Assessing the use of acute malnutrition indicators for nutrition surveillance

Results from 682 283 child observations in 27 low- and middle-income countries

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Contents

Abstract

Surveillance with anthropometric indicators is crucial for detecting any deterioration in the nutritional status of a population. It provides information on trends, which enables the progress and effectiveness of interventions to be monitored, and facilitates geographical and contextual situation analysis, which informs the prioritisation of actions and allocation of resources. For these purposes it is essential that the indicators used for monitoring yield comparable results. However, the two indicators most widely used to identify acute malnutrition in children – the weight-for-height/length Z-score (WHZ) and the absolute value of mid-upper arm circumference (MUAC) – provide discrepant results when applied to the same populations.

The aim of this report is to shed light on the relationships between WHZ and MUAC in identifying possible population-level patterns of acute malnutrition, and to explore how they relate to individual characteristics such as sex, age and stunting status, in order to guide their interpretation and use to inform nutrition interventions. The MUAC-for-age Z score (MUACZ) is also assessed to explore the possibility of using this indicator as part of population-based surveillance, taking into account the age bias that exists when assessing children for acute malnutrition using the absolute MUAC measurement only.

The Joint Research Centre–United Nations Children's Fund collaboration was set up to collate, harmonise and analyse a large data set composed of surveys from 19 West and Central Africa region countries, seven Eastern and Southern Africa region countries and Yemen. In total, 135 national and subnational representative surveys containing 682 283 child observations from 27 countries (2011–2018) were collated. We use descriptive statistics and regression analyses to analyse these data.

The findings show that WHZ and MUAC measurements identify different manifestations of acute malnutrition and are thus complementary and additive, rather than being alternatives or exchangeable. Overall, and in most of the countries included, the global acute malnutrition prevalence was lower when using MUAC than when using WHZ or MUACZ. However, results at country and regional levels differed from findings described in other multicountry studies, suggesting that the relationship between the indicators does not follow a geographical pattern (no regional or country pattern could be identified) but rather depends on the sample characteristics of the population surveyed. Importantly, sex, age and stunting status were confirmed as impacting how children are diagnosed as acutely malnourished by the different indicators. Whereas absolute MUAC measurements consistently identified more acutely malnourished children in younger age groups (below 2 years), MUACZ identified more acute malnutrition in older children. In relation to sex, depending on the indicator, the prevalence of acute malnutrition was higher among girls (MUAC) or among boys (WHZ and MUACZ). With regard to stunting status, acute malnutrition was consistently higher among stunted children than among non-stunted children across the three indicators, although, among stunted children, MUACZ invariably identified the highest number of children with acute malnutrition compared with MUAC and WHZ. Finally, these discrepancies can result in discordant situation analysis if the same severity thresholds are applied to all acute malnutrition population estimates independently of the indicator used. Currently, the only global thresholds prescribed to categorise the severity of acute malnutrition within populations are those defined by the World Health Organization for wasting based on WHZ.

In conclusion, it is recommended that the indicator used to diagnose acute malnutrition is specified when reporting nutrition outcomes and that the results are disaggregated by sex, age (under and over 24 months) and stunting status for better interpretation. The MUACZ indicator showed potential for improving the estimation of acute malnutrition for surveillance but requires additional research. In addition, further investigations are needed to define global thresholds for describing the severity of acute malnutrition at population level when using the different indicators. Alternatively, to reconsider the age targeting of surveys to 0–23 months, in line with 1 000 days programming, and to develop population thresholds specific for this age group. Meanwhile, the World Health Organization population-based thresholds for interpreting the severity of global acute malnutrition in children under 5 years should be used exclusively for WHZ. To determine the severity of acute malnutrition derived from absolute MUAC measurements we recommend using alternative methods such as that developed by the integrated food security phase classification initiative.

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Executive summary

Ongoing surveillance with anthropometric indicators is crucial for detecting any deterioration in the nutritional status of a population; for providing information on trends to allow for comparisons over time; and for facilitating geographical and contextual comparisons, which can inform the prioritisation of actions and allocation of resources. The focus of this study was to understand the relationships between anthropometric indicators and to identify possible patterns to inform how the various indicators can be used to improve nutrition surveillance at population level.

The key messages from this research are focused towards population-based surveillance and how different anthropometric indicators can be used to estimate acute malnutrition levels, monitor changes and understand the overall nutritional situation of a population to inform decision-making and plan for nutritional interventions. Different anthropometric indicators are used by different countries and in different contexts for estimating the prevalence of malnutrition based on capacity, resources, access to affected populations, feasibility, etc. The results of this study contribute to a better understanding of how the different anthropometric indicators identify acute malnutrition in populations. These findings will contribute to the development of evidence-based guidance on how the indicators can be used and interpreted for estimating acute malnutrition among populations in different contexts.

The indicators described in this report refer to acute malnutrition indicators in children aged 6–59 months, with acute malnutrition diagnosed based on a low weight for height/length (measured by the weight-for-height/length Z-score (WHZ)) or a low mid-upper arm circumference (MUAC) (measured by the absolute value of the MUAC or by the MUAC -for age- Z-score (MUACZ)). The focus of this report is on global acute malnutrition; thus, the indicators analysed are the WHZ below 2 standard deviations (WHZ2), the MUAC below 125 mm (MUAC125) and the MUACZ below 2 standard deviations (MUACZ2).

Key conclusions

The Joint Research Centre–United Nations Children's Fund collaboration has resulted in a comprehensive survey data set including 682 283 child observations from 27 countries (19 countries in the West and Central Africa region, seven in the Eastern and Southern Africa region, and Yemen). This data set allowed for high-quality research to be carried out and can be used to carry out further research on anthropometric indicators in the geographical areas covered

The findings of this analysis are aligned with those of previous studies that show that WHZ and MUAC measurements identify different manifestations of acute malnutrition and are thus complementary and additive, not alternative or exchangeable. When using only one anthropometric indicator to estimate the prevalence of acute malnutrition, there will always be children who are acutely malnourished (diagnosed by other indicators) who will be excluded from the overall prevalence estimate.

Overall, and in most of the countries included, the acute malnutrition prevalence was lower when using MUAC125 than when using WHZ2 or MUACZ2.

The comparison of these findings with those of other studies at regional or country level shows that is not possible to define patterns or relationships between anthropometric indicators across the regions or countries studied.

Sex, age and stunting affect how children are diagnosed as acutely malnourished by the MUAC125, MUACZ2 and WHZ2 indicators.

- ✓ Absolute MUAC (MUAC125) consistently identifies more acutely malnourished children in younger age groups (below 2 years).
- ✓ The prevalence of acute malnutrition is always higher among younger children (below 2 years) for MUAC125 and WHZ2, and higher among older children for MUACZ2.
- ✓ The prevalence of acute malnutrition is higher among girls when using MUAC125 but higher among boys when using WHZ2 or MUACZ2.
- ✓ The prevalence of acute malnutrition is always higher among stunted children across the three indicators, although, among stunted children, MUACZ2 consistently identifies the highest number of children with acute malnutrition.

The use of the existing World Health Organization prevalence thresholds ([1]) to interpret the severity of acute malnutrition at population level when using wasting prevalence derived from MUAC measurements is likely to result in incorrect severity classifications.

Recommendations and future work

Acknowledging the variation in the prevalence of acute malnutrition when using different anthropometric indicators, it is strongly recommend that the indicator used to diagnose acute malnutrition is specified when reporting results and that the results are disaggregated by sex, age (under and over 2 years) and stunting status for better interpretation.

For nutrition surveillance at population level, the use of a combined indicator that includes children identified as acutely malnourished by WHZ and MUAC should be further explored and validated. The combined indicator should identify children who are malnourished either by WHZ or by MUAC or by both indicators simultaneously, without double-counting children. This indicator can be automatically calculated using the Emergency Nutrition Assessment for Standardized Monitoring and Assessment of Relief and Transitions software. It will provide more accuracy in estimating the levels of acute malnutrition, in calculating the number of children in need of treatment for acute malnutrition and in describing the overall nutrition situation in a population.

Using the comprehensive data set developed from this research and additional survey data sets from other regions if available, further research should be conducted to investigate and document differences between the anthropometric indicators when measuring severe acute malnutrition, taking into account age and sex to determine if there are any differences in the findings.

As absolute MUAC measurement is becoming popular as a practical indicator for nutrition surveillance and screening, there is a need to enhance the quality and accuracy of this indicator in providing malnutrition estimates. Further research is needed to explore ways of adjusting or correcting for age bias when using absolute MUAC estimates as an indicator for surveillance purposes. These include the possibility of developing formulas to convert absolute MUAC-based prevalence into MUACZ2 prevalence and developing global population-based thresholds for MUACZ that can be used to define severity uniformly across populations.

As using World Health Organization population-based thresholds to interpret the severity of wasting at population level when using wasting prevalence derived from MUAC estimates is likely to result in incorrect severity classifications, alternative population-based thresholds specifically for wasting prevalence derived from MUAC estimates should be developed. In the interim, the proposal is to use the methodology and thresholds developed by the Integrated Food Security Phase Classification ([2]) for the classification of acute malnutrition by MUAC until further guidance is developed for MUAC-specific population-based thresholds. Alternatively, targeting of surveys to children aged 0–23 months should be reconsidered, in line with the first 1 000 days programme, and population thresholds specific for this age group should be developed.

Innovation around weight-for-height data collection is needed to make it more practical and feasible to collect high-quality height data to measure WHZ for nutrition surveillance among communities.

Further research is needed to identify children who are most at risk of mortality. Children with wasting and stunting are at a higher risk of mortality. The research found that stunted children were more frequently identified as acutely malnourished, than non-stunted children, independently of the indicator used to diagnose acute malnutrition.

([1]) < 5 %, low; 5–10 %, medium; 10–15 %, high; and ≥ 15 %, very high (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6390397/)

([2]) http://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/manual/IPC_Technical_Manual_3_Final.pdf

1. Introduction

1.1. Background

Ongoing surveillance of anthropometric indicators is crucial for providing timely assistance to malnourished individuals and detecting the deterioration of the nutritional status of populations. At individual level, anthropometric indicators are used for screening at-risk malnourished individuals in need of treatment; at population level they are key for assessing rapid changes in nutritional status due to natural hazards, conflicts, pandemics or complex emergencies that require an agile and targeted response. Surveillance of anthropometric indicators can also provide information on trends, allowing for comparisons over time and against baseline results, and it permits geographical and contextual comparisons, which can inform the prioritisation of actions and the allocation of resources (Frison et al., 2016). Critically, it also allows the progress and effectiveness of international policies to be monitored, such as the sustainable development goals, in which adequate nutrition is a target that is measurable using anthropometric indicators, among other things (Inter-agency and Expert Group on SDG Indicators, n.d.). For these purposes, however, it is essential that the indicators used for monitoring yield comparable results. The diagnosis of acute malnutrition in children aged 6–59 months can be based on a low weight for height/length, a low mid-upper arm circumference (MUAC) and/or the presence of nutritional oedema (UNHCR and World Food Programme, 2011). Based on these measurements different indices can be built: weight-for-height/length Z-score (WHZ), absolute value of mid-upper arm circumference (MUAC) and MUAC-for-age Z-score (MUACZ), which are converted to acute malnutrition indicators using validated cut-off points (WHO, 1995) as described in detail below.

The WHZ is obtained by comparing the weight of the child to be assessed with the weight of a child with the same sex and height in the reference population (it is recommended that the World Health Organization (WHO) child growth standards reference population is used; WHO, 2006). According to this index, global acute malnutrition (GAM) is defined as a WHZ below – 2 and severe acute malnutrition (SAM) is defined as a WHZ below – 3 (WHO, 1995).

The MUAC is a measure of the circumference of the left upper arm, measured at the mid-point between the tip of the shoulder and the tip of the elbow. Based on this measurement, the following indicators can be created.

- ✓ A fixed cut-off value can be used for MUAC that is common to all children aged 6–59 months independent of age and sex (what we call the absolute MUAC). According to this procedure the cut-off point for GAM is a MUAC below 125 mm, and the cut-off point for SAM is a MUAC below 115 mm (UNCHR and World Food Programme, 2011).
- ✓ The MUAC-for-age Z-score (MUACZ) can be computed by comparing the MUAC of the child to be assessed with the MUAC of a child with the same age and sex in the reference population (it is recommended that the WHO child growth standards reference population is used; WHO, 2007). According to this procedure, a diagnosis of GAM would be obtained with a MUACZ below – 2 and a diagnosis of SAM would be obtained with a MUACZ below – 3 (WHO, 1995).

Nutritional or bilateral pitting oedema is a clinical sign that is used as a proxy for SAM; however, it is outside the scope of this study and is not covered in this report.

For child growth retardation due to malnutrition, also called chronic malnutrition (or stunting), one of the standard measures is the height-for-age Z-score obtained by comparing the height of the child to be assessed with the height of a child with the same age and sex in the reference population (WHO, 1995). Although this report is focused on the anthropometric indicators of acute malnutrition, stunting is considered as a related factor and is defined as a height-for-age Z-score (HAZ) below – 2 (HAZ2).

Table 1 summarises the acute malnutrition indicators used throughout this report.

Table 1. Common acute malnutrition anthropometric measurements and indicators for children under 5 years of age.

Index/measurement	Nutritional condition	Indicator	Abbreviation
Weight-for-height/length Z-score (WHZ)	GAM	WHZ < – 2	WHZ2
	SAM	WHZ < – 3	WHZ3
Mid-upper arm circumference (MUAC)	GAM	MUAC <– 125 mm	MUAC125
	SAM	MUAC < –115 mm	MUAC115
MUAC-for-age Z-score (MUACZ)	GAM	MUACZ < – 2	MUACZ2
	SAM	MUACZ < – 3	MUACZ3

The selection of indicators to be used in a nutrition surveillance system depends mainly on the objectives of the system and the feasibility of collecting, analysing and interpreting the nutrition indicators. Broadly, these activities are classified into two main categories: (1) surveillance to identify individuals with acute malnutrition (or acute malnutrition case detection) for programme/clinical referral and (2) surveillance to assess the severity of the nutrition situation in the population and to estimate the number of children in need of treatment, in order to target populations for humanitarian action and to implement development programmes.

Nutrition surveillance systems implemented for case detection of children with SAM to be referred to therapeutic programmes widely use the WHZ3 and the MUAC115 indicators, as recommended by the WHO and the United Nations Children's Fund (UNICEF). In 2009, a joint statement from these institutions recommended the use of WHZ3 and MUAC115 as independent criteria for identifying children for the management of SAM. However, the same publication identified that the cases selected using WHZ3 and MUAC115 were not the same, and that only about 40 % of cases selected using one criterion were also selected using the other criterion. Thus, the recommendation was to further investigate these differences and to continue to use both indicators as independent criteria for admission (WHO and UNICEF, 2009).

The subsequent research confirmed these discrepancies in a variety of contexts, not only for SAM case detection using WHZ3 and MUAC115, but also for GAM diagnosis using WHZ2 and MUAC125. Roberfroid et al. (2015) found that only 29 % of children defined as acutely malnourished were diagnosed by both MUAC125 and WHZ2 in 16 surveys from four countries. Grellety and Golden (2016) analysed the results of 1 832 anthropometric surveys from 47 countries and described an overall convergence of 28 % for GAM (WHZ2 and MUAC125) and 17 % for SAM (WHZ3 and MUAC115), with dramatic differences between countries but convergence consistently lower than 40 % in all countries.

Although the reasons for these discrepancies are not well understood, the evidence points to important roles of sex, age and stunting status in the relationship (and the consequent low diagnostic convergence) between absolute MUAC and WHZ. As a measurement of 125 mm for MUAC is the cut-off for diagnosing acute malnutrition among children aged 6 months to 5 years, independent of age and sex, this indicator preferentially identifies younger female children, who have thinner arms than older male children. The WHZ measurement does not include age, but the weight of a child is interpreted according to their height and taking into account their sex, thus the age/sex bias is minimised. On the other hand, the stunting status of a child (with children who are stunted having a shorter stature for a given age) can influence the identification of acute malnutrition using the WHZ indicator, which is based on height, thus limiting the identification of stunted children (with shorter stature) as acutely malnourished in certain cases.

As the MUACZ indicator computes the Z-score of the MUAC, taking into account the age and sex of a child, the European Commission's Joint Research Centre (JRC) hypothesised that the MUACZ indicator could have more diagnostic consistency with the WHZ indicator than is found between the WHZ and MUAC indicators. Thus, Custodio et al. (2018) carried out an analysis using 255 623 children's measurements from 17 surveys in Somalia and showed that the GAM diagnostic convergence between WHZ2 and MUACZ2 (28 %) was higher than that found between WHZ2 and MUAC125 (18 %) in Somalia overall and in the four livelihood groups analysed. This finding was further confirmed by Leidman et al. (2019), who analysed 882 small-scale surveys from 41 countries and showed an overall smaller proportion of children identified by both MUAC125 and WHZ2 (26 %) than identified by both MUACZ2 and WHZ2 (31 %), although the difference was not significant. Furthermore, the proportion of children diagnosed by each indicator differed by region and country, suggesting a regional or country pattern for this relationship. As the MUACZ2 indicator is rarely used for acute malnutrition screening, results using this indicator are not available in regular reports. Thus, it is important to provide further evidence on the diagnostic overlap of these three indicators (WHZ2, MUAC125 and MUACZ2) in different populations and to explore potential geographical patterns by providing results from large-scale surveys that are representative at national and subnational levels to enrich the discussion.

Furthermore, one important consequence of these discrepancies in acute malnutrition diagnosis at individual level is meaningful variations in the acute malnutrition population prevalence estimates, which affect the evaluation and comparison of the nutritional status of populations.

For surveillance systems aiming to assess the severity of the nutritional situation at population level, WHO recommends the use of the WHZ and MUACZ indicators but not absolute MUAC measurements (WHO, 1995). The rationale is that, as absolute MUAC measurements are strongly age and sex biased, the malnutrition estimates may be conditioned to the age and sex structure of the study population when this measure is used. This bias can be minimised if the MUAC measurements are adjusted by age and sex, as in the MUACZ indicator. However, to compute the MUACZ index accurate age data are required, which may be a challenge in certain humanitarian contexts, and therefore the WHZ has been the preferred index for producing acute malnutrition population estimates. Furthermore, the WHZ is the only indicator for acute malnutrition for which there are fixed prevalence thresholds to support the public health interpretation of results at global level (de Onis et al., 2019), which provides an additional advantage for policymakers and decision-makers.

Notwithstanding this, recently, more and more acute malnutrition population estimates have been reported based only on absolute MUAC measurements. The reasons for this are varied. On the one hand, MUAC measurements have an operational advantage over WHZ measurements in terms of the equipment, capacity and time required and the cost of data collection (Frison et al., 2016). In addition, the interpretation of absolute MUAC measurements, which is based on a single cut-off, is much simpler than the comparisons with a reference population required for MUACZ and WHZ measurements. In humanitarian contexts the use of absolute MUAC measurements is also justified by the belief that absolute MUAC measurements are better than the WHZ at identifying children at higher risk of death (Myatt, Khara and Collins, 2006), although there is no consensus about this (Isanaka et al., 2015) and the most recent evidence shows that there is no difference in mortality outcomes when children are identified as acutely malnourished by absolute MUAC or by WHZ (Guesdon et al., 2020; Schwinger et al., 2019). On the other hand, there is increasing support for the use of MUAC in generating GAM population estimates in non-humanitarian contexts, such as in large national or subnational surveys, grounded in the operational advantages of measuring MUAC as opposed to WHZ, which make it a better candidate for inclusion in non-nutrition multi-topic surveys (such as household budget surveys and food security surveys).

However, and as expected because of the different diagnostic capabilities of each indicator, acute malnutrition prevalence varies significantly when either MUAC125 or WHZ2 are used as indicators, and, most importantly, the differences found are not consistent across populations. In a recent analysis conducted by Bilukha and Leidman (2018) of 773 surveys from humanitarian settings, in 70 % of the surveys the prevalence of acute malnutrition according to WHZ2 was higher than the prevalence according to MUAC125, while in the remaining 30 % of the surveys the relationship was reversed, showing that the correlation between the population prevalence of acute malnutrition estimated by WHZ2 and that estimated by MUAC125 is poor and that there is

no possibility of generating a formula to convert from one to the other, as the magnitude and direction of the association between them vary according to the population.

In addition, the prevalence of acute malnutrition estimated by MUACZ2 and the prevalence estimated by WHZ2 and MUAC125 are also inconsistent across populations. Although there are studies showing high rates of convergence between MUACZ2 and WHZ2 results in Somalia and Bangladesh (Custodio et al., 2018; Hossain et al., 2017), the study by Leidman et al. (2019) testing this association in surveys from 41 countries found that the correlations between WHZ2 and MUACZ2 are as weak as the correlations with MUAC125, and that the direction of the relationships can reverse from one country to another.

As a consequence of these discrepant results, there is increasing confusion among policymakers and decision-makers about the comparability of acute malnutrition estimates derived from different indicators and on the feasibility of performing time and geographical comparisons when estimates are derived using different acute malnutrition indicators. Thus, it is of utmost importance to further explore and concisely describe the consequences of using each of the indicators for nutrition surveillance, including in non-humanitarian contexts, by including in the analysis large subnational and national surveys.

The study described in this report builds on the analysis conducted and experience gained in the JRC study in Somalia (Custodio, 2018). It uses data collected by nutrition surveys implemented by UNICEF in collaboration with Yemen and countries from the West and Central Africa region (WCAR) and the Eastern and Southern Africa region (ESAR). The goal was to assess the convergence in GAM prevalence estimated by WHZ, MUAC and MUACZ and the concordance of GAM diagnosis using the three indicators across different populations and taking into account age, sex and stunting status, factors already identified as playing a role in the discrepancies found previously.

The results build on the current evidence by providing a comprehensive analysis that includes both an assessment of individual acute malnutrition diagnosis and acute malnutrition population estimates using the three indicators WHZ2, MUAC125 and MUACZ2 and nationally representative data, which has not been carried out before. It is also the first time that the discrepancies in acute malnutrition prevalence estimated using the different indicators have been represented using maps at regional and country levels. The only other multicountry study that has explored the relationship between these three indicators used small-scale surveys in humanitarian contexts and provided results for acute malnutrition diagnosis at regional level but not at country level (Leidman et al., 2019). Other similar studies using large surveys have focused only on acute malnutrition diagnosis and have not considered the MUACZ2 indicator (Grellety and Golden, 2016; Roberfroid et al., 2015). Furthermore, providing additional results for the same or new geographical contexts will help elucidate if the previous findings remain when using different survey data, thus potentially allowing the definition of geographical patterns.

The objectives of this study are outlined in the following section.

1.2. Objectives

The general objectives of this study were as follows.

Objective 1. The first objective was to collate the national and subnational nutrition survey data sets provided by UNICEF, which included weight, height, age, sex and the MUAC variables, into a single, harmonised data set to perform the subsequent analyses.

Objective 2. The second objective was to calculate and compare the number and proportion of acutely malnourished children individually diagnosed by each of the three indicators (WHZ2, absolute MUAC125 and MUACZ2) by region and by country and stratify the analysis by sex, age and stunting status.

Objective 3. The third objective was to calculate and compare the acute malnutrition prevalence estimates at regional and country levels using the three indicators of acute malnutrition (WHZ2, MUAC125 and MUACZ2) and stratify the analysis by age, sex and stunting status.

1.3. Overall methodology

This study is the result of a collaboration between UNICEF and the European Commission's JRC. UNICEF provided the data sets used in the analyses and contributed to decisions on data management and analysis. The JRC processed the data and conducted the analysis. The results were presented to and discussed with the UNICEF team, and the JRC drafted the report, which was critically reviewed by UNICEF.

All analyses were conducted using Stata software version 16.0. The detailed methods used to address each of the objectives are described in the corresponding sections.

In Section 2 we describe the methods applied to achieve objective 1 and provide a detailed description of the resulting data set used in the subsequent analysis. In Section 3 we report the different methods used to meet objective 2 and describe the corresponding results. In Section 4 we address the methods used to achieve objective 3 and describe the related results. In Section 5 we discuss the results of the three objectives together. Finally, conclusions are provided in Section 6.

1.4. Ethical statement

This study used data provided under the terms of a letter of understanding signed between the JRC and UNICEF (reference: Ares (2018)3927496-24/07/2018). No individuals, cluster or village location could be identified so formal ethical clearance was not required. The analyses conducted in this report, being of a secondary nature, were conducted retrospectively on recorded data and ethical review was waived. The authors complied with the Declaration of Helsinki when conducting this work.

2. Objective 1: collated data set

The data provided by UNICEF comprised nutrition survey data sets from national and subnational surveys conducted in 28 countries over 10 years, between 2008 and 2018.

The general objective was to identify and collate the nutrition survey data sets containing information on child weight, height, age and sex and MUAC indicators into a single harmonised and cleaned data set for further analysis.

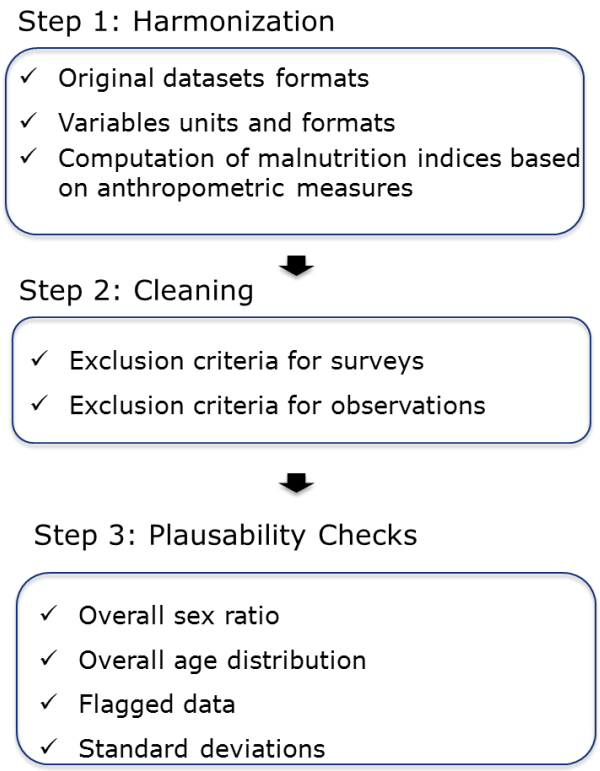
The specific objectives were to:

- ✓ harmonise the data in the collated data set in terms of variables and formats and compute the acute malnutrition indices and indicators using the anthropometric measures collected;
- ✓ clean the data in the collated data set to retain only variables of interest, as well as surveys and observations that fulfilled the overall quality criteria;
- ✓ apply the plausibility checks as described in Standardized Monitoring and Assessment of Relief and Transitions (SMART) guidelines (Action Against Hunger, 2015).

2.1. Harmonisation, data cleaning and plausibility checks

Harmonisation, data cleaning and plausibility checks are the three major activities involved in collating data sets and eventually preparing for further analysis. Figure 1 depicts the steps involved in data set collation.

Figure 1. Main steps and detailed actions for data set collation.



2.1.1. Harmonising data sets and key variables

The original data sets were retrieved in different formats (.csv, .as, .dbf, .xls, .sav, .rtf and .dta) and the first step towards harmonisation included transforming the data sets into Stata format (.dta). This exercise also included harmonisation of the key variables in terms of units and formats, as described in Table 2.

Table 2. Key harmonised variables in the data set.

Variable name	Variable description	Unit	Harmonised format
surveydate	Date of the survey	Date	dd-mm-yyyy
hh	Household number	Number	Numeric
id	Child number	Number	Numeric
cluster	Cluster number	Number	Numeric
strata	Strata name	String	String
birthdat	Child date of birth	Date	dd-mm-yyyy
agemons	Reported age of child in months	Number	Numeric
height	Height of child	Centimetres	Numeric
weight	Weight of child	Kilograms	Numeric
muac	Mid-upper arm circumference	Millimetres	Numeric
oedema	Presence of oedema	Yes/no	String
measure	Child height or length measured	Height/length	String
wtfactor	Statistical weight	Number	Numeric

These variables were given in different formats in the original data sets and were harmonised to the corresponding unique formats, as provided in Table 2.

For instance, survey date (*surveydate*) and child date of birth (*birthdat*) were provided in dd-mm-yy, mm-dd-yyyy, yy-mm-dd or yy-dd-mm formats; these were converted to dd-mm-yyyy formats in all the data sets. When available, these two variables were used to calculate the age of the children at the time of the surveys. For about 55 % of the total observations the age of the child could be calculated, which was the preferred age to enter into the computation of anthropometric indices. In the rest of the cases, when no survey date and/or child date of birth was available, we used the child's age as reported in the data set (*agemons*).

Child weight, height, sex, age and MUAC, as well as cluster number and statistical weight (*wtfactor*), were retrieved in either string or numeric formats and then formatted in numeric formats.

Furthermore, in the original data sets, child weight was reported in kilograms or grams, height in metres or centimetres, age in months or years and MUAC in centimetres or millimetres, with different decimal points and separators; these were harmonised accordingly into kilograms, centimetres, months and millimetres, respectively.

The strata variables were retrieved in numeric or text format in the original data sets. The research team made efforts to compile the corresponding matching names for numeric values based on the information available in the documented reports and/or based on additional information provided for the surveys.

The presence of oedema was retrieved in string (yes/no) or numeric (1/2, 0/1) format and then the corresponding values were confirmed using reports and converted to string (yes/no) format. This information was collected in few surveys. Similarly, *measure*, intended to capture if the child was measured standing (height) or lying down (length) was recorded in different formats/units and was harmonised as h = height and l = length; this information was available for only 30 % of observations. Thus, both presence of oedema (oedema) and type of measurement – height or length (*measure*) – were entered as missing values in the calculation of child anthropometric Z-scores.

The statistical weight (*wtfactor*), resulting from sampling design, was considered valid if it was computed following SMART guidelines, but this was reported in only 27 % of the surveys.

The anthropometric Z-scores (WHZ, MUACZ and HAZ) were computed based on the weight, height, MUAC, sex and age variables available in the data set ([3]) using the WHO 2006 child growth standards 'anthro' macro for Stata (WHO, 2016).

Most of the data sets contained more variables than the key variables specified in Table 2. Apart from those listed in Table 2, we kept only administrative and geographical variables to identify the administrative and geographical locations of the surveys (country, region, province, prefecture, etc).

2.1.2. Data cleaning

The harmonised data sets were appended into a single data set for further data cleaning ([4]), as described below:

2.1.2.1. Exclusion criteria – surveys

All surveys included in the harmonised data set were conducted using a two-stage cluster probability proportional to size design and many of them were stratified to be representative at lower administrative levels. For the subsequent analyses presented in this report, the data were aggregated at survey level or strata level (the lowest administrative level at which data are representative). We defined the survey domain as the smallest geographical unit of analysis at which the data collected are representative within each survey. Consequently, we included non-stratified surveys with one single survey domain corresponding to the overall sampling universe of the survey, and stratified surveys comprising as many survey domains as the existing strata in the surveys.

The surveys and survey domains retained in the data set fulfilled the following conditions.

- ✓ Reports had to be available describing the survey design and methodology; surveys without reports were excluded.
- ✓ For surveys with a stratified sampling design, the data sets had to contain a strata variable identified by administrative name; surveys with a stratified sampling design but without a strata variable were excluded.
- ✓ Surveys had to be missing less than 20 % of any of the key variables; surveys missing more than 20 % of any of the key variables were excluded.
- ✓ Surveys had to contain at least 196 observations; surveys with less than 196 observations were excluded.
- ✓ Surveys had to contain at least 25 clusters; surveys with less than 25 clusters were excluded.

([3]) In the case of Yemen, the weight and height variables were not available. We used the WHZ data provided instead, but were not able to compute HAZ and, subsequently, stunting for that country.

([4]) Additional variables such as country and country code, as well as survey year and months, were generated to identify each appended file. Furthermore, a filepath variable was generated to identify the paths from which the original datasets were retrieved.

2.1.2.2. Exclusion criteria – observations

A conservative approach was used to exclude all observations without valid information for constructing outcome indicators.

- ✓ Observations with valid information for key variables such as sex, age, height, weight and MUAC are essential for constructing the three child anthropometric indicators. Children with missing information for any of these variables were excluded, except for the Yemen data set ([5]).
- ✓ Only children aged from 6 to 59.99 months were included. Children aged outside this range were excluded.

([5]) Information on weight and height were not available in the Yemen dataset but computed Z scores were retrieved from the original datasets and used for this analysis.

2.1.3. Plausibility checks

The overall quality of the retained survey data sets was further assessed using the plausibility checks described in the SMART guidelines (Action Against Hunger, 2015). The assessments were carried out at survey domain level and included the following criteria: overall sex ratio and overall age distribution, flagged data and standard deviations.

2.1.3.1. Sex ratio and age distribution

The overall sex ratio and overall age distribution tests were performed to assess the representativeness of the survey samples with respect to the expected age and sex distribution of the child population. Boys and girls should be equally represented in surveys samples and we considered a male-to-female ratio above 1.25 to be a deviation from the normal demographic of a population. Surveys with male-to-female ratios above 1.25 were excluded.

We compared the value of the 6–29 months-to-30–59 months age ratio observed in surveys with the expected ratio of 0.85, as outlined in the SMART guidelines (Action Against Hunger, 2015). We found that 46 % of surveys had a problematic age distribution. To further explore this issue, we computed the proportions of children along five age categories and compared them with the proportions expected according to the SMART guidelines. Our results showed that in more than 85 % of surveys the proportion of children aged 6–17 months was above 0.24, compared with the expected proportion of 0.23, showing that this age category was over-represented in most surveys. On the contrary, older age groups were under-represented, with only 3 % of surveys showing a proportion of children in the age category 42–53 months above the 0.21 expected for this age group. In almost 20 % of surveys the proportion of children in the oldest category (54–59 months) was below 0.07, compared with the expected proportion of around 0.11.

The results suggest that problematic age distributions are due to a strong bias towards including more younger children than older children. The results were cross-checked and confirmed using plausibility checks published in the reports or directly produced by the research team using the Emergency Nutrition Assessment (ENA) for SMART software. Notwithstanding this, as the proportion of surveys to be excluded was almost 50 %, and the overall quality of the surveys remained acceptable according to the ENA overall plausibility test, we decided not to take any cleaning action based on problematic age distributions.

2.1.3.2. Flagged data and standard deviations

According to SMART guidelines, flagged data and standard deviation tests are the two most important assessments to be carried out as part of plausibility checks.

Flags refer to outliers, extreme values that are so far from the mean that they are unlikely to be correct measurements. WHO and SMART exclusion criteria are the most widely used criteria for identifying anthropometric flags. The WHO flags exclude all values outside ± 5.00 or ± 6.00 Z-scores (depending on the indicator) from the mean of the reference population (WHO child growth standards; WHO, 2016). The SMART flags exclude all values outside ± 3.00 Z-scores from the mean of the surveyed population.

The WHO flags were primarily used in this study. Cut-off points of ± 5.00 were used for WHZ and MUACZ and ± 6.00 for HAZ. Values of < 70 mm or > 220 mm were used as flag cut-off points for absolute MUAC. We also explored differences in acute malnutrition prevalence when different cut-offs for flags were used, and for this purpose we kept a parallel data set using SMART cut-offs that was also screened with the plausibility checks at a later stage ([6]).

While applying WHO flags, no survey had more than 5 % of outliers for WHZ, MUACZ or absolute MUAC. However, a few surveys had more than 7.5 % of flagged data for HAZ and were excluded. Surveys with less than 5 % of flagged data were not excluded.

When applying SMART cut-offs, no survey had more than 2.5 % of outliers for any of the indices (WHZ, MUAC, MUACZ or HAZ).

The standard deviations for the indicators were computed and tested after excluding flagged data independently for each indicator. For instance, before computing the standard deviation for WHZ the flags for

([6]) The dataset resulting from applying the SMART flags was used only to build Table 7, which compares results obtained from the two datasets.

WHZ were excluded. All surveys with standard deviations above 1.3 for WHZ and MUACZ and above 160 for MUAC were excluded.

In a final step, all flags for WHZ, MUACZ and MUAC according to the exclusion cut-offs described previously were removed. The flags for HAZ were excluded only when computing or analysing stunting status.

2.1.4. Construction of anthropometric indicators

The anthropometric indicators were constructed as dichotomic variables following the definitions provided in Section 1.1.

Furthermore, and in order to explore the acute malnutrition prevalences that would result from using WHZ2- and MUAC-based indicators simultaneously, we constructed combined indicators as described in Table 3.

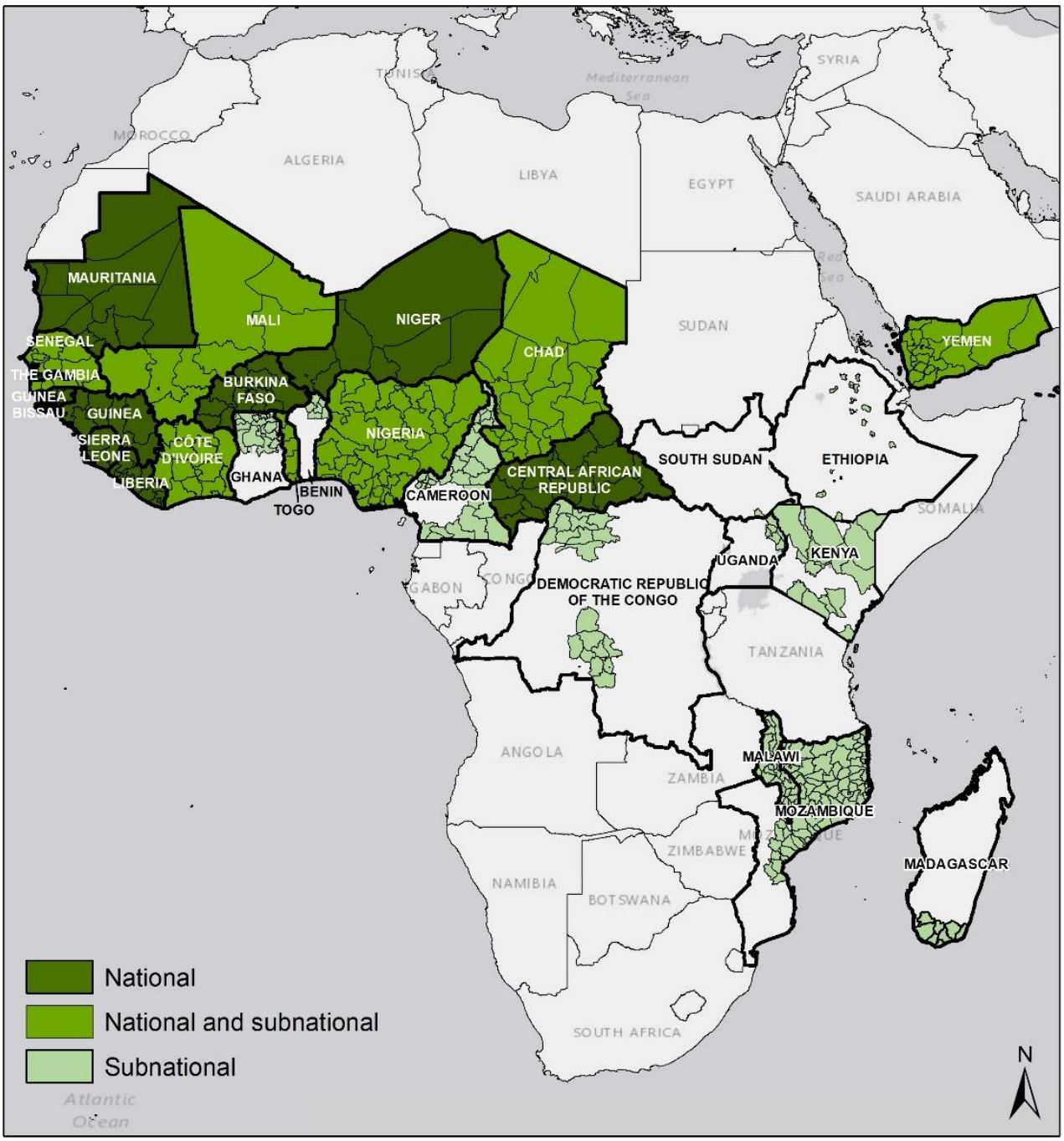
Table 3. Construction of dichotomic variables for anthropometric indicators.

Variable	**Value**	**Condition**
Acute malnutrition indicators		
WHZ2	1	If WHZ < – 2
	0	If WHZ2 > – 2
MUACZ2	1	If MUACZ < – 2
	0	If MUACZ > – 2
MUAC125	1	If MUAC < 125 mm
	0	If MUAC > 125 mm
Combined acute malnutrition indicators		
WHZ2_MUACZ2	1	If WHZ2 = 1 or MUACZ2 = 1
	0	If WHZ2 = 1 and MUACZ2 = 1
WHZ2_MUAC125	1	If WHZ2 = 1 or MUAC125 = 1
	0	If WHZ2 = 1 and MUAC125 = 1
Stunting indicator		
HAZ2	1	If HAZ < – 2
	0	If HAZ > – 2

2.2. Results: collated data set

The final collated data set included 682 283 children from 135 surveys (43 national and 92 subnational surveys), comprising 1 017 survey domains from 27 countries (19 countries from the WCAR, seven countries from the ESAR, and Yemen). The survey data were provided by UNICEF and the surveys were conducted between 2008 and 2018 (Figure 2 and Table 4).

Figure 2. Geographical representation of surveys included in the data set.



While all surveys in ESAR countries were carried out at subnational level, more than half of the surveys (42 versus 34) in WCAR countries were conducted at national level. In Chad, Côte d'Ivoire, Mali, Nigeria, Senegal, Togo and Yemen, the surveys were conducted at either national or subnational level.

Table 4. Sample characteristics.

Region/country	Survey years	Number of surveys				Children aged 6–59 months			
		Total	National	Subnational	Survey domains	Total	Female (%)	Aged 6–23 months (%)	Stunted (%)
Eastern and Southern Africa region		*36*	—	*36*	*118*	*77 338*	*49.7*	*37.8*	*31.9*
Ethiopia	2015, 2016	2	—	2	30	16 654	48.8	34.6	28.7
Kenya	2011, 2012, 2014, 2017, 2018	23	—	23	28	21 819	48.9	36.7	26.3
Madagascar	2017	1	—	1	8	7 188	50.6	33.2	38.8
Malawi	2015, 2016	3	—	3	16	6 738	51.7	32.0	40.1
Mozambique	2017	1	—	1	1	377	49.9	39.0	37.9
South Sudan	2017	1	—	1	1	457	52.3	32.8	42.4
Uganda	2015–2018	5	—	5	34	24 105	50.3	44.2	34.7
Middle East and North Africa									
Yemen	2012–2018	23	1	22	58	35 086	49.0	35.7	n.a.
West and Central Africa		*76*	*42*	*34*	*841*	*569 859*	*49.4*	*36.8*	*31.5*
Benin	2014	1	—	1	6	4 494	48.2	37.3	34.5
Burkina Faso	2011–2017	7	7	—	197	106 652	48.7	37.7	34.5
Cameroon	2011–2017	7	—	7	28	12 460	50.0	35.7	41.3
Central African Republic	2014	1	1	—	12	9 594	49.6	37.5	41.9
Chad	2010–2016	9	2	7	106	67 705	49.3	34.3	32.3
Côte d'Ivoire	2009–2012, 2014	5	1	4	37	21 412	49.5	40.7	34.3
Democratic Republic of the Congo	2009, 2013	2	—	2	6	6 844	48.6	35.2	50.2
Ghana	2013	1	—	1	3	2 669	49.3	77.7	23.4
Guinea	2011, 2015	2	2	—	17	17 727	49.3	36.7	31.6
Guinea Bissau	2012	1	1	—	9	4 780	50.3	36.5	28.1
Liberia	2016	1	1	—	10	3 165	50.2	32.8	32.1
Mali	2011–2017	7	5	2	69	64 008	49.1	37.6	25.4
Mauritania	2009, 2011–2016	8	8	—	80	61 774	49.4	37.4	22.7
Niger	2014–2016	3	3	—	24	28 390	51.1	32.8	39.8
Nigeria	2010–2013, 2015, 2016	8	1	7	100	58 809	49.7	36.2	42.4
Sierra Leone	2010, 2014	2	2	—	17	23 362	50.3	38.8	32.4
Senegal	2011–2014	4	3	1	82	53 389	49.0	35.8	20.1
The Gambia	2012, 2015	2	2	—	15	10 654	49.1	36.4	24.7
Togo	2008, 2009, 2012, 2014	5	3	2	23	11 971	49.7	35.2	29.7
Total		**135**	**43**	**92**	**1 017**	**682 283**	**49.4**	**36.9**	**31.6**

NB: n.a., not available.

The largest number of surveys was carried out in the WCAR (76), followed by the ESAR (36) and the Middle East and North Africa (MENA), represented only by Yemen (23). Countries with the highest share of observations in the WCAR were Burkina Faso (18 %), Chad (11 %) and Mali, Mauritania and Nigeria (10 %). Almost equal numbers of male and female children were retained for analysis (49 % female versus 51 % male), and the overall age ratio was 1:1.7 between children aged 6–23 months and children aged 24–59 months, decreasing to 1:1.6 in the ESAR, and deviating from the expected 1:2 ratio. As described in the previous section, these deviations were more substantial when observed at survey level, indicating a strong bias towards children aged below 2 years in the majority of the surveys, and suggesting a consistent imbalance in the age of children surveyed, with older children being under-represented.

The proportion of stunted children within each country's pooled data set ranged from 20 % to 50 %, but these values do not represent country prevalence and cannot be compared within countries, as each country's pooled sample results from aggregating all surveys conducted in that country, covering different populations, geographical areas and time periods.

2. Objective 2: diagnosis of acute malnutrition

Objective 2 was to explore the individual diagnosis of acute malnutrition by each of the three indicators and identify overlaps in diagnosis, that is, to identify children diagnosed as acutely malnourished by the following pairs of indicators (WHZ2 and MUACZ2, WHZ2 and MUAC125 and MUAC125 and MUACZ2) and, within those pairs, identify those diagnosed by only one of the indicators in the pair and those diagnosed by both indicators in the pair simultaneously.

In order to address this objective we first retrieved the subsets of children who were diagnosed as acutely malnourished by both indicators in a pair or uniquely by one of the indicators in the pair. This was carried out for each of the pairs and thus we obtained three subsets, one for WHZ2 and MUAC125, one for WHZ2 and MUACZ2, and one for MUAC125 and MUACZ2.

Second, we applied two different methodological approaches to the three subsets, as described in Sections 3.1 and 3.2.

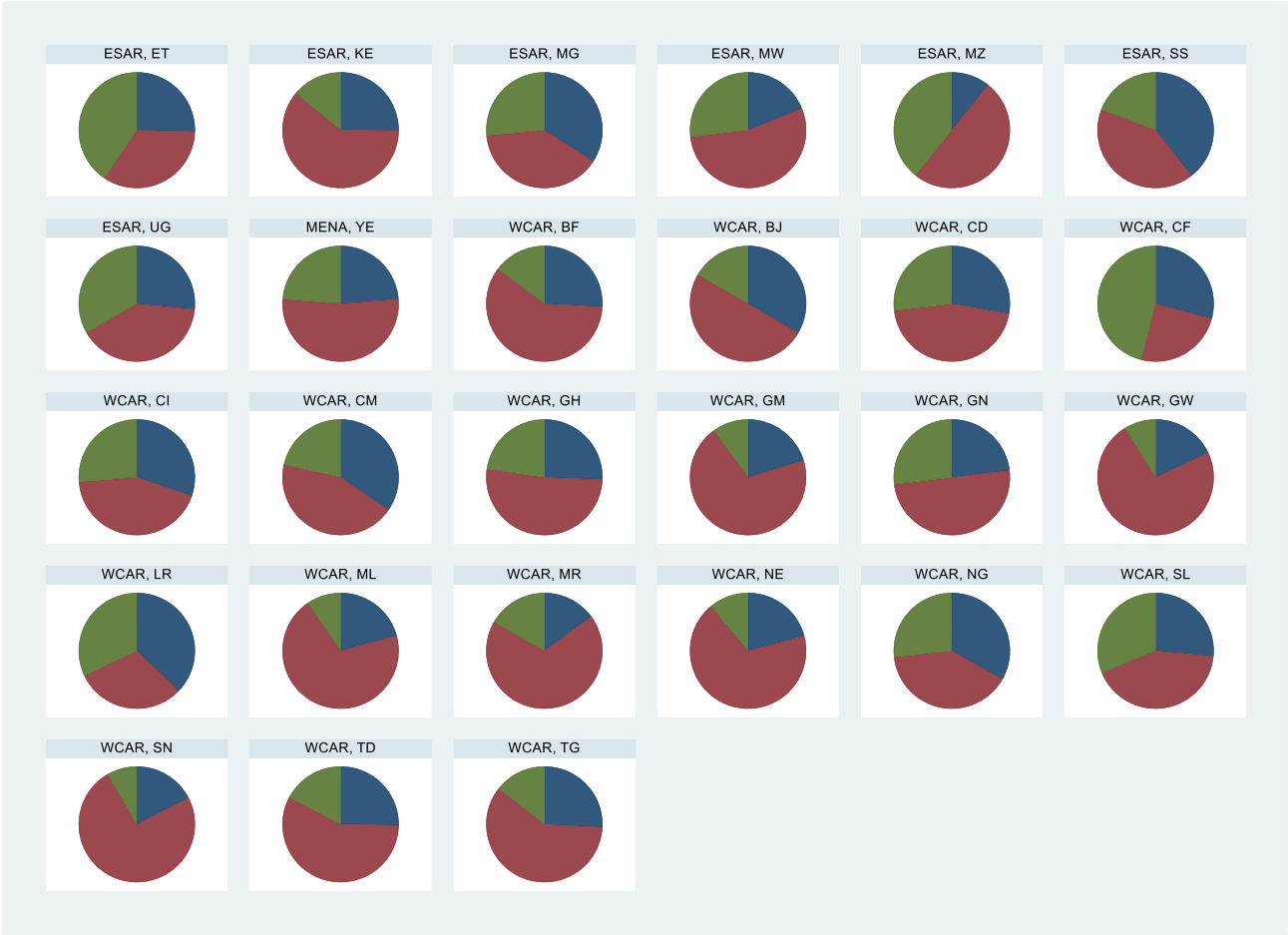
2.1. Diagnosis overlap at country level

In the first method we pooled the observations collected by all the surveys implemented in a given country and calculated the numbers and proportions of children in that pooled sample diagnosed by only one and by both indicators for each pair.

The first pair of indicators assessed was WHZ2 and MUAC125. The data set included 88 401 children diagnosed as acutely malnourished by either WHZ2 or MUAC125, of whom 50 405 (57 %) were diagnosed only by WHZ2, 16 564 only by MUAC125 (19 %) and 21 432 (24 %) by both indicators simultaneously. Out of all children diagnosed by either method, WHZ2 identified 81 % and MUAC125 43 %. At regional level the proportions were similar, although in the ESAR the proportion of children diagnosed by MUAC125 increased to 52 %, whereas in the MENA region the proportion diagnosed by MUAC125 decreased to 41 % (see Table A10).

As shown in Figure 3, the proportion of diagnostic overlap between these two indicators varies substantially between countries.

Figure 3. Pie charts showing the proportions of children with GAM diagnosed by WHZ2 and MUAC125 (blue), WHZ2 alone (red) and MUAC125 alone (green) among children diagnosed with GAM by either WHZ2 or MUAC125, all children aged 6–59 months.

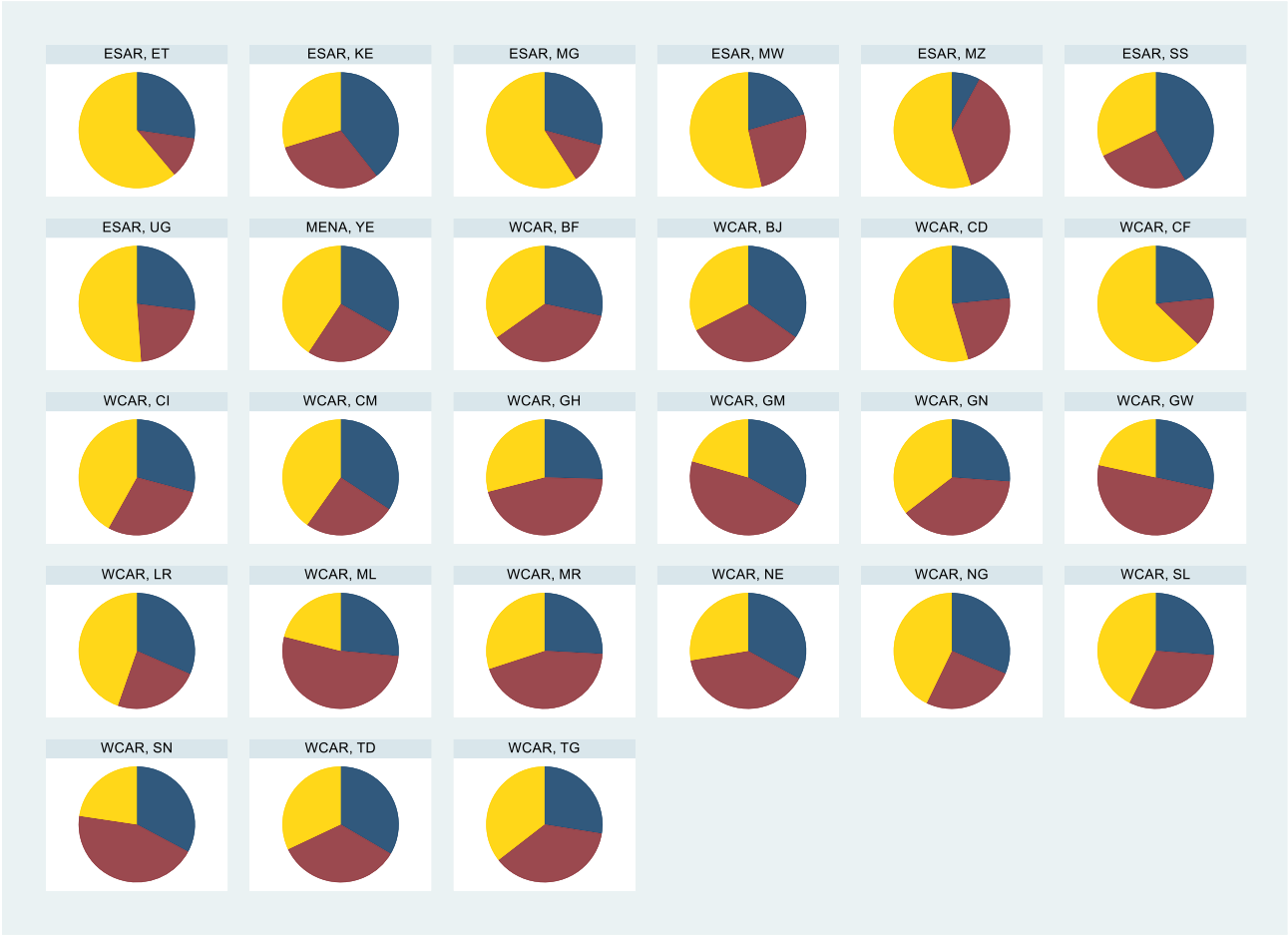


The proportion of children diagnosed by WHZ2 only ranged from 75 % in Senegal to 28 % in the Central African Republic. The country showing the highest diagnostic overlap between WHZ2 and MUAC125 was South Sudan (39 %) and the country showing the lowest diagnostic overlap was Mauritania (15 %). The largest difference between the proportion of children diagnosed by WHZ2 (including children diagnosed by WHZ2 only and children diagnosed by both MUAC125 and WHZ2) and the proportion of children diagnosed by MUAC125 (including children diagnosed only by MUAC125 only and children diagnosed by both MUAC125 and WHZ2) was found in Senegal (92 % of children identified as acutely malnourished by WHZ2 compared with 25 % identified as acutely malnourished by MUAC125), closely followed by Guinea-Bissau (92 % compared with 26 %).

Overall, consistently higher proportions of children were identified as acutely malnourished by WHZ2 only. The only countries showing a higher identification of acute malnutrition with MUAC125 compared with WHZ2 were Ethiopia (66 % of children identified by MUAC125 compared with 60 % identified by WHZ2) and the Central African Republic (73 % identified by MUAC125 and 55 % by WHZ2). Detailed data used to construct the pie charts are provided in Table A1.

Figure 4 shows the same comparison for WHZ2 and MUACZ2.

Figure 4. Pie charts showing the proportions of children with GAM diagnosed by WHZ2 and MUACZ2 (blue), WHZ2 alone (red) and MUACZ2 alone (yellow) among children diagnosed with GAM by either WHZ2 or MUACZ2, all children aged 6–59 months.



In total, 111 911 children were diagnosed as acutely malnourished by either WHZ2 or MUACZ2. Of these, 34 % were diagnosed only by WHZ2, 36 % were diagnosed only by MUACZ2 and 30 % were diagnosed by the two indicators simultaneously. In the overall sample, WHZ2 identified 64 % of the children diagnosed with acute malnutrition and MUACZ2 identified 66 % of the children identified as acutely malnourished. At the regional level the diagnostic overlap varied: in the ESAR 78 % of the children were identified by MUACZ2 and 53 % by WHZ2, whereas in the WCAR the relationship reverted, with a higher proportion (66 %) diagnosed by WHZ2 than by MUACZ2 (63 %). Contrasting results were found at country level, with The Gambia showing the highest proportion of children diagnosed by WHZ2 (79 %), followed by Mali (79 %), and Ethiopia showing the lowest proportion of children diagnosed by WHZ2 (38 %). The proportion of children diagnosed by MUACZ2 ranged from 47 % in Mali to 89 % in Ethiopia. At country level, there was no consistent pattern in which indicator identified more children with acute malnutrition, as in 13 of the 27 countries studied WHZ2 identified more children than MUACZ2, whereas in the remaining 14 countries the situation was reversed. Detailed data used to construct the pie charts are provided in Table A2.

The last pair to be analysed was MUAC125 and MUACZ2. In total, 80 805 children were diagnosed as acutely malnourished by either MUAC125 or MUACZ2; of these, 53 % were diagnosed by MUACZ2 only, 8 % were diagnosed by MUAC125 only and 39 % were diagnosed by both indicators simultaneously. Overall, 92 % of the children in the pair were identified by MUACZ2 and 47 % were identified by MUAC125. These proportions were similar for each of the regions analysed.

Figure 5 shows that in all countries the proportion of children diagnosed by MUACZ2 only is much higher than the proportion of children diagnosed by MUAC125 only, with the latter being below 10 % in most countries. In addition, the proportion of children identified by MUACZ2 (including MUACZ2 only and MUACZ2 and MUAC125 simultaneously) is over 90 % in most countries. Detailed data used to construct the pie charts are provided in Table A3.

Figure 5. Pie charts showing the proportions of children with GAM diagnosed by MUAC125 and MUACZ2 (blue), MUAC125 alone (green) and MUACZ2 alone (yellow) among children diagnosed with GAM by either MUAC125 or MUACZ2, all children aged 6–59 months.

2.2. Diagnosis overlap at survey level

The second method used to explore individual acute malnutrition diagnoses and diagnostic overlap involved first, computing the proportions of children diagnosed by each of the indicators alone and by both simultaneously within the pairs for each of the 1017 survey domains considered and, second, pooling the computed proportions at country level and calculating the median proportions and interquartile ranges (IQRs) for each country.

Surveys with fewer than 10 acutely malnourished children within a pair were excluded from the analysis.

Table 5 shows the median proportions and IQRs for each of the pairs for the overall sample and for each region and country.

Looking at the overall sample and the three region subtotals, the highest overlap between indicators within the same pair – children diagnosed by both indicators in the pair simultaneously – is seen for MUAC125 and

MUACZ2 (around 37 % for the overall sample and for each region), followed by WHZ2 and MUACZ2 (29 % for the overall sample and in the WCAR and ESAR, and 31 % in Yemen). The lowest overlap is seen between WHZ2 and MUAC125 (25 % in the overall sample and in the ESAR, 23 % in the WCAR and 22 % in Yemen).

At country level, the overlap is also highest between the two MUAC indicators (ranging from 28 % to 58 %, and in most countries the overlap is higher between WHZ2 and MUACZ2 (in 20 out of 27 countries), ranging from 8 % to 42 %, than between WHZ2 and MUAC125, ranging from 10 % to 32 %.

When the WHZ2 and MUAC125 pair is analysed, higher proportions of children are diagnosed by WHZ2 only than by MUAC125 only in all countries except the Central African Republic, Ethiopia and Liberia. The difference between the proportion of children diagnosed by MUAC125 only and the proportion of children diagnosed by WHZ2 only ranges from 8 percentage points in Uganda to 72 percentage points in Senegal.

On the contrary, when analysing the WHZ2 and MUACZ2 pair, all countries in the ESAR except for Kenya, seven countries in the WCAR, and Yemen show a higher proportion of children diagnosed by MUACZ2 only than by WHZ2 only.

For the third pairwise comparison the results are consistent across regions and countries. All countries show a higher proportion of children diagnosed by MUACZ2 only than by MUAC125 only, with differences ranging from 18 percentage points to 60 percentage points.

Table 5. Proportion of acutely malnourished children aged 6–59 months diagnosed by each diagnostic indicator for the three indicator pairs (MUAC125 and WHZ2, MUACZ2 and WHZ2 and MUAC125 and MUACZ2), by country.

	WHZ2 and MUAC125				WHZ2 and MUACZ2				MUAC125 and MUACZ2			
Country	N	Median (IQR) (%), WHZ2 only	Median (IQR) (%), MUAC125 only	Median (IQR) (%), both	N	Median (IQR) (%), WHZ2 only	Median (IQR) (%), MUACZ2 only	Median (IQR) (%), both	N	Median (IQR) (%), MUAC125 only	Median (IQR) (%), MUACZ2 only	Median (IQR) (%), both
ESAR	12 854	43.64 (35.06–64.89)	27.12 (16.05–37.50)	25.0 (17.65–30.0)	17 866	18.94 (13.13–34.78)	50.72 (32.98–58.68)	28.66 (23.15–35.68)	15 002	6.33 (4.55–8.33)	56.25 (48.65–62.25)	36.75 (29.63–43.13)
ET	2 498	35.43 (23.94–45)	39.23 (31.25–46.97)	24.04 (20.51–28.24)	3 832	11.31 (6.59–14.95)	60.98 (52.67–70.06)	26.52 (22.56–33.59)	3 657	6.15 (4.79–8.33)	57.04 (49.69–61.29)	35.74 (31.52–41.36)
KE	4 727	67.5 (54.74–75.23)	12.88 (8.67–17.11)	19.32 (15.7–27.75)	5 796	36.47 (19.52–43.48)	26.73 (21.03–36)	37.73 (29.84–42.59)	4 281	6.31 (5.13–8.17)	59.9 (54.2–66.32)	32.86 (26.42–40)
MG	1 022	39.22 (36.71–41.17)	26.62 (23.69–27.98)	34.67 (32.6–36.72)	1 846	10.6 (8.88–13.95)	58.8 (54.66–61.33)	30.31 (26.35–33.18)	1 727	5.79 (3.77–6.83)	64.25 (60.8–67.88)	29.77 (26.8–33.75)
MW	272	53.33 (35.29–72.5)	20 (10.71–38.89)	17.5 (13.33–22.22)	495	18.34 (10.32–35.57)	59.3 (44.83–73.5)	18.11 (13.56–23.61)	391	5.88 (4.55–8.33)	64.52 (56–72)	27.78 (19.64–38.89)
MZ	28	50 (50–50)	39.29 (39.29–39.29)	10.71 (10.71–10.71)	38	36.84 (36.84–36.84)	55.26 (55.26–55.26)	7.89 (7.89–7.89)	25	4 (4–4)	44 (44–44)	52 (52–52)
SS	96	42.71 (42.71–42.71)	18.75 (18.75–18.75)	38.54 (38.54–38.54)	115	25.22 (25.22–25.22)	32.17 (32.17–32.17)	42.61 (42.61–42.61)	90	4.44 (4.44–4.44)	38.89 (38.89–38.89)	56.67 (56.67–56.67)
UG	4 172	39.82 (32.53–49.64)	31.57 (27.06–37.33)	27.16 (22.73–31.03)	5 744	20.14 (14.01–30.58)	51.44 (41.52–56.36)	27.16 (22.15–30.65)	4 823	7.02 (5.37–10)	48.3 (43.9–55.38)	42.56 (40.19–48.89)
MENA	5 843	56.58 (39.39–65.31)	20.37 (13.04–34.67)	21.6 (16.67–26)	7 542	27.19 (16.09–35.96)	37.7 (26.67–53.98)	30.51 (24.62–38.67)	6 075	7.64 (5.56–10.14)	55.51 (51.98–61.11)	35.95 (30–40.24)
YE	5 843	56.58 (39.39–65.31)	20.37 (13.04–34.67)	21.6 (16.67–26)	7 542	27.19 (16.09–35.96)	37.7 (26.67–53.98)	30.51 (24.62–38.67)	6 075	7.64 (5.56–10.14)	55.51 (51.98–61.11)	35.95 (30–40.24)
WCAR	67 639	61.47 (47.38–72.97)	14.49 (8.12–23.53)	23.35 (15.63–30.43)	83 836	37.66 (28.21–49.17)	30.86 (21.57–41.33)	28.95 (23.20–34.43)	57 812	8.70 (5.71–12.14)	53.08 (44.94–61.90)	37.24 (29.29–45.24)
BF	11 837	61.76 (53.03–70.18)	12.9 (8.11–17.74)	24.39 (18.75–30.43)	15 505	37.5 (30.43–46.67)	33.33 (26.19–40)	27.59 (22.58–31.58)	10 710	8.33 (5.77–12)	57.08 (50–63.64)	34.29 (27.27–40.74)
BJ	487	52.71 (45.37–56.45)	16.25 (11.11–17.74)	33.06 (28.92–37.66)	606	31.76 (31.03–36.36)	28.49 (27.27–39.66)	34.68 (32.41–38.89)	456	10.08 (9.09–11.49)	44.94 (42.53–50.91)	42.58 (38.18–48.15)
CD	547	49.75 (38.96–57.14)	29.66 (18.68–33.75)	25.72 (20.9–34.84)	896	17.76 (17.02–28.32)	54.57 (43.09–64.68)	20.36 (18.58–25.86)	744	5.31 (3.76–9.76)	53.74 (52.44–75.19)	35.94 (21.05–43.43)
CF	1 112	26.36 (15.88–37.25)	45.78 (35.91–49.99)	29.16 (23.27–32.24)	1 634	12.99 (7.91–25.97)	61.47 (49.77–70.25)	23.59 (22.09–26.22)	1 529	6.66 (5.5–10.39)	45.95 (40.98–50.32)	47.34 (41.41–51.96)
CI	1 613	44.21 (32.38–52.44)	24.16 (15.89–40.06)	32.5 (25.83–37.38)	2 097	27.96 (19.05–33.33)	39.6 (30.67–55.13)	32.61 (23.33–37)	1 656	9.3 (5.63–12.24)	43.42 (35.14–52)	47.37 (40–52)
CM	1 082	43.91 (34.31–58.62)	21.84 (15.25–31.25)	30.35 (23.33–45)	1 437	23.08 (17.07–31.58)	41.46 (32.56–48.84)	32.56 (25.71–41.46)	1 156	6.24 (3.23–10)	48.97 (41.18–55.41)	42.33 (35.71–50.65)
GH	339	48.75 (44.14–58.78)	21.25 (17.57–30.63)	25.23 (23.65–30)	369	40.52 (40.22–52.17)	31.52 (24.22–33.62)	25.86 (23.6–28.26)	245	17.86 (16.67–18.95)	35.79 (26.19–37.88)	45.45 (45.26–55.95)
GM	1 220	69.81 (63–83.82)	9.43 (4.35–12.96)	20.37 (13.24–25.68)	1 385	40.91 (36.9–61.43)	22.58 (13.16–24.62)	36.36 (25–37.8)	824	10.38 (7.14–13.11)	56.98 (47.54–61.9)	33.93 (26.19–40.66)
GN	1 602	50 (38.46–57.55)	27.38 (21.67–31.82)	23.44 (19.17–28.85)	1 826	33.33 (27.14–47.71)	36.17 (28.38–50)	26.77 (22.86–28.44)	1 300	12.5 (10–15.15)	39.69 (35–45.83)	50 (41.03–52.5)
GW	325	76 (66.67–78.26)	10 (4.55–13.04)	15.15 (11.11–24)	378	52.11 (46–52.63)	20 (17.11–28)	29.41 (23.91–30.26)	205	10 (2.7–10.53)	61.54 (47.37–64.86)	32.43 (27.27–42.11)
LR	192	27.31 (17.65–40.45)	30.61 (26.35–40.37)	38.22 (28.45–49.39)	238	18.52 (17.07–28.57)	37.04 (30.3–46.43)	27.27 (25–42.42)	190	10.09 (5.9–14.84)	32.74 (25.38–45.35)	52.86 (45.35–57.28)
ML	7 584	70.13 (62.39–79.35)	7.63 (3.92–13.41)	19.72 (15.63–25.88)	8 717	54.55 (44.12–63.53)	18.75 (12.63–26.29)	26.28 (20.99–30.67)	4 586	9.49 (7.14–13.87)	50.63 (44.75–56.62)	38.92 (32.93–45.45)
MR	7 798	66.92 (59.91–76.52)	17.52 (12.12–25.25)	12.83 (8.52–17.79)	9 296	42.58 (34.49–56.95)	30.33 (22.22–39.71)	24.74 (17.37–29.74)	5 784	10.59 (7.96–13.64)	58.29 (48.28–64.71)	30.95 (23.93–36.11)
NE	4 538	69.24 (59.51–78.04)	11.94 (8.02–15)	19.08 (14.59–25.16)	5 623	40.71 (31.12–51.63)	29.22 (20.1–33.76)	31.2 (25.3–38.17)	3 693	4.85 (3.55–8.11)	60.54 (52.19–66.5)	33.7 (28.57–41.66)
NG	7 837	45.95 (35.48–55.18)	24.09 (15.42–31.18)	30.58 (23.53–37)	10 119	28.67 (21.79–37.19)	40.81 (31.7–47.78)	30.8 (24.33–34.44)	8 316	8.79 (6.25–11.57)	44.44 (39.43–51.64)	46.15 (38.3–50)
SL	2 043	43.4 (36–48.15)	32.02 (28.03–36.05)	24.27 (18.33–28.79)	2 457	30.77 (26.42–33.33)	44.78 (39.64–53.85)	23.34 (15.38–29.23)	1 923	10.96 (6.9–12.88)	41.98 (36.21–46.58)	46.15 (42.47–51.77)
SN	5 651	77.59 (71.54–84.21)	6.44 (4.41–10)	14.81 (10–18.87)	6 709	45.99 (38.6–56.79)	20.35 (15.25–25.56)	33.33 (26.98–36.89)	3 979	6.67 (4.17–9.21)	66.67 (59.09–73.33)	27.03 (21.43–33.91)
TD	10 974	61.38 (41.89–69.44)	15.23 (9.85–21.88)	24.7 (17.78–30.51)	13 417	37.01 (23.66–46.84)	29.23 (22.22–40)	32.76 (25.29–38.89)	9 613	8.56 (6.33–10.48)	51.35 (44.87–58.24)	39.01 (32.38–45.16)
TG	839	65 (50–83.33)	12.5 (5.26–18.42)	20 (10.53–28.57)	1 119	40 (31.31–61.54)	30.3 (18.18–40.82)	28.4 (10–32.65)	754	7.8 (5.56–14.29)	54.97 (46.55–61.11)	34.11 (28.17–42.86)
All	86 336	59.37 (44.44–71.54)	15.78 (8.82–26.05)	23.33 (15.87–30.14)	109 244	35.96 (26.56–47.37)	32.57 (22.72–44.32)	28.97 (23.33–34.57)	78 889	8.33 (5.55–11.58)	53.96 (45.76–61.90)	37.20 (29.37–44.82)

We next explored the overlap in diagnosis between indicators within each pair when the sample is stratified by sex, age and stunting status.

Figure 6 shows the diagnostic overlap between WHZ2 and MUAC125, that is, the median proportion of children diagnosed simultaneously by WHZ2 and MUAC125 among children diagnosed by either of these two indicators. The results are provided by country and stratified by sex, age and stunting status.

Figure 6. Diagnostic overlap between WHZ2 and MUAC125 stratified by sex, age and stunting status.

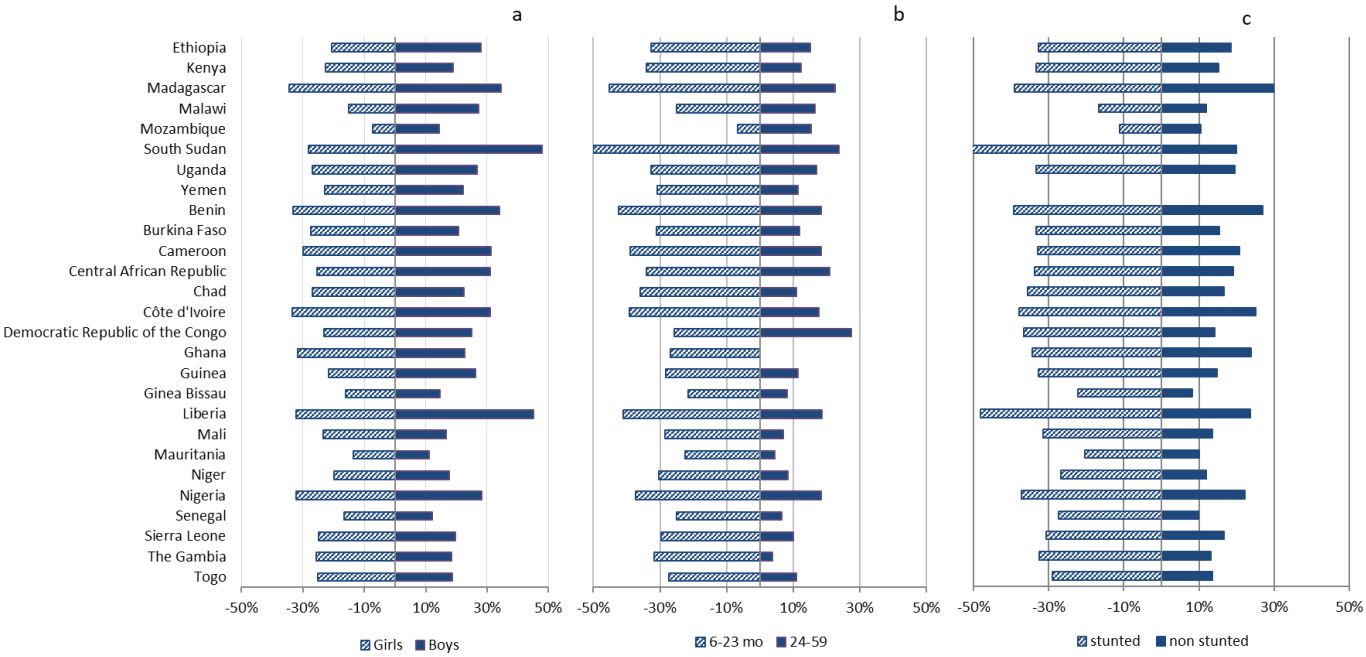


Figure 6a shows that the diagnostic overlap between WHZ2 and MUAC125 does not have a particular pattern in relation to the sex of the child, as the proportion of children diagnosed by both indicators (WHZ2 and MUAC125) is about the same among girls (left side of Figure 6a) and among boys (right side of Figure 6a). In some countries, such as South Sudan, the overlap is higher among boys (48 %) than among girls (around 28 %), but in others, such as Nigeria, the overlap is higher among girls (32.3 %) than among boys (28.2 %). The median proportions and IQRs by sex are provided in Table A4.

However, in relation to the age of the children and stunting status clear patterns can be seen. The diagnostic overlap between these two indicators is substantially higher in children aged 6–23 months (ranging from 7 % to 50 %) than in children aged 24–59 months (ranging from 4 % to 28 %) (Figure 6b). Similarly, the diagnostic overlap is higher among stunted children (ranging from 11 % to 48 %) than among non-stunted children (ranging from 8 % to 30 %) (Figure 6c).

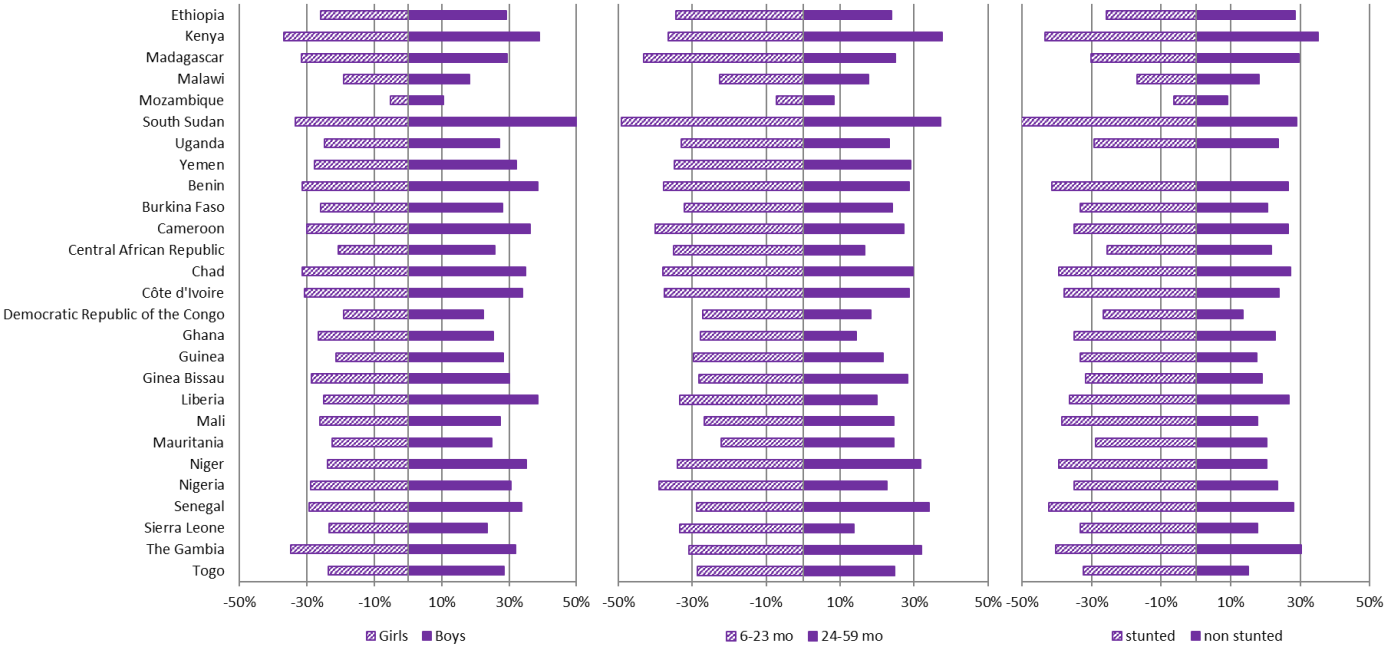
The reason for the age pattern may be that among older children (aged 24–59 months) the proportion of children diagnosed by MUAC125 is extremely low compared with the proportion diagnosed by WHZ2 for all countries analysed. Many countries show a difference of more than 60 percentage points between the proportion of children diagnosed by WHZ2 only and the proportion diagnosed by MUAC125 only. The median proportions and IQRs by age are provided in Table A5.

With regard to stunting, the reason for the higher diagnostic overlap among stunted children may be dissimilar. The difference between the proportion of children diagnosed by WHZ2 only and the proportion diagnosed by MUAC125 only reduces drastically among stunted children (thus increasing the overlap), and in some countries can reverse the relationship found between these two indicators in the overall sample or among non-stunted children. Thus, when only stunted children are analysed, countries such as Mozambique in the ESAR or Liberia and Sierra Leone in the WCAR show higher proportions of children diagnosed by MUAC125 than by WHZ2,

whereas the opposite result is found if the analysis is not stratified by stunting status or among non-stunted children. The median proportions and IQRs by stunting status are provided in Table A6.

Figure 7 shows the diagnostic overlap between WHZ2 and MUACZ2, that is, the median proportion of children diagnosed simultaneously by WHZ2 and MUACZ2 among children diagnosed by either of these two indicators. The results are provided by country and stratified by sex, age, and stunting status.

Figure 7. Diagnostic overlap between WHZ2 and MUACZ2 stratified by sex, age and stunting status.



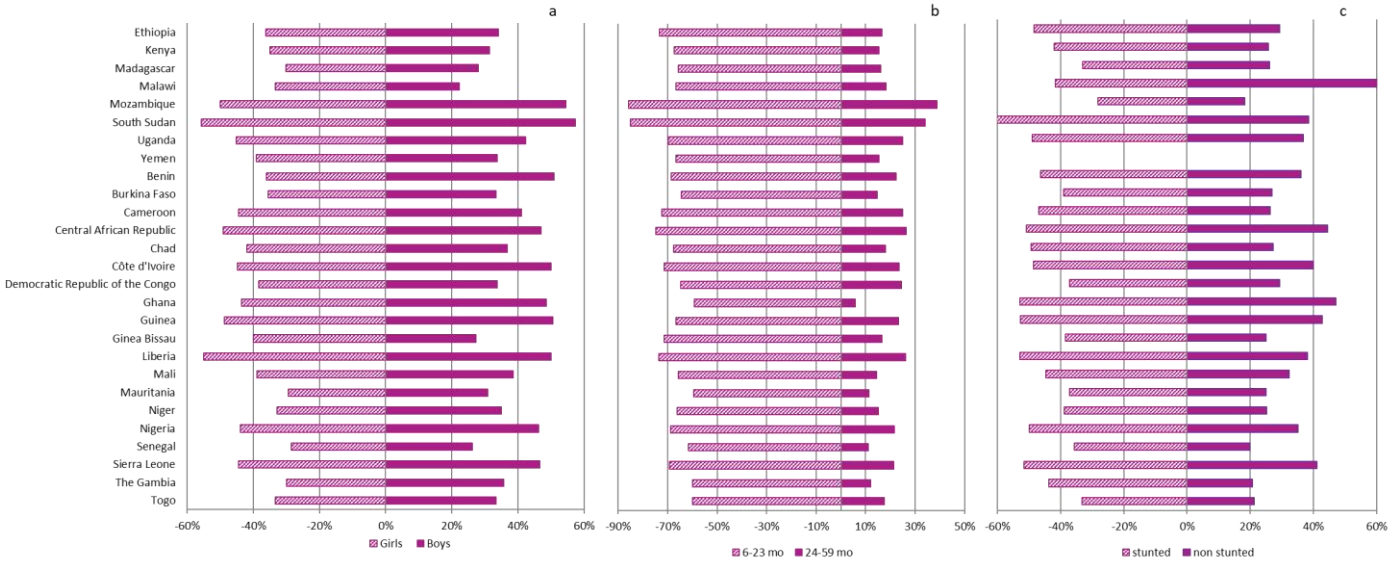
Although in most countries the proportion of children diagnosed by both indicators simultaneously is very similar between girls and boys, there is a consistently higher overlap among boys (right side of Figure 7a), with countries such as South Sudan and Liberia showing a diagnostic overlap between WHZ2 and MUACZ2 among boys that is more than 10 percentage points higher than the overlap observed among girls (51 % in boys and 33 % in girls for South Sudan and 38 % in boys and 25 % in girls for Liberia). The median proportions and IQRs by sex are provided in Table A7.

The patterns in diagnostic convergence between WHZ2 and MUACZ2 when the analysis is stratified by age (Figure 7b) and by stunting status (Figure 7c) are similar to those previously described for WHZ2 and MUAC125 but with less marked differences. The overlap between MUACZ2 and WHZ2 is higher among younger children (aged 6–23 months) and stunted children for most countries. The overlap between MUAC-based indicators and WHZ2 is low among children aged 24–59 months in most of the WCAR countries. The median proportions and IQRs by age are provided in Table A8.

For the group of stunted children, all countries except two show the same pattern of higher proportions of children being diagnosed by MUACZ2 than by WHZ2, whereas for the non-stunted children this is true for most countries in the ESAR but only for the Central African Republic in the WCAR. The median proportions and IQRs by stunting status are provided in Table A9.

Figure 8 depicts the diagnostic overlap for the last pair of indicators, MUAC125 and MUACZ2, stratified by sex, age and stunting status.

Figure 8. Diagnostic overlap between MUAC125 and MUACZ2 stratified by sex, age and stunting status.



In 15 of the 27 countries analysed the overlap between MUAC125 and MUACZ2 is higher among boys than among girls (see Table A10); thus, there is no clear pattern in the diagnostic overlap between MUAC125 and MUACZ2 according to sex (Figure 8a).

However, the same pattern observed in the diagnostic overlap between indicators in the other pairs is seen here in relation to age (Figure 8b). The diagnostic overlap between MUAC125 and MUACZ2 is much higher among children aged 6–23 months (ranging from 60 % to 90 %) than among older children (ranging from 6 % to 39 %). This may be related to the fact that, within this pair, among children aged 24–59 months no children are diagnosed by MUAC125 only. All children in this age range are diagnosed by MUACZ2, and only a small proportion (ranging from 6 % in Ghana to 34 % in South Sudan) are also diagnosed by MUAC125 (see Table A11).

When looking at the differences in diagnosis according to stunting status, the diagnostic overlap is higher among stunted children than among non-stunted children (Figure 8c). Among children diagnosed with acute malnutrition by the MUAC125 and MUACZ2 pair, among stunted children, MUACZ2 identifies more than 92 % in all countries, with variations between countries in the proportion of children identified by MUACZ2 only or by both MUAC125 and MUACZ2 simultaneously (see Table A12).

3. Objective 3: prevalence of acute malnutrition

In this section we aimed to explore the consequences of acute malnutrition diagnostic discrepancies described in the previous section for acute malnutrition estimates at population level.

Thus, the general objective was to calculate and compare the acute malnutrition prevalence estimates by country and region using the three different indicators of acute malnutrition (WHZ2, absolute MUAC125 and MUACZ2) and stratifying by sex, age and stunting status.

The secondary objectives were to:

- ✓ compare the prevalence of acute malnutrition obtained by the combined indicators (WHZ2_MUAC125 and WHZ2_MUACZ2) and WHZ2;
- ✓ compare the prevalence of acute malnutrition obtained using different cut-offs for flags of anthropometric indicators (WHO flags and SMART flags).

To address these objectives we used different methodological approaches.

- ✓ We calculated the prevalence of acute malnutrition using the three indicators and the combined indicators at national and subnational levels using the most recent and complete survey available for each country and:
  - represented the mean prevalence obtained using WHZ2, MUACZ2 and MUAC125 spatially;
  - compared the prevalence obtained with the combined indicators (WHZ2_MUAC125 and WHZ2_MUACZ2) with the prevalence obtained with WHZ2;
  - compared the prevalence obtained for WHZ2, MUACZ2 and MUAC125 using this data set, created using the WHO flags (the main data set), with the prevalence computed for WHZ2, MUACZ2 and MUAC125 using the data set created using the SMART flags'.
- ✓ We calculated the prevalence of acute malnutrition with the three indicators in all survey domains of the data set and:
  - computed the median prevalences at country level;
  - computed the correlation between the prevalences within pair of indicators;
  - performed multivariable models including the three prevalences and other variables of interest.

The following sections describe in detail the methods and results of each of these approaches.

3.1. Calculation of acute malnutrition prevalence at national and subnational levels

Using this approach we aimed to replicate the results for acute malnutrition prevalence using the three different indicators in a real-life scenario, that is, using the results from existing surveys, to compare the results obtained within the same survey sample.

For this purpose we selected from each country the most recent and complete survey covering the largest share of the population. Although all surveys may be complete in terms of other key variables, not all of them provide the statistical weight required to aggregate results at higher levels. This is why for countries with national and subnational surveys we selected the most recent national survey with statistical weights available in the data set. For countries with only subnational surveys, we selected the surveys covering the largest areas with statistical weights, if available, or independent surveys that complemented each other geographically, although not conducted in the same year.

We thus estimated acute malnutrition prevalence at national or subnational level depending on survey availability in the data set for each country. We applied the svy command in Stata to take into account the clustering and stratification of the sampling, and included the statistical weighting factors when available.

We calculated the mean prevalence and 95 % confidence interval for each of the three indicators (WHZ2, MUAC125 and MUACZ2) and for the combined indicators (WHZ2_MUACZ2 and WHZ2_MUAC125). The analyses carried out are outlined in the following sections.

3.1.1. Spatial representation of WHZ2, MUACZ2 and MUAC125

The mean prevalences obtained for the selected surveys in each country are represented using either regional or national maps. The maps are shaded according to the prevalence threshold categories for WHZ2, as defined by WHO and UNICEF (Table 6) (de Onis et al., 2019).

Table 6. Prevalence thresholds and corresponding labels for WHZ2.

GAM	< 2.5 %	Very low
	2.5 % to < 5 %	Low
	5 % to < 10 %	Medium
	10 % to < 15 %	High
	≥ 15 %	Very high

Source: de Onis et al. (2018).

It is important to stress that these maps are not intended for regional or country situation analysis as the selected surveys cover different areas, populations and time periods. They are provided for the purpose of comparing the prevalence of acute malnutrition using the different indicators when applied to the same populations within existing surveys.

All maps shown in this section are complemented with tables in the annex that include confidence intervals.

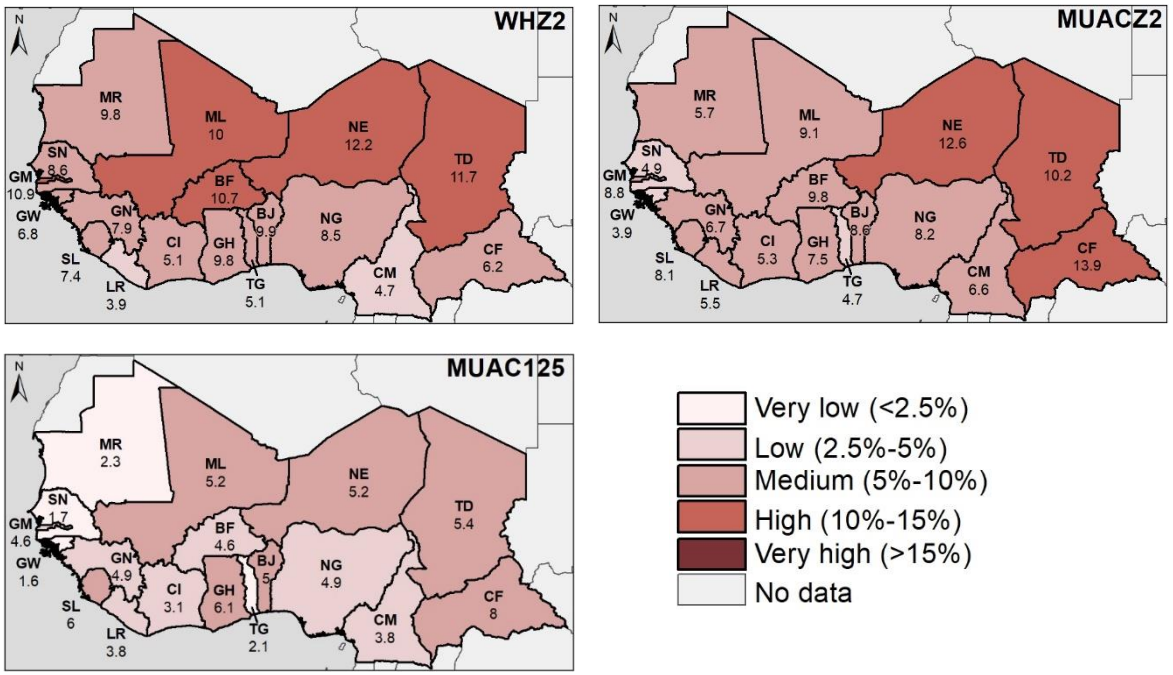
3.1.1.1. West and Central Africa region

In the final data set there were 42 national surveys and 34 subnational surveys from the WCAR. Except for Benin, Cameroon, Democratic Republic of the Congo and Ghana, for all countries in the region there was at least one national survey. Thus, the regional WCAR map shows national estimates for all countries except for those. For Benin, the only survey available is representative at admin 1[7] level, for the department of Alibori; for Cameroon, the selected subnational survey covered the six regions in the north of the country; and for Ghana, the only survey available was conducted in the three regions of north Ghana. For the Democratic Republic of the Congo, the only survey included in the data set is representative at admin 2[8] level only and was excluded from the spatial representation.

Figure 9 shows the acute malnutrition estimates by country for each of the indicators explored (WHZ2, MUACZ2 and MUAC125), representing data for the surveys selected in these countries. The figure shows that, for the same population, within the same survey, the resulting acute malnutrition prevalence and classification according to thresholds differ substantially depending which indicator is used.

[7] Administrative boundaries of the first sub-national level
[8] Administrative boundaries of the second sub-national level

Figure 9. Acute malnutrition prevalence measured using WHZ2, MUACZ2 and MUAC125 in the WCAR, children aged 6–59 months.

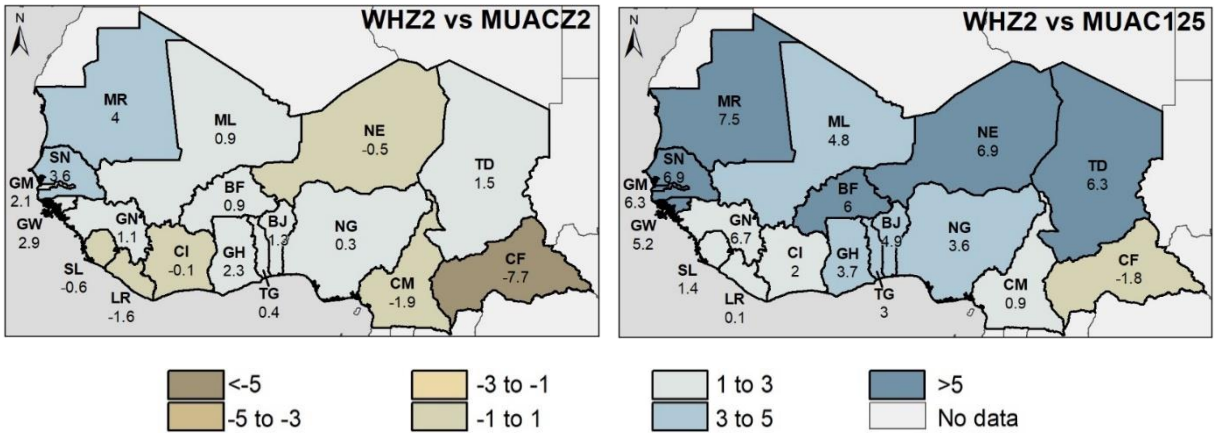


NB: These maps should not be interpreted as regional situation analysis maps as the surveys selected represent different geographical areas and correspond to different years. Year of survey for national surveys: 2010 (Sierra Leone), 2011 (Côte d'Ivoire, Mali), 2012 (Burkina Faso, Cameroon, Guinea-Bissau, Togo), 2013 (Ghana), 2014 (Benin, Central African Republic, Senegal), 2015 (Guinea, Nigeria, The Gambia), 2016 (Chad, Mauritania, Niger). Coverage and year of survey for subnational surveys: Benin: Alibory department 2014, Cameroon: six regions in north Cameroon 2012, Ghana: three regions in north Ghana 2013.

Overall, most of the surveys fall within the 'high' or 'medium' category thresholds when prevalence is measured by WHZ2 or MUACZ2, and within the 'medium', 'low' or 'very low' category thresholds when prevalence is measured by MUAC125. There seems to be more convergence in acute malnutrition prevalence when prevalence is measured by WHZ2 and MUACZ2 than when it is measured by MUAC125, which consistently yields lower prevalences than the other two indicators. However, there is no full convergence between WHZ2 and MUACZ2 either, with key differences in selected countries. For example, acute malnutrition prevalence in Burkina Faso survey would be considered 'high' by WHZ2, 'medium' by MUACZ2 and 'low' by MUAC125. Similarly, in Chad and Niger, acute malnutrition prevalence would be classified as 'high' according to WHZ2 and MUACZ2, but 'medium' according to MUAC125.

The direction and the magnitude of these differences are summarised in Figure 10.

Figure 10. Differences in country acute malnutrition prevalence (percentage points) in the WCAR resulting from the subtraction of MUACZ2 mean prevalence from WHZ2 mean prevalence (left) and of MUAC125 mean prevalence from WHZ2 mean prevalence (right).



As shown in Figure 10, the differences between WHZ2 and MUACZ2 are negative in the majority of the cases, meaning that WHZ2 values are smaller than MUACZ2, while in the comparison of WHZ2 and MUAC125 most of the differences are positive (the only exception is the Central African Republic), reflecting that WHZ2 prevalence is higher than MUAC125 prevalence in all the surveys represented in this map except for that from the Central African Republic.

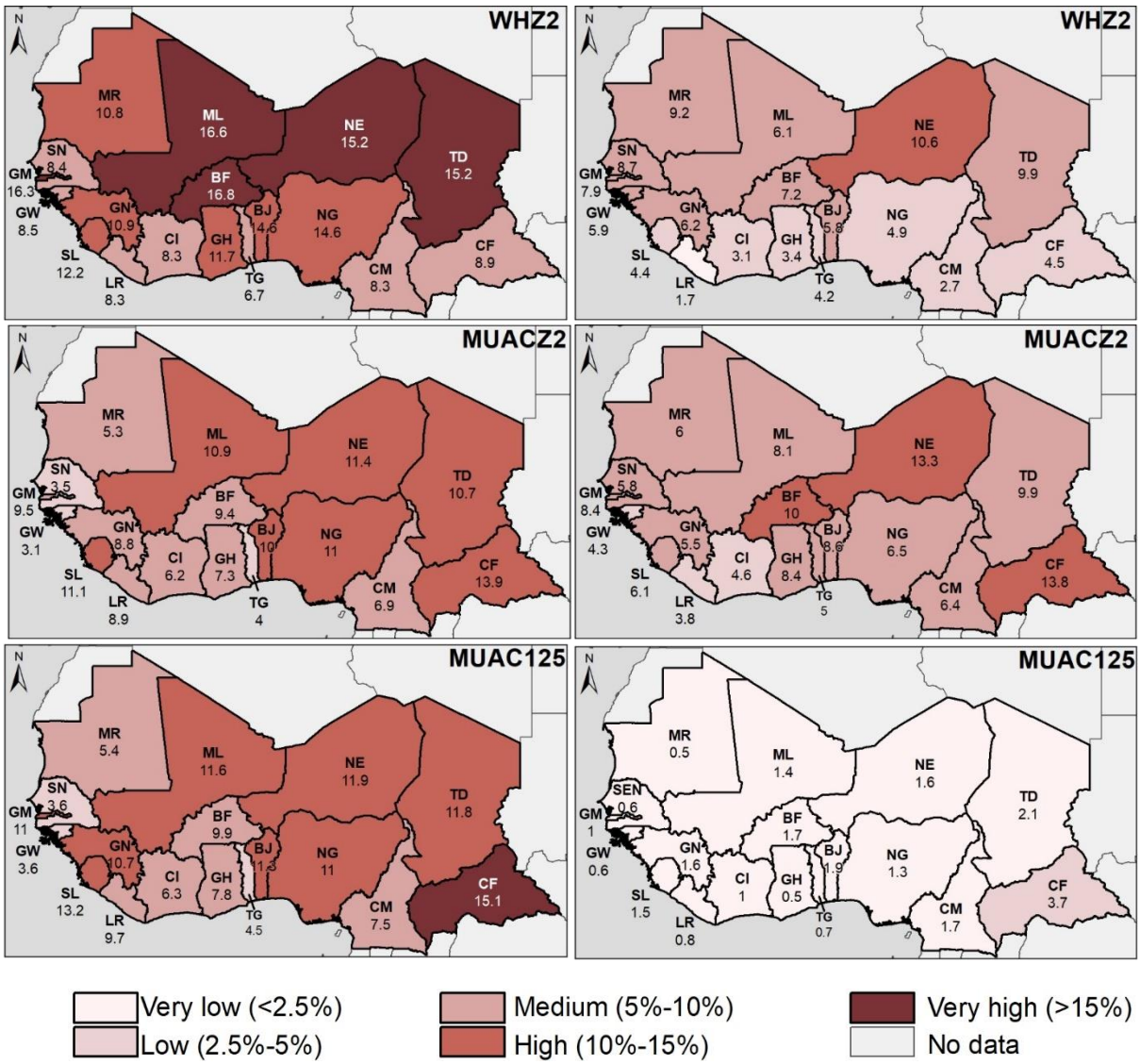
With regard to the magnitude, the differences between WHZ2 and MUAC125 are much larger than those observed between WHZ2 and MUACZ2. The largest difference between WHZ2 and MUACZ2 is seen in Mauritania (7.5 percentage points) and the smallest is seen in Liberia (0.1 percentage points).

The mean prevalences and confidence intervals for the surveys represented in Figures 9 and 10 are detailed in Table A13.

When the analysis is stratified by age group the similarity between acute malnutrition prevalence measured by WHZ2 or by MUACZ2 and acute malnutrition prevalence measured by MUAC125 is much higher for children aged 6–23 months than for the older age group, for whom convergence is low (Figure 11). According to MUAC125, all the selected surveys in the WCAR would have an acute malnutrition prevalence below 5 % for children aged 24–59 months, and all countries except for the Central African Republic would be classified as having a 'very low' prevalence of acute malnutrition. In contrast, according to WHZ2 and MUACZ2, most countries would be classified as having a 'medium' or 'high' prevalence of acute malnutrition in the same age group. On the other hand, there is more convergence between acute malnutrition prevalence measured by WHZ2 and acute malnutrition prevalence measured by MUACZ2 in the 24–59 months age group than in the 6–23 months age group.

Figure 11. Acute malnutrition prevalence measured by WHZ2, MUACZ2 and MUAC125 in the WCAR, stratified by age category.

(a) Children aged 6–23 months (b) Children aged 24–59 months



NB: These maps should not be interpreted as regional situation analysis maps as the surveys selected represent different geographical areas and correspond to different years. Year of survey for national surveys: 2010 (Sierra Leone), 2011 (Côte d'Ivoire, Mali), 2012 (Burkina Faso, Cameroon, Guinea-Bissau, Togo), 2013 (Ghana), 2014 (Benin, Central African Republic, Senegal), 2015 (Guinea, Nigeria, The Gambia), 2016 (Chad, Mauritania, Niger). Coverage and year of survey for subnational surveys: Benin: Alibory department 2014, Cameroon: six regions in north Cameroon 2012, Ghana: three regions in north Ghana 2013.

As a general pattern, in most countries in the WCAR and for the three indicators studied, the acute malnutrition prevalences are lower among children aged 24–59 months than among younger children (6–23 months of age).

The mean prevalences and confidence intervals for the samples included in Figure 11 are provided in Table A14.

3.1.1.2. Eastern and Southern Africa region

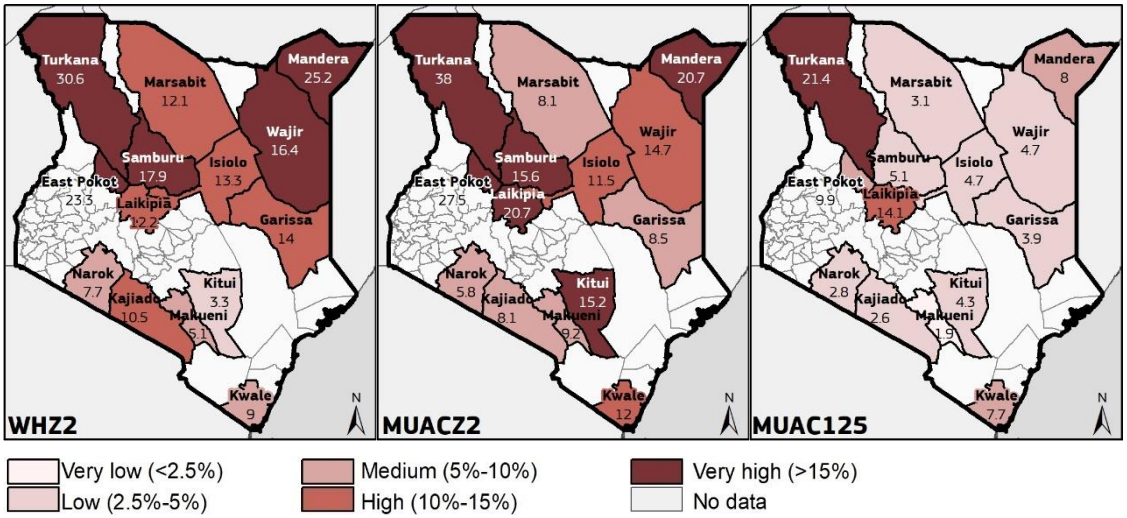
In the ESAR all surveys included in the data set were carried out at subnational level and are representative at admin 1, admin 2 or admin 3 level. In this region, countries that had a larger geographical area covered by the different surveys in the data set are represented individually. Thus, in the maps for each of the selected

countries (Kenya, Madagascar and Uganda) the most recent and complete surveys at subnational level are included. The subnational surveys represented can be independent of each other and thus pertain to different time periods. For all the countries in the ESAR detailed values are provided in Table A15.

3.1.1.2.1. Kenya

Figure 12 shows the acute malnutrition prevalence in Kenya measured using the three indicators, depicting independent SMART surveys conducted at county level over different time periods, for all children aged 6–59 months.

Figure 12. County acute malnutrition prevalence in Kenya measured by WHZ2, MUACZ2 and MUAC125, children aged 6–59 months.



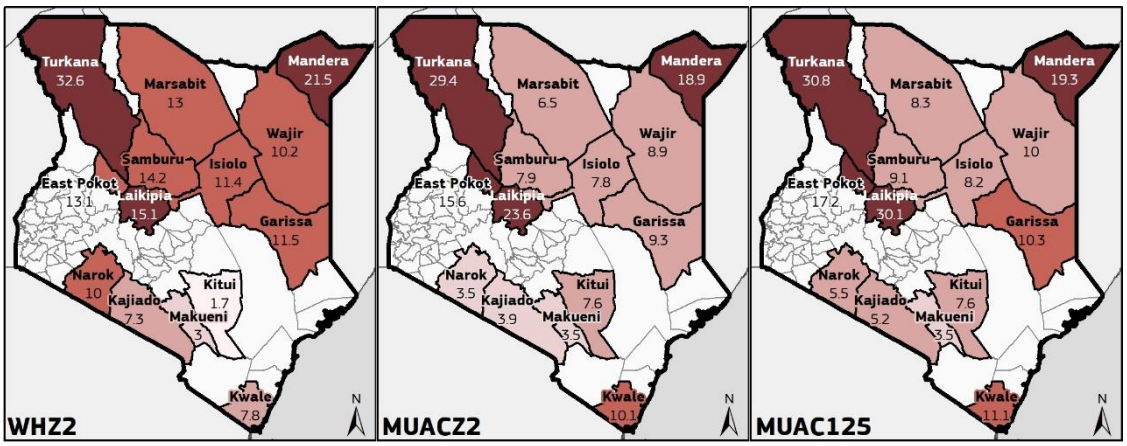
NB: These maps should not be interpreted as country analysis maps as the surveys selected correspond to different years. Year of survey: 2011 (Makueni, Turkana), 2012 (Kitui, Kwale, Laikipia), 2017 (East Pokot, Mandera, Samburu, Wajir) and 2018 (Garissa, Isiolo, Kajiado, Marsabit, Narok).

Figure 12 shows that the pattern found for the national surveys in the WCAR is also found in the county surveys in Kenya, with higher convergence between county classifications for WHZ2 and MUACZ2 (with 'medium', 'high' and 'very high' prevalences) than with MUAC125, for which prevalences are consistently lower than those estimated by the other two indicators, resulting in most of the counties being classified as 'low prevalence'.

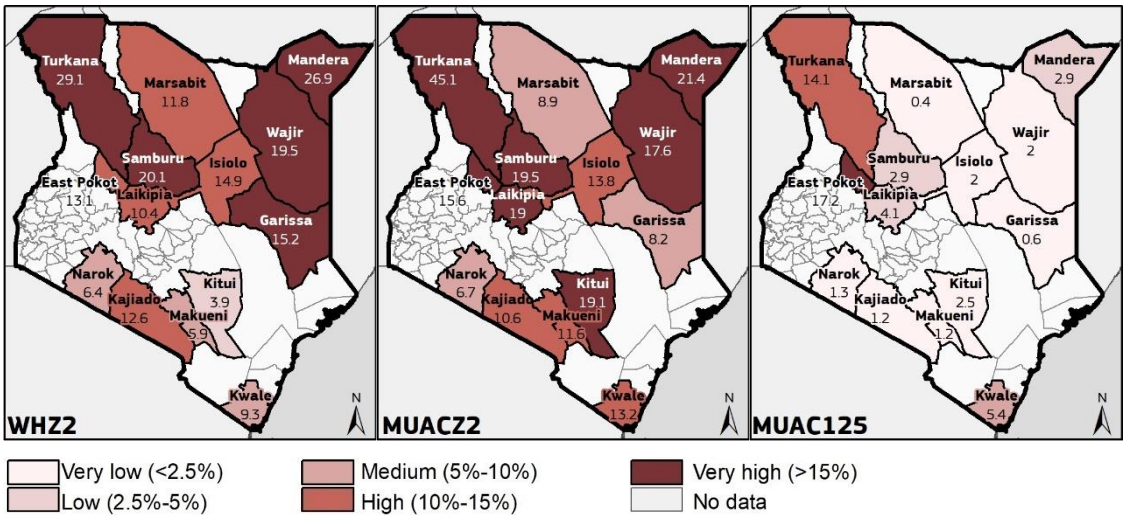
Figure 13 shows the prevalence of acute malnutrition in each of the county surveys stratified by age category. The acute malnutrition estimates provided by MUAC125 are substantially lower among children aged 24–59 months than among children aged below 2 years.

Figure 13. County acute malnutrition prevalence in Kenya measured by WHZ2, MUACZ2 and MUAC125 stratified by age category.

(a) Children aged 6–23 months



(b) Children aged 24–59 months



NB: These maps should not be interpreted as country situation analysis maps as the surveys selected correspond to different years. Year of survey: 2011 (Makueni, Turkana), 2012 (Kitui, Kwale, Laikipia), 2017 (East Pokot, Mandera, Samburu, Wajir), 2018 (Garissa, Isiolo, Kajiado, Marsabit, Narok).

However, the overall pattern observed in the WCAR of higher acute malnutrition prevalences among younger children for all indicators does not hold in the subnational surveys in Kenya, as the WHZ2 and MUACZ2 estimates are higher among older children than among younger children in some of the county surveys (e.g. Mandera 2017, Wajir 2017). Thus, the degree of agreement in survey classification between WHZ2 and MUACZ2 is similar for the two age categories, although the degree of agreement is much higher among children aged 6–23 months when either of the two indicators is compared with MUAC125.

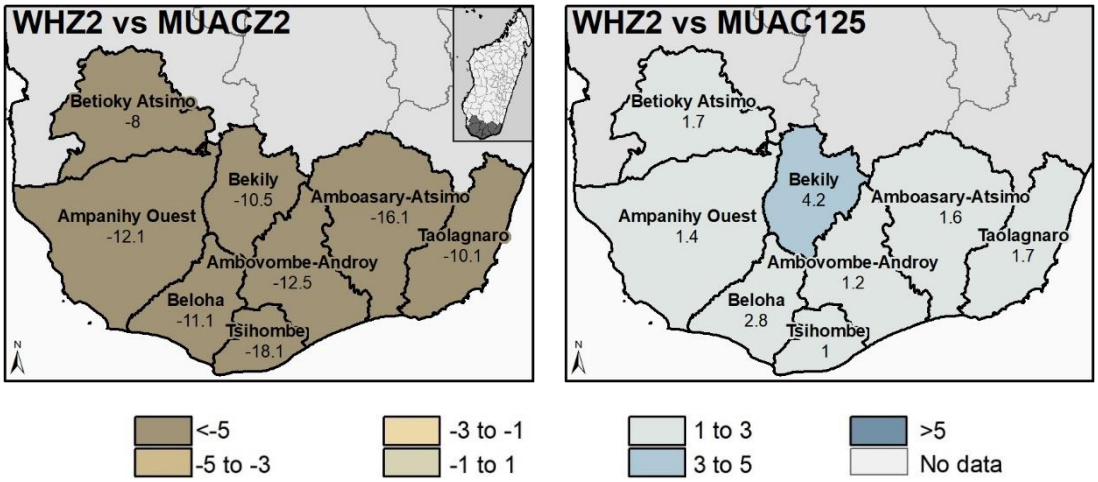
Table A16 provides detailed results for the analysis in Kenya stratified by age category.

3.1.1.2.2. Madagascar

For Madagascar, the only survey available covers eight districts of three regions in the south. The survey was carried out in 2017 and the results are representative at district level, as they are represented below.

Figure 14 shows the differences between WHZ2 prevalence and MUACZ2 prevalence (left) and between WHZ2 prevalence and MUAC125 prevalence (right).

Figure 14. Differences in district acute malnutrition prevalence (percentage points) in Madagascar resulting from the subtraction of MUACZ2 mean prevalence from WHZ2 mean prevalence (left) and of MUAC125 mean prevalence from WHZ2 mean prevalence (right), children aged 6–59 months, 2017.



The WHZ2 versus MUACZ2 map shows consistently negative differences of large magnitude, indicating that the MUACZ2 prevalences are substantially higher (by more than 10 percentage points in all districts except one) than the WHZ2 prevalences.

On the contrary, when comparing WHZ2 and MUAC125 prevalences (subtracting the MUAC125 means from the WHZ2 means), the differences are all positive and of smaller magnitude (ranging from 1 to 4.2 percentage points). Thus, MUAC125 also consistently yields lower prevalences than WHZ2 in Madagascar, but the level of agreement in classification of districts according to prevalence thresholds appears to be higher between WHZ2 and MUAC125 than between MUACZ2 and WHZ2.

Detailed mean prevalences and confidence intervals are provided in Table A15.

3.1.1.2.3. Uganda

All the surveys included in the data set for Uganda were carried out in the seven districts of Karamoja province, in the north-east of the country.

For the mapping exercise we used data from the most recent survey available, conducted in July 2018 and covering all seven districts. This is represented in Figure 15.

Figure 15. District acute malnutrition prevalence in Karamoja province, Uganda, measured by WHZ2, MUACZ2 and MUAC125, children aged 6–59 months, July 2018.

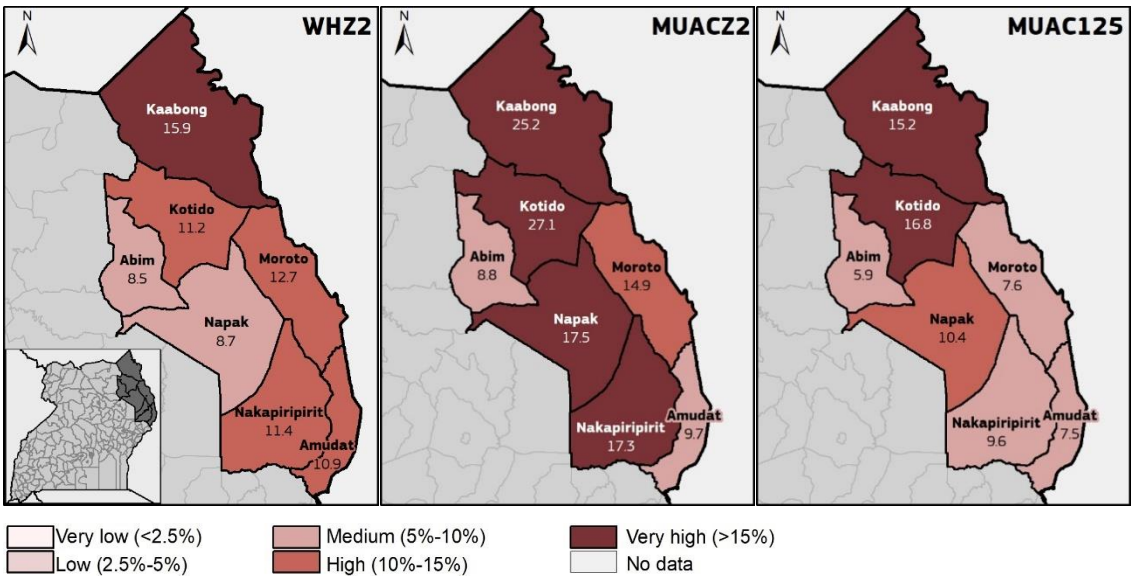


Figure 15 shows that acute malnutrition prevalence is highest when measured by MUACZ2 in all districts except for Amudat, and that, although MUAC125 yields the lowest prevalences in general, in Kotido and Napak the prevalence measured by MUAC125 is higher than that measured by WHZ2. Detailed mean prevalences and confidence intervals are provided in Table A15.

3.1.1.3. Yemen (Middle East and North Africa region)

Yemen is the only country in the MENA region for which survey data were available. We used the most recent surveys conducted in each governorate, to cover all governorates represented in the data set. All surveys included for Yemen were carried out between 2016 and 2017.

Figure 16. Governorate acute malnutrition prevalence in Yemen measured by WHZ2, MUACZ2 and MUAC125, children aged 6–59 months, 2016 and 2017.

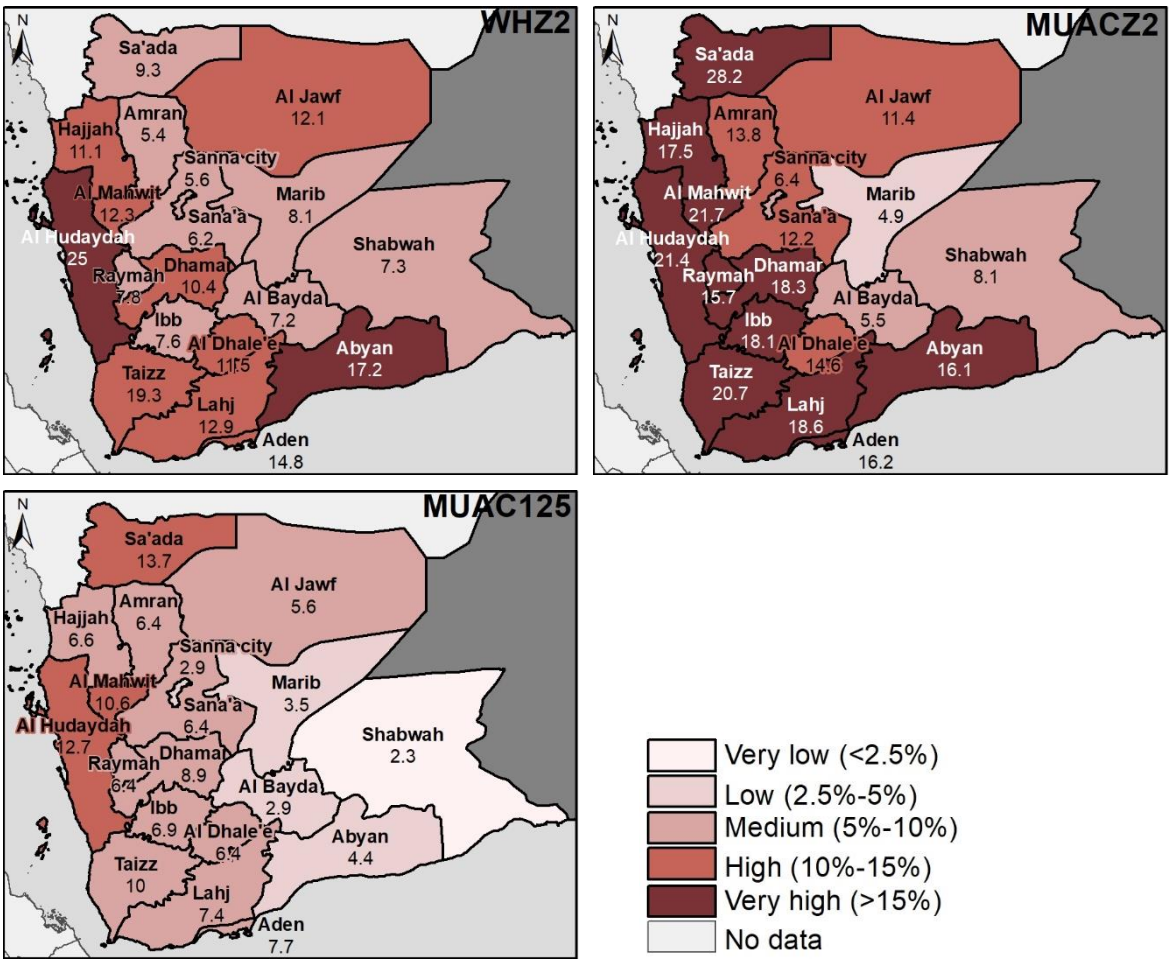
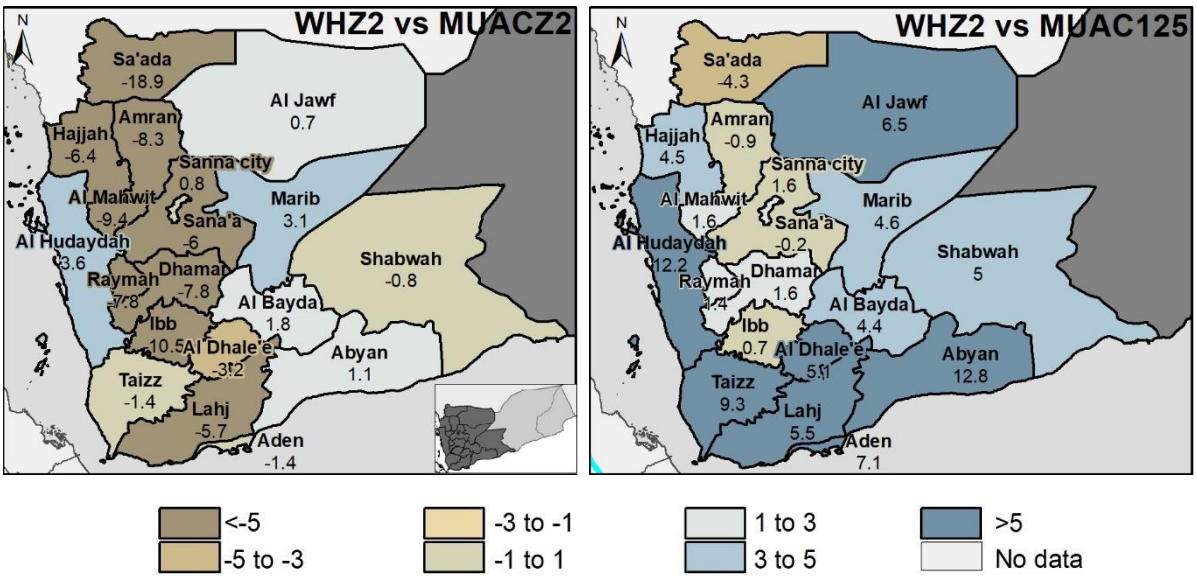


Figure 16 shows that acute malnutrition prevalence measured by MUAC125 in Yemen is substantially lower than that measured by WHZ2 or MUACZ2, resulting in most of the governorates being classified as 'medium' prevalence according to MUAC125 but 'high' or 'very high' prevalence according to WHZ2 and MUACZ2.

When comparing WHZ2 and MUACZ2 prevalences the results are mixed, with the majority of the governorates showing a higher prevalence with MUACZ2 than with WHZ2, and the other governorates showing the reverse relationship. These differences are better captured in in Figure 17.

Figure 17. Differences in governorate acute malnutrition prevalence (percentage points) in Yemen resulting from the subtraction of MUACZ2 mean prevalence from WHZ2 mean prevalence (left) and of MUAC125 mean prevalence from WHZ2 mean prevalence (right).



The left-hand map in Figure 17 shows that most governorates show large magnitude differences (more than 5 percentage points) when MUACZ2 prevalence is higher than WHZ2 prevalence (most of the governorates), while the differences are much smaller, below 5 percentage points, in the governorates where WHZ2 prevalence is higher than MUACZ2 prevalence.

In the right-hand map we see the opposite effect when WHZ2 is compared with MUAC125, as the magnitude of the differences is much higher in the governorates where WHZ2 prevalence is higher than MUAC125 prevalence (ranging from 4.4. to 12.8 percentage points) than in the governorates where MUAC125 yields higher estimates (only four governorates, with differences ranging from 0.2 to 4.3 percentage points).

Detailed data used to compile Figures 16 and 17 can be found in Table A17.

3.1.2. Comparison of acute malnutrition prevalence using different cut-offs for flags

In order to compare the acute malnutrition estimates obtained when using the SMART flags in the data set cleaning process with those obtained when using the WHO flags, we performed the same calculations in the selected national WCAR surveys using the data set resulting from excluding observations according to SMART flags.

Table 7 shows the mean prevalences and 95 % confidence intervals obtained for both data sets: that excluding flags according to WHO cut-offs (used throughout this report) and that excluding flags according to SMART cut-offs (used only for this specific comparison).

The prevalence at national level did not differ substantially between the two data sets, with differences ranging from 0.2 to 0.7 percentage points. These differences may not be significant in terms of prevalence or categorisation of populations in terms of acute malnutrition prevalence thresholds, but they may have an impact on the calculated acute malnutrition burden, depending on the size of the population surveyed.

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Table 7. Comparison of acute malnutrition prevalences estimated by WHZ2, MUACZ2 and MUAC125 using SMART and WHO exclusion cut-offs.

	WHZ2							**MUACZ2**							**MUAC125**						
	WHO exclusion cut-off			SMART exclusion cut-off			Difference	WHO exclusion cut-off			SMART exclusion cut-off			Difference	WHO exclusion cut-off			SMART exclusion cut-off			Difference
	Mean	95 % confidence interval		Mean	95 % confidence interval			Mean	95 % confidence interval		Mean	95 % confidence interval			Mean	95 % confidence interval		Mean	95 % confidence interval		
BF 2012	10.7	9.9	11.5	10.3	9.5	11.1	0.4	9.8	9.0	10.6	9.4	8.6	10.2	0.4	4.6	4.2	5.1	4.2	3.8	4.7	0.4
CF 2014	6.2	5.6	6.8	5.7	5.2	6.3	0.4	13.9	12.9	14.9	13.6	12.6	14.6	0.3	8.0	7.3	8.7	7.7	7.0	8.4	0.3
CI 2011	5.1	4.5	5.7	4.6	4.0	5.1	0.6	5.3	4.6	6.0	4.7	4.0	5.4	0.6	3.1	2.6	3.6	2.5	2.0	3.0	0.6
GM 2015	10.9	9.8	12.1	10.6	9.5	11.7	0.4	8.8	7.7	9.9	8.6	7.5	9.7	0.2	4.6	3.7	5.5	4.4	3.5	5.2	0.3
GW 2012	6.8	5.8	7.8	6.4	5.5	7.3	0.4	3.9	3.1	4.6	3.5	2.8	4.2	0.4	1.6	1.2	2.1	1.3	0.9	1.7	0.3
LR 2016	3.9	3.3	4.5	3.2	2.6	3.7	0.7	5.5	4.7	6.2	4.7	4.0	5.5	0.7	3.8	3.1	4.4	3.0	2.5	3.6	0.7
ML 2011	10.0	8.9	11.1	9.5	8.4	10.6	0.5	9.1	8.1	10.1	8.7	7.7	9.6	0.5	5.2	4.6	5.8	4.7	4.1	5.3	0.5
MR 2016	9.8	9.1	10.5	9.4	8.7	10.2	0.4	5.8	5.2	6.3	5.4	4.9	5.9	0.4	2.3	2.0	2.6	1.9	1.6	2.1	0.4
NE 2016	12.2	11.3	13.0	11.9	11.0	12.7	0.3	12.6	11.7	13.6	12.4	11.4	13.3	0.3	5.2	4.6	5.7	4.8	4.3	5.4	0.3
NG 2015	8.5	7.9	9.0	8.1	7.6	8.6	0.4	8.2	7.6	8.7	8.1	7.5	8.7	0.0	4.9	4.5	5.3	4.6	4.2	5.0	0.2
SL 2010	7.4	6.9	8.0	6.9	6.4	7.5	0.5	8.1	7.5	8.7	7.6	7.0	8.2	0.5	6.0	5.6	6.5	5.6	5.1	6.0	0.5
SN 2014	8.9	8.0	9.7	8.7	7.8	9.6	0.2	5.1	4.4	5.8	4.9	4.2	5.6	0.2	1.7	1.4	2.0	1.5	1.2	1.8	0.1
TD 2016	11.7	11.1	12.4	11.2	10.6	11.8	0.5	10.2	9.6	10.8	9.7	9.1	10.3	0.5	5.4	5.0	5.9	4.9	4.5	5.3	0.5

3.1.3. Comparison of acute malnutrition prevalence using combined indicators

Given that each indicator has a proven ability to identify a number of unique cases of acute malnutrition, resulting in discrepancies in prevalences and country categorisations according to acute malnutrition estimates, we combined the indicators to explore potential impacts on the prevalence of GAM.

We combined the WHZ2 indicator with each of the MUAC-based indicators individually and calculated the prevalence of acute malnutrition for the combined indicators as described in Section 2.1.4 (WHZ2_MUACZ2 and WHZ2_MUAC125) in the same selected WCAR national surveys. We then subtracted the mean estimates for the combined indicators from the WHZ2 means in the same surveys in order to assess the differences between the combined indicators and WHZ2 as the reference method (Table 8).

Table 8. Differences in acute malnutrition prevalence when subtracting the prevalence measured by combined indicators from the WHZ2 prevalence.

	WHZ2			**WHZ2_MUACZ2**			**Difference from WHZ2**	**WHZ2_MUAC125**			**Difference from WHZ2**
	Mean	95 % confidence interval		Mean	95 % confidence interval			Mean	95 % confidence interval		
BF 2012	10.7	9.9	11.5	15.7	14.7	16.7	– 5.0	12.3	11.5	13.1	– 1.6
CF 2014	6.2	5.6	6.8	16.5	15.4	17.5	– 10.3	11.2	10.4	12.0	– 5.1
CI 2011	5.1	4.5	5.7	7.7	6.9	8.5	– 2.6	6.4	5.6	7.1	– 1.2
GM 2015	10.9	9.8	12.1	14.5	13.2	15.9	– 3.6	12.5	11.3	13.7	– 1.6
GN 2015	7.9	7.3	8.4	11.5	10.8	12.3	– 3.7	10.5	9.7	11.2	– 2.6
GW 2012	6.8	5.8	7.8	8.3	7.2	9.4	– 1.5	7.3	6.3	8.3	– 0.5
LR 2016	3.9	3.3	4.5	7.2	6.4	8.1	– 3.3	5.7	4.9	6.4	– 1.8
ML 2011	10.0	8.9	11.1	14.6	13.3	15.9	– 4.6	12.0	10.8	13.1	– 1.9
MR 2016	9.8	9.1	10.5	12.8	11.9	13.6	– 3.0	10.9	10.2	11.7	– 1.2
NE 2016	12.2	11.3	13.0	17.9	16.9	19.0	– 5.8	14.0	13.1	14.9	– 1.8
NG 2015	8.5	7.9	9.0	12.5	11.8	13.1	– 4.0	10.2	9.7	10.8	– 1.8
SL 2010	7.4	6.9	8.0	12.0	11.3	12.7	– 4.6	10.5	9.9	11.1	– 3.1
SN 2014	8.9	8.0	9.7	10.9	9.9	11.9	– 2.0	9.4	8.5	10.3	– 0.6
TD 2016	11.7	11.1	12.4	17.5	16.7	18.3	– 5.8	14.4	13.7	15.1	– 2.7
TG 2012	5.1	4.1	6.0	7.8	6.6	9.0	– 2.8	5.8	4.7	6.8	– 0.7

The differences between the combined indicators and WHZ2 are all negative, as prevalence is always higher when a combination of indicators is used.

However, the differences between the WHZ2_MUAC125 combined indicator and WHZ2 are less than 3.2 percentage points in all WCAR surveys analysed except for the Central African Republic survey, and in many surveys the 95 % confidence intervals of the WHZ2 mean and the WHZ2_MUAC125 mean overlap, suggesting the differences are non-significant.

On the other hand, the WHZ2_MUACZ2 combined indicator yields the highest prevalences for these surveys compared with WHZ2 or WHZ2_MUAC125. The differences between WHZ2_MUACZ2 and WHZ2 are much larger (ranging from 1.5 to 10.3 percentage points) than the differences between WHZ2_MUAC125 and WHZ2, and only in a few surveys do the 95 % confidence intervals for WHZ2 and WHZ2_MUACZ2 overlap.

3.2. Calculation of acute malnutrition prevalence at survey domain level

In order to use the data from all surveys available in the data set, and as the statistical weight needed to properly aggregate the data at higher administrative levels was accessible in only 30 % of the surveys, we used the survey domain as the unit of analysis in the following assessments, thus complementing the results obtained at national and subnational levels for the selected surveys analysed above (see Section 2.1.2 for a detailed description of the survey domain).

For the analyses in this section we used all surveys in the data set, calculating the acute malnutrition prevalence at survey domain level for each of the three indicators (WHZ2, MUAC125 and MUACZ2).

3.2.1. Graphical representation of acute malnutrition median prevalences

In this analysis we pooled the survey-level prevalences at global, regional and country levels and computed the median prevalence and IQR for each of these levels. These are shown in Table A18.

When we computed the median prevalences for the pooled sample including all surveys in the data set, the highest prevalence was found for WHZ2 (9.5 %), followed closely by MUACZ2 (9.0 %) and then by MUAC125 (4.6 %). This pattern was also found for the WCAR overall (9.9 %, 7.9 % and 4.0 % for WHZ2, MUACZ2 and MUAC125, respectively). However, in the ESAR and in Yemen, the highest median prevalence was found for MUACZ2 (17.4 % in the ESAR and 16 % in Yemen) followed by WHZ2 (10.7 % and 11.1 %, respectively) and MUAC125 (7.6 % and 7 %, respectively). The median prevalences by country are shown in Figure 18.

Figure 18. Median prevalence of acute malnutrition measured by MUAC125, WHZ2 and MUACZ2, children aged 6–59 months.

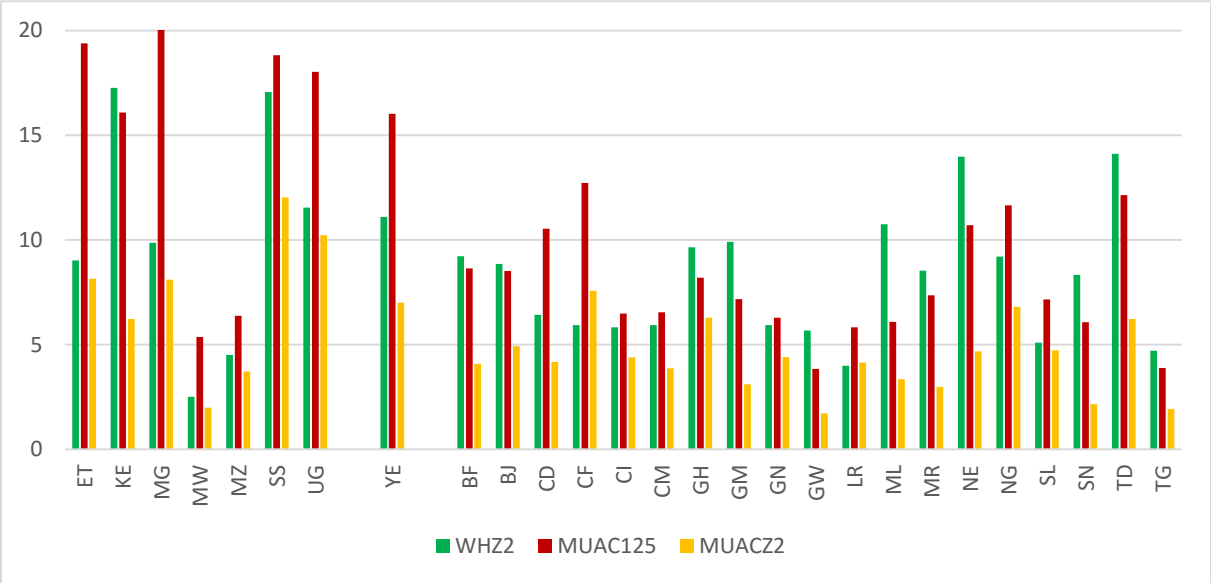


Figure 18 shows that the highest median prevalence is provided by MUACZ2 in Yemen and all countries within the ESAR (countries grouped in the left-hand side of the figure) except for Kenya, where the WHZ2 prevalence is slightly higher than the MUACZ2 prevalence (17.3 % versus 16.1 %). In Ethiopia and Madagascar the differences between MUACZ2 and WHZ2 are about 10 percentage points or more.

For the majority of the countries in the WCAR (except the Central African Republic and Democratic Republic of the Congo), the differences between the median prevalence estimated by WHZ2 and that estimated by MUACZ2 are small, and, although most of the countries show a higher median prevalence for WHZ2, in seven of the 19 countries represented the median prevalence is higher for MUACZ2.

In Yemen and in all countries of the ESAR (except Ethiopia) and of the WCAR (except the Central African Republic and the Democratic Republic of the Congo), the lowest prevalence is consistently estimated by MUAC125.

Figure 19 shows the acute malnutrition median prevalences at country level stratified by sex. The prevalence of acute malnutrition measured by WHZ2 or by MUACZ2 is consistently higher among boys than among girls, with the highest differences between these two groups observed in Niger for WHZ2 (7.7 % among girls and 19.7 % among boys) and for MUACZ2 (7.8 % among girls and 13.0 % among boys).

For MUAC125 the pattern is the opposite, as MUAC125 prevalence is higher among girls than among boys in all countries analysed, although the differences overall seem to be less stark than the differences observed for the two other indicators. The largest difference between sex groups in the MUAC125 median prevalence is found in Ethiopia (10.2 % among girls and 7.0 % among boys). All median prevalences and IQRs are provided in Table A19.

These results have important programmatic implications, as depending on the indicator chosen to estimate acute malnutrition the child population more at risk according to sex may vary.

Figure 19. Median prevalence of acute malnutrition measured by MUAC125, WHZ2 and MUACZ2 and stratified by sex.

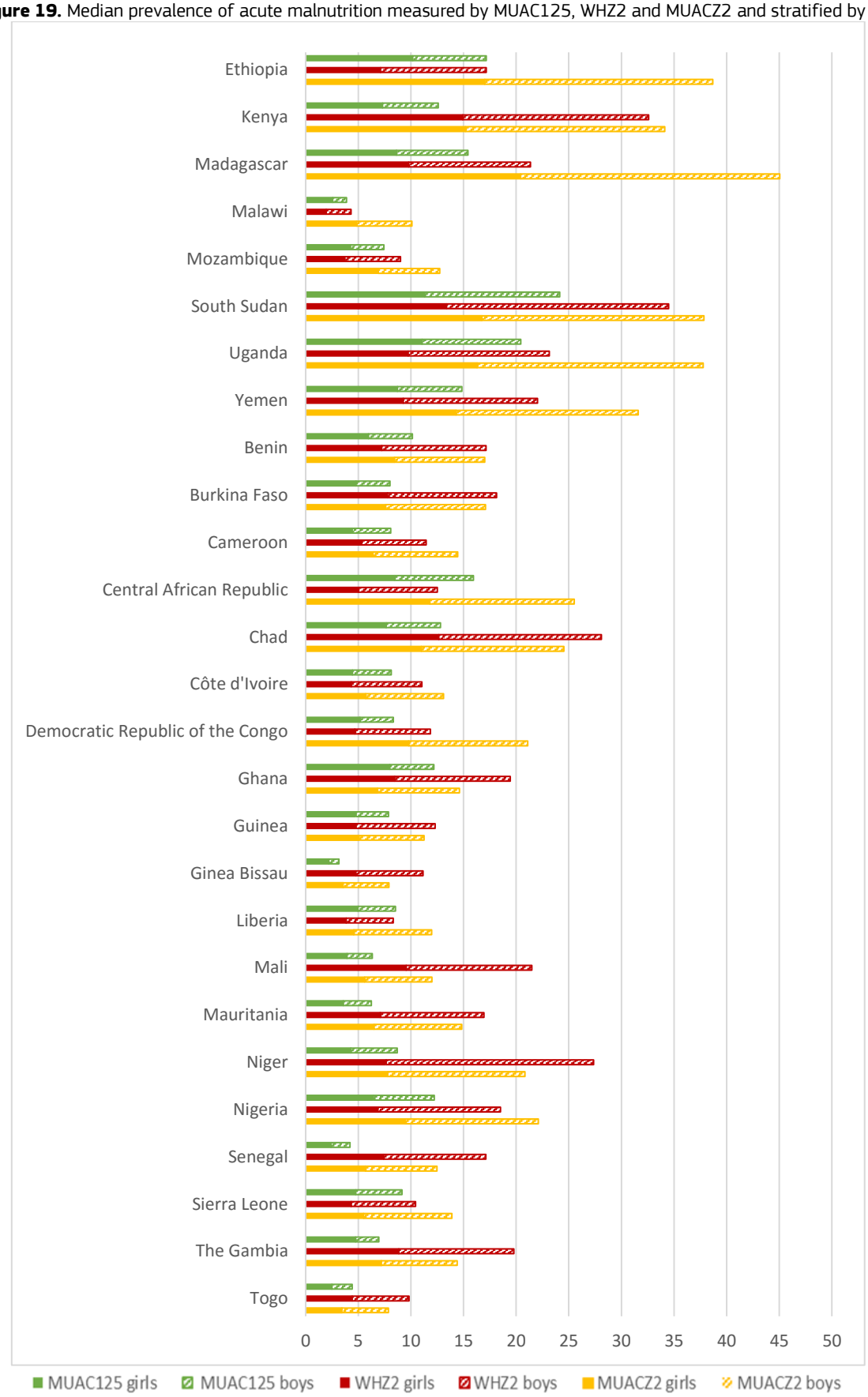


Figure 20 shows the acute malnutrition median prevalences at country level stratified by age category (6–23 months and 24–59 months). The prevalence of acute malnutrition estimated by WHZ2 or by MUAC125 is consistently higher among children in the 6–23 months age range (with the exception of Kenya for WHZ2), although the magnitude of the differences between the age groups is much larger for MUAC125, being above 10 percentage points in nine of the 27 countries analysed. The highest differences are found in South Sudan for both indicators (28.7 % for WHZ2 and 25.3 % for MUAC125 among children aged 6–23 months compared with 11.4 % for WHZ2 and 5.5 % for MUAC125 among children aged 24–59 months).

For MUACZ2, the median prevalence is higher among children aged 24–59 months for all countries in the ESAR (except South Sudan) and for Yemen and seven countries in the WCAR. However, the relationship reverses in the remaining 12 countries of the WCAR, where MUACZ2 median prevalence is higher among younger children, with the highest difference seen in Liberia (9.8 % for children aged 6–23 months and 3.6 % for children aged 24–59 months).

All median prevalences and IQRs are provided in Table A20.

These results have important programmatic implications, as depending on the indicator chosen to estimate acute malnutrition and the age distribution of the population, the acute malnutrition estimates can vary dramatically.

Figure 20. Median prevalence of acute malnutrition measured by MUAC125, WHZ2 and MUACZ2 and stratified by age category.

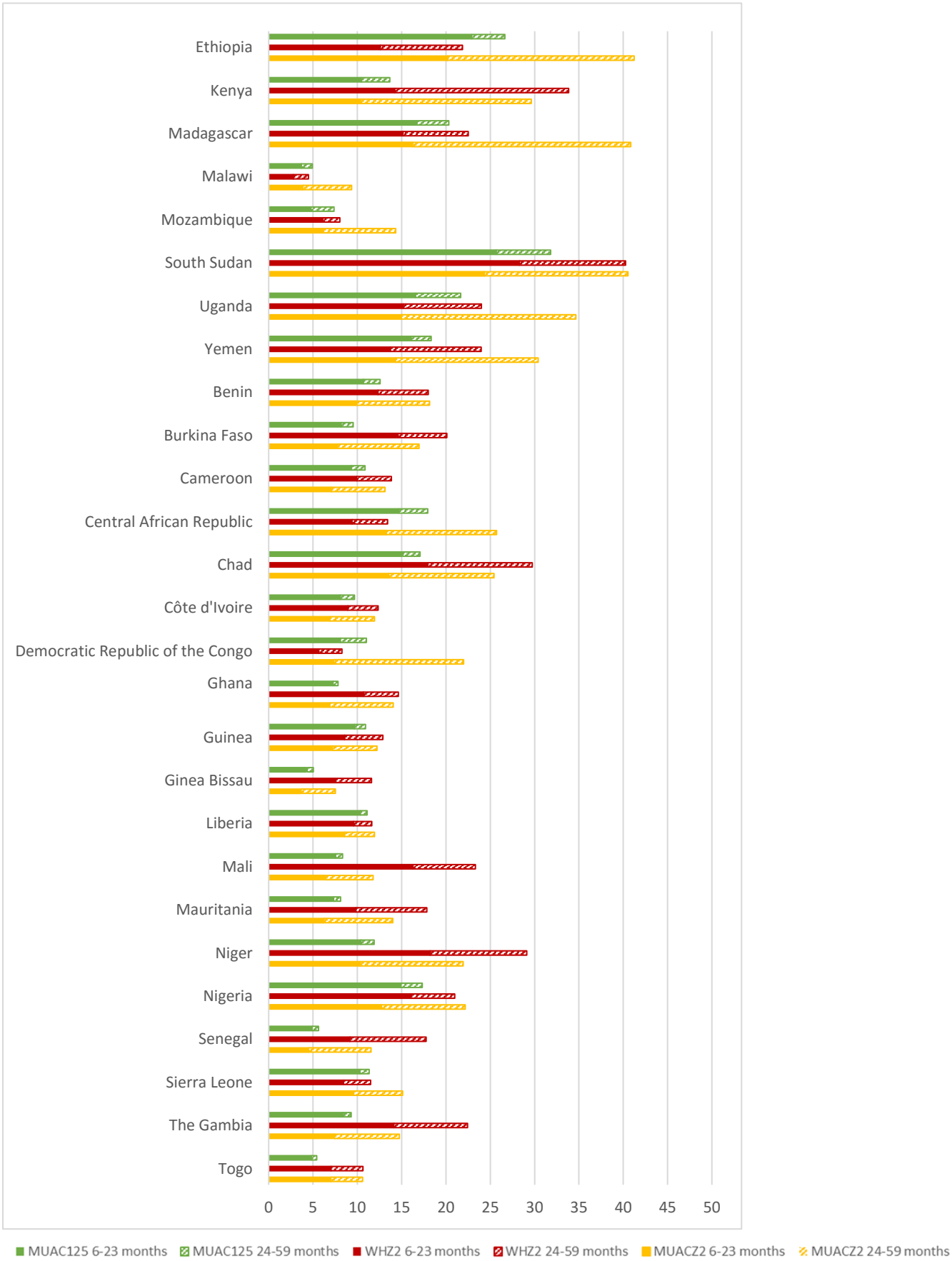


Figure 21 shows the acute malnutrition median prevalences at country level stratified by stunting status (stunted or not stunted).

The prevalence of acute malnutrition is consistently higher among stunted children than among non-stunted children, independently of the indicator used. However, the magnitude of the differences varies depending on the indicator, with MUACZ2 and MUAC125 showing larger differences between these two groups than WHZ2.

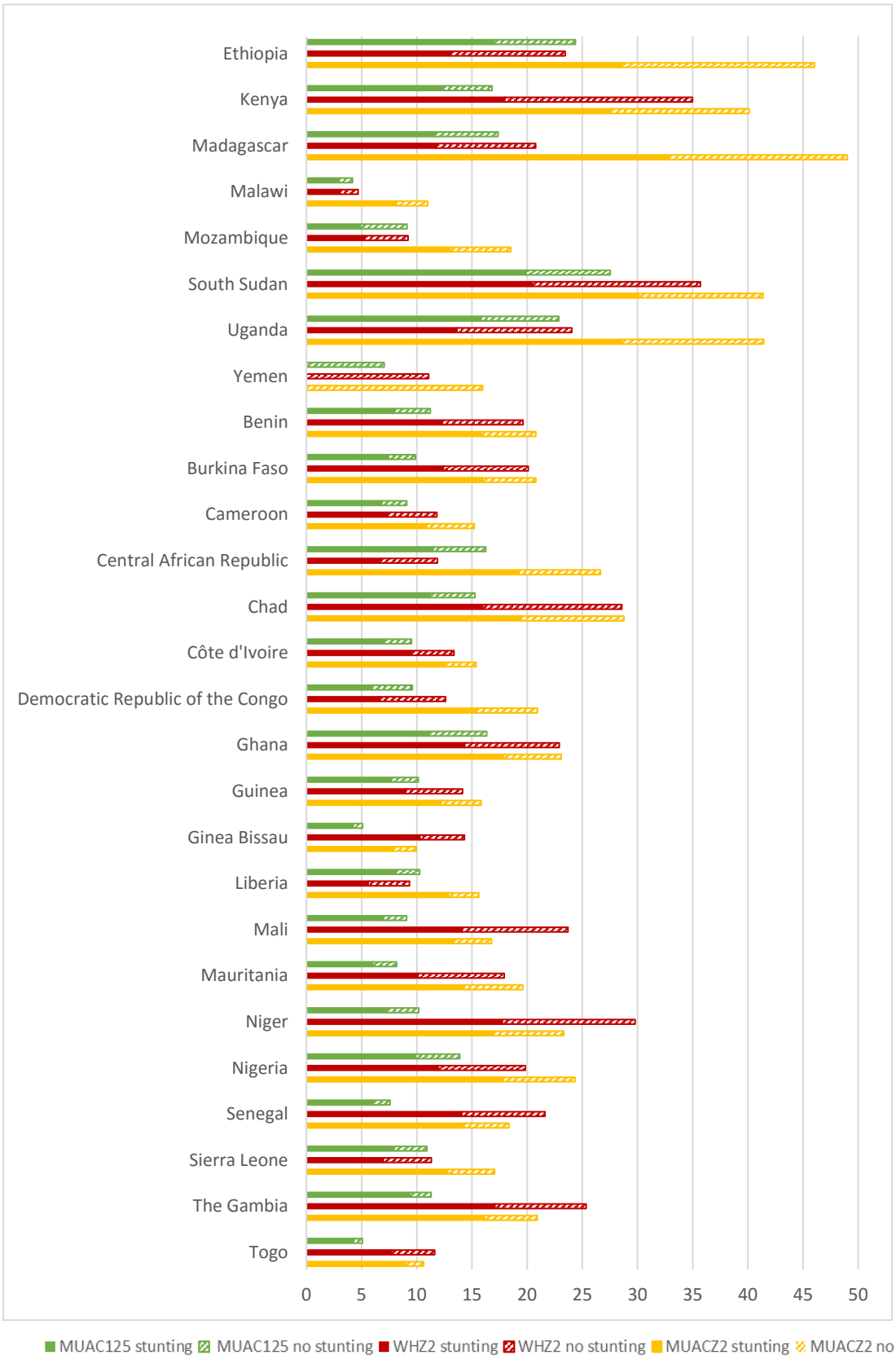
The major differences are found for MUACZ2, as in 17 of the 27 countries analysed the MUACZ2 median prevalence among stunted children is larger than the median prevalence among non-stunted children by more than 10 percentage points. The largest difference is observed in South Sudan, where MUACZ2 prevalence among stunted children is 30.1 % and among non-stunted children is 11.3 %.

The differences between stunted and non-stunted children for WHZ2 are much smaller. The largest difference is observed in The Gambia and is below 10 percentage points (8 % among non-stunted children and 17 % among stunted children).

The median acute malnutrition prevalence among stunted children is highest for MUACZ2 in the majority of the countries analysed; however, among stunted children, the MUAC125 prevalence is higher than the WHZ2 prevalence in only seven of the 27 countries and thus, overall, WHZ2 yields higher acute malnutrition estimates than MUAC125 among stunted children as well. All medians and IQRs for Figure 21 are provided in Table A21.

These results have important programmatic implications, as the stunting distribution of the population surveyed, along with the acute malnutrition indicator used, will have an impact on the overall prevalence estimates.

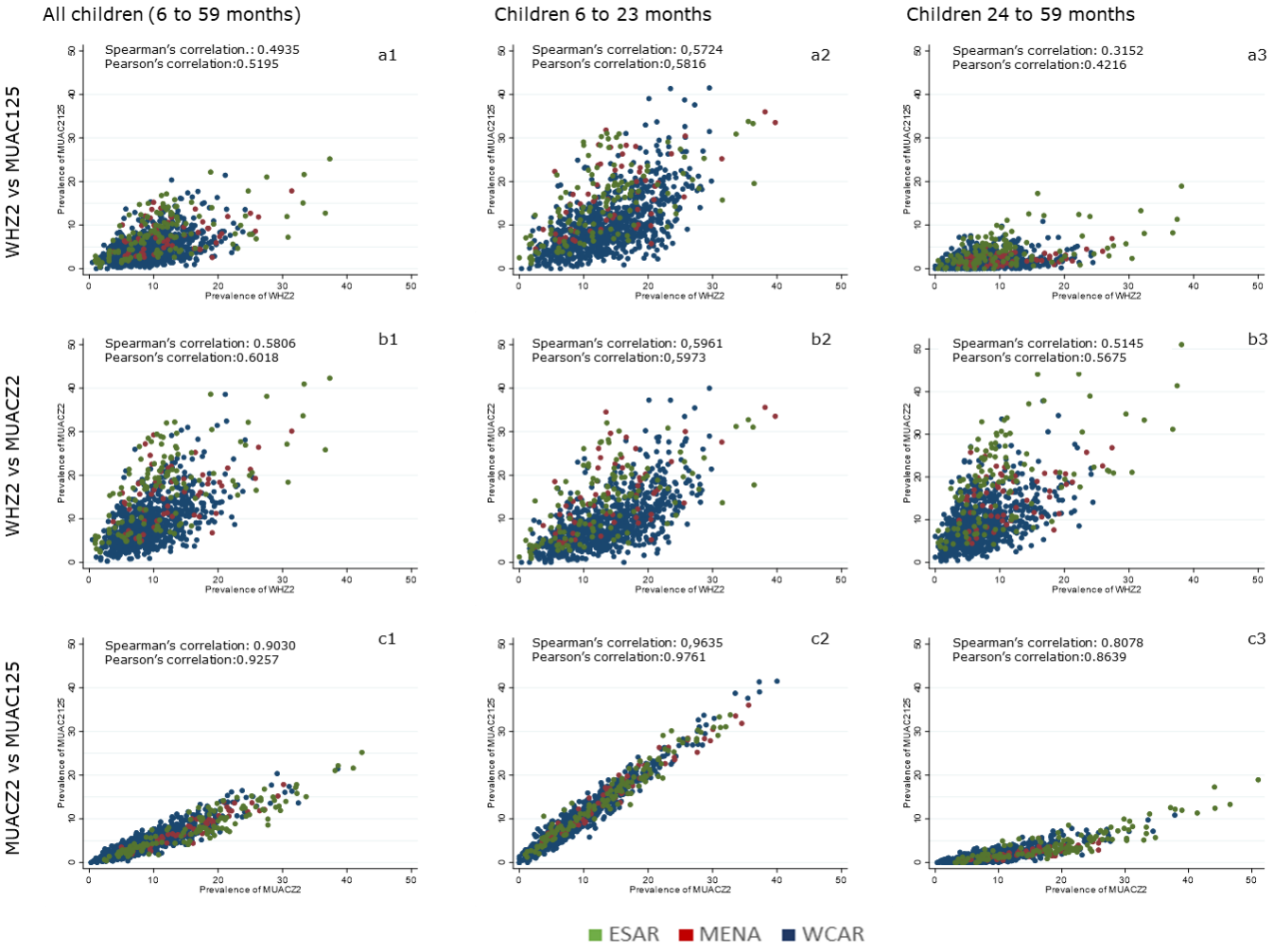
Figure 21. Median prevalence of acute malnutrition measured by MUAC125, WHZ2 and MUACZ2 and stratified by stunting status.



3.2.2. Correlations between acute malnutrition median prevalences

In order to further explore the relationship between acute malnutrition prevalence estimated by each of the three indicators assessed, we plotted the correlations of survey domain-level prevalences for each of the three indicator pairs (WHZ2 versus MUAC125, WHZ2 versus MUACZ2 and MUACZ2 versus MUAC125) for all children in the sample (6–59 months of age) stratified by age category (6–23 months and 24–59 months), as shown in Figure 22.

Figure 22. Pairwise correlations of acute malnutrition prevalence by indicator (WHZ2 versus MUAC125, WHZ2 versus MUACZ2, and MUAC125 versus MUACZ2) (n = 1 025).



NB: Scatter plots of the correlation are colour-coded by region as follows: ESAR, green; MENA (represented by Yemen), red; and WCAR, blue. (a) Prevalence estimated by WHZ2 (*x*-axis) versus MUAC125 (*y*-axis), (b) prevalence estimated b WHZ2 (*x*-axis) versus MUACZ2 (*y*-axis), and (c) prevalence estimated by MUACZ2 (*x*-axis) versus MUAC125 (*y*-axis) for all children (6–59 months of age – (a1), (b1) and (c1)) and stratified by age ((a2), (b2) and (c2) for children aged 6–23 months; (a3), (b3) and (c3) for children aged 24–59 months).

Figure 22 shows that the correlation between WHZ2 and MUAC125 is weak overall, with correlation values of around 0.5 for all children (Spearman's correlation = 0.49 and Pearson's correlation = 0.52), slightly higher values for children aged 6–23 months (Spearman's correlation = 0.57 and Pearson's correlation = 0.58), and values dropping below 0. 5 among children aged 24–59 months (Spearman's correlation = 0.32 and Pearson's correlation = 0.42).

The correlation between WHZ2 and MUACZ2 is not much stronger, with values around 0.6 (Spearman's correlation = 0.58 and Pearson's correlation = 0.60) for all children and no major differences between the age groups.

Finally the correlation between MUACZ2 and MUAC125 is strong and positive, with values around 0.90 for all children (Spearman's correlation = 0.90 and Pearson's correlation = 0.93), and clear differences between the age categories. Values increase to 0.96 for Spearman's correlation and to 0.98 for Pearson's correlation when considering only children aged 6–23 months, and decrease to 0.90 and 0.86 for Spearman's and Pearson's correlations, respectively, when only children older than 24 months are considered.

3.2.3. Multivariable associations

The final approach that we undertook to explore the relationship between the acute malnutrition survey domain prevalences estimated by each of the three indicators was to perform two multivariable linear regression models with MUACZ2 and MUAC125 prevalences as outcomes, and including the following explanatory variables: WHZ2 prevalence, HAZ2 (stunting) prevalence, and age ratio and sex ratio of the survey domain sample (Table 9). We calculated the age ratio as the proportion of children aged 6–23 months to the proportion of children aged 24–59 months in the sample. We retained all predictor variables in the multivariable models regardless of their significance in univariate models.

Table 9. Multivariable regression models for the prevalence of acute malnutrition diagnosed by MUACZ2 and MUAC125.

	Prevalence MUACZ < – 2	***P*-value**	**Prevalence MUAC < 125 mm**	***P*-value**
	Estimate (95 % CI)		Estimate (95 % CI)	
Acute malnutrition (WHZ < – 2) prevalence	0.74 (0.67 to 0.82)	< 0.0001	0.34 (0.29 to 0.39)	< 0.0001
HAZ2 prevalence	0.21 (0.19 to 0.24)	< 0.0001	0.14 (0.12 to 0.15)	< 0.0001
Two-category age ratio (6–23-to-24–59 months)	– 0.58 (– 1.72 to 0.57)	0.3255	– 2.20 (– 2.80 to 1.59)	< 0.0001
Sex ratio (male-to-female)	– 2.31 (– 5.37 to 0.74)	0.1378	– 2.23 (– 3.97 to 0.49)	0.0118
R^2	0.509		0.495	
Acute malnutrition (WHZ < – 2) prevalence	0.79 (0.72 to 0.87)	< 0.0001	0.39 (0.34 to 0.43)	< 0.0001
R^2	0.362		0.27	

The results show that more than 36 % of the variability in MUACZ2 prevalence is explained by WHZ2 prevalence, and this increases to more than 51 % when stunting, age and sex are introduced in the model. Stunting and WHZ2 are significantly associated with MUACZ2 prevalence, but sex and age ratio are not.

On the other hand, only 27 % of the variability in MUAC125 prevalence is explained by WHZ2 prevalence, increasing to 50 % when stunting, age and sex are introduced in the model. All the covariates (sex and age ratios and stunting) are significantly associated with MUAC125 prevalence at the 0.05 level.

These results confirm the low correlation between the acute malnutrition prevalences estimated by the three indicators and described in the previous sections, as well as the high influence of age and sex on MUAC125 prevalence estimates.

4. Discussion

After applying the inclusion criteria to all the surveys, the data set used in this study contained the anthropometry and demographic data of 682 283 children aged 6–59 months. The quality issue most frequently encountered was a problematic age distribution in the surveys. Age categories deviated from the expected ratios in many of the surveys in the data set, suggesting a consistent bias towards unbalanced samples, with more children in the younger age categories (below 2 years of age) being surveyed. The reasons for this may be multiple. Older children may be out of the home more frequently (attending nursery school, playing outside or contributing to family duties away from the home) and thus may not be available for survey measurements. It may also be linked to programme targeting of children below 2 years of age as part of the first 1 000 days initiative, which can result in unintentional bias towards younger children. This was the case in the survey conducted in Ghana, which aimed to describe the nutritional status of children aged 6–59 months and infant and young child feeding practices in children aged 6–23 months. The household interviews comprised mothers/primary caregivers and children aged 6–23 months, and anthropometric measurements were carried out for all children aged 6–59 months in the household. In the resulting sample in this survey 80 % of children were in the 6–23 months age range and only 20 % were in the 24–59 months age range.

The age distribution was identified as problematic in around 50 % of the surveys, which was taken into account by stratifying all the analyses included in the report by age category. As discussed below, the results show that the age distribution of the sample has an impact on GAM estimates, depending on the indicator used, thus showing the importance of having properly balanced samples in terms of age categories.

It is recommended that special care is taken to ensure that children aged over 2 years are correctly represented in nutrition surveys targeting children aged 6–59 months. Alternatively, targeting of surveys at children aged 0–23 months, in line with the first 1 000 days initiative, should be reconsidered, and population thresholds specific for this age group should be developed.

Finally, the data set compiled enabled the results to be disaggregated at national and subnational levels, as per the stratification design of the samples, and contained the statistical weights for 30 % of the surveys, thus allowing for detailed and precise analysis at different levels. In the present report the data set compiled was employed to explore the use of WHZ2, MUAC125 and MUACZ2 as GAM indicators for nutrition surveillance, but it could also enable other research questions in relation to anthropometric indicators to be addressed within the geographical areas covered.

4.1. Diagnosis of acute malnutrition (individual level)

In terms of the individual diagnosis of acute malnutrition, the two criteria most widely used for admission to feeding programmes are the WHZ and the absolute MUAC and, thus, the diagnostic concordance/discordance between MUAC125 and WHZ2 has already been assessed in a number of studies. Roberfroid et al. (2015) analysed data from 14 409 children in four countries, Grellety and Golden (2016) analysed data from 1 832 surveys including observations on 1 284 068 children from 47 countries, and Leidman et al. (2019) analysed 882 surveys from 41 countries including 622 877 children.

Our results show a diagnostic overlap between these two indicators of 24–25 %, which is in line with the findings in the pooled samples in the previous studies, which showed a diagnostic overlap in the 25–30 % range (Grellety and Golden, 2016; Leidman et al., 2019; Roberfroid et al., 2015). These results suggest that, at most, only one out of three children aged 6–59 months in multicountry samples are diagnosed simultaneously by WHZ2 and MUAC125. There are discrepancies between studies in the results by country but the diagnostic overlap does not increase beyond 40 % in any country in the previous studies. Our findings suggest that South Sudan has the highest proportion of children identified by both indicators simultaneously (39 %), whereas in the study by Grellety and Golden (2016) the overlap for these indicators in South Sudan is 10 percentage points lower (29 %); Sierra Leone is the country with the highest diagnostic overlap (39 %) in the study by Grellety and Golden (2016), which in our study shows a substantially lower overlap of 26 %.

There are also discrepancies in the results at country level regarding the proportion of children diagnosed by the different criteria. According to our results all countries but two show a higher proportion of children diagnosed by WHZ2 than by MUAC125, as in the four countries analysed by Roberfroid et al. (2015) and in

around 70 % of the countries analysed by Grellety and Golden (2016). However, countries such as the Democratic Republic of the Congo, Côte d'Ivoire, Madagascar, Malawi, Mozambique, Sierra Leone and Uganda were defined by Grellety and Golden (2016) as contexts where MUAC125 identifies more children as acutely malnourished than WHZ2, whereas our results indicated the opposite. Ethiopia is one of only two countries in our sample showing a higher proportion of children identified by MUAC125 than by WHZ2, whereas in the study by Grellety and Golden (2016) the opposite result is found.

Results are provided at regional level in the study by Leidman et al. (2019). Similarly to our results, in both the ESAR and the WCAR the proportion of children with acute malnutrition identified by WHZ2 is higher than that identified by MUAC125 (80 % versus 37 % in the ESAR and 74 % versus 53 % in the WCAR), although our findings reveal a smaller difference between the proportions of children diagnosed by each criterion in the ESAR (69 % diagnosed by WHZ2 and 52 % diagnosed by MUAC125) and a larger difference between the proportions in the WCAR (85 % diagnosed by WHZ2 and 38 % diagnosed by MUAC125).

These contrasting results challenge the idea that there are country or regional patterns in relation to the diagnostic capacities of these two indicators (Grellety and Golden, 2016; Myatt et al., 2009; Roberfroid et al., 2015); rather, they support the hypothesis that results are dependent on other individual characteristics of the children measured, such as age, sex or stunting status.

In fact, our results show that the diagnostic overlap between indicators increases substantially among children aged under 2 years, reaching around 50 % in Madagascar and South Sudan, whereas the overlap for children aged over 2 years is below 30 % in all countries, and around 10 % for most countries in the WCAR. These age-dependent results have also been seen in the study by Roberfroid et al. (2015). Beyond the diagnostic overlap, the fact that the number and proportion of children diagnosed as acutely malnourished by MUAC125 drops drastically in children aged over 2 years has been widely described (Isanaka et al., 2015; Myatt & Duffield, 2007; Roberfroid et al., 2015). It is known that MUAC increases with age, thus, when using a non-standardised cut-off point as the criterion to diagnose acute malnutrition, younger/smaller children are more likely to be selected than older children. This is a recognised bias when using absolute MUAC as the only indicator to diagnose acute malnutrition, but its use as the only indicator has been justified on the grounds that younger children may intrinsically be at higher risk of death than older children. Furthermore, the use of absolute MUAC measurements has been extended due to the simplicity of absolute MUAC as a screening tool (with direct interpretation as opposed to WHZ and MUACZ) and its potential to be scaled up, with measurements taken at the family or community level (Briend et al., 2016; Goossens et al., 2012).

Our findings also indicate contrasting results with regard to the diagnosis of acute malnutrition between stunted and non-stunted children, depending on the indicator used for diagnosis. MUAC125 categorises more children as acutely malnourished among stunted children, whereas WHZ2 identifies more acutely malnourished children among non-stunted children. The overlap between these two indicators is higher for stunted children in all countries analysed, in line with previous studies (Grellety and Golden, 2016; Roberfroid et al., 2015). Thus, countries such as Madagascar, Malawi, Sierra Leone and Uganda show a higher proportion of acutely malnourished children diagnosed by MUAC125 than by WHZ2 among stunted children, whereas the relationship is reversed for non-stunted children or in the overall sample. The fact that MUAC125 identifies a higher proportion of children with acute malnutrition among stunted children has been hypothesised to be because MUAC is a proxy for muscle mass, which is reduced in stunted children; thus, the acute malnutrition diagnosed by MUAC among stunted children reflects as much a child's stunting status as acute malnutrition status (Briend et al., 2012). According to this theory, and as argued by Roberfroid et al. (2015), the higher overlap among stunted children is due to those children with a low WHZ2, who will be additionally identified by MUAC125 because of their stunting status. The programmatic implications of this phenomenon are not clear. Some authors argue that using absolute MUAC is an efficient way of targeting young wasted and stunted children who are at higher risk of mortality (Briend et al., 2016). Other authors believe that many stunted children identified as acutely malnourished by MUAC are less severely malnourished than the MUAC indicates; thus, treatment would be less effective or is not required in such children (who would be moderately acutely malnourished and stunted), for whom the use of therapeutic foods is not recommended due to the potential risks associated with the double burden of malnutrition (WHO, 2017).

These and other potential consequences of implementing programmes using MUAC as the only criterion for diagnosis have been extensively discussed by Guesdon et al. (2020), who refer to innovative approaches being piloted with the 'expanded MUAC only approach', which proposes using MUAC125 as the sole anthropometric criterion for screening and admission, classifying cases as severe using MUAC115, and using ready-to-use-therapeutic food for the management of both moderate and severe cases of acute malnutrition

(Briend et al., 2012; GNC, 2017; Goossens et al., 2012). The results from the current study confirm the need for further reflection before wider implementation of this approach.

As the age bias is one of the limitations described for MUAC125, and one of the factors accounting for the conflicting results in acute malnutrition diagnosis with WHZ2, exploring the age-adjusted MUAC indicator may provide further insights into the use of anthropometric indicators for nutrition surveillance. However, there are few studies providing such information. In the early 1990s studies showed that the MUACZ indicator was a more useful indicator than absolute MUAC in understanding the pattern of undernutrition in a context such as Bangladesh (Brown et al., 1982) (Hall et al., 1993). Based on these and other results, in 1993 a WHO Expert Committee developed age- and sex-specific MUAC reference data and recommended the use of MUAC Z-scores as the best way to correctly interpret MUAC data with regard to nutritional status (de Onis, Yip and Mei, 1997). However, MUACZ scores have seldom been used since then, partly because this indicator requires age for its construction and age may be difficult to ascertain accurately in certain contexts with high burdens of malnutrition (Myatt, Khara and Collins, 2006), and mainly because of the simplicity provided by absolute MUAC measurements, which besides not requiring age do not require reference data for their interpretation (Briend et al., 2016).

Thus, there are few studies assessing MUACZ2 as an acute malnutrition indicator compared with WHZ2 and MUAC125 (Custodio et al., 2018) and, according to our knowledge, the only multicountry study conducted for such a purpose is that by Leidman et al. (2019), which provides results disaggregated at regional level that differ from our results in the regions analysed.

In the WCAR, our findings show a higher proportion of children identified by WHZ2 (67 %) than by MUACZ2 (50 %), while in the study by Leidman et al. (2019) the opposite results are found: 72 % of the children in this region are identified by MUACZ2 compared with 53 % identified by WHZ2. These discrepancies may reflect the different countries and types of surveys included in each of the studies. For the WCAR, the study by Leidman et al. (2019) included 217 small-scale field nutrition surveys conducted in humanitarian settings in 13 countries, while our analysis was based on 76 national and subnational surveys from 19 countries in the region. Thus, the condition of the children was likely to be worse in the sample analysed by Leidman et al. (2019), with the children living in worse conditions and being at higher risk of stunting. In most countries in the current study, among the stunted children there was a higher proportion of children diagnosed as acutely malnourished by MUACZ2 than by WHZ2, in line with results showing that MUACZ is more strongly associated with stunting than WHZ and absolute MUAC in Somalia (Custodio et al., 2018). This may be associated with the already mentioned capacity of the MUAC measurement to capture the muscle mass reduction that occurs in stunted children, although these results suggest that this capacity is maximised when MUAC is adjusted by age. This was also observed in a study in Kenya, where an age- and sex-adjusted measure of lean body mass (the upper arm muscle area Z-score) explained most of the variability in the progression of stunting among school-aged children (Friedman et al., 2005).

These results support the hypothesis that WHZ and MUAC measurements capture different manifestations of acute malnutrition, thus complementing each other, as when adjusted by age and sex the children identified are different. According to our results they are complementary and additive instead of alternative approaches, as suggested by Grellety and Golden (2016).

Notably, when we explore the diagnostic overlap between the two MUAC measurements – the unadjusted MUAC125 and the age- and sex-adjusted MUACZ2 – we find that, for the overall sample, only 35 % of the children are identified simultaneously by these two indicators. This is in line with the results from the study by Leidman et al. (2019), who found a diagnostic overlap of 42 %. This disagreement between the indicators is intrinsically related to the adjustment–unadjustment of the MUAC measure by sex and age, as the diagnostic overlap increases to 90 % when only children below 2 years old are considered. In addition, in the whole sample no children aged 2 years or older are identified only by MUAC125 and not MUACZ2 (as described by Leidman et al., 2019). Similarly, in 20 of the 27 countries analysed no male children were identified only by MUAC125, suggesting that when the MUAC measurement is not adjusted only girls would be categorised as acutely malnourished that would not be by MUACZ. This is consistent with results from an early study carried out in Bangladesh (Hall et al., 1993).

Moreover, the overlap between these two indicators is also consistently higher among stunted children than among non-stunted children, suggesting that the size of the children may also play a role in the association between these two MUAC indicators. It would be very interesting in this discussion to also compare how the two MUAC measurements relate to morbidity or mortality outcomes, but little research has been carried out in this area. We found only a small study conducted in Guinea-Bissau, which concluded that both indicators had the

same prognostic ability to predict short-term mortality (Richard et al., 2012). Therefore, more studies are needed to ascertain how MUACZ estimates relate to morbidity, mortality and other outcomes of interest. The fact is that the indicator that consistently identifies more children as acutely malnourished among stunted children may have a potential advantage in efficiently targeting wasted and stunted children among all children in the 6–59 months age range, shown to be those at higher risk of mortality (Briend et al., 2016). Thus, we suggest that further research should be conducted on this topic.

In this study we focused only on the diagnosis of GAM, but studies exploring the diagnosis of both GAM and SAM have found that diagnostic differences are more striking in the identification of SAM, and thus the consequences of these results are even more relevant and urgently need to be addressed (Custodio et al., 2018) (Grellety and Golden, 2016). Further research is needed to investigate differences between the anthropometric indicators when measuring SAM, taking into account age, sex and stunting status.

Some promising research initiatives are searching for alternative indicators that are simple and feasible to collect in the field and that are able to overcome the discrepancies described for the anthropometric indicators described in the current study (Medialdea et al., 2021). However, these indicators are not yet validated nor available to be used, thus we need to find a way of optimising the anthropometric indicators that are currently available for nutrition surveillance to best serve the purpose of identifying children in need of treatment and to prioritise actions and resources. Confirming our results, the most recent ontogenetic studies show that growth and developmental rates for children under and over 2 years of age and in female and male children distort the discriminant function of anthropometric indicators, resulting in misclassification (Medialdea et al., 2019). Thus, age (under and over 2 years of age) and sex are factors that need to be considered when classifying the nutritional status of infants and children if we aim to leave no one behind.

4.2. Prevalence of acute malnutrition (population level)

Furthermore, these acute malnutrition diagnostic discrepancies translate into differences in the population figures used for nutrition situation analysis, thus also affecting the classification of populations and the prioritisation of humanitarian and development funding.

The prevalence of acute malnutrition is widely used as a benchmark for the severity of a nutritional emergency and to characterise populations in order to prioritise humanitarian funding, but how these prevalence data diverge depending on the indicator used has only recently been evaluated. Results from Somalia and in overall samples in multicountry studies are in line with our results, indicating that when MUAC125 is the indicator used, the acute malnutrition prevalence is lower than when using WHZ2 or MUACZ2 (Bilukha and Leidman, 2018) (Custodio et al., 2018) (Leidman et al., 2019).

However, when compared at country level, the results are contradictory. In our sample, 25 of the 27 countries analysed showed a higher prevalence of acute malnutrition for WHZ2 than for MUAC125, whereas in the study by Leidman et al. (2019) countries such as the Democratic Republic of the Congo, Liberia, Madagascar and Uganda displayed the opposite results to our findings, showing a higher prevalence for MUAC125. These conflicting results, as discussed previously, may be due to the types of survey (and consequently the population samples) included in each of the studies, opposing the idea that 'country profiles' can be defined, as children´s characteristics such as sex, age and size impact the results more than characteristics linked to their place of origin.

The results from this study show that when measuring acute malnutrition with MUAC125, girls seem to be most affected, whereas boys are more vulnerable if WHZ2 or MUACZ2 is used. In relation to age, acute malnutrition is more prevalent among children aged younger than 2 years when either WHZ2 or MUAC125 criteria are used, whereas estimates of MUACZ2 prevalence are higher among children aged 2 years or older in the majority of the countries. These results have important programmatic implications, as according to the indicator used the group of children prioritised for acute malnutrition prevention or treatment programmes may be different.

In relation to stunting the results are always in the same direction: acute malnutrition prevalence is higher among stunted children than among non-stunted children, independently of the indicator used. Stunting is the result of suboptimal conditions in terms of diet and health, and it has been shown in other studies how wasting episodes are related to stunting status (Martin-Canavate et al., 2020) (Schoenbuchner et al., 2019); therefore, this association is expected. However, it is important to note that the prevalence of acute malnutrition is highest among stunted children when MUACZ2 is the indicator used, while differences in prevalence between stunted

and non-stunted children are lowest when acute malnutrition is measured by WHZ2. As already mentioned, it is important thus to be aware that the age, sex and stunting distribution of the samples surveyed, along with the indicator used, will have an impact on the overall estimation of the nutrition situation of populations.

In order to avoid these discrepancies, and to enable comparisons to be made between the results obtained using different indicators, efforts have been made to elucidate formulas to convert prevalence measured by MUAC125 into prevalence measured by WHZ2. However, these initiatives have not been successful, as the convergence between WHZ2 and MUAC125 is too low (Bilukha and Leidman, 2018). Our results confirm this low convergence, which is only slightly improved when WHZ2 prevalence is compared with MUACZ2 prevalence. The multivariable models in our study show that WHZ2 alone explains 27 % of the variability in MUAC125 prevalence (24 % in the Leidman et al. (2019) study) compared with 36 % of the variability in MUACZ2 prevalence (33 % in the Leidman et al. (2019) study). Interestingly, when the models are adjusted by age, sex and stunting status, the variability explained for the population estimates for both indicators (MUAC125 and MUACZ2) is approximately equal, at around 50 %, although age and sex are significant only for the MUAC125 multivariable model. This suggests that, in the case of MUACZ2, including the stunting status of children increases the convergence with WHZ2 prevalence to 50 %, while in the case of MUAC125 the increase from 24 % to 49 % is due to taking sex and age into account in addition to stunting status. Thus, if age and sex are taken into account in the indicator itself, then only stunting status makes a difference to the estimates. However, only 50 % of the variability is explained in this way and thus 50 % of the variability in acute malnutrition prevalence measured by the MUAC-based indicators is not explained by the nutritional status of the child according to WHZ or stunting, nor by age or sex. Other characteristics of the types of malnutrition identified by these indicators need to be elucidated to further understand these relationships.

More promising is the convergence between MUAC125 prevalence and MUACZ2 prevalence, for which the correlation is greater than 0.9. Leidman et al. (2019) have already proposed that it may be possible to devise a relatively reliable formula for the conversion of MUAC125 prevalence into MUACZ2 prevalence. Further research should be dedicated to this aim. Furthermore, our results contribute to this idea, with the nuance that it may be of interest to explore different formulas according to the age categorisation of children, as the correlation among children aged under 2 years was close to 1.0 in this study.

The interest in finding formulas that convert MUAC-based prevalence into WHZ2 prevalence is also linked to the need to use standard thresholds for the categorisation of populations. For WHZ2, the WHO outlined guidance on global thresholds in 1995 (WHO, 1995) that have been widely used to categorise and compare crisis situations and guide action over the past few decades. These thresholds were revised recently by a joint WHO–UNICEF Technical Expert Advisory Group on Nutrition Monitoring (de Onis et al., 2019), which redefined thresholds for wasting (WHZ < – 2), stunting (HAZ < – 2) and overweight (WHZ > + 2) according to the standard deviations from the reference populations, thus using the Z-scores.

For WHZ2, the prevalence thresholds for wasting are 'very low' (< 2.5 %), 'low' (2.5–5 %), 'medium' (5–10 %), 'high' (10–15 %) and 'very high' > 15 %), which is in line with past thresholds except for the 'very low' category, which did not exist previously.

Currently there are no separate thresholds for classifying a crisis based on the prevalence of wasting as assessed by MUAC, and the efforts dedicated to defining thresholds have been unsuccessful. The aim is to introduce thresholds that categorise populations according to MUAC125 in a way that is consistent with WHZ2 thresholds. However, this is not possible due to the poor correlation between the population prevalence of wasting estimated by WHZ and the population prevalence of wasting estimated by MUAC, as described previously (Bilukha and Leidman, 2018).

Nevertheless, WHZ2 thresholds are widely used to categorise populations based on wasting estimated by MUAC125, especially in multitopic surveys such as food security and nutrition surveys, and this is highly problematic. As the maps in this report show, if measurements are made using MUAC125 but WHZ2 thresholds are applied, populations are consistently categorised at lower levels of prevalence. This lowers the level of severity of the nutrition situation being assessed, and means that comparing the nutrition situation between crises is not possible if different indicators are used to define acute malnutrition.

Initiatives such as the Integrated Food Security Phase Classification and the Cadre Harmonisé that aim to improve food security and nutrition analysis have established alternative methods to overcome this problem. One method is not to use results based on MUAC125 directly, but to use additional information on the nutrition situation to help interpret the results. Another method is to use 'range thresholds' for MUAC125 that help to frame the categorisation of the population being assessed in a way that is consistent with WHZ2 thresholds, through the use of additional evidence. A final method is to establish a communication protocol that clearly distinguishes the acute malnutrition indicator that has been used for the classification of the population in terms of nutrition (e.g. using stripes when colouring maps if the indicator used is MUAC125). All these recommendations are set out in the recently updated manuals for these two initiatives (Cadre Harmonisé Partners, 2020; IPC Global Partners, 2019).

However, our study indicates that the highly discrepant results obtained when only children aged over 2 years are analysed would not converge despite the methodological adjustments in place within these initiatives, thus calling, once again, for attention to be given to the age of the children sampled.

In addition, there are also no thresholds for MUACZ2, nor have efforts been made to establish them, even though the convergence in the categorisation of populations with WHZ2 thresholds is much higher than with MUAC125 and less dependent on age. In addition, for this MUAC-based indicator it would be possible to establish global standard thresholds based on the same methodology used for the other nutrition indicators that are based on Z-scores (de Onis et al., 2019). Further research on formulas for converting MUAC125 prevalence into MUACZ2 prevalence, and global thresholds for MUACZ2, could provide relevant evidence for resolving the conflicting classification of populations when these indicators are used.

Finally, another area debated by the nutrition community is the pertinence of combining the indicators and using more than one indicator to diagnose malnutrition, as they seem to be complementary rather than alternatives. The results from this study indicate that, in terms of prevalence, the acute malnutrition estimates obtained using the WHZ2_MUAC125 indicator differ from the WHZ2 estimates by less than 1 percentage point for the national surveys in the WCAR, while the prevalences obtained using the combined WHZ2_MUACZ2 indicator can be up to 10 percentage points higher than the prevalences obtained using WHZ2. However, and even if the percentage point differences are low, the implications in terms of burden are unknown and further research is required in this area.

5. Conclusions

The JRC–UNICEF collaboration resulted in a comprehensive data set including survey data from all WCAR countries, part of the ESAR, and Yemen, allowing for high-quality research to be carried out on anthropometric indicators in the geographical areas covered.

The results show that the acute malnutrition indicators cannot be used interchangeably for nutrition surveillance, as they yield different results in terms of acute malnutrition screening and population estimate calculations. The age, sex and size of children play an important role in the diagnostic capacity of each indicator. Consequently, sample characteristics affect the acute malnutrition population estimates, and no regional or country pattern can be defined in terms of the relationship between the indicators.

Further research is under way to validate indicators that overcome these limitations. Meanwhile, we should find ways to optimise the use of the currently available indicators, by combining them or improving their convergence by taking determinants into account, such as by assessing children aged under and over 2 years separately. This will contribute to the ultimate goal of leaving no child behind.

6. Key Messages

- The JRC–UNICEF collaboration resulted in a comprehensive survey data set including 682 283 child observations from 27 countries (19 countries in the WCAR, 7 in the ESAR, and Yemen). This data set allowed for high-quality research to be carried out and can be used to explore further the use of anthropometric indicators in the geographical areas covered.

- The findings of this analysis are aligned with those of previous studies that show that WHZ and MUAC measurements identify different manifestations of acute malnutrition and are thus complementary and additive rather than being alternatives or exchangeable. When using only one anthropometric indicator to estimate the prevalence of acute malnutrition, there will always be acutely malnourished children (diagnosed by other indicators) who will be excluded from the overall prevalence estimate.

- The comparison of these findings with those of other studies at regional or country level shows that it is not possible to define patterns or relationships between anthropometric indicators across the regions and countries studied.

- Sex, age and stunting status affect how children are diagnosed as acutely malnourished by the different indicators (MUAC125, MUACZ2 and WHZ2).

- Absolute MUAC measurements consistently identify more acutely malnourished children in younger age groups (under 2 years).

- The prevalence of acute malnutrition will always be higher among younger children (under 2 years) for MUAC125 and WHZ2 and higher among older children for MUACZ2.

- Depending on the indicator used to measure acute malnutrition, the prevalence will be higher among girls (MUAC125) or among boys (WHZ2 and MUACZ2).

- The prevalence of acute malnutrition is always higher among stunted children across the three indicators. MUACZ2 consistently identifies the highest number of acutely malnourished children among stunted children compared with MUAC125 and WHZ2.

- The use of the existing WHO population-based prevalence thresholds ([9]) to interpret the severity of wasting at the population level when using wasting prevalence derived from MUAC measurements is likely to result in incorrect severity classifications.

([9]) <5 %, 'low'; 5–10 %, 'medium'; 10–15 %, 'high'; and ≥ 15 %, 'very high' ((https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6390397/)

7. Recommendations for next steps and further research

- ✓ Acknowledging the variation in the prevalence of acute malnutrition when using different anthropometric indicators, it is recommended that the indicator used to diagnose acute malnutrition is specified when reporting results and that the results are disaggregated by sex, age (under and over 2 years) and stunting status for better interpretation.

- ✓ For nutrition surveillance at population level, the use of a combined indicator that includes children identified as acutely malnourished by WHZ and MUAC should be further explored and validated. The combined indicator should identify children who are malnourished either by WHZ or by MUAC or by both indicators, without double-counting children; this indicator can be automatically calculated using the ENA for SMART software. This will provide more accuracy in estimating the levels of acute malnutrition and the overall nutrition situation in a population.

- ✓ Using the comprehensive data set developed from this research and additional survey data sets from other regions if available, further research should be conducted to investigate and document differences between the anthropometric indicators when measuring SAM, taking into account age and sex to determine if there are any differences in the findings.

- ✓ As absolute MUAC measurement is becoming popular as a practical indicator for nutrition surveillance and screening, there is a need to enhance the quality and accuracy of this indicator in providing malnutrition estimates. Further research is needed to explore ways of adjusting or correcting for age bias when using absolute MUAC estimates as an indicator for surveillance purposes. These include the possibility of developing formulas to convert absolute MUAC-based prevalence into MUACZ2 prevalence and developing global population-based thresholds for MUACZ2 that can be used to define severity uniformly across populations. Alternatively, the age targeting of surveys to 0–23 months should be reconsidered, in line with 1 000 days programming, and to develop population thresholds specific for this age group.

- ✓ As using WHO population-based thresholds to interpret the severity of wasting at population level when using wasting prevalence derived from MUAC estimates is likely to result in incorrect severity classifications, alternative population-based thresholds specifically for wasting prevalence derived from MUAC estimates should be developed. In the interim, the proposal is to use the methodology and thresholds developed by the Integrated Food Security Phase Classification ([10]) for the classification of acute malnutrition by MUAC until further guidance is developed for MUAC-specific population-based thresholds.

- ✓ Innovation around weight-for-height data collection is needed to make it more practical and feasible to collect high-quality height data to measure WHZ for nutrition surveillance among communities.

- ✓ Further research is needed to identify children who are most at risk of mortality. Children with wasting and stunting are at a higher risk of mortality. The research found that stunted children were consistently identified as acutely malnourished using all the indicators investigated.

([10]) http://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/manual/IPC_Technical_Manual_3_Final.pdf

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List of abbreviations and definitions

BF	Burkina Faso
BJ	Benin
CD	Democratic Republic of the Congo
CF	Central African Republic
CI	Côte d'Ivoire
CM	Cameroon
ENA	Emergency Nutrition Assessment
ESAR	Eastern and Southern Africa region
ET	Ethiopia
GAM	global acute malnutrition
GH	Ghana
GM	The Gambia
GN	Guinea
GW	Guinea Bissau
HAZ	height-for-age Z-score
HAZ2	height-for-age Z-score below – 2
IQR	interquartile range
JRC	Joint Research Centre
KE	Kenya
LR	Liberia
MENA	Middle East and North Africa
MG	Madagascar
ML	Mali
MR	Mauritania
MUAC	mid-upper arm circumference
MUACZ	MUAC-for-age Z-score
MUACZ2	MUAC-for-age Z-score < – 2
MW	Malawi
MZ	Mozambique
NE	Niger
NG	Nigeria
SAM	severe acute malnutrition
SL	Sierra Leone
SMART	Standardized Monitoring and Assessment of Relief and Transitions
SN	Senegal
SS	South Sudan
TD	Chad
TG	Togo
UG	Uganda
UNICEF	United Nations Children's Fund
WCAR	West and Central Africa region
WHO	World Health Organization
WHZ	weight-for-height/length Z-score
WHZ2	weight-for-height/length Z-score < – 2
YE	Yemen

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Annex

Table A1. Diagnosis of GAM by WHZ2, MUAC125 or both criteria in 27 countries.

Country	N(WHZ2_MUAC125)	WHZ2 only (%)	MUAC125 only (%)	Both criteria (%)	%WHZ2 minus %MUAC 125	Total WHZ2 (%)	Total MUAC125 (%)
BF	12 257	59.5	14.7	25.8	44.78	85.30	40.52
BJ	487	50.1	16.2	33.7	33.88	83.78	49.90
CD	547	46.1	26.1	27.8	19.93	73.86	53.93
CF	1 387	27.8	45.1	27.1	– 17.38	54.87	72.24
CI	1 621	43.4	25.7	30.9	17.64	74.28	56.63
CM	1 122	44.2	21.4	34.4	22.82	78.61	55.79
ET	2 498	34.2	40.5	25.3	– 6.24	59.53	65.77
GH	339	51.6	22.7	25.7	28.91	77.29	48.38
GM	1 340	69.1	9.6	21.3	59.55	90.45	30.90
GN	1 602	50.6	26.5	22.9	24.16	73.53	49.38
GW	325	73.5	8.3	18.2	65.23	91.69	26.46
KE	5 050	61.7	13.3	25.0	48.32	86.65	38.34
LR	271	36.2	29.9	33.9	6.27	70.11	63.84
MG	1 022	39.9	26.4	33.7	13.50	73.58	60.08
ML	7 596	70.1	9.0	20.9	61.14	91.02	29.88
MR	8 070	68.6	16.5	14.9	52.06	83.46	31.40
MW	311	54.7	26.4	19.0	28.30	73.63	45.34
MZ	70	37.1	35.7	27.1	1.43	64.29	62.86
NE	4 538	67.3	11.2	21.5	56.15	88.81	32.66
NG	7 837	40.7	26.3	33.0	14.34	73.68	59.33
SL	2 043	42.6	31.0	26.3	11.60	68.97	57.37
SN	5 929	74.6	8.0	17.4	66.64	92.04	25.40
SS	96	42.7	18.8	38.5	23.96	81.25	57.29
TD	11 189	57.9	16.8	25.2	41.09	83.16	42.07
TG	839	60.3	14.2	25.5	46.13	85.82	39.69
UG	4 172	40.5	32.9	26.6	7.67	67.14	59.47
YE	5 843	52.9	23.5	23.6	29.45	76.52	47.06

Table A2. Diagnosis of GAM by WHZ2, MUACZ2 or both criteria in 27 countries.

Country	N(WHZ2_ MUACZ22)	WHZ2 only (%)	MUACZ2 only (%)	Both criteria (%)	%WHZ2 minus %MUACZ2	Total WHZ2 (%)	Total MUACZ2 (%)
BF	16 096	36.5	35.0	28.5	0.21	9.50	9.29
BJ	606	32.3	32.7	35.0	– 0.04	9.08	9.12
CD	896	21.3	54.9	23.8	– 4.40	5.90	10.30
CF	2 005	15.7	62.0	22.3	– 7.60	6.22	13.81
CI	2 097	27.6	42.6	29.8	– 1.47	5.62	7.09
CM	1 492	24.5	40.9	34.6	– 1.91	6.89	8.80
ET	3 832	11.4	61.2	27.5	– 11.47	8.93	20.40
GH	369	45.5	29.0	25.5	2.29	9.82	7.53
GM	1 527	45.9	20.6	33.5	3.34	10.50	7.15
GN	1 826	38.1	35.5	26.5	0.27	6.65	6.38
GW	378	50.3	21.2	28.6	2.30	6.23	3.93
KE	6 224	30.6	29.7	39.7	0.24	19.00	18.76
LR	339	25.7	44.0	30.4	– 1.36	4.18	5.54
MG	1 846	11.4	59.3	29.4	– 12.30	10.46	22.76
ML	8 734	52.6	20.8	26.6	4.32	10.77	6.45
MR	9 613	44.1	29.9	26.0	2.14	10.63	8.48
MW	495	25.7	53.7	20.6	– 2.06	3.40	5.46
MZ	111	18.9	59.5	21.6	– 4.21	4.21	8.41
NE	5 623	37.7	28.3	34.0	1.86	14.20	12.34
NG	10 119	25.3	42.9	31.7	– 3.03	9.82	12.85
SL	2 457	31.1	42.7	26.3	– 1.22	6.03	7.25
SN	7 034	44.5	22.4	33.1	2.78	9.75	6.98
SS	115	25.2	32.2	42.6	– 1.75	17.07	18.82
TD	13 672	34.3	31.9	33.7	0.48	13.44	12.96
TG	1 119	36.6	35.7	27.7	0.09	6.01	5.92
UG	5 744	21.7	51.2	27.1	– 7.05	11.62	18.67
YE	7 542	25.8	40.7	33.5	– 3.20	12.74	15.95

Table A3. Diagnosis of GAM by MUAC125, MUACZ2 or both criteria in 27 countries.

Country	N(MUACZ22 _MUAC125)	MUACZ2 only (%)	MUAC125 only (%)	Both criteria (%)	%MUACZ2 minus %MUAC12	Total MUACZ2 (%)	Total MUAC125 (%)
BF	11 183	55.59	8.57	35.84	47.0	91.4	44.4
BJ	456	46.71	10.09	43.20	36.6	89.9	53.3
CD	744	60.35	5.24	34.41	55.1	94.8	39.7
CF	1 825	45.10	7.34	47.56	37.8	92.7	54.9
CI	1 671	45.06	9.16	45.78	35.9	90.8	54.9
CM	1 211	48.31	7.02	44.67	41.3	93.0	51.7
ET	3 657	55.07	7.11	37.82	48.0	92.9	44.9
GH	245	33.06	17.96	48.98	15.1	82.0	66.9
GM	916	54.80	9.83	35.37	45.0	90.2	45.2
GN	1 300	39.15	13.00	47.85	26.2	87.0	60.8
GW	205	58.05	8.29	33.66	49.8	91.7	42.0
KE	4 592	57.84	5.90	36.26	51.9	94.1	42.2
LR	284	39.08	11.27	49.65	27.8	88.7	60.9
MG	1 727	64.45	5.27	30.28	59.2	94.7	35.6
ML	4 600	50.65	9.93	39.41	40.7	90.1	49.3
MR	6 007	57.82	10.47	31.71	47.3	89.5	42.2
MW	399	64.66	7.77	27.57	56.9	92.2	35.3
MZ	95	53.68	5.26	41.05	48.4	94.7	46.3
NE	3 693	59.87	5.14	34.99	54.7	94.9	40.1
NG	8 325	44.14	9.25	46.61	34.9	90.8	55.9
SL	1 923	39.05	11.91	49.04	27.1	88.1	60.9
SN	4 204	64.18	7.14	28.69	57.0	92.9	35.8
SS	90	38.89	4.44	56.67	34.4	95.6	61.1
TD	9 782	51.88	8.24	39.88	43.6	91.8	48.1
TG	773	56.92	8.28	34.80	48.6	91.7	43.1
UG	4 823	48.6	6.7	44.7	41.9	93.3	51.4
YE	6 075	54.7	7.9	37.4	46.8	92.1	45.3

Table A4. Median proportion of children diagnosed by WHZ2, MUAC125 and both indicators by sex.

		Female						**Male**					
		WHZ < – 2 only		MUAC < 125 mm only		Both		WHZ < – 2 only		MUAC < 125 mm only		Both	
Region	Country	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)
ESAR	ET	337	30.13 (16.67–37.93)	639	48.36 (42.86–57.58)	260	20.64 (15.56–25.93)	518	41.28 (31.11–53.33)	372	27.98 (17.14–38.18)	372	27.89 (20.59–34.38)
	KE	1 184	58.57 (43.85–67.93)	448	18.23 (12.61–26.21)	598	22.65 (17.33–30.47)	1 710	74.39 (63.79–81.14)	199	7.74 (2.99–11.18)	588	18.83 (13.39–26.5)
	MG	167	30.31 (29.13–37.59)	177	33.06 (28.89–38.52)	173	34.53 (30.07–36.49)	241	48.74 (40.32–52.34)	93	16.22 (14.38–21.08)	171	34.5 (29.74–37.38)
	MW	75	50 (33.33–62.5)	48	37.5 (15.38–50)	28	15 (0–27.27)	81	70.59 (36.36–82.35)	14	11.11 (0–28.57)	26	27.27 (5.88–29.41)
	MZ	6	42.86 (42.86–42.86)	7	50 (50–50)	1	7.14 (7.14–7.14)	8	57.14 (57.14–57.14)	4	28.57 (28.57–28.57)	2	14.29 (14.29–14.29)
	SS	19	41.3 (41.3–41.3)	14	30.43 (30.43-30.43)	13	28.26 (28.26–28.26)	22	44 (44–44)	4	8 (8–8)	24	48 (48–48)
	UG	656	33.86 (22.99–40)	852	39.38 (33.33–47.13)	528	26.82 (23.88–30.19)	1 035	47.66 (37.5–56.06)	519	23.27 (17.65–30.23)	582	26.73 (20.73–33.33)
MENA	YE	1 133	42.58 (26.56–52.17)	928	31.82 (21.31–46.97)	697	22.93 (17.24–30.95)	1 960	65.64 (53.33–75.36)	444	12.7 (4.71–20.83)	681	22.11 (13.64–27.12)
WCAR	BF	2 622	50 (38.71–63.16)	1 202	20 (11.76–29.03)	1 563	27.27 (20–35.29)	4 448	71.43 (62.5–80.77)	521	6.67 (3.03–10.91)	1 481	20.69 (15–28)
	BJ	92	39.8 (32.26–43.1)	59	24.25 (17.65–31.91)	78	33.22 (28.13–39.66)	152	60.36 (48–69.23)	20	7.71 (2.08–11.54)	86	33.93 (22.92–44.44)
	CD	88	42.48 (23.81–47.37)	87	39.4 (31.58–46.03)	58	23.03 (19.57–30.16)	164	53.41 (51.06–61.76)	56	21.95 (9.43–23.53)	94	24.91 (23.26–38.04)
	CF	99	19.29 (10.18–32.17)	305	54.74 (47.82–61.21)	144	25.29 (21.13–29.59)	177	32.84 (21.03–51.41)	210	34.44 (26.04–41.34)	177	31.11 (22.3–35.17)
	CI	237	32.05 (20–42.02)	263	34.85 (21.24–52.08)	233	33.33 (25.17–40.02)	458	55.28 (40.15–61.72)	154	14.29 (7.9–34.43)	268	31.01 (20.71–35.21)
	CM	191	32.29 (24–42.86)	149	29.29 (18.18–37.5)	183	29.91 (23.08–39.02)	287	49.59 (38.46–66.67)	79	14.84 (5.41–21.43)	193	31.26 (22.22–46.15)
	GH	60	34.15 (32.65–41.1)	52	34.15 (26.03–38.78)	51	31.71 (28.57–32.88)	115	64.1 (53.23–76)	25	9.33 (7.69–24.19)	36	22.58 (14.67–28.21)
	GM	349	62.07 (50–85.71)	86	14.29 (6.67–22.22)	132	25.53 (8.7–28.79)	508	79.31 (71.95–87.88)	29	3.57 (2.08–6.9)	116	18.42 (8.93–23.17)
	GN	314	38.46 (33.33–50)	286	35.29 (32.14–44.44)	170	21.62 (18.75–25.64)	497	61.61 (44–68.57)	138	15.56 (11.43–22.22)	197	26.32 (19.05–30)
	GW	94	68.42 (45–72)	27	20 (12–21.43)	33	16 (11.11–28.57)	145	85.37 (82.35–88.89)	0	0 (0–0)	26	14.63 (11.11–17.65)
	LR	22	18.33 (10.8–30)	35	40 (33.33–52.65)	30	32.05 (26.14–45)	32	30.3 (17.42–51.3)	19	15.48 (9.13–29.92)	36	45.13 (21.59–60.61)
	ML	2 135	63.33 (51.11–71.15)	468	11.54 (6.67–18.97)	865	23.4 (18.18–29.55)	3 182	78.18 (70–85.71)	212	3.85 (1.3–7.41)	722	16.67 (11.97–24.14)
	MR	2 210	60.83 (46.67–71.24)	854	22.08 (17.03–35.83)	577	13.48 (7.95–21.31)	3 138	75.86 (63.82–82.57)	434	12.05 (5.56–16.95)	585	11.19 (7.58–19.77)
	NE	873	54.95 (45.33–64.93)	351	22.36 (15.81–27.92)	364	19.76 (16.37–26.33)	2 183	77.12 (68.8–82.5)	157	5.36 (3.53–7.68)	610	17.71 (14.5–25.58)
	NG	1 006	30.5 (21.41–44.54)	1 294	34.96 (24.78–43.31)	1 232	32.17 (23.33–42.45)	2 181	54.45 (45.18–66.15)	769	15.3 (8.17–22.38)	1 355	28.19 (20–35.44)
	SL	328	38.24 (26.13–41.18)	382	40.99 (31.71–45.83)	281	24.75 (20.18–37.82)	543	53.33 (48.39–60)	252	25.58 (18.87–30.54)	257	19.7 (14.29–28.3)
	SN	1 663	71.65 (62.07–80)	349	12.5 (5.88–16.13)	495	16.67 (10.71–25)	2 543	83.33 (77.08–90)	111	2.49 (0–5.26)	490	12.05 (7.69–18.97)
	TD	2 607	51.21 (36.36–61.36)	1 252	22.47 (15.38–32.56)	1 420	26.89 (19.05–32.43)	3 743	69.56 (53.68–77.22)	597	8.49 (4.35–13.92)	1 355	22.36 (16.46–31.11)
	TG	185	51.11 (40–58.33)	87	18.75 (14.29–26.67)	113	25 (15–33.33)	321	77.78 (57.45–94.12)	32	5 (0–9.09)	101	18.75 (0–31.91)

Table A5. Median proportion of children diagnosed by WHZ2, MUAC125 and both indicators by age category.

		Age 6–23 months						**Age 24–59 months**					
		WHZ < – 2 only		MUAC < 125 mm only		Both		WHZ < – 2 only		MUAC < 125 mm only		Both	
Region	Country	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)
ESAR	ET	178	12.2 (8.47–19.05)	768	56.83 (50–61.36)	415	32.58 (25–38.1)	677	65.48 (50–75)	243	19.07 (9.68–27.91)	217	15.19 (11.43–21.62)
	KE	710	38.28 (28.26–49.29)	492	25.86 (17.35–32.29)	718	33.97 (28.39–42.73)	2 184	81.99 (69.91–91.71)	155	3.92 (2.04–5.85)	468	12.5 (4.7–20.76)
	MG	124	23.96 (20.8–24.09)	182	31.71 (29.81–34.93)	237	45.31 (41.91–47.76)	284	59.94 (54.16–63.98)	88	19.32 (15–21.81)	107	22.68 (16.57–26.88)
	MW	48	33.33 (12.5–58.82)	47	40 (25–55.56)	29	25 (11.76–28.57)	108	73.91 (50–86.96)	15	5.26 (0–30)	25	16.67 (6.25–20)
	MZ	8	53.33 (53.33–53.33)	6	40 (40–40)	1	6.67 (6.67–6.67)	6	46.15 (46.15–46.15)	5	38.46 (38.46–38.46)	2	15.38 (15.38–15.38)
	SS	16	29.63 (29.63–29.63)	11	20.37 (20.37–20.37)	27	50 (50–50)	25	59.52 (59.52–59.52)	7	16.67 (16.67–16.67)	10	23.81 (23.81–23.81)
	UG	796	29.94 (23.33–43)	919	35.2 (25.71–42.65)	800	32.77 (26.32–36.67)	895	53.24 (40.74–67.57)	452	25.46 (18.42–35)	310	17.08 (13.16–23.68)
MENA	YE	836	26.98 (18.84–37.93)	1 164	35.83 (25.81–50)	1 029	30.8 (25–39.58)	2 257	81.15 (71.74–88)	208	5.85 (2.63–13.51)	349	11.4 (7.77–15.38)
WCAR	BF	3 751	53.49 (42.67–60.87)	1 337	15.91 (10.71–22.73)	2 443	31.03 (23.33–38.1)	3 319	80 (68.42–87.5)	386	6.9 (0–14.29)	601	12 (6.45–20)
	BJ	115	36.34 (30–44.44)	60	20.37 (15.38–26.32)	130	42.38 (36.54–50)	129	71.37 (63.33–78.05)	19	8.66 (4.17–16.13)	34	18.48 (15.63–20.83)
	CD	116	46.39 (33.33–50)	91	34.92 (21.67–41.67)	86	25.61 (17.5–39.02)	136	52.06 (47.22–63.89)	52	22.92 (12.9–25)	66	27.55 (20.45–30.56)
	CF	97	16.86 (9.47–20.43)	354	50 (43.3–56.21)	233	34.14 (30.48–36.52)	179	47.22 (27.13–62.12)	161	34.3 (22.07–43.85)	88	21.02 (11.95–25.95)
	CI	390	34.11 (21.67–45.3)	319	27.4 (19.05–40)	399	39.14 (28.57–43.67)	305	63.69 (49–75)	98	13.33 (0–25)	102	17.67 (1.79–31.41)
	CM	203	29.75 (20–40.43)	158	23.83 (16.67–36.21)	282	38.97 (32.76–50)	275	66.67 (53.85–71.43)	70	14.84 (9.68–22.22)	94	18.33 (7.69–27.27)
	GH	156	46.67 (40.38–57.25)	75	21.33 (18.12–32.69)	86	26.92 (24.64–32)	19	80 (80–100)	2	10 (0–20)	1	0 (0–10)
	GM	329	52.13 (41.94–61.36)	93	14.81 (6.82–20)	210	31.82 (22.22–40)	528	91.18 (84.38–96.43)	22	2.94 (0–6.67)	38	3.85 (2.27–8.82)
	GN	323	33.33 (26.67–40.63)	345	37.14 (30–42.31)	289	28.21 (22.95–36.67)	488	77.61 (66.67–82.76)	79	13.79 (8.82–16.67)	78	11.54 (8.82–16.67)
	GW	104	63.64 (56–71.43)	21	12 (7.69–21.43)	46	21.43 (20–32)	135	86.21 (80–91.67)	6	3.45 (0–6.67)	13	8.33 (5–13.33)
	LR	28	19.9 (15.39–30.95)	47	38.42 (27.16–43.93)	57	41.05 (30.08–53.13)	26	61.25 (32.5–73.21)	7	18.75 (0–26.79)	9	18.75 (0–55)
	ML	2 621	60 (49.41–69.35)	587	10.64 (6.67–17.65)	1 318	28.57 (22.35–35)	2 696	90.91 (81.82–94.74)	93	2.53 (0–5.71)	269	7.14 (3.85–12.5)
	MR	1 816	45.55 (31.7–59.48)	1 098	29.79 (21.77–40.86)	912	22.51 (14.29–27.73)	3 532	90 (84.52–95.35)	190	3.54 (0–7.45)	250	4.42 (0.4–7.74)
	NE	1 164	52.67 (42.08–61.02)	386	17.22 (11.47–21.14)	718	30.42 (25.27–35.22)	1 892	88 (76.7–90.37)	122	4.81 (2.5–8.88)	256	8.37 (5.9–13.39)
	NG	1 612	35.29 (26.13–45.99)	1 646	27.27 (18.7–36.27)	2 051	37.24 (27.54–43.37)	1 575	66.67 (55.05–82.29)	417	14.5 (4.76–21.43)	536	18.42 (7.57–26.2)
	SL	441	32.5 (26.53–37.5)	525	35.71 (33.33–42.86)	464	29.75 (23.4–38.02)	430	73.53 (69.23–78.95)	109	16.67 (12–27.27)	74	10.16 (3.33–15)
	SN	1 279	57.5 (50–69.23)	384	13.33 (7.14–20.83)	711	25 (20–36)	2 927	91.67 (86.96–95.12)	76	0.61 (0–3.64)	274	6.67 (2.7–11.11)
	TD	2 015	36.51 (27.27–47.37)	1 484	24.57 (16.36–36.36)	2 065	35.83 (27.91–44.71)	4 335	85.06 (66.67–90.41)	365	4.76 (0–11.11)	710	10.97 (6.67–20.93)
	TG	236	50 (42.11–66.67)	88	18.18 (9.52–25)	152	27.27 (20–41.18)	270	83.33 (66.67–100)	31	0 (0–9.09)	62	11.11 (0–22.73)

Table A6. Median proportion of children diagnosed by WHZ2, MUAC125 and both indicators by stunting status.

		Not stunted						**Stunted**					
		WHZ < – 2 only		MUAC < 125 mm only		Both		WHZ < – 2 only		MUAC < 125 mm only		Both	
Region	Country	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)
ESAR	ET	680	45.3 (33.3–55.2)	571	35.3 (26.7–42.9)	340	18.5 (15.6–22.9)	174	18.3 (10.9–23.1)	437	45.7 (35–57.7)	290	32.7 (25–38.5)
	KE	2 197	75.7 (60.3–82)	346	10.9 (6.7–14.9)	579	15.3 (9.7–22.1)	693	46 (40–58.8)	298	17.5 (10.9–24.3)	603	33.3 (26.2–41.4)
	MG	246	51.2 (40.2–52.5)	110	21.3 (19–24.2)	154	29.8 (27.6–36.4)	161	30.7 (25.2–37.7)	160	32.2 (25.3–34.9)	190	39 (34.3–41.2)
	MW	105	72.2 (50–81.3)	20	11.1 (0–28.6)	24	12 (0–20.8)	65	33.3 (25–53.1)	62	44.9 (27.9–58.3)	35	16.7 (3.8–23.6)
	MZ	10	52.6 (52.6–52.6)	7	36.8 (36.8–36.8)	2	10.5 (10.5–10.5)	4	44.4 (44.4–44.4)	4	44.4 (44.4–44.4)	1	11.1 (11.1–11.1)
	SS	27	67.5 (67.5–67.5)	5	12.5 (12.5–12.5)	8	20 (20–20)	14	26.4 (26.4–26.4)	12	22.6 (22.6–22.6)	27	50.9 (50.9–50.9)
	UG	1 143	52.8 (43.5–62.1)	590	26.8 (17.6–32)	445	19.5 (16.1–26)	538	26.5 (20.6–39.4)	777	37.7 (32.4–43.1)	657	33.3 (26.4–37.8)
WCAR	BF	4 306	72.7 (63–82.8)	693	10 (4.3–15.6)	1 106	15.4 (10.4–24.1)	2 759	50 (40–61.1)	1 015	15.8 (10.2–22)	1 929	33.3 (25–40)
	BJ	138	63.8 (51.7–67.3)	29	12.6 (5.4–23.1)	58	26.9 (23.7–32.6)	106	44.7 (34.4–48.5)	49	16.1 (15.6–20.5)	105	39.3 (34.9–40)
	CD	129	63.3 (52.9–69.2)	47	20.6 (17.6–27.3)	32	14.2 (12.7–17.6)	117	35.3 (29.4–44.1)	93	30.6 (19.4–34.7)	116	36.5 (26.5–40)
	CF	168	39.4 (26.3–47.4)	202	39.4 (31.7–48.9)	111	19.2 (17.3–25)	108	16.3 (9.6–32.3)	313	46.9 (39–56.4)	210	33.7 (29.7–37.3)
	CI	362	53.3 (46.7–63.6)	171	20 (12.5–35.7)	161	25 (10–29.4)	334	37 (25–45)	242	22.2 (16.7–38.1)	332	37.9 (28.6–44.8)
	CM	260	65.5 (55.4–78.2)	57	10 (6.5–21.5)	99	20.8 (10–29.7)	223	32.1 (24.7–44.7)	172	24.6 (15.8–40)	272	32.8 (24–50.3)
	GH	124	51.8 (50.6–65.5)	43	21.4 (10.7–27.8)	52	23.8 (21.5–26.8)	51	41.7 (28.1–50)	34	26.6 (20.8–37.5)	35	34.4 (23.4–37.5)
	GM	583	81.5 (71.6–88.9)	49	7.9 (1.9–11.1)	91	13.2 (4.4–17.3)	273	57.7 (49.3–63.6)	66	9.1 (5.9–17.6)	155	32.4 (27.8–35.3)
	GN	556	63.7 (56.8–68.9)	198	20.9 (15.9–25.7)	133	14.8 (9.5–20)	253	32 (25.7–45.7)	222	33.3 (23.1–36.8)	228	32.6 (30–35.6)
	GW	138	85.7 (81–91.7)	8	3.3 (0–8.3)	16	8.3 (5.9–14.3)	101	61.5 (54.5–70.6)	19	10.5 (5.7–21.4)	42	22.2 (17.6–36.4)
	LR	45	50 (40–63.6)	19	18.2 (9.1–40)	22	23.6 (18.2–40)	16	10.4 (6.3–28.6)	39	43.1 (21.4–62.5)	48	48.1 (31.3–60)
	ML	3 872	80.5 (73–86.7)	310	5.6 (2.5–8.9)	683	13.6 (10.8–17.6)	1 424	53.8 (45.5–65.2)	364	11.2 (5.3–17.8)	892	31.4 (25.6–38.6)
	MR	4 132	74.8 (66.4–83.1)	746	14.2 (7.7–20.6)	587	10 (5.4–14.3)	1 208	51.9 (38–63.8)	531	23.1 (15.6–36.6)	567	20.4 (12.5–28.6)
	NE	1 683	78.7 (73.2–86)	166	9.6 (3.9–12.3)	262	11.9 (7–15.5)	1 361	58.1 (42.9–71.5)	341	14.9 (8.2–19.3)	698	26.7 (21.9–35.6)
	NG	1 811	60.6 (46.1–72.2)	795	18.5 (8.3–26.2)	804	22.2 (14.1–29.2)	1 365	33.5 (25–44.4)	1 236	27.6 (17.7–34.6)	1 742	37.2 (30.8–44.7)
	SL	587	55 (50.9–66.7)	279	25 (22.2–30)	195	16.7 (11.3–21.6)	283	28.9 (26.3–36.7)	348	36.8 (28.6–50)	339	30.6 (26.3–37)
	SN	3 113	85.1 (78.6–89.5)	245	5.3 (1.6–8.7)	433	9.8 (5.9–14)	1 091	62 (52.4–75)	215	9.9 (0–14.9)	544	27.4 (16.2–35.7)
	TD	4 463	75 (57.5–81)	726	9.9 (5.6–17.2)	1 033	16.7 (11.1–22.2)	1 873	41.5 (29–52.4)	1 110	20.4 (15.6–30.8)	1 720	35.6 (28–44)
	TG	318	77.8 (70–92.9)	51	7.7 (0–16.7)	63	13.5 (0–18.5)	186	50 (37.5–71.4)	65	14.3 (10–22.2)	151	28.9 (16.7–47.1)

Table A7. Median proportion of children diagnosed by WHZ2, MUACZ2 and both indicators by sex.

		Female						**Male**					
		WHZ < – 2 only		MUACZ < – 2 only		Both		WHZ < – 2 only		MUACZ < – 2 only		Both	
Region	Country	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)
ESAR	ET	192	12.37 (6.78–16.67)	1 076	63.33 (54.55–70.83)	405	25.81 (16.67–30.61)	243	11.84 (7.27–16.18)	1 269	58.37 (50–66.22)	647	29.25 (21.88–36.89)
	KE	797	34.94 (18.72–43.43)	851	29.15 (20.45–38.98)	985	36.77 (27.87–42.63)	981	33.81 (20.4–44.63)	865	25.33 (19–37)	1 317	38.97 (33.05–43.59)
	MG	84	10.81 (7.97–12.22)	504	59.8 (53.36–64.12)	256	31.71 (27.22–34.09)	126	11.76 (10.05–15.04)	590	57.47 (54.72–60.76)	286	29.46 (25.92–31.21)
	MW	62	18.33 (6.25–32.58)	134	62.02 (45.44–71.71)	51	19.09 (13.39–25)	65	17.14 (11.25–37.86)	132	56.33 (50–75)	51	18.3 (8.57–28.41)
	MZ	6	31.58 (31.58–31.58)	12	63.16 (63.16–63.16)	1	5.26 (5.26–5.26)	8	42.11 (42.11–42.11)	9	47.37 (47.37–47.37)	2	10.53 (10.53–10.53)
	SS	14	25.93 (25.93–25.93)	22	40.74 (40.74–40.74)	18	33.33 (33.33–33.33)	15	24.59 (24.59–24.59)	15	24.59 (24.59–24.59)	31	50.82 (50.82–50.82)
	UG	560	23.25 (13.73–31.58)	1 373	52.91 (43.55–60.98)	624	24.85 (20.88–27.45)	684	18.64 (14.08–31.13)	1 570	49.58 (40.38–55.46)	933	27.19 (24.66–33.9)
MENA	YE	797	25.34 (14.29–35.23)	1 480	45.25 (29.17–59.65)	1 033	27.71 (22.22–39.71)	1 150	25.21 (18.18–36.25)	1 591	36.49 (26.09–49.24)	1 491	32.06 (25.49–40.82)
WCAR	BF	2 412	37.7 (28.13–47.22)	2 446	35.48 (27.27–45.24)	1 773	25.81 (19.23–31.82)	3 293	38.6 (30–47.37)	2 945	32 (23.08–39.29)	2 636	28.07 (23.81–33.96)
	BJ	79	29.76 (21.43–33.33)	103	35.9 (33.33–41.46)	91	31.33 (28.85–39.39)	117	35.24 (29.85–42.86)	95	27.27 (20–34.48)	121	38.55 (30.95–41.79)
	CD	73	16 (14.81–28.57)	210	57.29 (51.43–68.89)	73	19.12 (16.67–20.93)	118	18.99 (17.8–28.07)	282	53.22 (40–61.26)	140	22.34 (17.54–28.77)
	CF	85	12.31 (6.84–24.7)	478	65.06 (53.68–72.67)	158	20.61 (18.51–25.43)	125	16.73 (7.55–26.04)	559	57.47 (47.92–67.61)	229	25.83 (23.86–27.04)
	CI	241	28.13 (22.86–33.33)	412	44.83 (33.33–58.33)	232	30.77 (16.67–37.5)	338	27.78 (20.97–35)	481	33.33 (27.27–54.35)	393	34.04 (25–41.18)
	CM	166	23.08 (14.29–36.84)	263	40 (30–53.85)	208	30 (23.08–38.46)	188	20.83 (18.18–36.36)	319	40.91 (27.27–48.89)	293	36.36 (26.92–44.19)
	GH	70	40 (34.09–48.05)	55	33.33 (29.87–38.64)	41	26.67 (22.08–27.27)	98	45.83 (40.85–55.95)	52	25 (19.05–33.8)	53	25.35 (25–29.17)
	GM	273	42.25 (35.48–57.58)	140	21.74 (13.73–29.03)	208	34.78 (24.24–38.46)	371	46 (38.71–62.86)	140	19.54 (7.32–23.26)	253	32 (25–37.78)
	GN	296	31.43 (21.43–42.62)	333	40 (32.14–50)	188	21.26 (18.18–29.51)	399	35.14 (26.15–51.28)	315	34.78 (24.39–42.5)	295	28.3 (24.07–30.77)
	GW	78	46.15 (40–50)	43	22.58 (15.38–37.5)	49	28.57 (24–37.5)	112	47.62 (46.43–55)	37	17.65 (14.58–28.57)	59	30 (23.81–33.33)
	LR	26	25 (16.67–33.33)	43	41.67 (33.33–55)	30	25 (20–42.86)	27	18.18 (9.52–35)	58	35 (20–53.85)	45	38.46 (23.81–41.18)
	ML	2 014	53.7 (43.9–62.22)	858	19.83 (13.24–29.58)	986	26.09 (19.05–30.61)	2 570	54.55 (44.59–65.22)	955	17.86 (12.2–26.09)	1 334	27.27 (20–32.18)
	MR	1 832	44.68 (34.98–57.74)	1 242	30.19 (18.94–41.04)	955	22.61 (14.43–29.71)	2 265	39.8 (30.4–55.31)	1 544	31.41 (22.13–41.08)	1 458	24.76 (18.9–33.21)
	NE	661	34.61 (27.59–47.4)	830	39.27 (30.5–46.67)	576	23.85 (17.16–30.54)	1 459	43.16 (33.4–53.97)	763	21.71 (13.78–27.11)	1 334	35.1 (29.42–41.19)
	NG	969	25.67 (16.99–37.6)	1 992	45.76 (37.72–52.51)	1 269	28.8 (19.31–34.16)	1 595	29.75 (22.98–39.57)	2 353	38.28 (29.06–45.77)	1 941	30.64 (25–37.54)
	SL	340	28.06 (23.33–38.24)	482	47.09 (36.36–54.55)	269	23.32 (15.79–30)	423	31.25 (26.09–37.25)	566	48.54 (36.47–53.85)	377	23.53 (20.63–29.03)
	SN	1 261	45.73 (36.84–56.25)	720	23.15 (14.81–31.03)	897	29.23 (21.74–38.46)	1 717	45.83 (38.89–54.1)	798	18.3 (13.16–25)	1 316	33.67 (26.67–39.44)
	TD	2 084	36.59 (25.71–45.83)	1 963	31.21 (23.26–41.86)	1 943	31.41 (25.58–37.93)	2 512	35.83 (21.05–46.51)	2 329	29.07 (20.29–38.6)	2 586	34.84 (27.14–40.37)
	TG	166	39.13 (25–52.94)	194	39.13 (22.22–43.75)	132	23.53 (10–33.33)	244	40 (28.99–70)	205	30 (9.52–38.24)	178	28.57 (14.29–35.29)

Table A8. Median proportion of children diagnosed by WHZ2, MUACZ2 and both indicators by age category.

		Age 6–23 months						**Age 24–59 months**					
		WHZ < – 2 only		MUACZ < – 2 only		Both		WHZ < – 2 only		MUACZ < – 2 only		Both	
Region	Country	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)
ESAR	ET	176	11.22 (8–18.75)	661	53.1 (38.3–58.62)	417	34.29 (27.78–40.43)	259	9.86 (5.77–15.38)	1 684	65.91 (54.1–74.63)	635	23.96 (17.78–30.77)
	KE	720	40.6 (30.31–49.82)	407	23.36 (14.52–29.78)	708	36.37 (31.08–41.42)	1 058	29.63 (17.29–40.25)	1 309	29.09 (23.85–41.13)	1 594	37.51 (28.95–44.53)
	MG	130	26.49 (22.55–28.25)	159	29.81 (27.62–34.04)	231	43.17 (40.37–47.68)	80	4.69 (3.46–8.81)	935	70.29 (66.49–72.1)	311	24.87 (19.17–27.5)
	MW	56	36.67 (16.25–61.25)	40	38.75 (25–60)	29	22.5 (6.25–30.95)	71	17.65 (7.7–25.83)	226	64.4 (52–78.24)	73	17.65 (11.25–22.23)
	MZ	8	57.14 (57.14–57.14)	5	35.71 (35.71–35.71)	1	7.14 (7.14–7.14)	6	25 (25–25)	16	66.67 (66.67–66.67)	2	8.33 (8.33–8.33)
	SS	17	32.08 (32.08–32.08)	10	18.87 (18.87–18.87)	26	49.06 (49.06–49.06)	12	19.35 (19.35–19.35)	27	43.55 (43.55–43.55)	23	37.1 (37.1–37.1)
	UG	807	33.62 (21.92–42.27)	845	34.55 (25.64–38.67)	789	33 (26.92–37.5)	437	11.74 (7.29–18.58)	2 098	66.48 (55.81–70.45)	768	23.34 (19.79–25.4)
MENA	YE	802	27.52 (20–40)	983	30.95 (20–46.15)	1 063	34.89 (27.5–41.46)	1 145	24.67 (14.55–34.78)	2 088	44.88 (29.31–58.59)	1 461	29.01 (24–36.96)
WCAR	BF	3 774	52.78 (45.45–61.76)	1 127	13.7 (8.16–20)	2 420	32 (25–37.8)	1 931	23.53 (15.58–35)	4 264	51.35 (40–59.57)	1 989	24.19 (17.44–30.43)
	BJ	124	40.89 (38.89–48.08)	47	15.86 (9.21–22.22)	121	37.71 (35.85–51.32)	72	23.03 (17.19–32.2)	151	45.92 (36.11–59.38)	91	28.62 (26.32–32.2)
	CD	114	41.76 (35.48–50.88)	85	32.36 (22.92–37.21)	88	27.08 (20.93–35.42)	77	11.74 (8.04–18.29)	407	61.08 (59.09–77.78)	125	18.21 (10.71–27.06)
	CF	102	16.23 (11.98–25.61)	316	48.68 (38.87–54.42)	228	35.09 (32.04–38.79)	108	11.08 (6.86–22.26)	721	69.71 (56.75–78.61)	159	16.71 (12.19–20.97)
	CI	410	34.55 (26.32–50)	286	25 (15.38–37.5)	380	37.5 (27.78–41.67)	169	14.29 (9.09–25)	607	54.55 (46.15–64.29)	245	28.57 (18.92–33.33)
	CM	209	33.33 (20.83–48.89)	136	16.67 (11.11–35.9)	277	40 (30–64.29)	145	16.67 (8.7–25.81)	446	54.17 (44–64.81)	224	27.27 (16–32.26)
	GH	157	48.65 (41.58–59.4)	66	20.27 (15.04–30.69)	85	27.72 (25.56–31.08)	11	17.86 (5.56–33.33)	41	67.86 (53.33–77.78)	9	14.29 (13.33–16.67)
	GM	333	53.26 (45.59–65.91)	76	11.54 (6.67–16.28)	206	30.77 (25–41.3)	311	34.38 (28.81–56.25)	204	28.41 (17.65–35.71)	255	32 (28.13–38.98)
	GN	340	38.89 (30.36–50)	249	28.57 (25–32.31)	272	29.63 (26.47–34)	355	33.33 (20.59–44.44)	399	43.04 (27.78–60.78)	211	21.67 (17.14–23.53)
	GW	102	62.5 (57.14–70)	12	6.25 (0–8.33)	48	28.21 (20–34.78)	88	37.5 (33.33–43.59)	68	31.25 (28.21–40.63)	60	28.21 (25–32.43)
	LR	37	28.57 (17.39–38.46)	43	25 (20–38.46)	56	33.33 (30–53.33)	16	16.67 (8.33–23.53)	58	58.33 (53.33–72.22)	19	20 (12.5–25)
	ML	2 704	63.46 (53.23–71.79)	506	9.09 (5–14.29)	1 235	26.79 (20–34.57)	1 880	45.45 (32.35–58.14)	1 307	27.63 (19.23–39.47)	1 085	24.59 (17.78–31.17)
	MR	1 811	50 (38.19–67.16)	834	26.43 (15.21–35.15)	917	22.22 (16.67–31.3)	2 286	38.79 (29.06–51.76)	1 952	31.7 (24.74–45.81)	1 496	24.57 (17.83–29.82)
	NE	1 070	50 (42.31–57.01)	341	15.39 (11.66–18.14)	812	33.91 (28.75–39.67)	1 050	34.52 (24.16–44.79)	1 252	36.06 (28.44–42.46)	1 098	31.78 (22.5–35.3)
	NG	1 662	37.03 (28.08–46.67)	1 407	24.39 (17.19–32.74)	2 001	38.89 (29.97–43.93)	902	20.71 (13.07–32.43)	2 938	54.1 (44.44–65.04)	1 209	22.69 (16.06–27.02)
	SL	447	33.33 (28.95–42.11)	419	31.82 (27.01–42.11)	458	33.33 (27.08–37.88)	316	25.2 (22.58–30.77)	629	58 (54.84–66.67)	188	13.64 (9.52–17.89)
	SN	1 273	60.3 (45–72.22)	309	11.11 (7.14–16.67)	717	28.76 (19.51–37.21)	1 705	40.41 (32.56–50.85)	1 209	23.95 (20–31.91)	1 496	34.08 (26.32–39.29)
	TD	2 074	40 (30–50)	1 234	21.5 (13.89–32.43)	2 006	37.81 (27.78–44.83)	2 522	33.49 (18.18–44.3)	3 058	33.64 (25.37–49.12)	2 523	29.73 (21.28–36.84)
	TG	238	56.41 (45.45–75)	67	14.29 (5–21.74)	150	28.57 (14.29–42.5)	172	30 (15.66–63.64)	332	48.48 (28.57–57.14)	160	24.64 (7.14–30.95)

Table A9. Median proportion of children diagnosed by WHZ2, MUACZ2 and both indicators by stunting status.

		Not stunted						**Stunted**					
		WHZ < – 2 only		MUACZ < – 2 only		Both		WHZ < – 2 only		MUACZ < – 2 only		Both	
Region	Country	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)
ESAR	ET	353	15.3 (11.5–21.2)	1 355	56.4 (46.3–63.7)	667	28.6 (21.7–32.3)	81	5.2 (0.6–7.1)	981	66.7 (55.8–75.6)	383	25.7 (19.3–34.8)
	KE	1 426	43.9 (25.2–52.6)	899	21.7 (15.4–32.1)	1 350	35.1 (26.3–39.6)	348	17.8 (12.4–23.1)	810	38.3 (30.9–49.3)	948	43.4 (35.1–50)
	MG	152	19.3 (13.5–21.2)	457	51.1 (48–59.3)	248	29.7 (24.1–35.8)	58	5.9 (4.7–7.6)	637	62.1 (60.4–66.2)	293	30.3 (29.4–33.7)
	MW	89	36.7 (20–55)	72	40 (25–61.5)	40	18.2 (10–23.3)	38	11.5 (7.2–16.2)	194	69.5 (63.1–79.5)	62	17 (11–25.8)
	MZ	10	45.5 (45.5–45.5)	10	45.5 (45.5–45.5)	2	9.1 (9.1–9.1)	4	25 (25–25)	11	68.8 (68.8–68.8)	1	6.3 (6.3–6.3)
	SS	22	48.9 (48.9–48.9)	10	22.2 (22.2–22.2)	13	28.9 (28.9–28.9)	7	10.6 (10.6–10.6)	25	37.9 (37.9–37.9)	34	51.5 (51.5–51.5)
	UG	909	31.7 (21.4–42.9)	1 284	46 (32.1–52.7)	679	23.6 (20–26.7)	327	11.3 (8–19.2)	1 647	58.3 (52.6–62.5)	868	29.3 (26.2–35.1)
WCAR	BF	3 831	54.2 (45.1–63.9)	1 849	24.1 (16.7–31.7)	1 581	20.5 (14.9–26.9)	1 869	23.4 (17–31.6)	3 519	41.7 (33.3–50)	2 819	33.3 (27.5–39.7)
	BJ	125	44.9 (39.4–50)	72	29.9 (24.1–33.3)	71	26.6 (25–30)	71	22.3 (19.2–24.3)	125	37 (26.5–44.4)	140	41.5 (33.3–50)
	CD	118	40.6 (35.3–56.7)	101	41.4 (26.8–51.4)	43	13.5 (10.4–17.6)	69	10.6 (9.2–11.7)	384	64.3 (48.7–70.8)	164	26.7 (20–32.1)
	CF	143	28.8 (14.7–35.9)	342	49.1 (41.1–64.2)	136	21.6 (18.1–25.7)	67	8.2 (3–13.5)	695	65.5 (58.7–72.2)	251	25.6 (23–27.6)
	CI	337	41.7 (33.3–53.3)	292	32.4 (15–40)	186	24 (17.4–33.3)	239	18.8 (11.8–28.3)	590	43.3 (36.8–58.8)	427	37.9 (28.6–42.9)
	CM	215	46.6 (28.6–62.1)	130	27.7 (17.8–34.2)	144	26.5 (22–34)	144	12.5 (9.4–22.2)	442	49.5 (37.6–56.7)	351	35.1 (24.4–40)
	GH	126	54.4 (50.6–64)	46	22.8 (12.8–27.8)	50	22.8 (21.5–23.3)	42	18.9 (17.1–38.7)	61	45.7 (37.3–45.9)	44	35.1 (24–37.1)
	GM	468	58.4 (49.1–70.6)	98	14.3 (4.2–18.9)	206	30.2 (20.8–34.1)	176	30 (22.8–40.9)	181	30.5 (20–33)	252	40.4 (37.5–43.2)
	GN	506	58 (46.2–62.5)	234	23.5 (20–28.6)	183	19 (16.7–22.2)	188	22.2 (12.5–24.1)	406	42.9 (37.9–56.3)	293	31.7 (30.2–40)
	GW	119	71.4 (63.2–74.2)	25	17.1 (7.7–18.2)	35	17.4 (15.8–20)	71	35 (29.6–44.4)	55	25 (21.4–37)	72	33.3 (29.6–40)
	LR	42	47.7 (28.6–61.5)	24	21.6 (15.4–28.6)	25	26.8 (18.2–36.4)	13	5.4 (0–15.8)	80	53.6 (40–62.5)	51	36.4 (28.6–50)
	ML	3 528	70 (57.5–77.8)	770	11.8 (7.1–18.8)	1 027	17.6 (14.9–22.7)	1 044	32.7 (22.8–41.2)	1 026	27.7 (20.6–37.5)	1 272	38.6 (31.3–42.2)
	MR	3 300	52.8 (40.6–64.4)	1 495	24 (18.3–32)	1 419	20.3 (14.6–27.6)	789	25 (16.7–34.3)	1 273	42.3 (32.2–60)	986	28.9 (20–36.8)
	NE	1 308	54.4 (48.4–65.5)	498	19.8 (15.3–26.3)	637	20.4 (17.1–30.4)	809	28.6 (21.5–35.4)	1 080	31.4 (27.6–39.2)	1 250	39.5 (33.6–45.1)
	NG	1 659	49.1 (35–59.7)	1 345	28.6 (20–39)	956	23.4 (17.2–28.4)	899	17 (10.6–23.7)	2 946	48.7 (38.4–56.2)	2 208	35 (29.2–40)
	SL	556	45.8 (42.9–50)	389	37.5 (31.6–41.7)	226	17.6 (12.5–21.1)	206	15 (11.9–18.5)	648	52 (43.9–66.7)	416	33.3 (20–36.2)
	SN	2 342	55.3 (46.3–65.5)	780	17.6 (12.2–22.2)	1 204	28 (19.1–32.1)	633	27 (20–38.1)	734	27.7 (20–36.4)	1 002	42.3 (33.3–50)
	TD	3 394	46.2 (34–56.9)	1 873	23.6 (15–34)	2 102	27.2 (20–34.4)	1 193	21.5 (13.3–30.6)	2 395	38.1 (29.9–46.9)	2 400	39.5 (33.3–45.8)
	TG	290	60 (48.4–81.3)	123	23.1 (10.7–33.3)	91	15 (7.7–27.4)	119	28.6 (13.6–40)	274	42.9 (25–51.1)	218	32.3 (20–42.3)

Table A10. Median proportion of children diagnosed by MUACZ2, MUAC125 and both indicators by sex.

		Female						**Male**					
		MUAC < 125 mm only		MUACZ < – 2 only		Both		MUAC < 125 mm only		MUACZ < – 2 only		Both	
Region	Country	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)
ESAR	ET	235	11.36 (9.52–16.67)	817	47.29 (40.32–54.72)	664	36.24 (31.82–45)	25	0.99 (0–1.92)	1 197	63 (56.86–71.93)	719	34.09 (28.07–42.27)
	KE	246	11.81 (9.16–16.67)	1 036	51.95 (43.97–58.84)	800	34.94 (27.14–41.88)	17	0 (0–1.12)	1 412	67.23 (63.38–73.7)	770	31.48 (26.2–36.21)
	MG	84	10.81 (6.99–12.08)	494	60.67 (54.61–63.34)	266	30.2 (28.62–35.54)	7	0.89 (0.29–1.47)	619	70.38 (67.99–73)	257	27.99 (25.97–31.41)
	MW	29	11.11 (8.33–14.29)	117	54.55 (48.48–68.18)	64	33.33 (22.73–37.5)	1	0 (0–0)	135	75 (64.29–83.33)	45	22.22 (16.67–35.71)
	MZ	1	7.14 (7.14–7.14)	6	42.86 (42.86–42.86)	7	50 (50–50)	0	0 (0–0)	5	45.45 (45.45–45.45)	6	54.55 (54.55–54.55)
	SS	3	6.98 (6.98–6.98)	16	37.21 (37.21–37.21)	24	55.81 (55.81–55.81)	1	2.13 (2.13–2.13)	19	40.43 (40.43–40.43)	27	57.45 (57.45–57.45)
	UG	303	13.74 (9.38–19.74)	920	38.79 (31.65–48.48)	1 077	45.24 (41.94–51.02)	20	0 (0–1.45)	1 422	57.58 (50.48–62.79)	1 081	42.42 (36.3–48.88)
MENA	YE	445	14.25 (11.11–19.23)	1 333	45.38 (39.13–53.7)	1 180	39.01 (31.25–44.83)	35	0 (0–2.13)	1 992	66.04 (59.21–73.21)	1 090	33.83 (25.93–39.53)
WCAR	BF	872	17.45 (11.76–23.81)	2 323	46.29 (37.5–54.55)	1 890	35.5 (27.59–44.12)	55	0 (0–0)	3 628	65.67 (57.89–73.91)	1 942	33.33 (25–40.54)
	BJ	43	19.62 (13.79–21.43)	100	43.06 (40–45.24)	94	35.99 (33.33–44.83)	3	1.04 (0–2.22)	113	47.92 (44–58.62)	103	51 (41.38–52.08)
	CD	37	12.25 (9.8–20)	175	42 (37.5–74.51)	108	38.31 (15.69–50)	2	0 (0–1.02)	274	65.15 (61.02–75.61)	148	33.85 (24.39–38.98)
	CF	99	12.31 (10.17–21.32)	286	39.78 (36.24–42.02)	350	49.12 (40.9–50.8)	6	0 (0–1.23)	407	52.41 (42.63–55.93)	381	46.98 (44.07–56.47)
	CI	133	18.52 (10.34–22.22)	279	33.33 (27.27–40.74)	361	44.83 (39.13–57.14)	17	0 (0–3.45)	462	50 (43.75–60)	404	50 (38.1–54.55)
	CM	77	13.39 (6.25–20)	215	42.86 (30.43–46.15)	254	44.51 (36.84–54.55)	3	0 (0–0)	339	58.57 (42.86–69.05)	268	41.13 (30.95–53.85)
	GH	40	30.77 (25.64–31.03)	33	25.86 (15.38–30.77)	63	43.59 (43.1–53.85)	4	3.7 (0–6.67)	48	48.15 (35.56–51.35)	57	48.65 (48.15–57.78)
	GM	77	20.83 (13.33–22.22)	207	50 (45.45–56.67)	141	30 (24.24–37.5)	6	0 (0–6.25)	254	61.54 (56.86–73.68)	139	35.71 (26.32–42.86)
	GN	148	20.93 (15–25)	213	29.09 (23.53–40.74)	308	48.72 (39.02–58.14)	21	2.5 (0–5.26)	296	46.15 (42–56.25)	314	50.64 (40–56.1)
	GW	17	14.29 (5.88–20)	49	42.86 (33.33–57.14)	43	40 (33.33–42.86)	0	0 (0–0)	70	72.73 (66.67–80)	26	27.27 (20–33.33)
	LR	19	19.44 (13.03–33.33)	24	19.44 (12.7–34.31)	46	55.05 (43.14–61.11)	1	0 (0–0)	46	50 (36.16–55.49)	54	50 (44.13–63.84)
	ML	430	19.14 (14.43–25.36)	942	38.8 (33.33–49.14)	902	38.95 (33.33–46.82)	26	0 (0–1.68)	1 378	60 (54.06–65.77)	908	38.59 (33.33–45.37)
	MR	549	20.64 (15.19–26.67)	1 317	47.11 (38.89–55.56)	876	29.41 (21.74–38.89)	49	0 (0–2.63)	2 026	67.86 (60–74.19)	967	30.84 (24–39.13)
	NE	175	11.48 (7.84–15.91)	866	56.53 (46.69–64.5)	540	32.84 (24.96–40.39)	15	0 (0–0.87)	1 345	65.02 (57.35–68.89)	752	34.97 (29.95–42.46)
	NG	694	17.39 (13.33–23.81)	1 429	37.88 (32.08–43.24)	1 831	43.94 (36.36–51.28)	75	0 (0–2.22)	2 243	51.61 (43.75–61.82)	2 044	46.3 (37.8–53.26)
	SL	207	20 (14.29–22.55)	295	30.23 (26.47–37.5)	456	44.44 (42.5–54.29)	22	1.32 (0–2.66)	456	50 (44–58.62)	487	46.57 (37.93–52.17)
	SN	266	13.79 (8.33–19.7)	1 031	57.89 (47.76–66.67)	572	28.57 (21.05–35.71)	19	0 (0–0)	1 511	72.73 (66.67–82.35)	580	26.19 (16.67–33.33)
	TD	715	16.02 (12.2–20)	1 949	40.9 (33.33–50)	1 957	41.99 (33.33–50)	77	0 (0–2.67)	3 040	60.71 (54.76–67.35)	1 875	36.8 (30.43–43.48)
	TG	60	15.76 (10–28.57)	179	44.12 (37.5–56.76)	136	33.33 (23.08–41.07)	2	0 (0–0)	248	66.67 (57.14–75)	129	33.33 (22.22–41.67)

Table A11. Median proportion of children diagnosed by MUACZ2, MUAC125 and both indicators by age category.

		Age 6–23 months						**Age 24–59 months**					
		MUAC < 125 mm only		MUACZ < – 2 only		Both		MUAC < 125 only		MUACZ < – 2 only		Both	
Region	Country	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)
ESAR	ET	260	16.95 (13.64–28.81)	155	11.38 (8.93–13.33)	923	73.33 (57.14–75)	0	0 (0–0)	1 859	83.42 (77.55–87.5)	460	16.58 (12.5–22.45)
	KE	263	20 (16.76–25.82)	168	12.5 (8.34–15.89)	947	67.3 (59.98–73.18)	0	0 (0–0)	2 280	84.56 (75.61–89.13)	623	15.44 (10.87–24.39)
	MG	91	19.37 (15.27–23.17)	62	12.84 (10.46–14.5)	328	65.69 (62.33–72.61)	0	0 (0–0)	1 051	83.92 (81.73–87.27)	195	16.08 (12.73–18.27)
	MW	30	25 (16.67–33.33)	9	0 (0–14.29)	59	66.67 (42.86–75)	0	0 (0–0)	243	81.82 (73.68–94.12)	50	18.18 (5.88–26.32)
	MZ	1	14.29 (14.29–14.29)	0	0 (0–0)	6	85.71 (85.71–85.71)	0	0 (0–0)	11	61.11 (61.11–61.11)	7	38.89 (38.89–38.89)
	SS	4	10 (10–10)	2	5 (5–5)	34	85 (85–85)	0	0 (0–0)	33	66 (66–66)	17	34 (34–34)
	UG	323	17.26 (12.7–23.08)	238	12.68 (8.6–14.81)	1 396	69.83 (65.48–75)	0	0 (0–0)	2 104	74.98 (70.65–79.31)	762	25.02 (20.69–29.35)
MENA	YE	480	19.35 (15.38–25)	333	13.34 (10–17.14)	1 713	66.67 (60.53–73.08)	0	0 (0–0)	2 992	84.58 (82.5–87.5)	557	15.42 (12.5–17.5)
WCAR	BF	927	20 (14.29–28.57)	694	15.19 (9.09–21.43)	2 847	64.61 (54.55–70.73)	0	0 (0–0)	5 257	85.28 (80–90)	985	14.72 (10–20)
	BJ	46	22.79 (18.52–28.57)	24	10.4 (7.41–11.76)	144	68.67 (58.82–74.07)	0	0 (0–0)	189	77.64 (75.56–81.13)	53	22.36 (18.87–24.44)
	CD	39	16.67 (15.94–22.22)	35	15.28 (8.33–31.03)	138	64.7 (50–75)	0	0 (0–0)	414	75.63 (66.67–87.38)	118	24.37 (12.62–33.33)
	CF	105	16.11 (12.77–21.52)	62	8.05 (7.16–12.11)	482	74.76 (65.95–77.66)	0	0 (0–0)	631	73.7 (67.81–78.14)	249	26.3 (21.86–32.19)
	CI	150	17.86 (12.5–22.22)	100	11.11 (7.14–17.65)	565	71.43 (65–77.5)	0	0 (0–0)	641	76.47 (68.97–82.5)	200	23.53 (17.5–31.03)
	CM	80	16.03 (7.69–25.81)	52	8.66 (0–15.63)	359	72.5 (64.52–83.33)	0	0 (0–0)	502	75 (70.59–81.82)	163	25 (18.18–29.41)
	GH	44	22.45 (20.27–25)	34	18.06 (16.22–18.37)	117	59.18 (56.94–63.51)	0	0 (0–0)	47	94.12 (91.3–100)	3	5.88 (0–8.7)
	GM	83	23.53 (16.67–28)	62	12.5 (11.11–22.22)	220	60 (56.25–64.71)	0	0 (0–0)	399	88 (83.33–94.74)	60	12 (5.26–16.67)
	GN	169	23.81 (20–28.21)	56	6.67 (3.57–11.76)	465	66.67 (64.04–71.43)	0	0 (0–0)	453	76.67 (68.42–80)	157	23.33 (20–31.58)
	GW	17	22.22 (6.67–25)	10	0 (0–21.43)	50	71.43 (66.67–75)	0	0 (0–0)	109	83.33 (81.82–88.89)	19	16.67 (11.11–18.18)
	LR	20	16.8 (8.93–26.97)	11	8.12 (0–16.23)	84	73.51 (67.53–75.96)	0	0 (0–0)	59	73.86 (63.33–87.08)	16	26.14 (12.92–36.67)
	ML	456	20 (14.96–27.05)	293	12.82 (9.23–17.32)	1 448	65.62 (58.43–72.32)	0	0 (0–0)	2 027	85.58 (81.82–90.8)	362	14.42 (9.2–18.18)
	MR	598	25.36 (21.43–33.33)	340	13.56 (8.33–21.43)	1 404	59.52 (50–66.67)	0	0 (0–0)	3 003	88.76 (83.33–94.74)	439	11.24 (5.26–16.67)
	NE	190	13.97 (10.57–22.06)	239	16.87 (13.51–22.47)	914	66.26 (58.11–73.12)	0	0 (0–0)	1 972	84.86 (82.51–88.16)	378	15.14 (11.84–17.49)
	NG	769	17.95 (14.19–23.81)	480	12 (7.84–17.65)	2 922	68.75 (62.34–75)	0	0 (0–0)	3 192	78.46 (72.73–84.62)	953	21.54 (15.38–27.27)
	SL	229	18.18 (15.38–23.42)	117	11.02 (8.33–17.95)	760	69.23 (63.64–73.53)	0	0 (0–0)	634	78.57 (73.3–87.5)	183	21.43 (12.5–26.7)
	SN	285	22.22 (13.79–30)	217	15.38 (7.69–25)	803	61.54 (50–72.41)	0	0 (0–0)	2 325	88.89 (83.33–92.86)	349	11.11 (7.14–16.67)
	TD	792	19.56 (15.22–25.64)	483	11.83 (8.89–15)	2 757	67.64 (61.29–73.33)	0	0 (0–0)	4 506	81.92 (74.29–88.75)	1 075	18.08 (11.25–25.71)
	TG	62	21.36 (14.81–40)	41	14.84 (8–20)	173	60 (45.45–72)	0	0 (0–0)	386	82.53 (77.78–90.91)	92	17.47 (9.09–22.22)

Table A12. Median proportion of children diagnosed by MUACZ2, MUAC125 and both indicators by stunting status.

		Not stunted						**Stunted**					
		MUAC < 125 mm only		MUACZ < – 2 only		Both		MUAC < 125 mm only		MUACZ < – 2 only		Both	
Region	Country	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)	N	% (IQR)
ESAR	ET	207	7.8 (6.1–14.6)	1 318	59.7 (51.9–63.9)	704	29.3 (24.3–35.3)	53	1.7 (0–8)	690	46.9 (36.9–53.7)	674	48.4 (39.4–61.5)
	KE	199	8.1 (5.3–11.7)	1 523	66 (55.5–72.3)	726	25.8 (17.9–33.3)	64	3.2 (0–4.9)	921	55.8 (46.1–62.6)	837	42 (32.5–50)
	MG	64	8.1 (6.1–11.1)	505	65.2 (62.7–67.7)	200	26.2 (21.5–30.4)	27	2.8 (2.1–3.8)	607	63.4 (58.4–68.3)	323	33 (28.6–38.7)
	MW	18	10 (0–24)	86	72.7 (56–75)	26	18.2 (0–27.3)	13	4.7 (0–9.8)	172	63.4 (53.9–71.2)	84	28.2 (19.7–43.4)
	MZ	1	7.7 (7.7–7.7)	4	30.8 (30.8–30.8)	8	61.5 (61.5–61.5)	0	0 (0–0)	7	58.3 (58.3–58.3)	5	41.7 (41.7–41.7)
	SS	3	11.5 (11.5–11.5)	13	50 (50–50)	10	38.5 (38.5–38.5)	1	1.7 (1.7–1.7)	21	35 (35–35)	38	63.3 (63.3–63.3)
	UG	209	10.8 (7–14.3)	1 137	53.3 (46.3–60)	826	36.8 (31.4–42.5)	114	4.7 (2.5–7)	1 195	45.9 (41.1–51.1)	1 320	49 (44.4–54.5)
WCAR	BF	598	14.8 (7.7–20.5)	2 229	57.1 (46.9–66.7)	1 201	26.9 (18.8–36.7)	330	4.2 (0–7.5)	3 724	55.9 (50–65.7)	2 614	39 (29.5–45.2)
	BJ	28	16.3 (12.9–18.8)	84	47.4 (41.7–48.4)	59	36 (34.4–38.7)	18	6.6 (4.5–7.5)	129	45.6 (43.3–53.3)	136	46.4 (40–53.3)
	CD	26	16 (12.2–17.1)	91	48.4 (34.6–65.9)	53	29.4 (22–50)	13	2.1 (0–4.9)	352	59.7 (53.2–79.3)	196	37.1 (20.7–42.6)
	CF	66	13.6 (8.8–14.5)	231	40 (35.7–48.1)	247	44.6 (38.3–52.7)	39	4.1 (2.8–8.5)	462	47.2 (42.4–52.8)	484	50.8 (41–55)
	CI	103	19 (12–23.5)	249	38.1 (27.3–55.2)	229	40 (32–50)	50	3.8 (0–7.7)	493	47.7 (38.7–56.6)	524	48.6 (39.6–55.6)
	CM	45	12.7 (0–20)	163	55.5 (40–67.4)	111	26.4 (13.3–44.5)	37	3.4 (0–7.7)	386	46.9 (39.6–53.1)	407	46.9 (43.1–52.7)
	GH	36	27.8 (25–29.5)	37	25 (25–34.1)	59	47.2 (36.4–50)	8	6.3 (3.3–9.8)	44	37.3 (28.1–53.3)	61	52.9 (43.3–65.6)
	GM	56	15.9 (8.8–21.4)	220	61.1 (50–71)	84	20.8 (11.1–29.5)	27	5 (0–7.3)	239	50 (46.9–59.3)	194	43.8 (40–50)
	GN	108	19.2 (14.3–28.6)	194	37.5 (31.8–46.2)	223	42.9 (35.7–45)	61	6.5 (3.8–11.1)	310	42.9 (35.8–45.7)	389	52.8 (44.4–59.1)
	GW	6	0 (0–12.5)	42	63.6 (60–76.9)	18	25 (20–33.3)	11	7.1 (0–12.5)	77	54.5 (50–60.9)	50	38.5 (31.8–40)
	LR	14	25 (14.3–33.3)	22	36.7 (11.1–50)	27	38.1 (33.3–50)	10	5.9 (3.7–20)	54	40.6 (15.4–44.4)	77	52.9 (42.1–64.7)
	ML	316	14.3 (9.1–22.7)	1 120	51 (43.7–61.9)	677	32.4 (25–38.5)	141	4.5 (2–8)	1 183	50 (41.7–56.5)	1 115	44.6 (37.2–53.2)
	MR	436	13.8 (10–18.2)	2 017	60.3 (51.2–67.9)	897	25 (19.2–33.1)	164	6.2 (2.1–10.3)	1 325	56.3 (45.7–64.8)	934	37.2 (28.2–46.5)
	NE	115	9.1 (5.7–13.9)	822	63.6 (56–73.8)	313	25.2 (19.6–32.5)	75	2.4 (0.6–6.6)	1 366	55.2 (45.8–64.2)	964	38.9 (33.3–48.4)
	NG	503	17.3 (11.4–23.8)	1 205	44.4 (36.4–57.1)	1 096	35.1 (27–45.2)	265	4.2 (2–7.1)	2 441	45.5 (38.9–51.9)	2 713	50 (42.7–55.3)
	SL	149	18.2 (13.2–22.6)	290	42.9 (33.8–46.7)	325	41.2 (31.3–43)	77	5.7 (2.9–7.1)	454	44.9 (36.8–45.7)	610	51.6 (47.4–56.1)
	SN	212	7.4 (2.8–13)	1 518	70.9 (62.5–80)	466	20 (13–25)	75	2.2 (0–6.3)	1 052	59.4 (51.4–66.7)	684	35.6 (28.6–42.9)
	TD	491	10.8 (8–15.4)	2 707	60.2 (52.9–67.6)	1 268	27.3 (20.8–34)	300	5.6 (3.1–8.8)	2 265	44.4 (37–51.1)	2 530	49.4 (43.5–55.7)
	TG	39	9.5 (0–22.2)	139	60 (42.9–80)	75	21.3 (0–42.9)	24	3.9 (1.2–12.5)	300	56.3 (50–67.6)	192	33.3 (25.5–45.8)

Table A13. National and subnational GAM prevalence in the WCAR by country.

	WHZ2			**MUACZ2**			**MUAC125**		
	Mean	95 % confidence intervals		Mean	95 % confidence intervals		Mean	95 % confidence intervals	
BF 2012	10.7	9.9	11.5	9.8	9.0	10.6	4.6	4.2	5.1
CF 2014	6.2	5.6	6.8	13.9	12.9	14.9	8.0	7.3	8.7
CI 2011	5.1	4.5	5.7	5.3	4.6	6.0	3.1	2.6	3.6
GM 2015	10.9	9.8	12.1	8.8	7.7	9.9	4.6	3.7	5.5
GW 2012	6.8	5.8	7.8	3.9	3.1	4.6	1.6	1.2	2.1
LR 2016	3.9	3.3	4.5	5.5	4.7	6.2	3.8	3.1	4.4
ML 2011	10.0	8.9	11.1	9.1	8.1	10.1	5.2	4.6	5.8
MR 2016	9.8	9.1	10.5	5.8	5.2	6.3	2.3	2.0	2.6
NE 2016	12.2	11.3	13.0	12.6	11.7	13.6	5.2	4.6	5.7
NG 2015	8.5	7.9	9.0	8.2	7.6	8.7	4.9	4.5	5.3
SL 2010	7.4	6.9	8.0	8.1	7.5	8.7	6.0	5.6	6.5
SN 2014	8.9	8.0	9.7	5.1	4.4	5.8	1.7	1.4	2.0
TD 2016	11.7	11.1	12.4	10.2	9.6	10.8	5.4	5.0	5.9
TG 2012	5.1	4.1	6.0	4.7	3.7	5.7	2.1	1.4	2.7
BJ Alibori 2014	9.1	8.2	10.0	9.1	8.2	10.1	5.4	4.6	6.2
CM six regions 2012	4.7	3.9	5.6	6.6	5.5	7.7	3.8	3.0	4.6
GH north 2013	9.8	8.4	11.3	7.5	6.4	8.7	6.1	5.2	7.1
GN 2015	7.9	7.3	8.4	6.7	6.1	7.3	4.9	4.3	5.5

Table A14. National and subnational GAM prevalence in the WCAR by country, stratified by age category.

	WHZ2						**MUACZ2**						**MUAC125**					
	6–23 months			24–59 months			6–23 months			24–59 months			6–23 months			24–59 months		
	Mean	95 % confidence		Mean	95 % confidence		Mean	95 % confidence		Mean	95 % confidence		Mean	95 % confidence		Mean	95 % confidence	
BF 2012	16.8	15.4	18.1	7.2	6.5	8.0	9.4	8.3	10.5	10.0	9.1	11.0	9.9	8.8	11.0	1.7	1.4	2.0
CF 2014	8.9	7.8	10.0	4.5	3.9	5.2	14.0	12.5	15.4	13.8	12.6	15.1	15.1	13.7	16.6	3.7	3.2	4.3
CI 2011	8.3	6.9	9.6	3.1	2.5	3.8	6.2	5.1	7.3	4.7	3.8	5.5	6.3	5.2	7.5	1.0	0.6	1.3
GM 2015	16.3	13.8	18.7	7.9	6.7	9.0	9.5	7.7	11.3	8.4	7.2	9.6	11.0	8.8	13.3	1.0	0.5	1.4
GW 2012	8.5	6.9	10.0	5.9	4.7	7.1	3.1	2.2	4.1	4.3	3.3	5.3	3.6	2.6	4.6	0.6	0.2	0.9
LR 2016	8.4	6.7	10.0	1.7	1.2	2.1	8.9	7.3	10.6	3.8	3.0	4.5	9.7	8.0	11.5	0.8	0.4	1.1
ML 2011	16.6	14.7	18.4	6.1	5.2	7.1	10.9	9.4	12.4	8.1	7.0	9.2	11.6	10.2	13.0	1.4	1.0	1.8
MR 2016	10.8	9.6	12.0	9.2	8.4	10.1	5.3	4.5	6.1	6.0	5.3	6.7	5.4	4.7	6.2	0.5	0.3	0.7
NE 2016	15.2	13.8	16.6	10.6	9.5	11.7	11.4	10.0	12.8	13.3	12.0	14.6	11.9	10.5	13.4	1.6	1.2	2.0
NG 2015	14.6	13.5	15.7	5.0	4.5	5.5	11.0	10.0	11.9	6.5	6.0	7.1	11.0	10.1	12.0	1.3	1.1	1.6
SL 2010	12.2	11.1	13.2	4.4	3.9	4.9	11.1	10.2	12.1	6.1	5.5	6.8	13.2	12.1	14.2	1.5	1.2	1.8
SN 2014	8.6	7.4	9.8	9.0	7.9	10.1	3.3	2.6	4.0	6.1	5.2	7.0	3.6	2.9	4.3	0.6	0.4	0.8
TD 2016	15.2	14.0	16.4	9.9	9.2	10.6	10.8	9.7	11.8	9.9	9.2	10.7	11.8	10.7	12.8	2.1	1.8	2.4
TG 2012	6.7	5.0	8.4	4.2	2.9	5.4	4.0	2.4	5.7	5.1	3.8	6.3	4.5	2.9	6.2	0.7	0.3	1.1

Table A15. Subnational GAM prevalence in ESAR countries (Ethiopia, Kenya, Madagascar, Malawi, Mozambique, South Sudan and Uganda).

	WHZ2			**MUACZ2**			**MUAC125**		
	Mean	95 % CIs		Mean	95 % CIs		Mean	95 % CIs	
Ethiopia									
Amhara, Woreda	12.9	9.1	16.6	21.3	17.1	25.6	10.3	7.2	13.5
Amhara, Woreda	11.1	7.7	14.5	28.9	24.6	33.3	12.7	9.7	15.6
Amhara, Woreda	10.2	6.9	13.6	19.4	14.8	24.0	8.3	5.4	11.3
Afar, Woreda 1	8.9	6.3	11.5	17.3	13.1	21.6	7.6	4.9	10.4
Afar, Woreda 2	13.2	10.0	16.4	19.0	14.3	23.8	7.1	4.9	9.4
Afar, Woreda 3	10.8	7.7	13.8	19.4	14.6	24.3	6.2	2.8	9.6
SNNPR, Woreda 1	3.1	1.1	5.0	10.7	7.5	14.0	1.8	0.4	3.2
SNNPR, Woreda 2	6.2	3.8	8.6	21.4	16.5	26.3	7.4	4.6	10.2
SNNPR, Woreda 3	3.7	1.6	5.8	15.8	11.9	19.8	6.5	3.8	9.2
SNNPR, Woreda 4	4.0	2.3	5.7	7.9	5.6	10.3	3.8	2.3	5.3
SNNPR, Woreda 5	9.0	6.3	11.6	19.4	15.8	23.0	11.8	8.7	14.9
SNNPR, Woreda 6	12.0	8.4	15.5	32.0	26.9	37.1	17.2	13.6	20.7
Oromia, Woreda 1	9.1	6.5	11.8	28.5	24.0	33.1	15.0	11.2	18.8
Oromia, Woreda 2	11.5	9.0	13.9	28.7	23.9	33.5	14.2	11.8	16.7
Oromia, Woreda 3	6.5	4.6	8.4	9.6	6.3	12.9	5.7	3.5	7.8
Oromia, Woreda 4	5.0	3.4	6.6	17.1	14.0	20.3	7.3	5.6	9.1
Tigray, Woreda 1	6.8	4.7	8.9	17.1	13.4	20.8	8.2	5.5	10.9
Tigray, Woreda 2	4.7	2.8	6.7	15.7	12.5	18.9	9.9	7.0	12.7
Tigray, Woreda 3	7.8	5.7	9.8	26.6	22.1	31.1	14.7	11.5	17.9
Kenya									
Makueni 2011	5.1	3.0	7.1	9.2	6.2	12.3	1.9	0.7	3.1
Turkana 2011	30.6	28.4	32.8	38.3	36.2	40.5	21.4	19.5	23.2
Kitui 2012	3.2	1.5	4.9	15.4	10.7	20.0	4.1	2.1	6.2
Kwale 2012	8.8	4.7	12.9	12.1	6.7	17.5	7.5	3.8	11.2
Laikipia 2012	12.2	9.0	15.5	20.8	15.4	26.1	14.2	10.0	18.4
East Pokot 2017	23.5	18.5	28.5	27.7	21.0	34.4	9.9	5.4	14.4
Mandera 2017	25.3	21.3	29.2	20.6	15.7	25.5	7.9	5.2	10.5
Samburu 2017	18.1	14.1	22.1	15.6	10.9	20.4	5.0	3.0	6.9
Wajir 2017	16.4	13.6	19.3	14.7	11.7	17.7	4.7	3.2	6.2
Garissa 2018	14.0	11.3	16.7	8.5	6.0	11.1	3.9	2.3	5.5
Isiolo 2018	13.4	10.5	16.3	11.3	8.4	14.1	4.6	2.9	6.3
Kajiado 2018	10.7	7.6	13.7	8.2	5.6	10.7	2.7	1.5	3.8
Marsabit 2018	12.2	10.3	14.1	8.1	6.6	9.6	3.1	2.2	3.9
Narok 2018	7.7	5.0	10.4	5.6	2.9	8.3	2.8	1.4	4.2
Madagascar									
Ambosary 2017	13.6	10.9	16.2	29.7	25.8	33.5	11.9	9.3	14.5
Ambovombe 2017	10.1	7.9	12.3	22.6	18.7	26.6	8.9	6.7	11.1
Ampanihy 2017	9.1	6.9	11.3	21.3	18.4	24.2	7.6	5.6	9.6
Bekily 2017	11.2	8.6	13.9	21.8	18.0	25.5	7.1	5.2	9.0
Beloha 2017	13.8	10.9	16.6	24.8	21.1	28.6	11.0	8.6	13.3
Betioky 2017	8.9	6.8	11.1	16.9	13.6	20.3	7.2	5.0	9.4
Taolagnaro 2017	8.2	6.0	10.5	18.3	14.9	21.6	6.5	4.4	8.7

Tsihombe 2017	9.6	7.1	12.1	27.7	23.2	32.3	8.6	6.4	10.7
Malawi									
Chitipa/Karonga/R	1.6	0.6	2.7	2.7	1.1	4.3	0.4	– 0.2	1.0
Lake Chilwa	5.4	3.3	7.6	5.6	3.2	8.0	2.1	0.9	3.4
Lilongwe/Kasungu	3.1	1.4	4.7	4.6	2.6	6.5	2.4	0.9	3.9
Lower Shire	6.0	3.9	8.2	6.4	4.2	8.5	1.8	0.8	2.9
Rift Valley	2.0	0.8	3.2	4.5	2.3	6.8	1.4	0.2	2.6
Shire Highlands	5.8	3.5	8.1	4.9	2.9	6.9	2.2	0.7	3.6
Thyolo and	5.0	3.2	6.8	6.0	3.6	8.4	1.4	0.3	2.5
Mozambique									
Cahora-Bassa	3.5	1.3	5.8	7.4	4.3	10.4	1.8	0.1	3.4
Mogovolas 2017	4.5	2.7	6.4	6.4	3.5	9.2	3.7	2.0	5.4
Morrumbala 2017	4.5	2.9	6.2	11.6	8.2	15.0	6.8	5.1	8.5
South Sudan									
Ikitos	17.1	12.9	21.3	12.0	7.9	16.2	18.8	14.2	23.4
Uganda									
Karamoja	10.3	9.4	11.3	17.5	16.1	18.9	9.5	8.5	10.5
Abim	6.2	4.3	8.1	14.6	11.4	17.8	6.8	5.0	8.7
Amudat	14.2	11.6	16.8	8.9	6.2	11.7	4.3	2.8	5.7
Kaabong	10.3	7.9	12.7	17.6	13.8	21.4	10.0	7.0	13.0
Kotido	8.0	5.5	10.6	23.7	19.1	28.3	12.4	9.5	15.3
Moroto	15.0	11.6	18.4	17.1	12.6	21.5	10.3	7.0	13.7
Nakapiripirit	11.5	9.4	13.6	22.9	18.4	27.4	14.9	11.4	18.5
Napak	8.6	6.3	10.9	16.8	13.6	20.0	7.4	5.2	9.7

NB: SNNPR, Southern Nations, Nationalities, and Peoples' Region.

Table A16. Subnational GAM prevalence in Kenya at county level, stratified by age category in Kenya.

	WHZ2						**MUACZ2**						**MUAC125**					
	6–23 months			24–59 months			6–23 months			24–59 months			6–23 months			24–59 months		
	Mean	95 % confidence intervals		Mean	95 % confidence intervals		Mean	95 % confidence intervals		Mean	95 % confidence intervals		Mean	95 % confidence intervals		Mean	95 % confidence intervals	
Makueni 2011	3.0	0.0	5.9	5.9	3.3	8.6	3.6	1.0	6.1	11.6	7.7	15.5	3.6	1.0	6.1	1.2	0.0	2.5
Turkana 2011	32.7	29.6	35.7	29.1	26.4	31.7	29.4	26.6	32.3	45.1	42.3	47.9	30.8	28.0	33.7	14.1	12.3	16.0
Kitui 2012	1.7	– 0.3	3.8	3.9	1.6	6.1	7.6	2.5	12.6	19.1	13.6	24.5	7.6	2.7	12.4	2.5	0.7	4.3
Kwale 2012	7.8	3.5	12.2	9.3	4.6	14.0	10.1	5.2	15.0	13.2	7.2	19.3	11.1	6.6	15.5	5.4	1.6	9.2
Laikipia 2012	15.1	10.8	19.3	10.4	6.4	14.5	23.6	16.8	30.4	19.0	12.5	25.4	30.2	23.1	37.2	4.1	1.5	6.7
East Pokot 2017	13.1	8.1	18.1	29.5	22.7	36.3	15.6	7.5	23.7	34.8	26.4	43.1	17.2	8.3	26.1	5.7	2.3	9.1
Mandera 2017	21.5	15.1	27.8	26.9	22.6	31.1	18.9	12.1	25.6	21.4	16.0	26.7	19.3	12.6	26.0	2.9	1.4	4.5
Samburu 2017	14.2	8.6	19.8	20.1	15.2	24.9	8.0	4.0	11.9	19.5	13.3	25.7	9.1	4.9	13.3	2.9	1.2	4.5
Turkana 2017	29.2	25.7	32.8	32.6	30.0	35.2	18.5	15.9	21.2	34.4	31.3	37.5	20.0	17.4	22.7	8.9	7.0	10.8
Wajir 2017	10.2	7.8	12.6	19.5	15.7	23.4	8.9	6.3	11.4	17.6	13.8	21.5	10.0	6.9	13.1	2.0	0.9	3.2
Garissa 2018	11.5	7.7	15.4	15.2	11.9	18.5	9.3	5.1	13.4	8.2	5.4	10.9	10.3	5.6	14.9	0.7	0.0	1.3
Isiolo 2018	11.4	7.5	15.3	14.9	11.5	18.3	7.8	4.0	11.7	13.8	9.6	17.9	8.2	4.8	11.7	2.0	0.6	3.4
Kajiado 2018	7.3	4.1	10.6	12.6	8.3	16.9	3.9	1.5	6.2	10.6	7.0	14.2	5.2	2.1	8.2	1.2	0.2	2.3
Marsabit 2018	13.0	9.9	16.2	11.8	9.5	14.1	6.5	4.3	8.8	8.9	7.0	10.8	8.4	5.8	10.9	0.4	0.0	0.8
Narok 2018	10.1	5.6	14.5	6.5	2.9	10.0	3.5	0.7	6.3	6.7	3.4	10.0	5.5	2.0	9.0	1.3	– 0.1	2.8

Table A17. Subnational GAM prevalence in Yemen at governorate level.

	WHZ2			**MUACZ2**			**MUAC125**		
	Mean	95 % confidence intervals		Mean	95 % confidence intervals		Mean	95 % confidence intervals	
Abyan 2016	17.2	13.7	20.7	16.1	12.7	19.5	4.4	2.5	6.3
Aden 2016	14.8	11.6	17.9	16.2	12.9	19.5	7.7	5.3	10.1
Al Bayda 2016	7.2	4.9	9.6	5.5	3.4	7.6	2.9	1.3	4.4
Al Dhale'e 2016	11.5	8.6	14.3	14.6	11.5	17.8	6.4	4.2	8.6
Al Hudaydah 2016	25.0	20.9	29.1	21.4	17.5	25.2	12.7	9.6	15.8
Al Jawf 2016	12.1	9.0	15.3	11.4	8.3	14.4	5.6	3.4	7.8
Al-Mahwit 2016	12.3	9.4	15.2	21.7	18.0	25.3	10.6	7.9	13.4
Amran 2016	5.4	3.5	7.4	13.8	10.8	16.7	6.4	4.3	8.5
Dhamar 2016	10.4	7.8	13.1	18.3	14.9	21.7	8.9	6.3	11.3
Hajjah 2016	11.1	8.4	13.8	17.5	14.2	20.8	6.6	4.5	8.8
Ibb 2016	7.6	5.1	10.2	18.1	14.4	21.8	6.9	4.5	9.3
Lahj 2016	12.9	9.7	16.1	18.6	14.8	22.3	7.4	4.9	9.9
Marib 2016	8.1	5.7	10.5	4.9	3.0	6.9	3.5	1.9	5.2
Raymah 2016	7.8	5.3	10.4	15.7	12.2	19.1	6.4	4.1	8.8
Sa'ada 2016	9.3	7.7	11.0	28.2	25.7	30.8	13.7	11.7	15.6
Sana'a 2016	6.2	4.0	8.5	12.2	9.2	15.3	6.4	4.2	8.7
Sanaa City 2016	5.6	3.2	7.9	6.4	3.9	8.8	2.9	1.2	4.6
Shabwah 2017	7.3	5.8	8.8	8.1	6.5	9.7	2.3	1.4	3.1
Taizz 2016	19.3	17.4	21.2	20.7	18.7	22.6	10.0	8.6	11.5

Table A18. Median prevalence of acute malnutrition among children aged 6–59 months by anthropometric indicator (WHZ2, MUACZ2 and MUAC125) and country.

Region	Country		Median prevalence:	Median prevalence:	Median prevalence:
		N	% (IQR)	% (IQR)	% (IQR)
ESAR		77 338	10.72 (6.62–13.56)	17.43 (8.91–21.76)	7.61 (4.12–11.96)
	ET	16 654	9.02 (6.18–11.46)	19.39 (15.82–26.2)	8.15 (7.14–12.65)
	KE	21 819	17.27 (9.66–25.07)	16.09 (8.48–23.31)	6.23 (3.66–11.09)
	MG	7 188	9.86 (9.02–12.4)	22.2 (19.79–26.29)	8.11 (7.14–9.92)
	MW	6 738	2.51 (1.25–5.22)	5.37 (4.45–6.21)	1.99 (1.4–2.64)
	MZ	377	4.51 (4.51–4.51)	6.37 (6.37–6.37)	3.71 (3.71–3.71)
	SS	457	17.07 (17.07–17.07)	18.82 (18.82–18.82)	12.04 (12.04–12.04)
	UG	24 105	11.55 (10.34–12.85)	18.03 (14.6–23.7)	10.23 (7.45–12.7)
MENA	YE	35 086	11.1 (8.38–16.89)	16.03 (10.57–19.29)	7.00 (4.48–10.04)
WCAR		569 859	9.01 (6.63–12.07)	7.88 (5.26–11.50)	4.07 (2.49–6.10)
	BF	106 652	9.22 (7.34–11.15)	8.64 (5.8–11.04)	4.09 (2.49–5.63)
	BJ	4 494	8.86 (8.13–9.27)	8.52 (7.62–10.6)	4.92 (4.45–6)
	CD	6 844	6.43 (4.66–6.89)	10.54 (7.27–12.84)	4.18 (2.17–6.35)
	CF	9 594	5.94 (5.32–6.98)	12.73 (10.82–18.98)	7.57 (5.99–11.22)
	CI	21 412	5.83 (4.06–7.09)	6.49 (4.55–8.67)	4.39 (2.77–5.52)
	CM	12 460	5.93 (4.11–7.25)	6.55 (5.05–9.77)	3.87 (2.83–5.82)
	GH	2 669	9.65 (9.16–10.38)	8.2 (6.55–8.42)	6.28 (5.19–7.37)
	GM	10 654	9.91 (9.16–11)	7.17 (4.1–9.3)	3.1 (1.65–4.86)
	GN	17 727	5.94 (4.81–7.31)	6.29 (4.53–7.16)	4.4 (2.88–5.5)
	GW	4 780	5.68 (4.05–7.37)	3.84 (2.46–4.88)	1.72 (1.36–2.16)
	LR	3 165	3.99 (3.27–5.62)	5.83 (3.48–7.28)	4.15 (2.69–4.97)
	ML	64 008	10.75 (9.01–13.61)	6.08 (3.99–7.55)	3.35 (2.25–4.22)
	MR	61 774	8.54 (6.34–12.72)	7.36 (4.77–10.91)	2.99 (1.98–5.2)
	NE	28 390	13.97 (11.37–15.35)	10.71 (6.97–14.28)	4.68 (2.8–5.75)
	NG	58 809	9.2 (7.11–11.71)	11.66 (6.51–15.87)	6.8 (3.65–10.01)
	SL	23 362	5.1 (4.15–6.46)	7.16 (5.03–7.62)	4.73 (2.87–5.3)
	SN	53 389	8.34 (7.18–10.48)	6.07 (4.39–7.86)	2.16 (1.27–3.1)
	TD	67 705	14.11 (10.04–17.4)	12.14 (8.78–15.34)	6.23 (4.65–8.4)
	TG	11 971	4.71 (3.74–6.9)	3.88 (1.83–7.33)	1.93 (0.66–3.44)
Total		682 283	9.45 (6.90–9.46)	9.01 (6.08–14.15)	4.58 (2.84–7.28)

Table A19. Prevalence of acute malnutrition among children aged 6–59 months by anthropometric indicator (WHZ, MUACZ2 and MUAC125) and country, disaggregated by sex.

				Median prevalence: WHZ < – 2		**Median prevalence: MUACZ < – 2**		**Median prevalence: MUAC < 125 mm**	
Region	Country	Female	Male	Female	Male	Female	Male	Female	Male
				% (IQR)	% (IQR)	% (IQR)	% (IQR)	% (IQR)	% (IQR)
ESAR	ET	8 129	8 525	7.11 (4.83–10.51)	10.05 (6.16–15.35)	17.01 (15.13–20.69)	21.67 (18.05–27.13)	10.17 (8.4–13.64)	6.99 (5.14–11.7)
	KE	10 669	11 150	14.92 (9.74–22.03)	17.67 (10.89–29.29)	15.18 (8.01–21.94)	18.95 (9.11–25.56)	7.3 (4.63–12.4)	5.3 (2.48–9.44)
	MG	3 640	35 48	9.79 (8.43–10.44)	11.57 (9.36–13.44)	20.42 (18.7–23.8)	24.62 (20.7–28.8)	8.63 (7.94–11.79)	6.79 (5.89–9.27)
	MW	3 482	3 256	1.95 (1.45–4.49)	2.36 (1.39–4.98)	4.84 (4.1–6.5)	5.26 (3.58–7.49)	2.57 (1.89–3.18)	1.31 (0.93–1.76)
	MZ	188	189	3.72 (3.72–3.72)	5.29 (5.29–5.29)	6.91 (6.91–6.91)	5.82 (5.82–5.82)	4.26 (4.26–4.26)	3.17 (3.17–3.17)
	SS	239	218	13.39 (13.39–13.39)	21.1 (21.1–21.1)	16.74 (16.74–16.74)	21.1 (21.1–21.1)	11.3 (11.3–11.3)	12.84 (12.84–12.84)
	UG	12 128	11 977	9.74 (7.17–11.54)	13.41 (10.97–15.46)	16.29 (12.85–20.25)	21.49 (14.79–25.06)	11.05 (7.98–14.83)	9.39 (5.77–11.11)
MENA	YE	17 186	17 900	9.27 (6.22–13.02)	12.76 (10.26–20)	14.29 (9.62–18.58)	17.3 (11.76–21.78)	8.72 (5.44–12.18)	6.12 (3.13–8.21)
WCAR	BF	51 961	54 691	7.77 (5.96–9.69)	10.37 (8.43–13.21)	7.59 (5.15–9.94)	9.49 (6.96–12.5)	4.78 (2.99–6.57)	3.23 (1.95–4.68)
	BJ	2 166	2 328	7.23 (6.56–8.56)	9.91 (8.86–11.5)	8.43 (8.26–8.64)	8.59 (6.96–12.47)	5.97 (5.57–6.49)	4.17 (3.48–5.97)
	CD	3 324	3 520	4.67 (3.69–6.35)	7.18 (5.63–9.07)	9.79 (5.43–10.17)	11.32 (8.98–15.28)	5.15 (1.58–6.78)	3.18 (2.75–5.96)
	CF	4 756	4 838	5.02 (4.29–5.73)	7.49 (5.81–8.24)	11.79 (8.27–17.5)	13.74 (11.33–20.12)	8.45 (6.36–12.22)	7.49 (5.18–10.11)
	CI	10 598	10 814	4.33 (2.61–6.02)	6.71 (4.79–8.45)	5.69 (4.15–7.25)	7.41 (5.11–10.66)	4.44 (2.89–6)	3.69 (2.88–5.2)
	CM	6 225	6 235	5.31 (2.59–7.05)	6.14 (4.27–9)	6.4 (3.85–8.88)	8.05 (4.3–10.99)	4.42 (3.04–6.45)	3.66 (1.65–5.25)
	GH	1 317	1 352	8.46 (7.26–9.23)	10.98 (10.78–11.53)	6.84 (6.54–9.09)	7.78 (6.27–9.81)	7.99 (7.35–8.46)	4.19 (3.05–6.78)
	GM	5 233	5 421	8.85 (8.33–9.61)	10.93 (9.92–12.87)	7.2 (4.31–8.73)	7.2 (3.89–10.29)	4.74 (1.22–5.15)	2.21 (1.24–3.85)
	GN	8 738	8 989	4.79 (3.49–6.35)	7.51 (5.87–8.58)	5.05 (4.29–7.1)	6.21 (4.93–8.16)	4.79 (3.46–6.58)	3.08 (2.17–4.63)
	GW	2 403	2 377	4.76 (4.37–6.53)	6.39 (4.46–9.26)	3.57 (2.64–5.24)	4.35 (2.36–4.79)	2.2 (1.29–3.27)	0.96 (0.5–1.45)
	LR	1 588	1 577	3.85 (2.53–4.48)	4.47 (3.17–6.45)	4.57 (3.83–5.44)	7.39 (3.6–8.16)	4.97 (3.57–5.47)	3.56 (1.8–4.59)
	ML	31 436	32 572	9.55 (7.57–11.76)	11.94 (9.83–15.3)	5.6 (3.83–7.03)	6.4 (4.68–8.55)	3.93 (2.94–5.27)	2.4 (1.77–3.66)
	MR	30 544	31 230	7.08 (5.39–11.15)	9.86 (6.91–15.11)	6.49 (3.89–8.73)	8.34 (5.36–12.68)	3.58 (2.33–6)	2.66 (1.5–4.08)
	NE	14 507	13 883	7.65 (6.9–8.74)	19.71 (13.74–23.19)	7.79 (5.31–11.92)	13.04 (9.16–17.14)	4.28 (2.88–7.14)	4.42 (3.05–6.15)
	NG	29 213	29 596	6.87 (3.77–9.76)	11.64 (8.65–14.35)	9.45 (4.71–14.48)	12.67 (7.92–17.82)	6.43 (3.62–11.33)	5.79 (3.75–8.69)
	SL	11 752	11 610	4.32 (3.07–5.15)	6.12 (4.81–8.5)	5.5 (4.56–6.86)	8.38 (5.87–8.8)	4.75 (3.43–5.85)	4.4 (2.51–4.94)
	SN	26 180	27 209	7.41 (6.09–9.22)	9.71 (7.76–12.58)	5.67 (3.51–7.08)	6.8 (4.78–8.7)	2.41 (1.6–3.86)	1.8 (0.93–2.67)
	TD	33 409	34 296	12.65 (8.54–15.27)	15.45 (11.7–19.53)	10.98 (7.58–13.95)	13.56 (9.82–17.43)	7.65 (5.07–9.77)	5.16 (3.65–7.05)
	TG	5 947	6 024	4.42 (2.62–6.11)	5.4 (4.27–7.73)	3.45 (1.99–6.55)	4.42 (1.43–8.12)	2.49 (1.03–3.93)	1.93 (0.32–2.78)

Table A20. Prevalences of GAM produced by each indicator using the mean at survey domain level, disaggregated by age category.

		Number of children		**Median prevalence: WHZ < – 2**		**Median prevalence: MUACZ < – 2**		**Median prevalence: MUAC < 125 mm**	
Region	Country	Age 6–23 months	Age 24–59 months	Age 6–23 months	Age 24–59 months	Age 6–23 months	Age 24–59 months	Age 6–23 months	Age 24–59 months
				% (IQR)	% (IQR)	% (IQR)	% (IQR)	% (IQR)	% (IQR)
ESAR	ET	5 767	10 887	10.37 (6.33–13.79)	7.74 (5.04–11.2)	17.25 (14.11–22.6)	19.67 (17.3–25.42)	18.79 (14.05–28.1)	3.11 (2.16–5.3)
	KE	8 006	13 813	14.43 (8.52–24.89)	19.42 (9.88–26.78)	10.45 (6.69–18.33)	19.27 (10.3–26.74)	10.67 (7.9–19.43)	2.91 (1.23–5.56)
	MG	2 383	4 805	15 (13.23–17.87)	7.37 (6.96–9.98)	16.26 (13.99–19.67)	24.6 (23.22–30.09)	16.47 (15.05–21.16)	3.59 (2.98–5.28)
	MW	2 155	4 583	2.31 (1.83–5.92)	2.34 (1.24–4.7)	3.56 (2.29–3.93)	6.37 (4.45–7.77)	3.88 (2.61–5.39)	1.06 (0.29–1.86)
	MZ	147	230	6.12 (6.12–6.12)	3.48 (3.48–3.48)	4.08 (4.08–4.08)	7.83 (7.83–7.83)	4.76 (4.76–4.76)	3.04 (3.04–3.04)
	SS	150	307	28.67 (28.67–28.67)	11.4 (11.4–11.4)	24 (24–24)	16.29 (16.29–16.29)	25.33 (25.33–25.33)	5.54 (5.54–5.54)
	UG	10 661	13 444	15.31 (11.65–17.18)	8.72 (6.86–10.93)	15.17 (10.71–19.57)	19.7 (15.3–26.64)	16.44 (11.69–19.55)	4.98 (3.29–7.14)
MENA	YE	12 538	22 548	13.73 (8.59–18.65)	10.24 (7.32–15.3)	14.44 (9.2–21.69)	16.02 (10.7–20.22)	15.88 (9.31–23.21)	2.25 (1.37–3.41)
WCAR	BF	40 161	66 491	14.62 (12.02–18.27)	5.43 (4.41–7.12)	7.59 (5.06–10.86)	9.14 (5.86–11.38)	8.01 (5.86–11.27)	1.31 (0.65–2.04)
	BJ	1 676	2 818	12.29 (11.73–16)	5.67 (5.42–7.13)	9.89 (6.98–10.49)	8.33 (7.5–9.45)	10.57 (9.13–12.04)	1.89 (1.48–2.16)
	CD	2 411	4 433	7.24 (7.11–11.49)	4.81 (3.38–6.78)	6.14 (4.86–7.91)	13.37 (9.09–15.4)	7.26 (3.88–8.7)	2.61 (1.15–5.13)
	CF	3 601	5 993	9.06 (7.22–10.57)	4.44 (3.7–5.57)	13.43 (9.72–19.66)	13.22 (9.07–18.58)	13.87 (11.55–21.79)	3.17 (2.64–5.45)
	CI	8 716	12 696	9.09 (6.08–11.59)	3.3 (2.1–4.04)	7.53 (5.44–9.42)	5.24 (4.04–7.96)	8.3 (5.44–10.25)	1.49 (0.73–2.03)
	CM	4 443	8 017	9.81 (5.21–13.14)	3.89 (2.43–5.02)	7.07 (5.02–10.39)	5.96 (4.31–9.19)	8.63 (6–10.82)	1.41 (0.83–2.84)
	GH	2 073	596	10.71 (9.99–13.76)	3.92 (2.54–5)	6.9 (6.58–8.42)	7.14 (6.5–16.67)	7.26 (7.19–8.84)	0.56 (0–0.98)
	GM	3 879	6 775	13.66 (12.5–16.51)	8.56 (7.11–9.17)	6.32 (5.29–9.76)	7.11 (4.89–9.04)	8.05 (3.25–10.18)	0.71 (0.3–1.4)
	GN	6 511	11 216	8.52 (7.79–9.64)	4.35 (2.81–6.25)	6.98 (5.86–10.19)	5.01 (3.87–6.81)	9.09 (6.31–12.14)	1.26 (0.87–1.86)
	GW	1 744	3 036	7.64 (5.95–8.91)	4.01 (2.95–5.94)	3.64 (1.89–4.17)	3.87 (3.17–4.74)	4.01 (2.41–4.45)	0.7 (0.43–0.74)
	LR	1 037	2 128	9.95 (6.78–11.63)	1.7 (1.13–2.51)	9.82 (6.78–11.97)	3.55 (1.53–4.88)	11.07 (8.47–13.54)	0.79 (0.47–1.13)
	ML	24 066	39 942	16.46 (13.77–20.22)	7.34 (5.59–8.56)	6.57 (4.79–8.68)	5.22 (3.97–7.65)	7.45 (5.47–9.33)	0.76 (0.39–1.21)
	MR	23 117	38 657	9.83 (6.33–13.49)	8.01 (5.16–13.18)	6.2 (3.63–9.5)	7.79 (5.08–11.23)	7.33 (4.58–11.08)	0.78 (0.32–1.47)
	NE	9 306	19 084	19.61 (15.85–22.02)	10.92 (8.48–12.24)	10.59 (7.45–13.95)	10.42 (7.58–13.3)	10.35 (6.27–13.4)	1.45 (0.97–2.1)
	NG	21 309	37 500	16.43 (12.15–20.15)	5.01 (3.74–6.83)	12.75 (8.02–18.5)	9.48 (5.44–14.43)	14 (8.57–21.35)	2.21 (0.81–3.34)
	SL	9 064	14 298	8.52 (6.79–9.74)	3.08 (2.39–3.83)	9.62 (5.23–10.4)	5.54 (4.34–6.85)	10.37 (5.7–11.58)	1.04 (0.51–1.57)
	SN	19 111	34 278	8.48 (6.48–12.3)	8.57 (6.6–9.96)	4.37 (2.55–6.21)	7 (5.06–9.27)	4.44 (2.55–6.63)	0.77 (0.47–1.27)
	TD	23 206	44 499	18.21 (13.79–22.63)	11.99 (7.61–15.5)	13.56 (9–16.67)	11.88 (8.23–15.53)	15.11 (10.42–18.85)	1.93 (1.27–3.11)
	TG	4 213	7 758	7.03 (4.94–12.34)	3.61 (2.44–5.2)	4 (1.38–5.72)	3.66 (1.73–8.41)	4.82 (1.85–7.07)	0.6 (0–1.83)

Table A21. Prevalences of GAM produced by each indicator using the mean at survey domain level, disaggregated by stunting status.

		Number of children		**Median prevalence: WHZ < – 2**		**Median prevalence: MUACZ < – 2**		**Median prevalence: MUAC < 125 mm**	
Region	Country	Not stunted	Stunted	Not stunted	Stunted	Not stunted	Stunted	Not stunted	Stunted
				% (IQR)	% (IQR)	% (IQR)	% (IQR)	% (IQR)	% (IQR)
ESAR	ET	11 852	4 782	8.4 (5.8–11.7)	9.9 (5.6–13.7)	16.9 (11.2–19.6)	26.2 (21.9–34.9)	6.7 (5.4–9.4)	16 (10.5–19.6)
	KE	16 065	5 719	17.1 (8.2–24)	17.8 (11.8–34.7)	12 (6.9–18.3)	26.4 (18–36.7)	3.8 (2.3–7.3)	11.8 (5.9–21.7)
	MG	4 400	2 785	9 (8.2–10.2)	11.5 (11–15.7)	16.2 (13.5–18.4)	32.9 (29.4–39.9)	5.5 (5–7)	11.6 (10.9–13.6)
	MW	4 035	2 696	1.5 (1.2–4.8)	2.8 (1.8–5.1)	2.8 (1.5–3.3)	9.4 (6.7–11.4)	1 (0.3–1.3)	3.6 (2.4–4.8)
	MZ	234	143	5.1 (5.1–5.1)	3.5 (3.5–3.5)	5.1 (5.1–5.1)	8.4 (8.4–8.4)	3.8 (3.8–3.8)	3.5 (3.5–3.5)
	SS	261	192	13.4 (13.4–13.4)	21.4 (21.4–21.4)	8.8 (8.8–8.8)	30.7 (30.7–30.7)	5 (5–5)	20.3 (20.3–20.3)
	UG	15 688	8 350	9.8 (7.8–11.6)	13.6 (11.1–15.9)	12.4 (7.9–15.5)	28.8 (21.4–34.2)	6 (4.3–8.3)	16.2 (11.3–20.5)
WCAR	BF	69 865	36 731	7.6 (5.9–9.3)	12.5 (9.8–15.2)	4.5 (2.9–6)	16.3 (12–20.1)	2.2 (1.3–3.3)	7.5 (5–9.7)
	BJ	2 941	1 551	7.2 (5.5–7.9)	12.9 (11.5–13)	4.9 (4.3–5.5)	16.1 (13.7–18.5)	2.9 (2.8–3.3)	8.4 (7.5–11.2)
	CD	3 393	3 425	5.1 (2.8–6.8)	6.7 (5.1–8.5)	4 (3.6–5.5)	16.3 (11.5–19.9)	2.5 (1.6–4.3)	6 (3.3–8.5)
	CF	5 572	4 022	5 (4.1–5.6)	7.7 (6.4–9.7)	7.6 (5.4–10.4)	19.6 (16.6–27.8)	5 (4–7.1)	10.4 (9–15.3)
	CI	14 048	7 326	3.5 (2.8–5)	9.1 (6.8–11.4)	2.7 (1.7–4.2)	13.3 (10.9–15.2)	2.1 (1.5–3)	7.6 (5.7–9.1)
	CM	7 288	5 131	4.1 (3–6)	7.6 (5.2–11.2)	2.9 (1.8–4)	11.3 (9.2–17.6)	1.5 (0.9–2.7)	6.9 (4.7–9.8)
	GH	2 044	625	8.5 (8.3–8.9)	14.1 (11.7–15.7)	4.9 (3.7–5.8)	17.5 (13.8–24)	5.1 (3.4–5.8)	11.6 (9.6–13.5)
	GM	7 992	2 628	8.1 (7.4–8.6)	17 (14.7–17.7)	4.4 (2.6–5.2)	15.8 (10.5–19.3)	1.6 (0.8–2.7)	9 (4.6–10.3)
	GN	12 102	5 583	5 (3.3–6.2)	9 (7.9–9.7)	2.8 (2.4–3.4)	13 (10.1–14)	2.2 (1.7–3.4)	7.9 (5.3–9.6)
	GW	3 437	1 341	4 (3.2–6.2)	10.9 (6.7–12.3)	1.7 (0.9–2.2)	8.1 (6.3–12.3)	0.6 (0.3–0.9)	4.2 (3.3–5.6)
	LR	2 145	1 016	3.3 (1.9–3.6)	5.5 (4.5–7.9)	2.1 (1.4–3.1)	12.7 (9.1–14.4)	1.8 (1.5–2.2)	8.5 (5.3–10.6)
	ML	47 614	16 242	9.7 (7.8–11.9)	14.5 (11.5–17.7)	3 (2.3–4.7)	13.5 (10.5–16.4)	2 (1.5–2.5)	7.2 (5.6–8.9)
	MR	47 690	13 999	7.8 (5.6–12.8)	10 (6–14.2)	5.3 (3.4–8.6)	14.3 (9.4–19.2)	2.2 (1.4–3.4)	6 (4.2–9.4)
	NE	17 049	11 252	11.1 (8.5–13.3)	18.1 (14.5–20.5)	5.9 (4.4–6.9)	18.6 (14.5–21.2)	2.6 (1.2–3.4)	7.9 (6.2–10.1)
	NG	33 800	24 841	7.5 (5.5–9.7)	12.3 (9–14.7)	5.2 (3.2–9.2)	18.4 (13.1–22.6)	3.2 (1.9–6.6)	10.3 (7.6–13)
	SL	15 773	7 548	4.2 (3.3–5.5)	7.2 (5.1–9.1)	3.9 (2.4–4.3)	13.3 (11.4–15)	2.7 (1.7–3.3)	8.3 (5.5–9.6)
	SN	42 645	10 702	7.2 (5.9–9.3)	14.2 (11.7–17.4)	3.9 (2.7–5.8)	14.3 (10.6–18.8)	1.2 (0.7–2)	5.7 (3.6–8.4)
	TD	45 753	21 841	12.4 (9.3–16.4)	16.1 (12.4–20.2)	8.7 (5.8–11.2)	19.9 (14.8–25.2)	3.6 (2.6–4.8)	11.7 (8.9–15.1)
	TG	8 408	3 556	3.8 (2.7–6.3)	8 (5.7–11.7)	1.6 (1–2.9)	8.9 (5.1–15.9)	0.8 (0.3–2.3)	4.5 (2.5–6.7)

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