence and Baltimore, HIV-positive participants were recruited by word of mouth and physician referral through HIV clinics. HIV-negative participants were recruited through flyers, word of mouth, and cross-recruitment from other research studies. All participants were eligible for this IPDMA.

All participants were weighed to the nearest 0.1 kg, without shoes and in light clothing, using a calibrated standing balance beam scale. Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer. MUAC was measured to the nearest 0.1 cm on the right arm at the midpoint between the acromion process of the scapula and the olecranon process of the ulna using a Gulick II tape with a tension device.

USA-HIV

References:

1. *Jacobson, D.L.; Tang, A.M.; Spiegelman, D.; et al. 2006. "Incidence of metabolic syndrome in a cohort of HIV-infected adults and prevalence relative to the U.S. population (National Health and Nutrition Examination Survey)." J Acquir Immune Defic Syndr. 43: 458–466.*
2. *Mangili, A.; Gerrior, J.; Tang, A.M.; et al. 2006. "Risk of cardiovascular disease in a cohort of HIV-infected adults: a study using carotid intima-media thickness and coronary artery calcium score." Clin Infect Dis. 43(11): 1482–1489.*

Participants were HIV-positive men and women who were enrolled in the Nutrition for Healthy Living (NFHL) study, a longitudinal study examining the causes and consequences of nutrition and metabolic abnormalities in people infected with HIV living in two U.S. cities: Boston, MA, and Providence, RI. Adults were included if they were HIV-positive, ≥18 years of age, lived in the study area, and were fluent in English. Participants were excluded if they had any of the following conditions at enrollment: pregnancy, thyroid disease, or malignancies other than Kaposi sarcoma. The NFHL study began in 1995 and ended in 2005. Beginning in 2000, a subset of NFHL participants were enrolled into a cardiovascular substudy. Visits continued every 6 months for these participants until 2013. To be eligible for the current IPDMA, participants had to have at least one MUAC measurement after the year 2000. One eligible visit per participant was selected at random for inclusion in this analysis.

Height (to the nearest 0.1 cm) was determined using a stadiometer, and weight (to the nearest 0.1 kg) was determined using a standardized standing beam balance. MUAC was measured to the nearest 0.1 cm on the right arm at the midpoint between the acromion process of the scapula and the olecranon process of the ulna using a Gulick II tape with a tension device.

VIE-FEM

Reference: Nguyen, P.; Ramakrishnan, U.; Katz, B.; et al. 2014. "Mid-upper-arm and calf circumferences are useful predictors of underweight in women of reproductive age in northern Vietnam." Food Nutr Bull. 35(3): 301–311.

The objectives of this study were to identify appropriate cutoffs for MUAC and calf circumference to screen for undernutrition in nonpregnant women of reproductive age in northern Vietnam and to compare measures of body size and composition across ethnic groups. The study participants were women between the ages of 18 and 45 years, from 20 communes located in four of nine districts of Thai Nguyen Province, Vietnam. A large proportion of these districts were people of ethnic minorities whose main occupation was farming. All participants with valid MUAC measurements were eligible for the current IPDMA.

Weight was measured to the nearest 0.1 kg using calibrated electronic Seca scales. Height was measured to the nearest 1.0 cm using a portable stadiometer with the subject in the standing position. MUAC was measured to the nearest 0.1 cm using a flexible, nonstretchable tape measure (UNICEF S0145630).

VIE-IDU

Reference: Tang, A.M.; Sheehan, H.B.; Jordan, M.R.; et al. 2011. "Predictors of Weight Change in Male HIV-Positive Injection Drug Users Initiating Antiretroviral Therapy in Hanoi, Vietnam." AIDS Research and Treatment. 2011: 890308.

This longitudinal study examined the predictors of weight change 6–12 months after ART initiation in current and former IDUs living in Vietnam. HIV-positive participants were recruited from the HIV/AIDS outpatient clinic at the National Hospital of Tropical Diseases (NHTD) in Hanoi, a United States President's Emergency Plan for AIDS Relief (PEPFAR)-supported clinic providing ART to approximately 800 people living with HIV. HIV-negative participants were recruited from an outpatient drug treatment center located across the street in the same hospital campus as the NHTD. Individuals were eligible if they were between the ages of 18 and 65 years and had a history of injection drug use within the past 5 years. Since there were few female drug users at both sites, participation was restricted to males only. Participants were followed every 6 months for 3 years. One study visit per participant, selected at random, was included in the current IPDMA.

Height and weight were measured on each participant wearing light clothing and with shoes removed. Height was measured to the nearest 0.1 cm using a wall-mounted stadiometer, and weight was measured to the nearest 0.1 kg using a balance beam scale. MUAC was measured to the nearest 0.1 cm on the right arm at the midpoint between the acromion process of the scapula and the olecranon process of the ulna using a Gulick II tape with a tension device.

ZAM

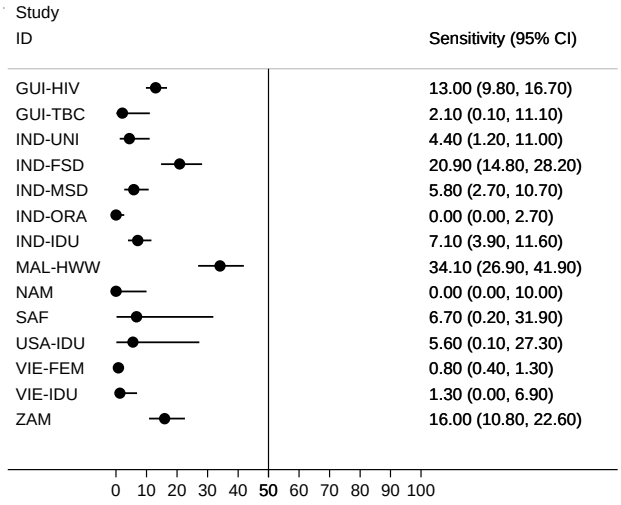
Unpublished

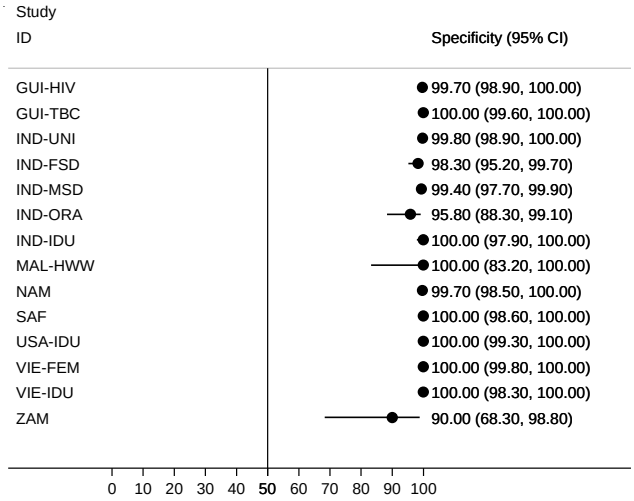
The primary objective of this randomized controlled trial was to determine the effect of treatment with RUTF on blood lipid profiles in HIV-infected adults on ART. Participants were followed prospectively during nutrition rehabilitation until cure, default, or death. Patients were recruited from those who were assessed as eligible for ART in Lusaka (urban setting) ART clinics based at Chipata, a governmental health center. Participants were eligible if they were eligible for ART or had started ART within past 4 weeks; between the ages of 18 and 49 years; had a MUAC <22.0 cm or BMI <17.0; and a CD4 count >50 cells/mm^3.

Height, weight, and MUAC were measured according to the same protocol as described above in MAL-HWW.

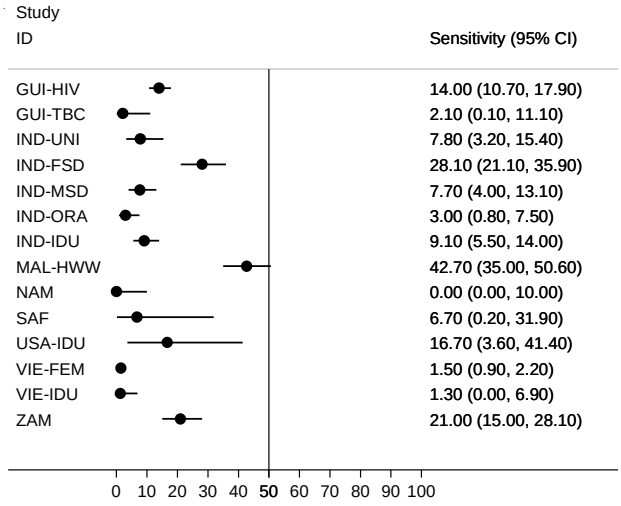
Annex B. Forest Plots of SENS and SPEC, by MUAC Cutoff

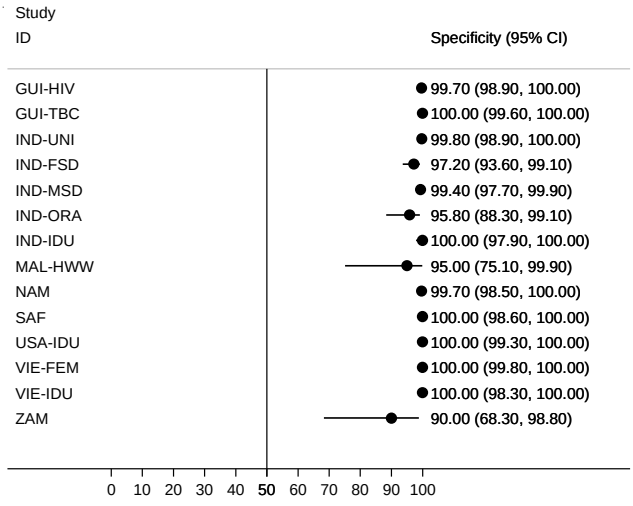
MUAC Cutoff: 19.0 cm



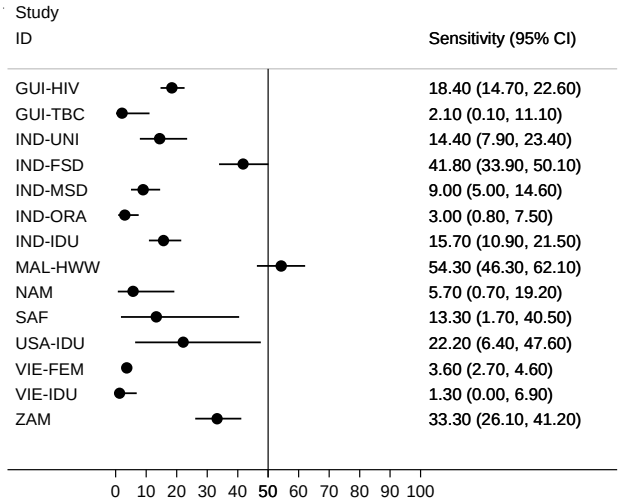


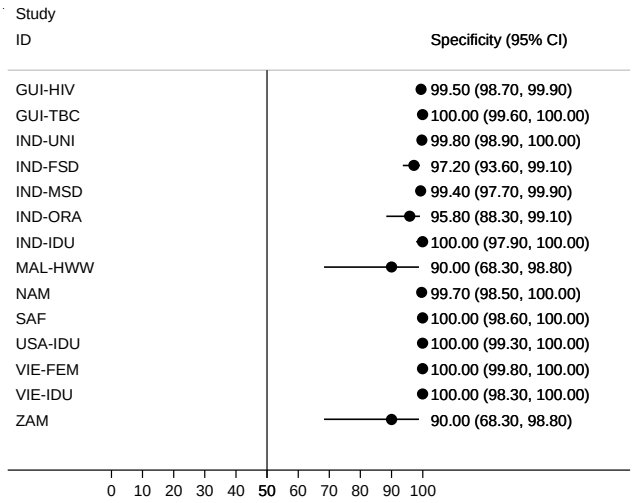
MUAC Cutoff: 19.5 cm



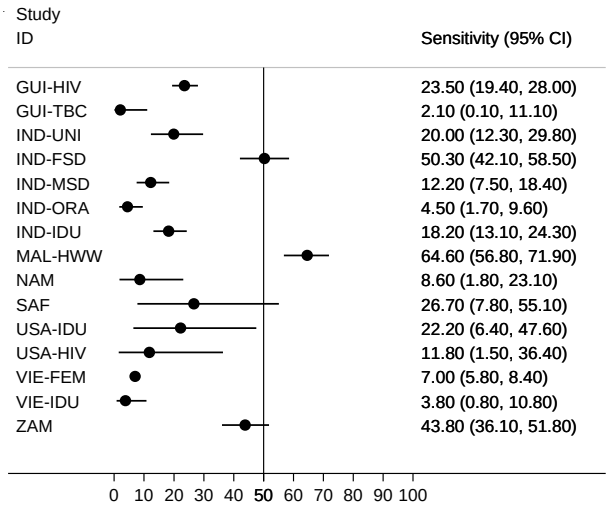


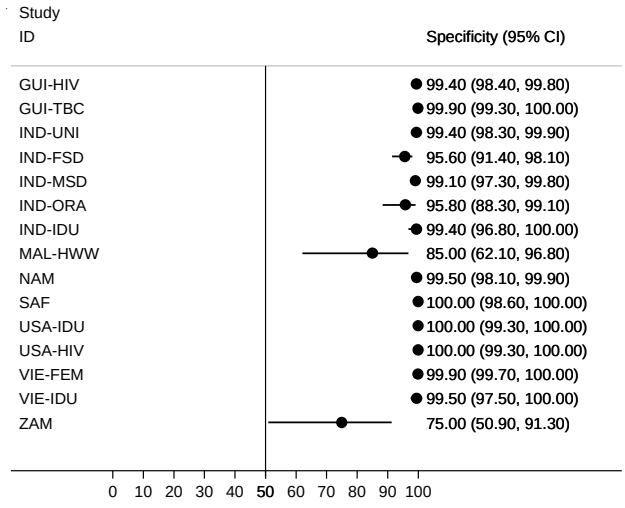
MUAC Cutoff: 20.0 cm



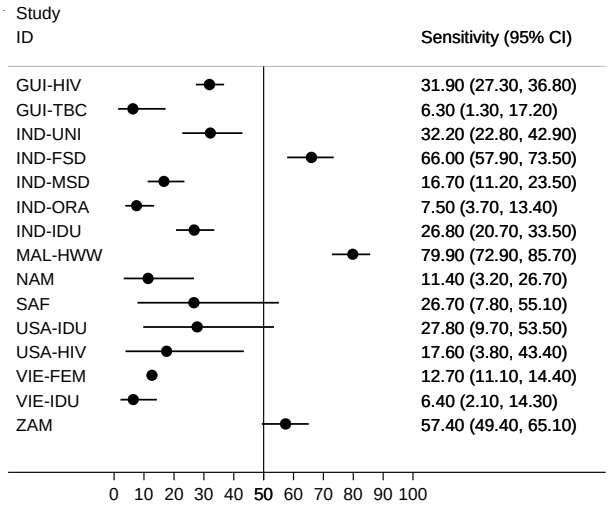


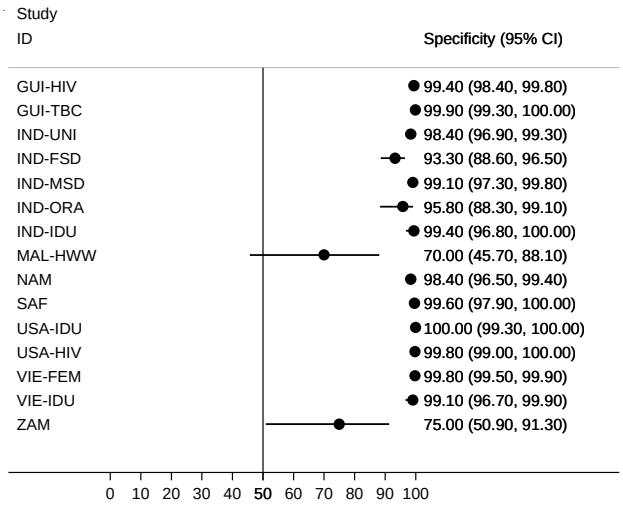
MUAC Cutoff: 20.5 cm



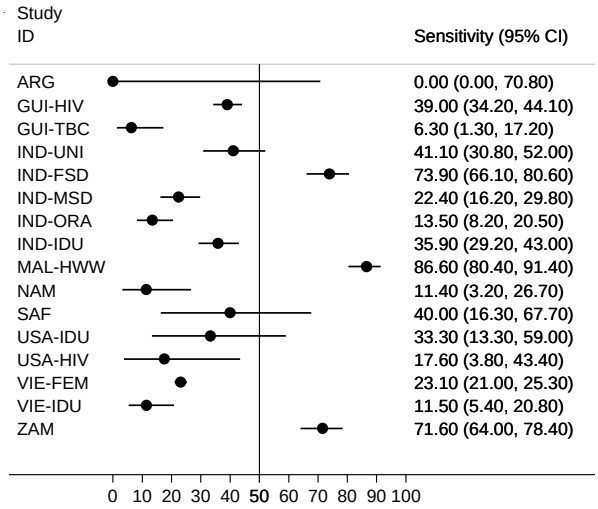


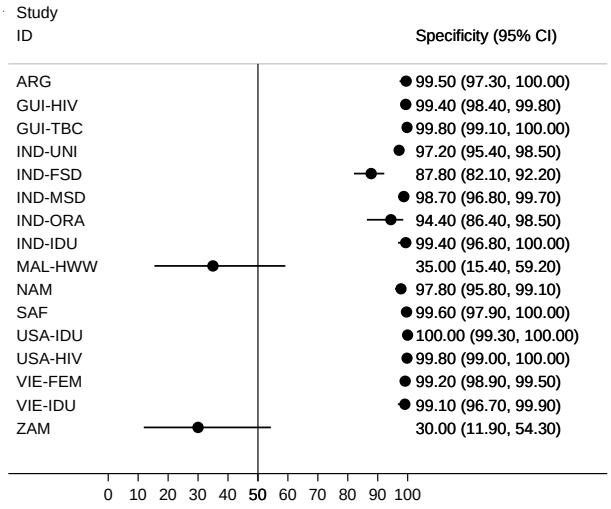
MUAC Cutoff: 21.0 cm



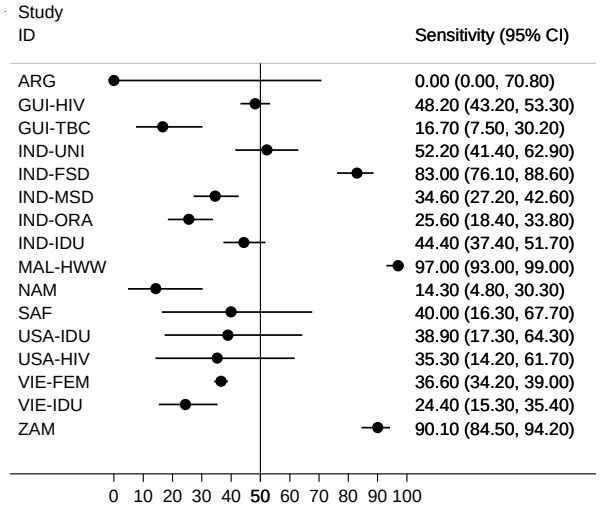


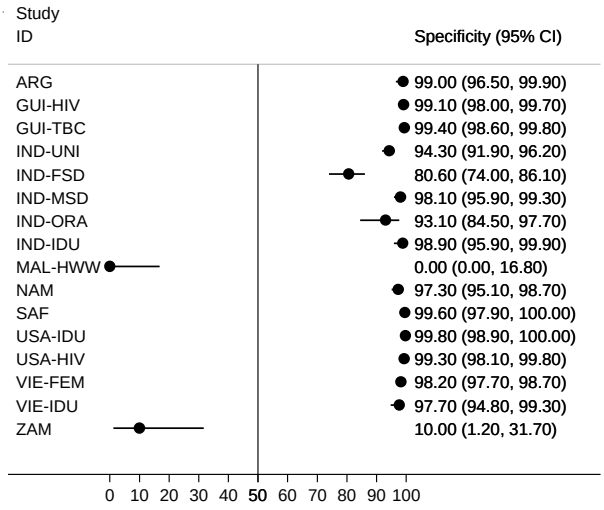
MUAC Cutoff: 21.5 cm



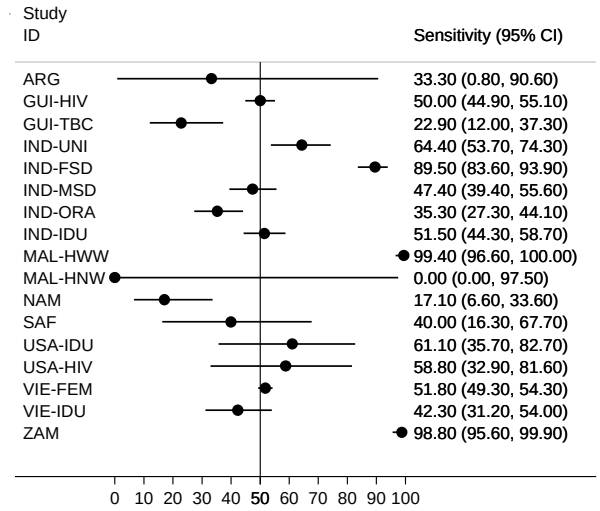


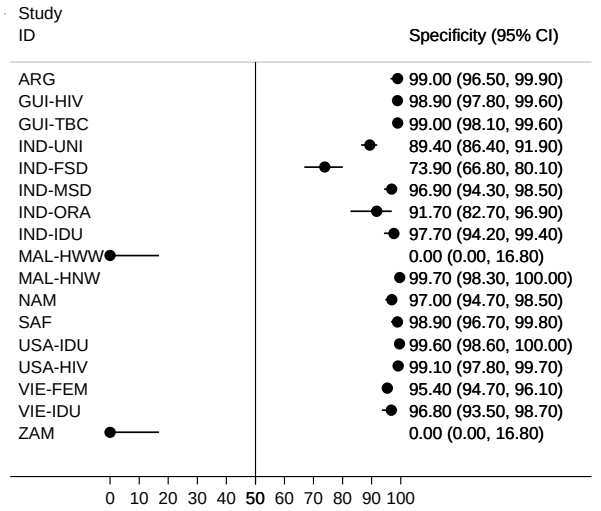
MUAC Cutoff: 22.0 cm



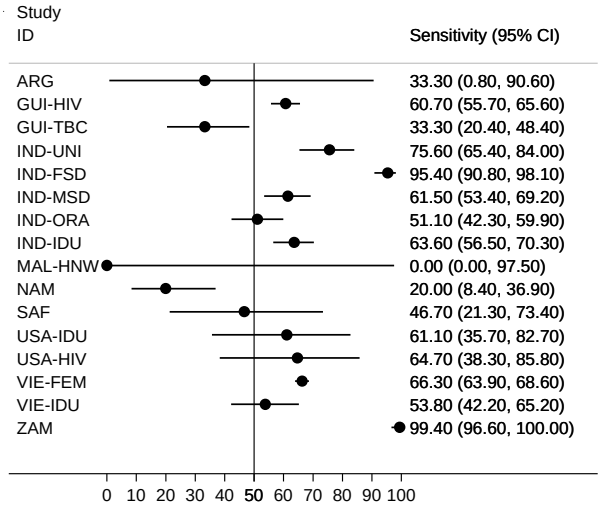


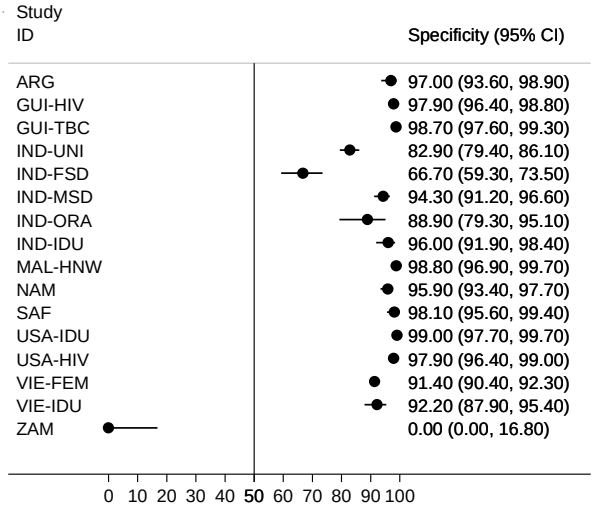
MUAC Cutoff: 22.5 cm



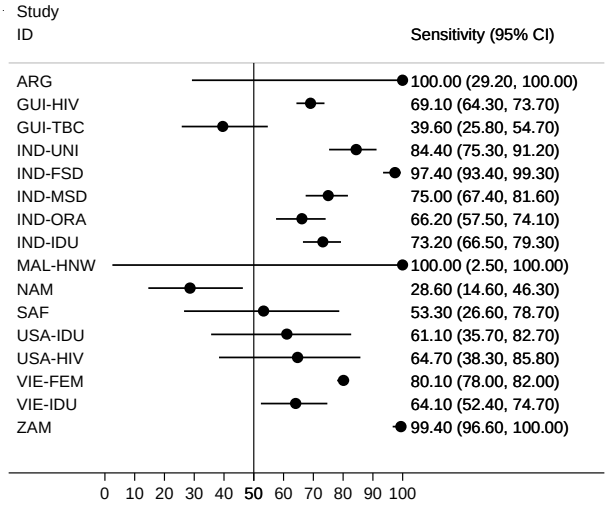


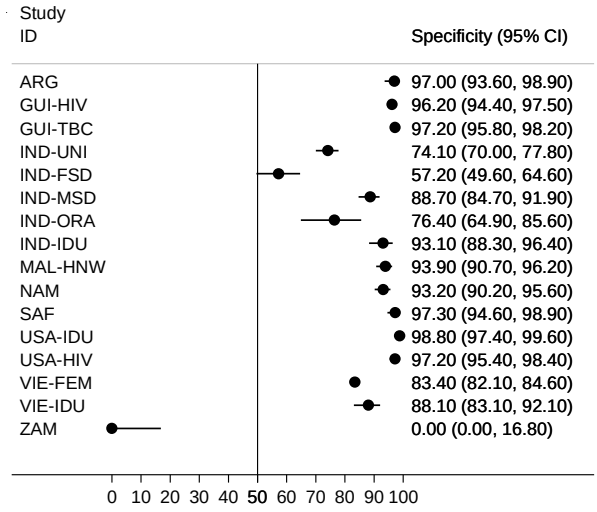
MUAC Cutoff: 23.0 cm



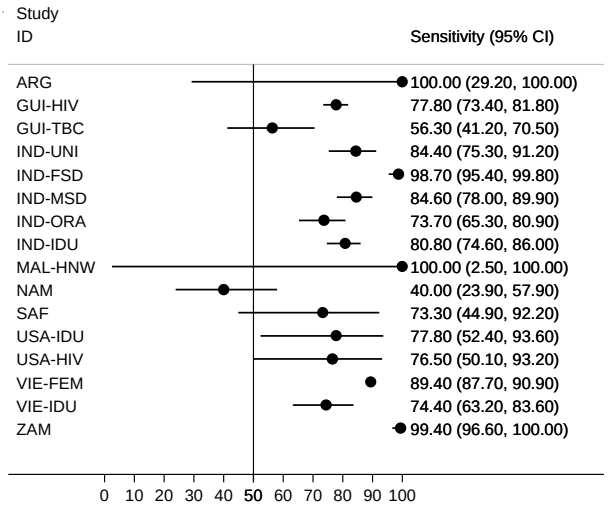


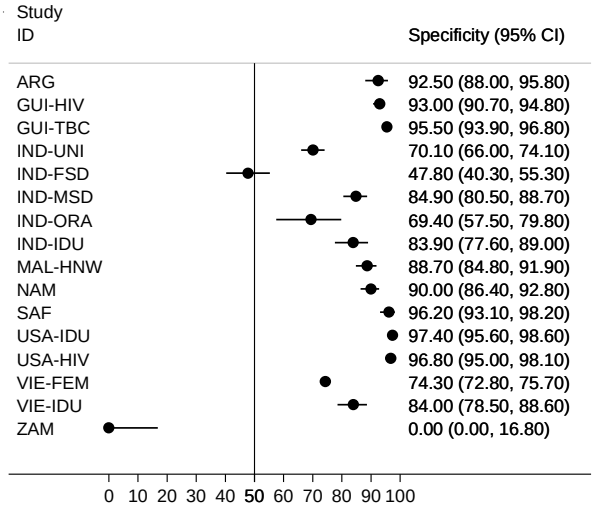
MUAC Cutoff: 23.5 cm



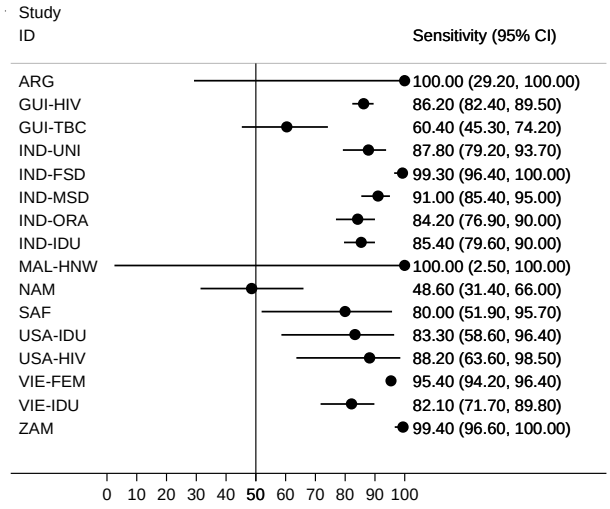


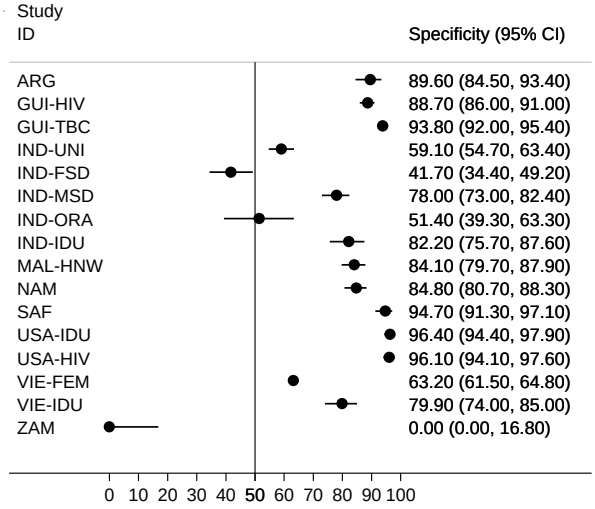
MUAC Cutoff: 24.0 cm



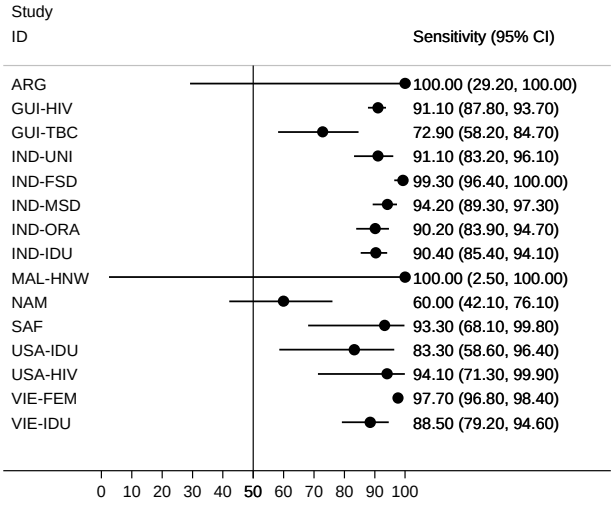


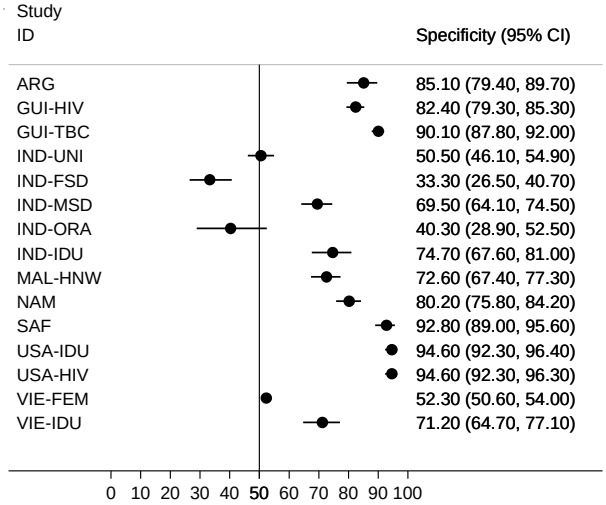
MUAC Cutoff: 24.5 cm



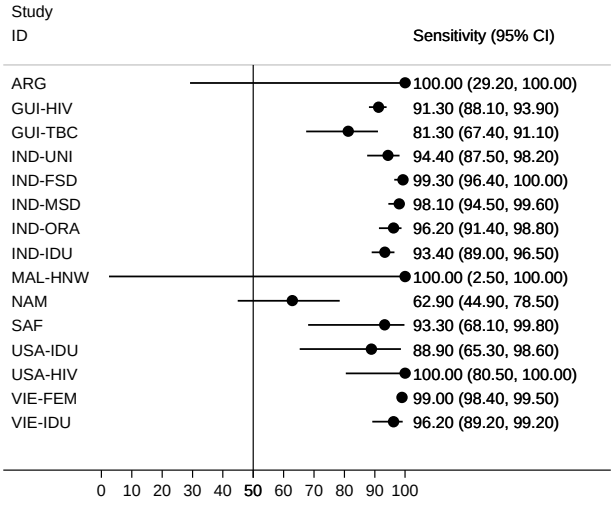


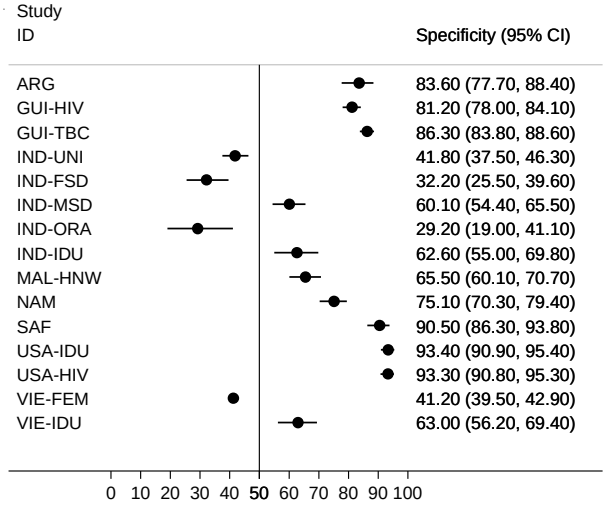
MUAC Cutoff: 25.0 cm



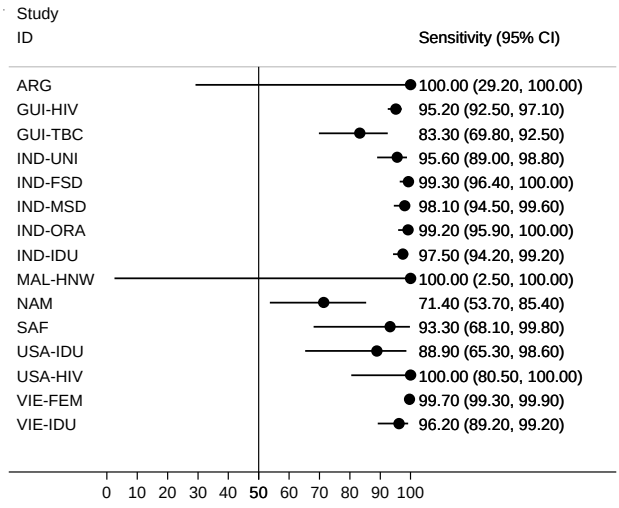


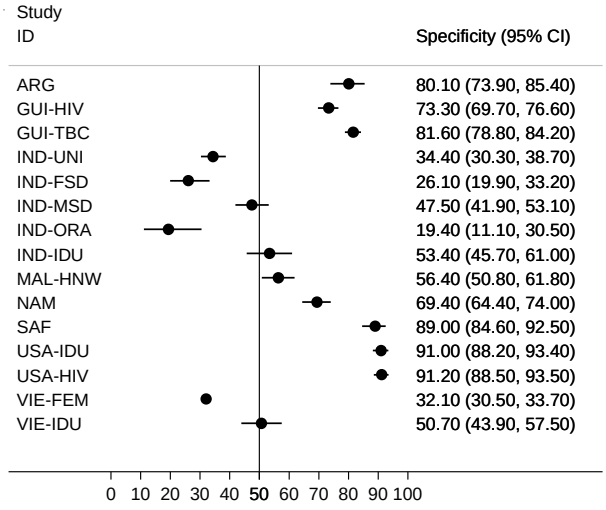
MUAC Cutoff: 25.5 cm



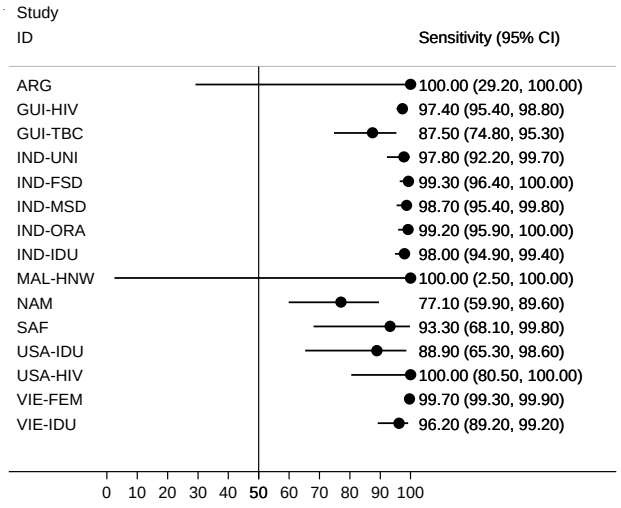


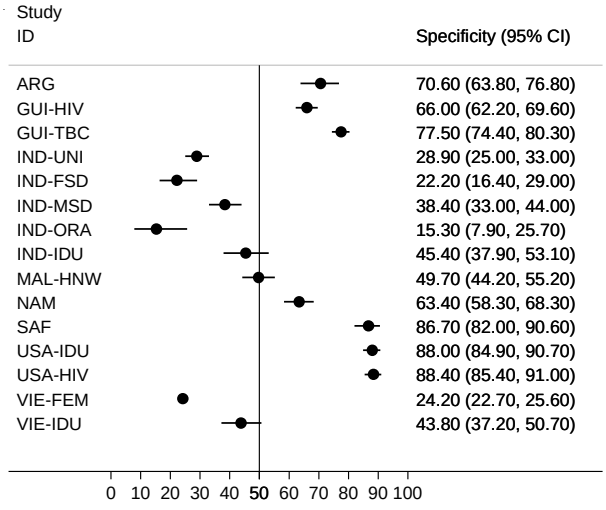
MUAC Cutoff: 26.0 cm





MUAC Cutoff: 26.5 cm





Annex C. SENS, SPEC, PPV, and NPV for MUAC Cutoffs, by Study

Table C-1. ARG: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	--- (---, ---)[a]	--- (---, ---)	--- (---, ---)	--- (---, ---)
19.5	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
20.0	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
20.5	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
21.0	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
21.5	0 (0, 70.8)	99.5 (97.3, 100)	0 (0, 97.5)	98.5 (95.8, 99.7)
22.0	0 (0, 70.8)	99 (96.5, 99.9)	0 (0, 84.2)	98.5 (95.7, 99.7)
22.5	33.3 (0.8, 90.6)	99 (96.5, 99.9)	33.3 (0.8, 90.6)	99 (96.5, 99.9)
23.0	33.3 (0.8, 90.6)	97 (93.6, 98.9)	14.3 (0.4, 57.9)	99 (96.4, 99.9)
23.5	100 (29.2, 100)	97 (93.6, 98.9)	33.3 (7.5, 70.1)	100 (98.1, 100)
24.0	100 (29.2, 100)	92.6 (88, 95.8)	16.7 (3.6, 41.4)	100 (98, 100)
24.5	100 (29.2, 100)	89.6 (84.5, 93.4)	12.5 (2.7, 32.4)	100 (98, 100)
25.0	100 (29.2, 100)	85.1 (79.5, 89.8)	9.1 (1.9, 24.3)	100 (97.9, 100)
25.5	100 (29.2, 100)	83.7 (77.8, 88.5)	8.3 (1.8, 22.5)	100 (97.8, 100)
26.0	100 (29.2, 100)	80.2 (74, 85.5)	7 (1.5, 19.1)	100 (97.7, 100)
26.5	100 (29.2, 100)	70.8 (64, 77)	4.8 (1, 13.5)	100 (97.5, 100)

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-2. GUI-HIV: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	13 (9.9, 16.8)	99.7 (98.9, 100)	96.2 (87, 99.5)	65.7 (62.7, 68.7)
19.5	14.1 (10.8, 17.9)	99.7 (98.9, 100)	96.5 (87.9, 99.6)	66 (62.9, 68.9)
20.0	18.4 (14.7, 22.6)	99.5 (98.7, 99.9)	96 (88.8, 99.2)	67.1 (64.1, 70.1)
20.5	23.5 (19.4, 28.1)	99.4 (98.4, 99.8)	95.8 (89.7, 98.9)	68.5 (65.4, 71.4)
21.0	32 (27.4, 36.8)	99.4 (98.4, 99.8)	96.9 (92.3, 99.1)	71 (67.9, 73.9)
21.5	39.1 (34.3, 44.2)	99.4 (98.4, 99.8)	97.5 (93.6, 99.3)	73.2 (70.2, 76.1)
22.0	48.3 (43.3, 53.4)	99.1 (98, 99.7)	96.9 (93.4, 98.9)	76.2 (73.2, 79.1)
22.5	50.1 (45.1, 55.2)	98.9 (97.8, 99.6)	96.6 (93, 98.6)	76.8 (73.8, 79.7)
23.0	60.9 (55.8, 65.7)	97.9 (96.4, 98.8)	94.4 (90.9, 96.9)	80.7 (77.8, 83.4)
23.5	69.3 (64.5, 73.8)	96.2 (94.4, 97.5)	91.6 (87.8, 94.5)	84 (81.2, 86.5)
24.0	78 (73.6, 82)	93 (90.7, 94.8)	86.9 (82.9, 90.2)	87.6 (84.9, 90)
24.5	86.4 (82.6, 89.7)	88.7 (86, 91)	82 (78, 85.6)	91.6 (89.2, 93.7)
25.0	91.3 (88.1, 93.9)	82.4 (79.3, 85.3)	75.6 (71.5, 79.4)	94.1 (91.8, 95.9)
25.5	91.6 (88.4, 94.1)	81.2 (78, 84.1)	74.4 (70.3, 78.3)	94.1 (91.9, 95.9)
26.0	95.4 (92.8, 97.2)	73.4 (69.8, 76.7)	68.2 (64.1, 72.1)	96.4 (94.3, 97.8)
26.5	97.7 (95.7, 98.9)	66.1 (62.3, 69.7)	63.2 (59.3, 67.1)	98 (96.2, 99.1)

Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-3. GUI-TBC: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	2.1 (0.1, 11.1)	100 (99.6, 100)	100 (2.5, 100)	94.6 (92.9, 96)
19.5	2.1 (0.1, 11.1)	100 (99.6, 100)	100 (2.5, 100)	94.6 (92.9, 96)
20.0	2.1 (0.1, 11.1)	100 (99.6, 100)	100 (2.5, 100)	94.6 (92.9, 96)
20.5	2.1 (0.1, 11.1)	99.9 (99.3, 100)	50 (1.3, 98.7)	94.6 (92.9, 96)
21.0	3.2 (0.1, 16.7)	100 (99.5, 100)	100 (2.5, 100)	96.1 (94.4, 97.3)
21.5	3.2 (0.1, 16.7)	99.9 (99.2, 100)	50 (1.3, 98.7)	96.1 (94.4, 97.3)
22.0	3.2 (0.1, 16.7)	99.6 (98.8, 99.9)	25 (0.6, 80.6)	96.1 (94.4, 97.3)
22.5	6.5 (0.8, 21.4)	99.3 (98.4, 99.8)	28.6 (3.7, 71)	96.2 (94.6, 97.4)
23.0	12.9 (3.6, 29.8)	99.2 (98.2, 99.7)	40 (12.2, 73.8)	96.4 (94.8, 97.6)
23.5	22.6 (9.6, 41.1)	98.4 (97.2, 99.2)	36.8 (16.3, 61.6)	96.8 (95.3, 97.9)
24.0	41.9 (24.5, 60.9)	97 (95.5, 98.1)	37.1 (21.5, 55.1)	97.5 (96.1, 98.5)
24.5	45.2 (27.3, 64)	95.6 (93.9, 97)	30.4 (17.7, 45.8)	97.6 (96.2, 98.6)
25.0	58.1 (39.1, 75.5)	92.9 (90.8, 94.7)	25.7 (16, 37.6)	98.1 (96.8, 99)
25.5	71 (52, 85.8)	89.7 (87.2, 91.8)	22.4 (14.6, 32)	98.7 (97.5, 99.4)
26.0	74.2 (55.4, 88.1)	86.1 (83.4, 88.5)	18.4 (12, 26.3)	98.8 (97.6, 99.5)
26.5	80.6 (62.5, 92.5)	82.2 (79.2, 84.9)	16 (10.6, 22.7)	99 (97.9, 99.6)

Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-4. IND-UNI: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	4.4 (1.2, 11)	99.8 (98.9, 100)	80 (28.4, 99.5)	85.5 (82.4, 88.3)
19.5	7.8 (3.2, 15.4)	99.8 (98.9, 100)	87.5 (47.3, 99.7)	86 (82.9, 88.7)
20.0	14.4 (7.9, 23.4)	99.8 (98.9, 100)	92.9 (66.1, 99.8)	86.8 (83.8, 89.5)
20.5	20 (12.3, 29.8)	99.4 (98.3, 99.9)	85.7 (63.7, 97)	87.5 (84.6, 90.1)
21.0	32.2 (22.8, 42.9)	98.4 (96.9, 99.3)	78.4 (61.8, 90.2)	89.1 (86.3, 91.6)
21.5	41.1 (30.8, 52)	97.2 (95.4, 98.5)	72.5 (58.3, 84.1)	90.3 (87.5, 92.7)
22.0	52.2 (41.4, 62.9)	94.3 (91.9, 96.2)	61.8 (50, 72.8)	91.8 (89.1, 94)
22.5	64.4 (53.7, 74.3)	89.4 (86.4, 91.9)	51.8 (42.1, 61.3)	93.4 (90.9, 95.5)
23.0	75.6 (65.4, 84)	82.9 (79.4, 86.1)	43.9 (35.9, 52.1)	95 (92.6, 96.9)
23.5	84.4 (75.3, 91.2)	74.1 (70, 77.8)	36.5 (30, 43.5)	96.4 (94.1, 98)
24.0	84.4 (75.3, 91.2)	70.1 (66, 74.1)	33.3 (27.2, 39.9)	96.2 (93.7, 97.9)
24.5	87.8 (79.2, 93.7)	59.1 (54.7, 63.4)	27.5 (22.4, 33.1)	96.5 (93.8, 98.2)
25.0	91.1 (83.2, 96.1)	50.5 (46.1, 54.9)	24.6 (20, 29.5)	97 (94.1, 98.7)
25.5	94.4 (87.5, 98.2)	42 (37.7, 46.5)	22.4 (18.3, 26.9)	97.7 (94.8, 99.3)
26.0	95.6 (89, 98.8)	34.6 (30.4, 38.9)	20.5 (16.8, 24.7)	97.8 (94.4, 99.4)
26.5	97.8 (92.2, 99.7)	29.1 (25.2, 33.2)	19.6 (16, 23.6)	98.7 (95.3, 99.8)

Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-5. IND-FSD: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	20.9 (14.8, 28.2)	98.3 (95.2, 99.7)	91.4 (76.9, 98.2)	59.4 (53.6, 65)
19.5	28.1 (21.1, 35.9)	97.2 (93.6, 99.1)	89.6 (77.3, 96.5)	61.4 (55.5, 67.1)
20.0	41.8 (33.9, 50.1)	97.2 (93.6, 99.1)	92.8 (83.9, 97.6)	66.3 (60.2, 72)
20.5	50.3 (42.1, 58.5)	95.6 (91.4, 98.1)	90.6 (82.3, 95.8)	69.4 (63.2, 75)
21.0	66 (57.9, 73.5)	93.3 (88.6, 96.5)	89.4 (82.2, 94.4)	76.4 (70.2, 81.8)
21.5	73.9 (66.1, 80.6)	87.8 (82.1, 92.2)	83.7 (76.4, 89.5)	79.8 (73.5, 85.2)
22.0	83 (76.1, 88.6)	80.6 (74, 86.1)	78.4 (71.3, 84.5)	84.8 (78.5, 89.8)
22.5	89.5 (83.6, 93.9)	73.9 (66.8, 80.1)	74.5 (67.5, 80.6)	89.3 (83.1, 93.7)
23.0	95.4 (90.8, 98.1)	66.7 (59.3, 73.5)	70.9 (64.2, 77)	94.5 (89, 97.8)
23.5	97.4 (93.4, 99.3)	57.2 (49.6, 64.6)	65.9 (59.4, 72.1)	96.3 (90.7, 99)
24.0	98.7 (95.4, 99.8)	47.8 (40.3, 55.3)	61.6 (55.2, 67.8)	97.7 (92, 99.7)
24.5	99.3 (96.4, 100)	41.7 (34.4, 49.2)	59.1 (52.9, 65.2)	98.7 (92.9, 100)
25.0	99.3 (96.4, 100)	33.3 (26.5, 40.7)	55.9 (49.8, 61.9)	98.4 (91.2, 100)
25.5	99.3 (96.4, 100)	32.2 (25.5, 39.6)	55.5 (49.4, 61.5)	98.3 (90.9, 100)
26.0	99.3 (96.4, 100)	26.1 (19.9, 33.2)	53.3 (47.4, 59.2)	97.9 (88.9, 99.9)
26.5	99.3 (96.4, 100)	22.2 (16.4, 29)	52.1 (46.2, 57.9)	97.6 (87.1, 99.9)

Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-6. IND-MSD: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	5.8 (2.7, 10.7)	99.4 (97.7, 99.9)	81.8 (48.2, 97.7)	68.3 (63.8, 72.5)
19.5	7.7 (4, 13.1)	99.4 (97.7, 99.9)	85.7 (57.2, 98.2)	68.7 (64.2, 72.9)
20.0	9 (5, 14.6)	99.4 (97.7, 99.9)	87.5 (61.7, 98.4)	69 (64.5, 73.2)
20.5	12.2 (7.5, 18.4)	99.1 (97.3, 99.8)	86.4 (65.1, 97.1)	69.7 (65.2, 73.9)
21.0	16.7 (11.2, 23.5)	99.1 (97.3, 99.8)	89.7 (72.6, 97.8)	70.8 (66.3, 75)
21.5	22.4 (16.2, 29.8)	98.7 (96.8, 99.7)	89.7 (75.8, 97.1)	72.2 (67.7, 76.3)
22.0	34.6 (27.2, 42.6)	98.1 (95.9, 99.3)	90 (79.5, 96.2)	75.4 (70.9, 79.4)
22.5	47.4 (39.4, 55.6)	96.9 (94.3, 98.5)	88.1 (79.2, 94.1)	79 (74.6, 82.9)
23.0	61.5 (53.4, 69.2)	94.3 (91.2, 96.6)	84.2 (76.2, 90.4)	83.3 (79.1, 87)
23.5	75 (67.4, 81.6)	88.7 (84.7, 91.9)	76.5 (68.9, 82.9)	87.9 (83.8, 91.2)
24.0	84.6 (78, 89.9)	84.9 (80.5, 88.7)	73.3 (66.2, 79.6)	91.8 (88.1, 94.7)
24.5	91 (85.4, 95)	78 (73, 82.4)	67 (60.2, 73.3)	94.7 (91.2, 97)
25.0	94.2 (89.3, 97.3)	69.5 (64.1, 74.5)	60.2 (53.8, 66.4)	96.1 (92.7, 98.2)
25.5	98.1 (94.5, 99.6)	60.1 (54.4, 65.5)	54.6 (48.6, 60.6)	98.5 (95.5, 99.7)
26.0	98.1 (94.5, 99.6)	47.5 (41.9, 53.1)	47.8 (42.2, 53.4)	98.1 (94.4, 99.6)
26.5	98.7 (95.4, 99.8)	38.4 (33, 44)	44 (38.7, 49.4)	98.4 (94.3, 99.8)

Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-7. IND-ORA: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	0 (0, 2.7)	95.8 (88.3, 99.1)	0 (0, 70.8)	34.2 (27.6, 41.1)
19.5	3 (0.8, 7.5)	95.8 (88.3, 99.1)	57.1 (18.4, 90.1)	34.8 (28.2, 41.9)
20.0	3 (0.8, 7.5)	95.8 (88.3, 99.1)	57.1 (18.4, 90.1)	34.8 (28.2, 41.9)
20.5	4.5 (1.7, 9.6)	95.8 (88.3, 99.1)	66.7 (29.9, 92.5)	35.2 (28.5, 42.3)
21.0	7.5 (3.7, 13.4)	95.8 (88.3, 99.1)	76.9 (46.2, 95)	35.9 (29.2, 43.2)
21.5	13.5 (8.2, 20.5)	94.4 (86.4, 98.5)	81.8 (59.7, 94.8)	37.2 (30.1, 44.6)
22.0	25.6 (18.4, 33.8)	93.1 (84.5, 97.7)	87.2 (72.6, 95.7)	40.4 (32.8, 48.2)
22.5	35.3 (27.3, 44.1)	91.7 (82.7, 96.9)	88.7 (77, 95.7)	43.4 (35.4, 51.7)
23.0	51.1 (42.3, 59.9)	88.9 (79.3, 95.1)	89.5 (80.3, 95.3)	49.6 (40.7, 58.5)
23.5	66.2 (57.5, 74.1)	76.4 (64.9, 85.6)	83.8 (75.3, 90.3)	55 (44.7, 65)
24.0	73.7 (65.3, 80.9)	69.4 (57.5, 79.8)	81.7 (73.6, 88.1)	58.8 (47.6, 69.4)
24.5	84.2 (76.9, 90)	51.4 (39.3, 63.3)	76.2 (68.5, 82.8)	63.8 (50.1, 76)
25.0	90.2 (83.9, 94.7)	40.3 (28.9, 52.5)	73.6 (66.2, 80.2)	69 (52.9, 82.4)
25.5	96.2 (91.4, 98.8)	29.2 (19, 41.1)	71.5 (64.3, 78)	80.8 (60.6, 93.4)
26.0	99.2 (95.9, 100)	19.4 (11.1, 30.5)	69.5 (62.4, 75.9)	93.3 (68.1, 99.8)
26.5	99.2 (95.9, 100)	15.3 (7.9, 25.7)	68.4 (61.3, 74.9)	91.7 (61.5, 99.8)

Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-8. IND-IDU: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	7.1 (3.9, 11.6)	100 (97.9, 100)	100 (76.8, 100)	48.6 (43.3, 53.9)
19.5	9.1 (5.5, 14)	100 (97.9, 100)	100 (81.5, 100)	49.2 (43.8, 54.5)
20.0	15.7 (10.9, 21.5)	100 (97.9, 100)	100 (88.8, 100)	51 (45.6, 56.4)
20.5	18.2 (13.1, 24.3)	99.4 (96.8, 100)	97.3 (85.8, 99.9)	51.6 (46.1, 57.1)
21.0	26.8 (20.7, 33.5)	99.4 (96.8, 100)	98.1 (90.1, 100)	54.4 (48.8, 60)
21.5	35.9 (29.2, 43)	99.4 (96.8, 100)	98.6 (92.5, 100)	57.7 (51.9, 63.3)
22.0	44.4 (37.4, 51.7)	98.9 (95.9, 99.9)	97.8 (92.2, 99.7)	61 (55, 66.7)
22.5	51.5 (44.3, 58.7)	97.7 (94.2, 99.4)	96.2 (90.6, 99)	63.9 (57.8, 69.7)
23.0	63.6 (56.5, 70.3)	96 (91.9, 98.4)	94.7 (89.5, 97.9)	69.9 (63.6, 75.6)
23.5	73.2 (66.5, 79.3)	93.1 (88.3, 96.4)	92.4 (87, 96)	75.3 (69, 81)
24.0	80.8 (74.6, 86)	83.9 (77.6, 89)	85.1 (79.2, 89.9)	79.3 (72.8, 85)
24.5	85.4 (79.6, 90)	82.2 (75.7, 87.6)	84.5 (78.7, 89.2)	83.1 (76.7, 88.4)
25.0	90.4 (85.4, 94.1)	74.7 (67.6, 81)	80.3 (74.4, 85.3)	87.2 (80.8, 92.1)
25.5	93.4 (89, 96.5)	62.6 (55, 69.8)	74 (68.1, 79.3)	89.3 (82.5, 94.2)
26.0	97.5 (94.2, 99.2)	53.4 (45.7, 61)	70.4 (64.7, 75.8)	94.9 (88.5, 98.3)
26.5	98 (94.9, 99.4)	45.4 (37.9, 53.1)	67.1 (61.4, 72.5)	95.2 (88.1, 98.7)

Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-9. MAL-HWW: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	32.9 (25.7, 40.8)	100 (83.2, 100)	100 (93.3, 100)	15.6 (9.8, 23.1)
19.5	41.6 (33.9, 49.6)	95 (75.1, 99.9)	98.5 (92.1, 100)	16.8 (10.4, 25)
20.0	53.4 (45.4, 61.3)	90 (68.3, 98.8)	97.7 (92, 99.7)	19.4 (11.9, 28.9)
20.5	64 (56, 71.4)	85 (62.1, 96.8)	97.2 (92, 99.4)	22.7 (13.8, 33.8)
21.0	79.5 (72.4, 85.5)	70 (45.7, 88.1)	95.5 (90.5, 98.3)	29.8 (17.3, 44.9)
21.5	86.3 (80, 91.2)	35 (15.4, 59.2)	91.4 (85.8, 95.4)	24.1 (10.3, 43.5)
22.0	96.9 (92.9, 99)	0 (0, 16.8)	88.6 (83, 92.9)	0 (0, 52.2)
22.5	99.4 (96.6, 100)	0 (0, 16.8)	88.9 (83.4, 93.1)	0 (0, 97.5)
23.0	--- (---, ---) [a]	--- (---, ---)	--- (---, ---)	--- (---, ---)
23.5	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
24.0	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
24.5	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
25.0	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
25.5	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
26.0	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
26.5	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-10. MAL-HNW: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	--- (---, ---) [a]	--- (---, ---)	--- (---, ---)	--- (---, ---)
19.5	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
20.0	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
20.5	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
21.0	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
21.5	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
22.0	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
22.5	0 (0, 97.5)	99.7 (98.3, 100)	0 (0, 97.5)	99.7 (98.3, 100)
23.0	0 (0, 97.5)	98.8 (96.9, 99.7)	0 (0, 60.2)	99.7 (98.3, 100)
23.5	100 (2.5, 100)	93.9 (90.7, 96.2)	4.8 (0.1, 23.8)	100 (98.8, 100)
24.0	100 (2.5, 100)	88.7 (84.8, 91.9)	2.6 (0.1, 13.8)	100 (98.7, 100)
24.5	100 (2.5, 100)	84.1 (79.7, 87.9)	1.9 (0, 10.1)	100 (98.7, 100)
25.0	100 (2.5, 100)	72.6 (67.4, 77.3)	1.1 (0, 6)	100 (98.5, 100)
25.5	100 (2.5, 100)	65.5 (60.1, 70.7)	0.9 (0, 4.8)	100 (98.3, 100)
26.0	100 (2.5, 100)	56.4 (50.8, 61.8)	0.7 (0, 3.8)	100 (98, 100)
26.5	100 (2.5, 100)	49.7 (44.2, 55.2)	0.6 (0, 3.3)	100 (97.8, 100)

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-11. NAM: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	0 (0, 10)	99.7 (98.5, 100)	0 (0, 97.5)	91.3 (88.1, 93.9)
19.5	0 (0, 10)	99.7 (98.5, 100)	0 (0, 97.5)	91.3 (88.1, 93.9)
20.0	5.7 (0.7, 19.2)	99.7 (98.5, 100)	66.7 (9.4, 99.2)	91.8 (88.6, 94.3)
20.5	8.6 (1.8, 23.1)	99.5 (98.1, 99.9)	60 (14.7, 94.7)	92 (88.9, 94.4)
21.0	11.4 (3.2, 26.7)	98.4 (96.5, 99.4)	40 (12.2, 73.8)	92.1 (89, 94.6)
21.5	11.4 (3.2, 26.7)	97.8 (95.8, 99.1)	33.3 (9.9, 65.1)	92.1 (89, 94.6)
22.0	14.3 (4.8, 30.3)	97.3 (95.1, 98.7)	33.3 (11.8, 61.6)	92.3 (89.2, 94.7)
22.5	17.1 (6.6, 33.6)	97 (94.7, 98.5)	35.3 (14.2, 61.7)	92.5 (89.4, 94.9)
23.0	20 (8.4, 36.9)	95.9 (93.4, 97.7)	31.8 (13.9, 54.9)	92.7 (89.6, 95.1)
23.5	28.6 (14.6, 46.3)	93.2 (90.2, 95.6)	28.6 (14.6, 46.3)	93.2 (90.2, 95.6)
24.0	40 (23.9, 57.9)	90 (86.4, 92.8)	27.5 (15.9, 41.7)	94.1 (91, 96.3)
24.5	48.6 (31.4, 66)	84.8 (80.7, 88.3)	23.3 (14.2, 34.6)	94.6 (91.5, 96.7)
25.0	60 (42.1, 76.1)	80.2 (75.8, 84.2)	22.3 (14.4, 32.1)	95.5 (92.5, 97.5)
25.5	62.9 (44.9, 78.5)	75.1 (70.3, 79.4)	19.3 (12.5, 27.7)	95.5 (92.5, 97.6)
26.0	71.4 (53.7, 85.4)	69.4 (64.4, 74)	18.1 (12.1, 25.6)	96.2 (93.2, 98.2)
26.5	77.1 (59.9, 89.6)	63.4 (58.3, 68.3)	16.7 (11.3, 23.3)	96.7 (93.6, 98.6)

Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-12. SAF: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	6.7 (0.2, 31.9)	100 (98.6, 100)	100 (2.5, 100)	95 (91.7, 97.2)
19.5	6.7 (0.2, 31.9)	100 (98.6, 100)	100 (2.5, 100)	95 (91.7, 97.2)
20.0	13.3 (1.7, 40.5)	100 (98.6, 100)	100 (15.8, 100)	95.3 (92.1, 97.5)
20.5	26.7 (7.8, 55.1)	100 (98.6, 100)	100 (39.8, 100)	96 (93, 98)
21.0	26.7 (7.8, 55.1)	99.6 (97.9, 100)	80 (28.4, 99.5)	96 (92.9, 98)
21.5	40 (16.3, 67.7)	99.6 (97.9, 100)	85.7 (42.1, 99.6)	96.7 (93.8, 98.5)
22.0	40 (16.3, 67.7)	99.6 (97.9, 100)	85.7 (42.1, 99.6)	96.7 (93.8, 98.5)
22.5	40 (16.3, 67.7)	98.9 (96.7, 99.8)	66.7 (29.9, 92.5)	96.7 (93.8, 98.5)
23.0	46.7 (21.3, 73.4)	98.1 (95.6, 99.4)	58.3 (27.7, 84.8)	97 (94.2, 98.7)
23.5	53.3 (26.6, 78.7)	97.3 (94.6, 98.9)	53.3 (26.6, 78.7)	97.3 (94.6, 98.9)
24.0	73.3 (44.9, 92.2)	96.2 (93.1, 98.2)	52.4 (29.8, 74.3)	98.4 (96.1, 99.6)
24.5	80 (51.9, 95.7)	94.7 (91.3, 97.1)	46.2 (26.6, 66.6)	98.8 (96.6, 99.8)
25.0	93.3 (68.1, 99.8)	92.8 (89, 95.6)	42.4 (25.5, 60.8)	99.6 (97.8, 100)
25.5	93.3 (68.1, 99.8)	90.5 (86.3, 93.8)	35.9 (21.2, 52.8)	99.6 (97.7, 100)
26.0	93.3 (68.1, 99.8)	89 (84.6, 92.5)	32.6 (19.1, 48.5)	99.6 (97.7, 100)
26.5	93.3 (68.1, 99.8)	86.7 (82, 90.6)	28.6 (16.6, 43.3)	99.6 (97.6, 100)

Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-13. USA-IDU: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	5.6 (0.1, 27.3)	100 (99.3, 100)	100 (2.5, 100)	96.7 (94.8, 98.1)
19.5	16.7 (3.6, 41.4)	100 (99.3, 100)	100 (29.2, 100)	97.1 (95.3, 98.4)
20.0	22.2 (6.4, 47.6)	100 (99.3, 100)	100 (39.8, 100)	97.3 (95.5, 98.5)
20.5	22.2 (6.4, 47.6)	100 (99.3, 100)	100 (39.8, 100)	97.3 (95.5, 98.5)
21.0	27.8 (9.7, 53.5)	100 (99.3, 100)	100 (47.8, 100)	97.5 (95.7, 98.6)
21.5	33.3 (13.3, 59)	100 (99.3, 100)	100 (54.1, 100)	97.7 (95.9, 98.8)
22.0	38.9 (17.3, 64.3)	99.8 (98.9, 100)	87.5 (47.3, 99.7)	97.8 (96.2, 98.9)
22.5	61.1 (35.7, 82.7)	99.6 (98.6, 100)	84.6 (54.6, 98.1)	98.6 (97.2, 99.4)
23.0	61.1 (35.7, 82.7)	99 (97.7, 99.7)	68.8 (41.3, 89)	98.6 (97.2, 99.4)
23.5	61.1 (35.7, 82.7)	98.8 (97.4, 99.6)	64.7 (38.3, 85.8)	98.6 (97.1, 99.4)
24.0	77.8 (52.4, 93.6)	97.4 (95.6, 98.6)	51.9 (31.9, 71.3)	99.2 (97.9, 99.8)
24.5	83.3 (58.6, 96.4)	96.4 (94.4, 97.9)	45.5 (28.1, 63.6)	99.4 (98.2, 99.9)
25.0	83.3 (58.6, 96.4)	94.6 (92.3, 96.4)	35.7 (21.6, 52)	99.4 (98.2, 99.9)
25.5	88.9 (65.3, 98.6)	93.4 (90.9, 95.4)	32.7 (19.9, 47.5)	99.6 (98.5, 99.9)
26.0	88.9 (65.3, 98.6)	91 (88.2, 93.4)	26.2 (15.8, 39.1)	99.6 (98.4, 99.9)
26.5	88.9 (65.3, 98.6)	88 (84.9, 90.7)	21.1 (12.5, 31.9)	99.5 (98.4, 99.9)

Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-14. USA-HIV: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	--- (---, ---)[a]	--- (---, ---)	--- (---, ---)	--- (---, ---)
19.5	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
20.0	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
20.5	11.8 (1.5, 36.4)	100 (99.3, 100)	100 (15.8, 100)	97.3 (95.5, 98.5)
21.0	17.6 (3.8, 43.4)	99.8 (99, 100)	75 (19.4, 99.4)	97.4 (95.8, 98.6)
21.5	17.6 (3.8, 43.4)	99.8 (99, 100)	75 (19.4, 99.4)	97.4 (95.8, 98.6)
22.0	35.3 (14.2, 61.7)	99.3 (98.1, 99.8)	60 (26.2, 87.8)	98 (96.4, 99)
22.5	58.8 (32.9, 81.6)	99.1 (97.8, 99.7)	66.7 (38.4, 88.2)	98.7 (97.3, 99.5)
23.0	64.7 (38.3, 85.8)	97.9 (96.4, 99)	50 (28.2, 71.8)	98.9 (97.6, 99.6)
23.5	64.7 (38.3, 85.8)	97.2 (95.4, 98.4)	42.3 (23.4, 63.1)	98.9 (97.5, 99.6)
24.0	76.5 (50.1, 93.2)	96.8 (95, 98.1)	43.3 (25.5, 62.6)	99.2 (98.1, 99.8)
24.5	88.2 (63.6, 98.5)	96.1 (94.1, 97.6)	41.7 (25.5, 59.2)	99.6 (98.6, 100)
25.0	94.1 (71.3, 99.9)	94.6 (92.3, 96.3)	35.6 (21.9, 51.2)	99.8 (98.9, 100)
25.5	100 (80.5, 100)	93.3 (90.8, 95.3)	32.1 (19.9, 46.3)	100 (99.3, 100)
26.0	100 (80.5, 100)	91.2 (88.5, 93.5)	26.6 (16.3, 39.1)	100 (99.2, 100)
26.5	100 (80.5, 100)	88.4 (85.4, 91)	21.5 (13.1, 32.2)	100 (99.2, 100)

[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-15. VIE-FEM: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	0.8 (0.4, 1.4)	100 (99.8, 100)	92.3 (64, 99.8)	68.8 (67.4, 70.1)
19.5	1.5 (0.9, 2.2)	100 (99.8, 100)	95.8 (78.9, 99.9)	68.9 (67.6, 70.2)
20.0	3.6 (2.7, 4.7)	100 (99.8, 100)	98.2 (90.6, 100)	69.4 (68.1, 70.7)
20.5	7.1 (5.8, 8.4)	99.9 (99.7, 100)	95.6 (90.1, 98.6)	70.1 (68.8, 71.4)
21.0	12.7 (11.1, 14.4)	99.8 (99.5, 99.9)	96.1 (92.4, 98.3)	71.4 (70.1, 72.7)
21.5	23.2 (21.1, 25.3)	99.3 (98.9, 99.5)	93.5 (90.5, 95.7)	73.8 (72.5, 75.1)
22.0	36.4 (34, 38.9)	98.3 (97.8, 98.7)	90.7 (88.1, 92.8)	77.2 (75.9, 78.4)
22.5	51.7 (49.2, 54.2)	95.5 (94.7, 96.1)	83.9 (81.4, 86.2)	81.2 (79.9, 82.4)
23.0	66.2 (63.8, 68.6)	91.5 (90.5, 92.4)	78 (75.7, 80.3)	85.5 (84.4, 86.7)
23.5	80 (77.9, 82)	83.5 (82.2, 84.7)	69 (66.8, 71.1)	90.1 (89, 91.2)
24.0	89.4 (87.7, 90.9)	74.5 (73, 76)	61.6 (59.6, 63.6)	93.9 (92.9, 94.8)
24.5	95.4 (94.2, 96.4)	63.4 (61.8, 65)	54.4 (52.5, 56.3)	96.8 (96, 97.5)
25.0	97.7 (96.9, 98.4)	52.5 (50.8, 54.2)	48.5 (46.8, 50.3)	98.1 (97.3, 98.6)
25.5	99.1 (98.5, 99.5)	41.4 (39.7, 43.1)	43.6 (42, 45.3)	99 (98.3, 99.5)
26.0	99.8 (99.4, 100)	32.2 (30.7, 33.8)	40.3 (38.7, 41.8)	99.7 (99.2, 99.9)
26.5	99.8 (99.4, 100)	24.3 (22.8, 25.8)	37.6 (36.1, 39.1)	99.6 (98.9, 99.9)

Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-16. VIE-IDU: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	1.3 (0, 6.9)	100 (98.3, 100)	100 (2.5, 100)	74.0 (68.6, 78.9)
19.5	1.3 (0, 6.9)	100 (98.3, 100)	100 (2.5, 100)	74.0 (68.6, 78.9)
20.0	1.3 (0, 6.9)	100 (98.3, 100)	100 (2.5, 100)	74.0 (68.6, 78.9)
20.5	2.6 (0.3, 9)	100 (98.3, 100)	100 (15.8, 100)	74.2 (68.8, 79.1)
21.0	6.4 (2.1, 14.3)	99.1 (96.7, 99.9)	71.4 (29, 96.3)	74.8 (69.4, 79.7)
21.5	9 (3.7, 17.6)	99.1 (96.7, 99.9)	77.8 (40, 97.2)	75.3 (69.9, 80.2)
22.0	23.1 (14.3, 34)	97.7 (94.8, 99.3)	78.3 (56.3, 92.5)	78.1 (72.7, 82.9)
22.5	38.5 (27.7, 50.2)	97.3 (94.1, 99)	83.3 (67.2, 93.6)	81.6 (76.4, 86.1)
23.0	50 (38.5, 61.5)	93.2 (89, 96.1)	72.2 (58.4, 83.5)	84 (78.7, 88.3)
23.5	64.1 (52.4, 74.7)	91.3 (86.8, 94.7)	72.5 (60.4, 82.5)	87.7 (82.7, 91.7)
24.0	76.9 (66, 85.7)	85.4 (80, 89.8)	65.2 (54.6, 74.9)	91.2 (86.5, 94.7)
24.5	83.3 (73.2, 90.8)	82.2 (76.5, 87)	62.5 (52.5, 71.8)	93.3 (88.8, 96.4)
25.0	91 (82.4, 96.3)	72.1 (65.7, 78)	53.8 (44.9, 62.5)	95.8 (91.5, 98.3)
25.5	96.2 (89.2, 99.2)	60.3 (53.5, 66.8)	46.3 (38.4, 54.3)	97.8 (93.6, 99.5)
26.0	96.2 (89.2, 99.2)	48.4 (41.6, 55.2)	39.9 (32.8, 47.3)	97.2 (92.2, 99.4)
26.5	96.2 (89.2, 99.2)	42.5 (35.8, 49.3)	37.3 (30.6, 44.4)	96.9 (91.1, 99.4)

Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Table C-17. ZAM: SENS, SPEC, PPV, and NPV for Each MUAC Cutoff (Values Expressed as % [95% CI])

MUAC Cutoff (cm)	SENS	SPEC	PPV	NPV
19.0	16 (10.8, 22.6)	90 (68.3, 98.8)	92.9 (76.5, 99.1)	11.7 (7.1, 17.8)
19.5	21 (15, 28.1)	90 (68.3, 98.8)	94.4 (81.3, 99.3)	12.3 (7.5, 18.8)
20.0	33.3 (26.1, 41.2)	90 (68.3, 98.8)	96.4 (87.7, 99.6)	14.3 (8.7, 21.6)
20.5	43.8 (36.1, 51.8)	75 (50.9, 91.3)	93.4 (85.3, 97.8)	14.2 (8.1, 22.3)
21.0	57.4 (49.4, 65.1)	75 (50.9, 91.3)	94.9 (88.5, 98.3)	17.9 (10.4, 27.7)
21.5	71.6 (64, 78.4)	30 (11.9, 54.3)	89.2 (82.6, 94)	11.5 (4.4, 23.4)
22.0	90.1 (84.5, 94.2)	10 (1.2, 31.7)	89 (83.2, 93.4)	11.1 (1.4, 34.7)
22.5	98.8 (95.6, 99.9)	0 (0, 16.8)	88.9 (83.4, 93.1)	0 (0, 84.2)
23.0	99.4 (96.6, 100)	0 (0, 16.8)	89 (83.5, 93.1)	0 (0, 97.5)
23.5	99.4 (96.6, 100)	0 (0, 16.8)	89 (83.5, 93.1)	0 (0, 97.5)
24.0	99.4 (96.6, 100)	0 (0, 16.8)	89 (83.5, 93.1)	0 (0, 97.5)
24.5	99.4 (96.6, 100)	0 (0, 16.8)	89 (83.5, 93.1)	0 (0, 97.5)
25.0	--- (---, ---) [a]	--- (---, ---)	--- (---, ---)	--- (---, ---)
25.5	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
26.0	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)
26.5	--- (---, ---)	--- (---, ---)	--- (---, ---)	--- (---, ---)

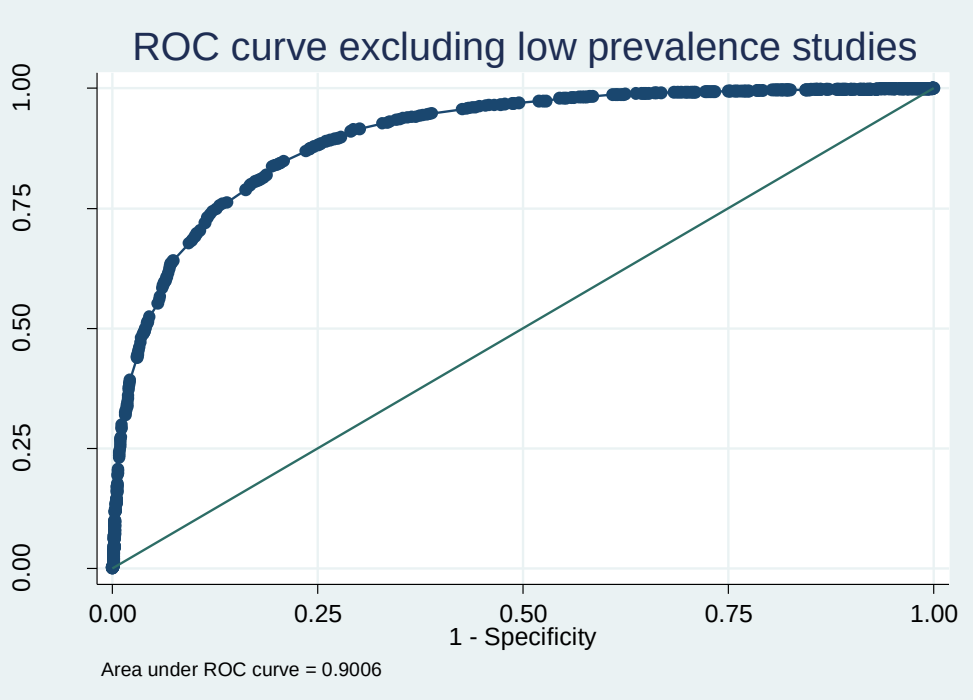
[a] "---" indicates studies that did not have individuals with MUAC measurements in this range.
Note: Results from 2x2 tables with any cell size <10 observations are grayed out due to reduced reliability of the estimate.

Annex D. Sensitivity Analyses

Summary estimates of SENS and SPEC after removal of nine studies* with low prevalence (<10%) of BMI<18.5 or low prevalence (<11 %) of individuals with BMI≥ 18.5

MUAC Cutoff (cm)	SENS (%)	SPEC (%)	Number of Studies Contributing Data
19.0	4.7 (1.7, 12.7)	99.7 (99, 99.9)	9
19.5	8.1 (3.6, 16.9)	99.6 (98.6, 99.9)	9
20.0	12 (5.4, 24.6)	99.6 (98.3, 99.9)	9
20.5	17 (8.2, 31.8)	99.2 (97.6, 99.7)	9
21.0	27.1 (14, 45.9)	98.5 (96, 99.5)	9
21.5	36.7 (20.5, 56.6)	97.4 (91.9, 99.2)	9
22.0	54.2 (31.8, 75)	94.1 (76.3, 98.7)	9
22.5	67.8 (40.7, 86.6)	90.8 (67.7, 97.9)	9
23.0	68.6 (54.9, 79.7)	91.8 (85.6, 95.4)	8
23.5	78.9 (68.3, 86.7)	86 (76.9, 91.8)	8
24.0	85.7 (77.6, 91.2)	78.9 (68.9, 86.3)	8
24.5	92.7 (91.7, 93.6)	67.1 (65.8, 68.3)	8
25.0	94.5 (91, 96.7)	61 (48.6, 72.1)	8
25.5	97.1 (94.8, 98.4)	52.1 (39.8, 64.2)	8
26.0	98.6 (96.9, 99.4)	41.7 (30.5, 53.8)	8
26.5	99.1 (98, 99.6)	34.7 (24.8, 46)	8

* Studies removed: ARG, GUI-TBC, MAL-HNW, MAL-HWW, NAM, SAF, USA-HIV, USA-IDU, and ZAM.



Annex E. Sex Subgroup Analyses: All Studies Combined, Stratified by Sex

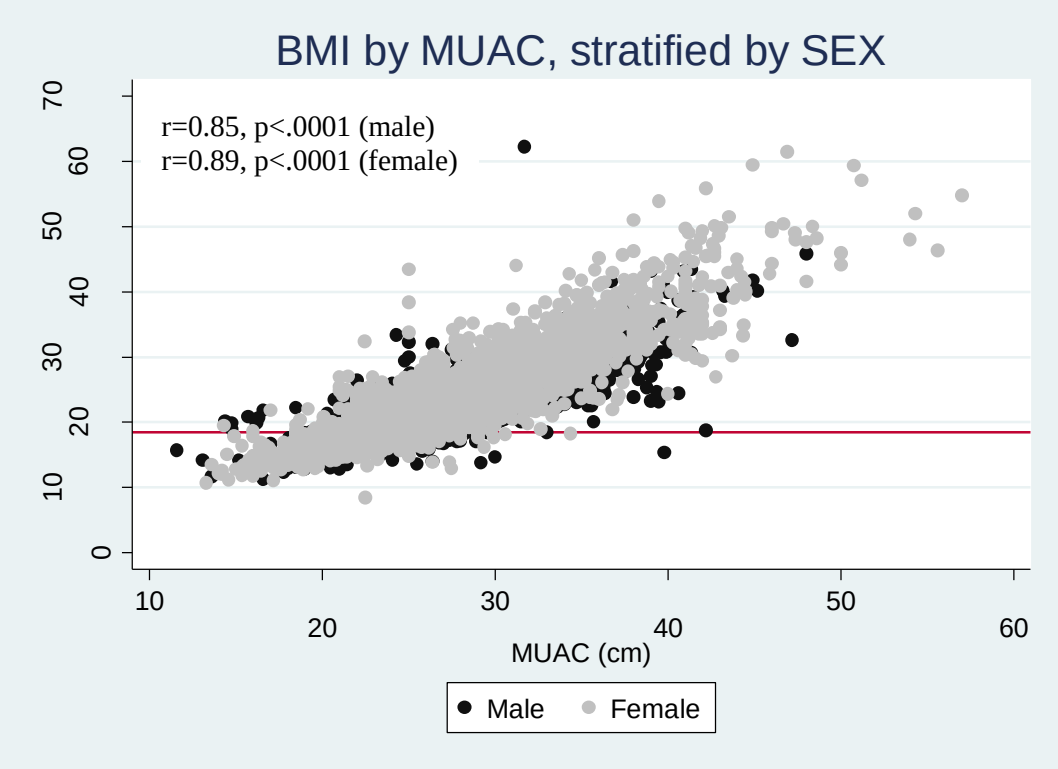


Table E-1. Summary Estimates of SENS and SPEC at Selected MUAC Cutoffs: Males

MUAC Cutoff (cm)	SENS (%)	SPEC (%)	Number of Studies Contributing Data
19.0	5.1 (2.0, 12.7)	99.4 (98.0, 99.8)	8
19.5	6.9 (3.2, 14.3)	99.5 (97.2, 99.9)	9
20.0	8.6 (3.6, 19.2)	99.7 (97.8, 99.9)	10
20.5	12.3 (6.1, 23.4)	99.3 (97.1, 99.8)	12
21.0	17.3 (9.1, 30.5)	99.0 (96.9, 99.7)	13
21.5	22.2 (10.9, 39.9)	98.6 (94.5, 99.7)	14
22.0	27.5 (15.6, 43.7)	98.5 (94.8, 99.6)	13
22.5	41.1 (25.6, 58.6)	97.3 (90.0, 99.3)	13
23.0	51.9 (34.2, 69.0)	95.5 (86.0, 98.7)	13
23.5	62.0 (44.1, 77.1)	92.4 (79.6, 97.4)	13
24.0	72.8 (59.0, 83.3)	88.4 (73.5, 95.5)	13
24.5	81.3 (70.6, 88.8)	82.8 (65.0, 92.6)	13
25.0	86.1 (79.4, 90.8)	82.1 (69.7, 90.1)	12
25.5	91.7 (85.4, 95.4)	76.6 (61.6, 87.0)	12
26.0	94.1 (88.0, 97.2)	69.1 (51.9, 82.3)	12
26.5	95.7 (90.6, 98.1)	60.9 (43.9, 75.7)	12

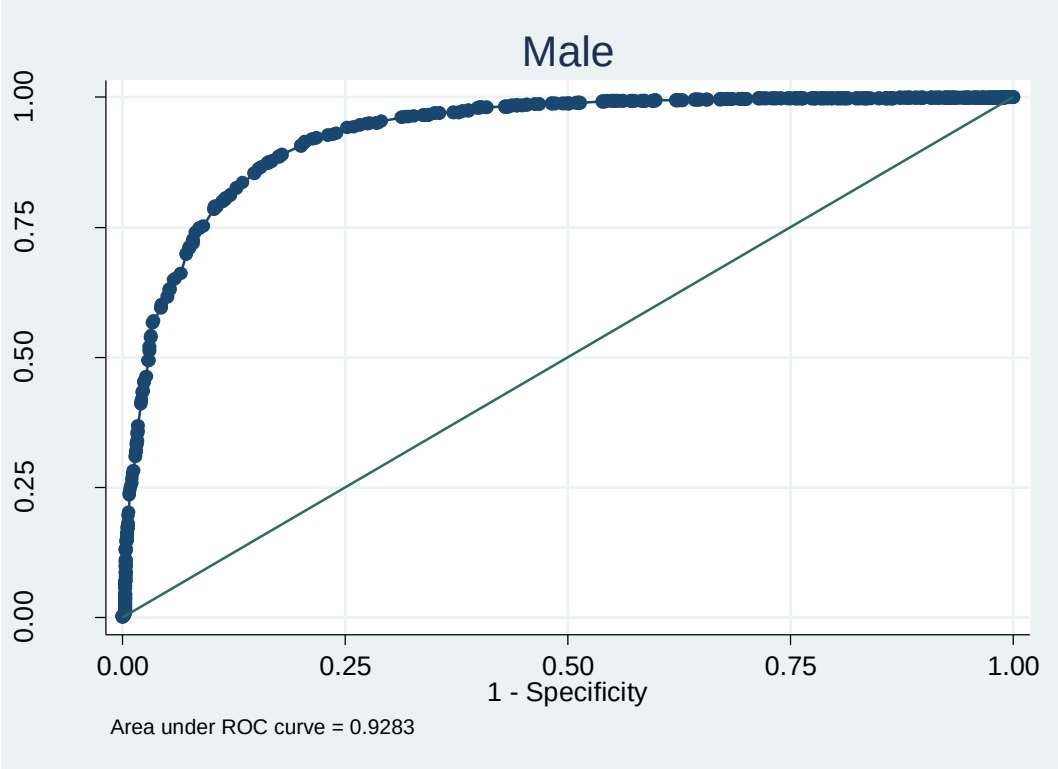
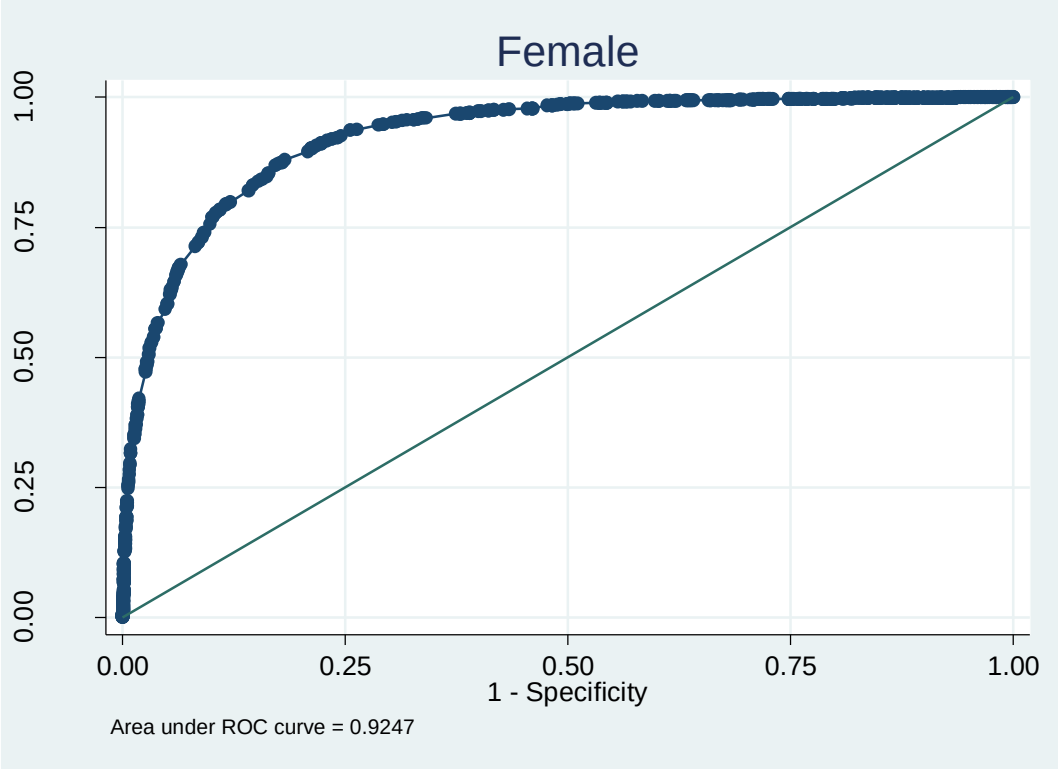


Table E-2. Summary Estimates of SENS and SPEC at Selected MUAC Cutoffs: Females

MUAC Cutoff (cm)	SENS (%)	SPEC (%)	Number of Studies Contributing Data
19.0	9.9 (4.2, 21.5)	99.7 (99.0, 99.9)	9
19.5	14.6 (6.8, 28.8)	99.7 (98.7, 99.9)	9
20.0	22.8 (13.2, 36.5)	99.5 (98.3, 99.9)	9
20.5	27.3 (16.5, 41.6)	99.2 (97.8, 99.7)	10
21.0	35.8 (21.5, 53.1)	98.8 (96.8, 99.6)	11
21.5	46.8 (30.9, 63.5)	98.1 (92.1, 99.5)	11
22.0	63.3 (41.2, 80.9)	94.5 (62.7, 99.4)	11
22.5	67.3 (42.1, 85.4)	95.9 (82.4, 99.2)	11
23.0	69.8 (53.6, 82.1)	95.3 (90.2, 97.8)	10
23.5	79.5 (67.7, 87.7)	92.3 (84.9, 96.3)	10
24.0	84.0 (78.0, 89.0)	88.0 (79.0, 93.0)	10
24.5	90.0 (83.7, 94.0)	84.7 (73.3, 91.8)	10
25.0	93.0 (88.0, 96.0)	78.0 (66.0, 87.0)	10
25.5	95.3 (88.9, 98.1)	73.6 (58.1, 84.8)	10
26.0	97.4 (93.0, 99.1)	66.8 (50.0, 80.2)	10
26.5	97.9 (94.5, 99.2)	61.4 (43.8, 76.4)	10


Female
0.00
0.25
0.50
0.75
1.00
0.00
0.25
0.50
0.75
1.00
1 - Specificity
Area under ROC curve = 0.9247

Annex F. HIV Subgroup Analyses: All Studies Combined, Stratified by HIV Status

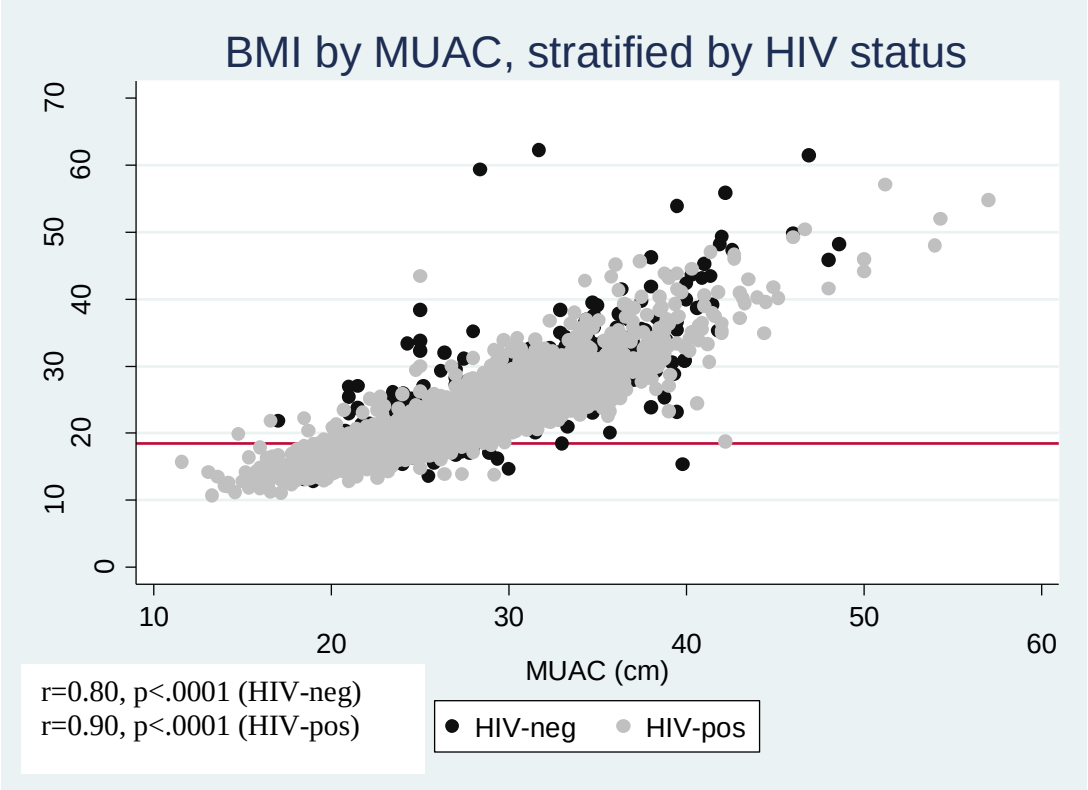


Table F-1. HIV-Negative: Summary Estimates of SENS and SPEC at Selected MUAC Cutoffs

MUAC Cutoff (cm)	SENS (%)	SPEC (%)	Number of Studies Contributing Data
19.0	4.0 (2.0, 9.0)	100.0 (98.0, 100.0)	2
19.5	5.0 (3.0, 11.0)	100.0 (98.0, 100.0)	2
20.0	11.0 (7.0, 17.0)	100.0 (98.0, 100.0)	2
20.5	12.0 (8.0, 19.0)	100.0 (98.0, 100.0)	2
21.0	11.0 (3.0, 31.0)	99.0 (97.0, 100.0)	3
21.5	14.0 (5.0, 34.0)	99.0 (95.0, 100.0)	4
22.0*	---	---	---
22.5	33.0 (18.0, 53.0)	99.0 (96.0, 100.0)	5
23.0	43.0 (28.0, 58.0)	98.0 (94.0, 99.0)	5
23.5	57.0 (39.0, 73.0)	97.0 (92.0, 99.0)	5
24.0	68.0 (47.0, 83.0)	93.0 (88.0, 97.0)	5
24.5	76.0 (58.0, 88.0)	91.0 (85.0, 95.0)	5
25.0	81.0 (63.0, 91.0)	87.0 (78.0, 93.0)	5
25.5	85.0 (65.0, 94.0)	84.0 (70.0, 92.0)	5
26.0	87.0 (69.0, 95.0)	78.0 (60.0, 89.0)	5
26.5	87.0 (72.0, 95.0)	70.0 (52.0, 83.0)	5

* Unable to estimate.

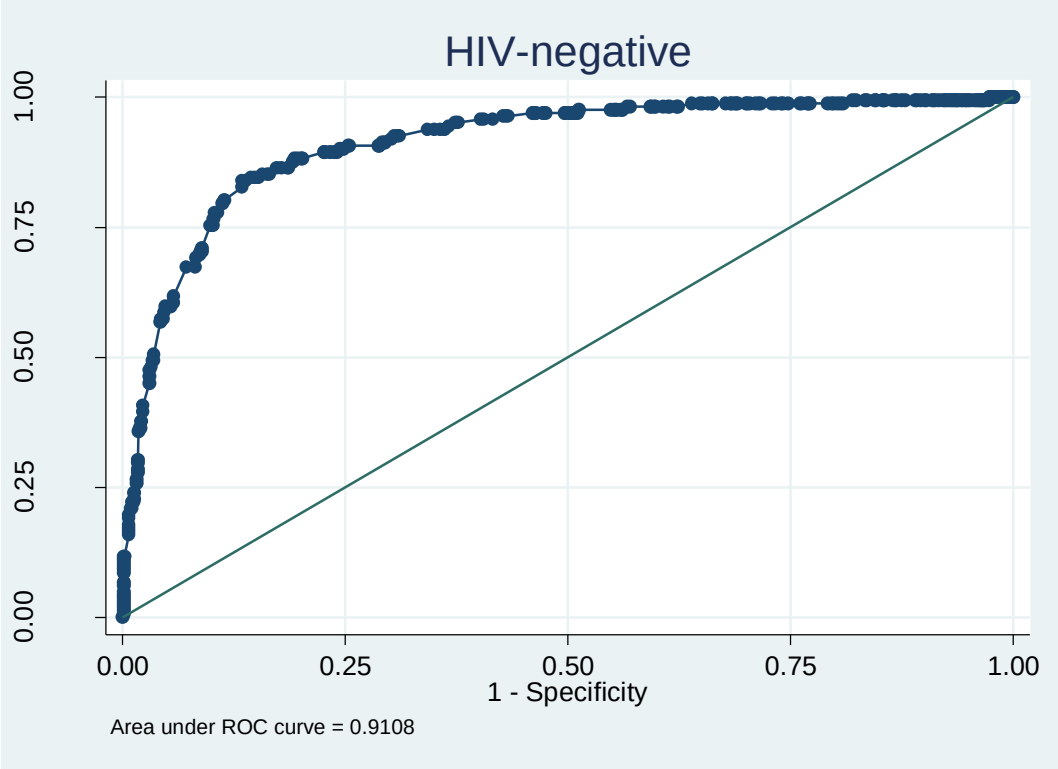
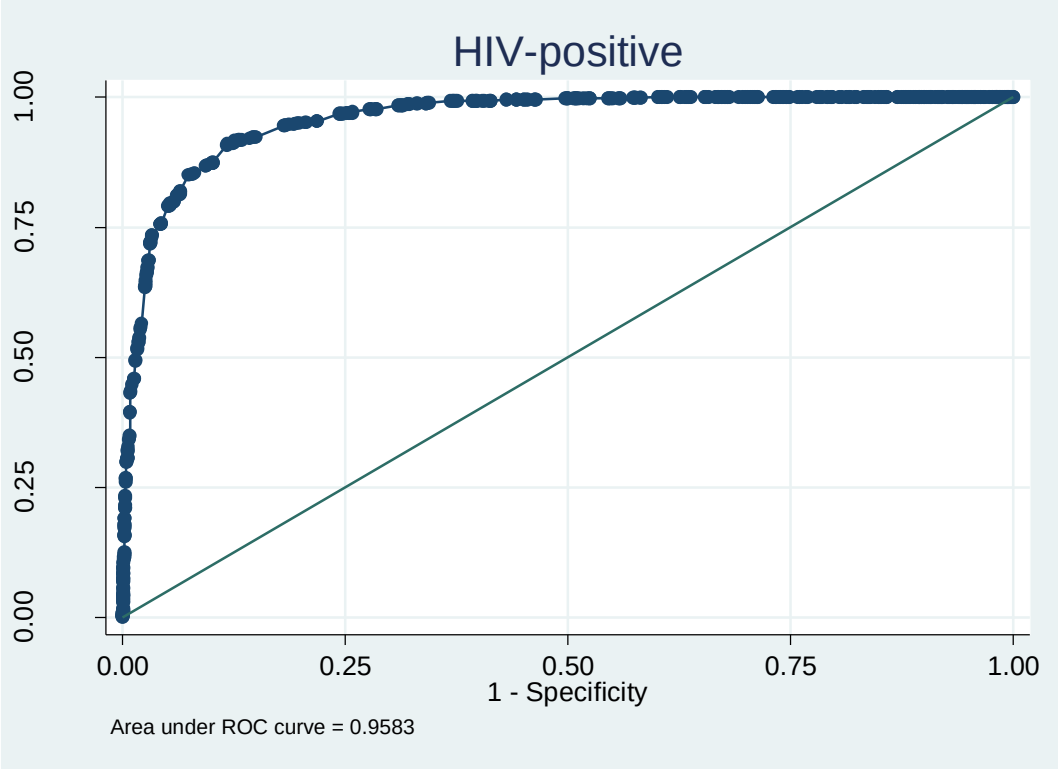


Table F-2. HIV-Positive: Summary Estimates of SENS and SPEC at Selected MUAC Cutoffs

MUAC Cutoff (cm)	SENS (%)	SPEC (%)	Number of Studies Contributing Data
19.0	11.5 (5.7, 22.1)	99.8 (96.2, 100.0)	6
19.5	14.7 (7.2, 27.7)	99.7 (96.2, 100.0)	6
20.0	19.9 (9.2, 37.9)	99.6 (95.7, 100.0)	6
20.5	22.3 (11.0, 40.0)	99.5 (95.0, 100.0)	8
21.0	33.2 (18.6, 52.0)	98.8 (94.4, 99.8)	8
21.5	39.4 (21.5, 60.7)	98.5 (87.3, 99.8)	9
22.0	58.1 (31.1, 81.0)	96.2 (54.0, 99.8)	9
22.5	69.1 (41.9, 87.4)	93.7 (52.6, 99.5)	10
23.0	70.5 (47.3, 86.4)	94.4 (74.3, 99.0)	9
23.5*	---	---	---
24.0	84.9 (73.4, 92.0)	83.7 (55.5, 95.5)	9
24.5	89.3 (82.3, 93.8)	79.1 (49.3, 93.7)	9
25.0	91.4 (88.8, 93.4)	81.2 (71.0, 88.4)	8
25.5	96.0 (84.3, 99.1)	75.8 (61.9, 85.7)	8
26.0	96.4 (94.2, 97.7)	68.8 (53.1, 81.2)	8
26.5	98.1 (96.5, 99.0)	61.6 (54.2, 68.6)	8

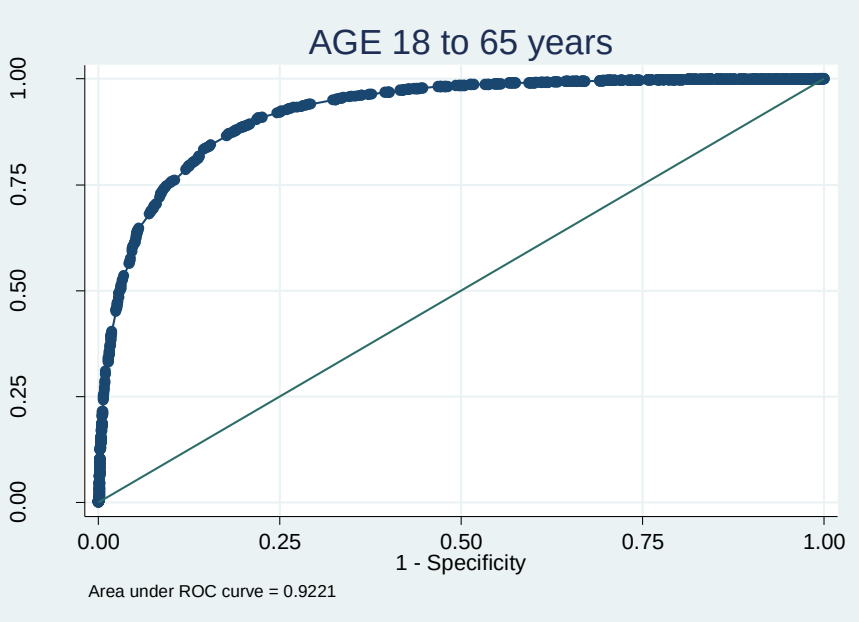
* Unable to estimate.


HIV-positive
0.00
0.25
0.50
0.75
1.00
1 - Specificity
Area under ROC curve = 0.9583

Annex G. Analyses Removing Ages >65 Years

Table G-1. Summary Estimates of SENS and SPEC at Selected MUAC Cutoffs (Comparison by Age Range)

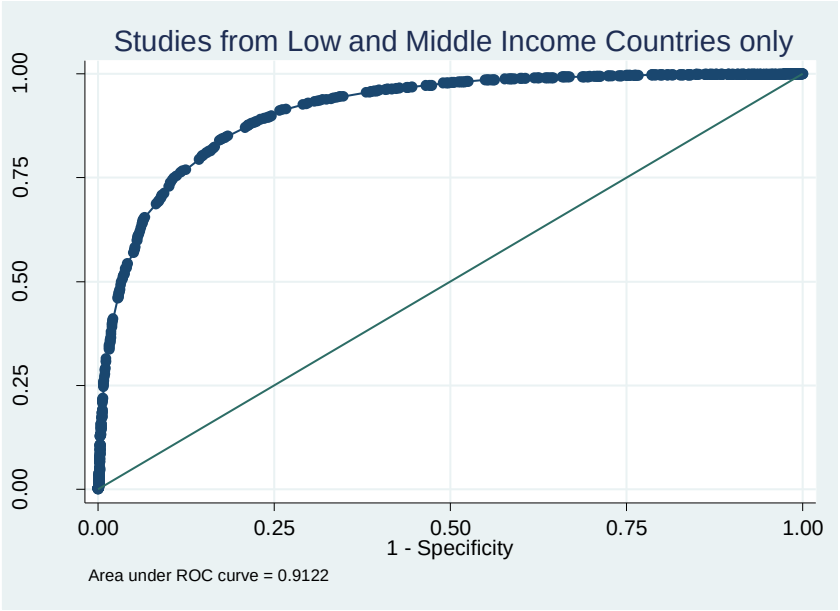
MUAC Cutoff (cm)	SENS		SPEC		Number of Studies Contributing Data	
	Age >18	Age 18–65	Age >18	Age 18–65	Age >18	Age 18–65
19.0	4.8 (2.1, 10.5)	4.4 (1.8, 10.4)	99.8 (99.1, 99.9)	99.7 (99.0, 99.9)	13	12
19.5	7.8 (4, 14.6)	7.8 (3.8, 15.0)	99.7 (98.9, 99.9)	99.6 (98.7, 99.9)	13	12
20.0	12.8 (7, 22.3)	12.4 (6.4, 22.7)	99.6 (98.7, 99.9)	99.6 (98.5, 99.9)	13	12
20.5	17.1 (10, 27.6)	16.8 (9.7, 27.7)	99.4 (98.1, 99.8)	99.2 (97.7, 99.7)	14	13
21.0	23.2 (13.7, 36.6)	22.8 (12.8, 37.2)	99 (97.4, 99.6)	99.0 (97.1, 99.6)	15	14
21.5	29.6 (17.8, 44.9)	29.2 (17.0, 45.4)	98.5 (95.3, 99.5)	98.4 (94.6, 99.5)	16	15
22.0	43.7 (26.4, 62.8)	44.0 (25.5, 64.3)	96.6 (87.7, 99.1)	96.0 (85.4, 99.0)	16	15
22.5	56.8 (32.5, 78.2)	58.1 (32.4, 80.1)	95.2 (81.9, 98.9)	94.6 (78.5, 98.8)	17	16
23.0	61.4 (41.4, 78.2)	62.8 (41.7, 79.9)	94.3 (86.8, 97.7)	93.9 (85.3, 97.6)	16	15
23.5	73.3 (56.8, 85.1)	74.6 (57.6, 86.4)	90.5 (80.1, 95.8)	89.5 (77.5, 95.5)	16	15
24.0	81.9 (73.4, 88.2)	81.7 (69.0, 89.9)	85.6 (78.5, 90.6)	85.8 (72.8, 93.2)	16	16
24.5	87.9 (78.6, 93.5)	87.6 (77.6, 93.5)	80.2 (65.4, 89.6)	80.2 (65.3, 89.8)	16	16
25.0	90.8 (84.5, 94.7)	89.9 (83.0, 94.3)	77.4 (66.1, 85.7)	77.6 (66.2, 86.0)	15	15
25.5	94.6 (89.7, 97.2)	94.3 (89.0, 97.1)	71.3 (58.1, 81.7)	71.9 (58.5, 82.3)	15	15
26.0	96.6 (92.5, 98.5)	96.4 (91.9, 98.4)	63.5 (48.5, 76.2)	64.2 (49.0, 76.9)	15	15
26.5	97.3 (94.1, 98.8)	97.2 (93.8, 98.8)	56.1 (41.1, 70.1)	56.9 (41.4, 71.1)	15	15



Annex H. Analyses Including Studies from Low- and Middle-Income Countries Only

Table H-1. Summary Estimates of SENS and SPEC at Selected MUAC Cutoffs (LMICs exclude the following studies: ARG, NAM, SFA, USA-HIV, and USA-HIV)

MUAC Cutoff (cm)	SENS		SPEC		Number of Studies Contributing Data	
	All	LMICs	All	LMICs	All	LMICs
19.0	4.8 (2.1, 10.5)	5.6 (2.3, 13.3)	99.8 (99.1, 99.9)	99.6 (98.5, 99.9)	13	10
19.5	7.8 (4, 14.6)	9.0 (4.3, 17.7)	99.7 (98.9, 99.9)	99.5 (98.1, 99.9)	13	10
20.0	12.8 (7, 22.3)	13.5 (6.5, 26.1)	99.6 (98.7, 99.9)	99.4 (97.8, 99.9)	13	10
20.5	17.1 (10, 27.6)	18.9 (9.6, 33.8)	99.4 (98.1, 99.8)	98.8 (96.1, 99.6)	14	10
21.0	23.2 (13.7, 36.6)	25.3 (12.7, 44.1)	99 (97.4, 99.6)	98.6 (95.5, 99.6)	15	11
21.5	29.6 (17.8, 44.9)	34.8 (18.7, 55.5)	98.5 (95.3, 99.5)	97.2 (89.1, 99.3)	16	11
22.0	43.7 (26.4, 62.8)	53 (29.4, 75.3)	96.6 (87.7, 99.1)	92.9 (69.7, 98.7)	16	11
22.5	56.8 (32.5, 78.2)	65.3 (30.5, 89)	95.2 (81.9, 98.9)	91.1 (58, 98.7)	17	12
23.0	61.4 (41.4, 78.2)	69.1 (41.9, 87.4)	94.3 (86.8, 97.7)	91.2 (74.8, 97.3)	16	11
23.5	73.3 (56.8, 85.1)	80.3 (61, 91.4)	90.5 (80.1, 95.8)	84.4 (65, 94)	16	11
24.0	81.9 (73.4, 88.2)	86.6 (73.3, 93.8)	85.6 (78.5, 90.6)	77.3 (57.3, 89.6)	16	11
24.5	87.9 (78.6, 93.5)	91.1 (81.3, 96)	80.2 (65.4, 89.6)	70 (49.4, 84.8)	16	11
25.0	90.8 (84.5, 94.7)	92.9 (87, 96.2)	77.4 (66.1, 85.7)	67.2 (53.7, 78.3)	15	10
25.5	94.6 (89.7, 97.2)	96.2 (92.5, 98.1)	71.3 (58.1, 81.7)	58.7 (44.9, 71.3)	15	10
26.0	96.6 (92.5, 98.5)	98.1 (95.2, 99.2)	63.5 (48.5, 76.2)	48.5 (34.8, 62.4)	15	10
26.5	97.3 (94.1, 98.8)	98.6 (96.7, 99.4)	56.1 (41.1, 70.1)	41.2 (28.6, 55)	15	10



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