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Classification of Dual Burden of Malnutrition in Young Children

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Abstract

Introduction: Available classifications and indices for assessment of malnutrition are limited to deficiencies. Societies with transitional nutrition have children suffering not only deficiencies, but also excess or both (dual burden). This paper proposes a classification of nutritional status for identifying normal and failure conditions due to deficiency, excess and dual burden as well as of their components.

Methods: One nutritional condition was considered normal and 12 malnutrition conditions were used for the proposed Malnutrition Anthropometric Index (MAI) as the summation of malnutrition conditions shares and comprising sub-indices of deficiencies (MAD), of excess (MAE) or dual burden (MADB). These indices and 95% CI for comparisons were computed utilizing data from 426 children from six to 59 months of age derived from household surveys of 14 rural bordering communities from Central America in 2013-2015, 9144 sampled national Guatemalan children, 3311 urban and 5833 rural in 2008-2009, and 5892 sampled national Burkina Faso children, 1311 urban and 4581 rural in 2010.

Results: Shares and 95% confidence intervals estimated for proposed indices were able to differentiate dual burden as well as other indices among study populations.

Conclusions: MAI was better estimate of malnutrition and sub-indices MAD, MAE and MADB and their components provided breakdown of malnutrition conditions as inputs for a better understanding of malnutrition and better decision-making.

Recommendations: Consider malnutrition conditions due to deficiencies as well as excess and dual burden in nutritional assessments of children. Use MAI as well as sub-indices MAD, MAE and MADB and their components in the analysis of results from anthropometric surveys in children for monitoring and evaluation purposes in actions and policies with impact on food and nutrition security.

Keywords: Double burden of malnutrition in young children; Malnutrition index; Nutritional status classification

Introduction

Current classifications and indices for assessing nutritional status in children are limited to malnutrition due to deficiencies [1-4]. In this sense these classifications are insufficient for guiding food and nutrition security public policies based on children malnutrition due to deficiencies, excess or both (dual burden). These indices of anthropometric failure consider categories of three standard Z scores and under-estimate malnutrition due to deficiencies because of the exclusion of malnutrition conditions due to excess as well as dual burden and consequently over-estimate the proportion of children in normal nutrition conditions.

Several studies in Central America, for example in Guatemala, have highlighted the occurrence of growth retardation (stunting) in early ages and by the fifth year, one half of children were stunted [5] and remained stunted by the ninth year of age [6]. Other studies in urban children of public school in Guatemala City found that almost one tenth children were stunted and of this proportion one fifth of girls and one fourth of boys were also obese [7]. This is dual burden of malnutrition which cannot be assessed using the available indices of anthropometric failure based on malnutrition due to deficiencies only.

On the other hand the country reports in the WHO database (WHO [8]) are based on separate standardized Z scores of height for age (HAZ), weight for height (WHZ) and body mass index (BMIZ). The percentages of children suffering stunting, wasting and obesity do not allow assessing dual burden of malnutrition. The estimates of stunting (HAZ<-2), wasting (WHZ or BMIZ<-2) and obesity (WHZ or BMIZ ≥ +2) were derived from surveys or censuses carried out by countries.

The problem of nutritional assessment reports of young children is that with transitional nutritional status of societies we do not know how much of stunting children are growing properly and how much are not, in particular malnourished due to deficiency such as wasting and malnourished due to excess such as overweight or obesity. These estimates do not provide inputs for estimating the dual burden of malnutrition.

The proposed classification of nutritional anthropometry status aims to estimate the proportion of acceptable normal nutritional condition as well as the proportions of nutritional failure conditions which are due to deficiency, excess and both (dual burden) and their components for providing inputs to guidelines for actions of public food and nutrition policies. The proportions of components for each of the three nutritional failure conditions (deficiency, excess and both or

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dual burden) help to understand the nature of malnutrition and the call for policy and actions in the short as well as medium and long-terms.

Methods

Table 1 describes in the last five columns to the right the 18 possible combinations of 2, 3 and 3 categories of the standardized nutritional anthropometric indexes of height for age (HAZ), body mass index (BMIZ) and weight for age (WAZ) depicting nutritional conditions. The HAZ two categories are stunting (HAZ<-2) and normal growth (HAZ ≥ -2), the BMIZ three categories are wasting (BMIZ<-2), normal nutrition (-2 ≤ BMIZ<+2) and overweight or obesity (BMIZ ≥ +2), and the WAZ three categories are low weight for age (WAZ<-2), normal weight for age (-2 ≤ WAZ<+2) and high weight for age (WAZ ≥ +2). Out of 18 possible combinations of HAZ, BMIZ and WAZ categories, 13 are considered feasible (one for normal, six for deficiencies, three for dual burden and three for excess) and five non-viable in the last five rows.

Column two describes categories of the nutritional status classification by Waterlow et al. [1] and column three Nandy et al. [3] categories. It is clear in Table 1 that Waterlow et al. [1] proposal comprised in the action? category in column two, all dual burden of malnutrition conditions and also malnutrition conditions due to deficiency such as stunting only as well as stunting with low weight for age; this probably was the reason for giving a questioning name to this category and the kind of action for stunted children. In addition, Waterlow et al. [1] did not include in any category of malnutrition conditions due to excess at all. The normal category was over-estimated.

Svedberg [2] and Nandy et al. [3] identified malnutrition conditions due to deficiency with letters B, C, D, E and F. However, it can be seen in Table 1 that categories E and F included dual burden of malnutrition conditions, so that it cannot be separated from malnutrition due to deficiency. In addition, they did not include any category of malnutrition conditions due to excess at all and the normal category was over-estimated, as in the case of Waterlow et al. [9].

The first row of categories corresponds to children in normal nutritional status, that is, with no malnutrition conditions of stunting (ST), wasting (WS), overweight or obesity (OW), low weight for age (LW) or high weight for age (HW) as shown in the last five columns.

The rows from two to seven of nutritional status categories correspond to children in malnutrition due to deficiency (MAD), that is, WS, WSLW, STWSLW, STLW, ST and LW; from eight to ten to children in malnutrition due to dual burden (MADB), that is, STOWLW, STOW and STOWHW; and from eleven to thirteen to children in malnutrition due to excess (MAE), that is, HW, OW and OWHW.

The proposed Malnutrition Anthropometric Index (MAI) is the summation of the proportions of all 12 malnutrition categories, that is, WS, WSLW, STWSLW, STLW, ST, LW, STOWLW, STOW, STOWHW, HW, OW and OWHW. The sub-indices MAD, MADB and MAE are the summations of their corresponding proportions of malnutrition categories. It is expected that the structures of MAI, MAD, MAE and MADB differ from population to population linked to dietary causal factors and other non-dietary factors and their interactions.

We found that conceptually five combinations are non-viable

Condition	Waterlow categories	Nandy et al. categories	Nutritional status categories	ST	WS	OW	LW	HW
Normal	Normal	A	NN	NO	NO	NO	NO	NO
Malnutrition Anthropometric Index (MAI)	-	-	-	-	-	-	-	-
Malnutrition due to Deficiency (MAD)	-	-	-	-	-	-	-	-
Wasting only (WS)	Action	B	WS	NO	YES	NO	NO	NO
Wasting (WS) with low weight for age (LW)	Action	C	WSLW	NO	YES	NO	YES	NO
Wasting (WS) with stunting (ST) and low weight for age (LW)	Priority	D	STWSLW	YES	YES	NO	YES	NO
Stunting (ST) with low weight for age (LW)	Action?	E	STLW	YES	NO	NO	YES	NO
Stunting only (ST)	Action?	F	ST	YES	NO	NO	NO	NO
Low weight for age only (LW)	-	Y	LW	NO	NO	NO	YES	NO
Malnutrition due to Dual Burden (MADB)	-	-	-	-	-	-	-	-
Stunting (ST) with overweight or obesity (OW) and low weight for age (LW)	Action?	E	STOWLW	YES	NO	YES	YES	NO
Stunting (ST) with overweight or obesity (OW)	Action?	F	STOW	YES	NO	YES	NO	NO
Stunting (ST) with overweight or obesity (OW) and high weight for age (HW)	Action?	F	STOWHW	YES	NO	YES	NO	YES
Malnutrition due to Excess (MAE)	-	-	-	-	-	-	-	-
High weight for age only (HW)	-	-	HW	NO	NO	NO	NO	YES
Overweight or obesity (OW) only	-	-	OW	NO	NO	YES	NO	NO
Overweight or obesity (OW) with high weigh for age (HW)	-	-	OWHW	NO	NO	YES	NO	YES
Non viable conditions	-	-						
Wasting (WS) with stunting (ST)	Priority	-	STWS	YES	YES	NO	NO	NO
Wasting (WS) with stunting (ST) and high weight for age (HW)	Priority	-	STWSHW	YES	YES	NO	NO	YES
Stunting (ST) with high weight for age (HW)	Action?	-	STHW	YES	NO	NO	NO	YES
Wasting (WS) with high weight for age (HW)	Action	-	WSHW	NO	YES	NO	NO	YES
Overweight or obesity (OW) with low weight for age (LW)	-	-	OWLW	NO	NO	YES	YES	NO

Table 1: Classification of the nutritional status of children.

conditions in the sense of plausibility. Overweight or obesity with low weight for age (OWLW) is contradictory.

The proposed classification and the estimations of index MAI, sub-indices MAD, MAE and MADB as well their 12 malnutrition conditions were illustrated by utilizing the following data: 426 children from six to 59 months of age from 14 bordering communities from rural Central America (RCA) in 2013-2015; 9144 sampled national Guatemalan children, 3311 urban (UGT) and 5833 rural (RGT) in 2008-2009; and 5892 children from Burkina Faso, 1311 urban (UBF) and 4581 rural (RBF) in 2010.

The RCA dataset includes anthropometric data collected in household surveys carried out in small rural villages in bordering municipalities of El Salvador, Guatemala, Honduras and Nicaragua by the Regional Programme of Food and Nutrition Security for Central America (PRESANCA II in Spanish) and the Regional Programme of Information Systems on Food and Nutrition Security (PRESISAN in Spanish), both of the General Secretariat of the Central American Integration System (SG-SICA in Spanish). These surveys were carried out in 2013, 2014 and 2015 as part of the baseline for measuring food and nutrition food insecurity [10].

The UGT, RGT, UBF and RBF national level survey datasets were downloaded from data repositories. The Guatemala 2008-2009 dataset is available at the Global Health Data Exchange [11] and Burkina Faso datasets at Measuredhs [12]. Demographic and Health Surveys (DHS) of the DHS Program supported by United States Agency for International Development (USAID).

The datasets were processed using software WHO ANTHRO PLUS with 2006 WHO growth patterns for computing HAZ, BMIZ and WAZ indices with valid measures of weight, height or length for age and sex. Measures of weight, height or length were obtained by trained and standardized personnel for the RCA study, while for the DHS survey data we assumed were standardized as required by DHS protocols. Recoding of HAZ, BMIZ and WAZ as well as proportion and confidence limits were estimated using software Epi-Info [13].

Results

Tables 2-6 report on RCA, UGT, RGT, UBF and RBF results respectively. The results are expressed in terms of number of children, estimates of proportions and 95% confidence limits. Note that RCA data for several villages were censuses of households, while in UGT, RGT, UBF and RBF were samples with sampling designs different than simple random samples. However we have assumed a simple random sampling for easiness of the illustrations.

For RCA (Table 2) only results for MAI, MAD, MADB and MAE are presented due to small number of children in their categories.

Figure 1 shows nutritional status classification for children in rural Central America the MAI was 51.2% comprising a MAD of 43.7%, a MAE of 4.0% and a MADB of 3.5%.

In urban Guatemala the MAI was 42.9% with MAD of 36.8%, MAE of 4.2%, and MADB of 2.0%. In contrast, rural Guatemala the MAI was higher by close to 20% points (63.2%), mainly due to a higher MAD (57.6%) as shown in Tables 3 and 4. The MAE in rural Guatemala was lower with 2.1% (95% CI from 1.7% to 2.5%) than in urban Guatemala with 4.2% (95% CI from 3.5% to 4.9%), while the opposite for MADB, rural Guatemala was higher with 3.5% (95% CI from 3.1% to 4.0%)

Condition	Nutritional status category	Number of children	Proportion (%)	Lower CL	Upper CL
Normal	NN	208	48.8	44	53.7
Malnutrition Anthropometric Index (MAI)	-	218	51.2	46.3	56
Malnutrition due to Deficiency (MAD)	-	186	43.7	38.9	48.5
Malnutrition due to Dual Burden (MADB)	-	15	3.5	2.1	5.9
Malnutrition due to Excess (MAE)	-	17	4	2.4	6.4

Table 2: Proportions and confidence limits (95%) of nutritional status categories in RCA children.

Condition	Nutritional status category	Number of children	Proportion (%)	Lower CL	Upper CL
Normal	NN	1891	57.1	55.4	58.8
Malnutrition Anthropometric Index (MAI)	-	1420	42.9	41.2	44.6
Malnutrition due to Deficiency (MAD)	-	1217	36.8	35.1	38.4
Wasting only (WS)	WS	4	0.1	0	0.3
Wasting (WS) with low weight for age (LW)	WSLW	5	0.2	0.1	0.4
Wasting (WS) with stunting (ST) and low weight for age (LW)	STWSLW	5	0.2	0.1	0.4
Stunting (ST) with low weight for age (LW)	STLW	288	8.7	7.8	9.7
Stunting only (ST)	ST	907	27.4	25.9	29
Low weight for age only (LW)	LW	8	0.2	0.1	0.5
Malnutrition due to Dual Burden (MADB)	-	65	2	1.5	2.5
Stunting (ST) with overweight or obesity (OW) and low weight for age (LW)	STOWLW	0	0	0	0.1
Stunting (ST) with overweight or obesity (OW)	STOW	65	2	1.5	2.5
Stunting (ST) with overweight or obesity (OW) and high weight for age (HW)	STOWHW	0	0	0	0.1
Malnutrition due to Excess (MAE)	-	138	4.2	3.5	4.9
High weight for age only (HW)	HW	6	0.2	0.1	0.4
Overweight or obesity only (OW)	OW	98	3	2.4	3.6
Overweight or obesity (OW) with high weigh for age (HW)	OWHW	34	1	0.7	1.4

Table 3: Proportions and confidence limits (95%) of nutritional status categories in UGT children.

Condition	Nutritional status category	Number of children	Proportion (%)	Lower CL	Upper CL
Normal	NN	2146	36.8	35.6	38
Malnutrition Anthropometric Index (MAI)	-	3687	63.2	62	64.4
Malnutrition due to Deficiency (MAD)	-	3361	57.6	56.3	58.9
Wasting only (WS)	WS	9	0.2	0.1	0.3
Wasting (WS) with low weight for age (LW)	WSLW	16	0.3	0.2	0.5
Wasting (WS) with stunting (ST) and low weight for age (LW)	STWSLW	18	0.3	0.2	0.5
Stunting (ST) with low weight for age (LW)	STLW	952	16.3	15.4	17.3
Stunting only (ST)	ST	2342	40.2	38.9	41.4
Low weight for age only (LW)	LW	24	0.4	0.3	0.6
Malnutrition due to Dual Burden (MADB)	-	206	3.5	3.1	4
Stunting (ST) with overweight or obesity (OW) and low weight for age (LW)	STOWLW	7	0.1	0.1	0.3
Stunting (ST) with overweight or obesity (OW)	STOW	199	3.4	3	3.9
Stunting (ST) with overweight or obesity (OW) and high weight for age (HW)	STOWHW	0	0	0	0.1
Malnutrition due to Excess (MAE)		120	2.1	1.7	2.5
High weight for age only (HW)	HW	2	0	0	0.1
Overweight or obesity only (OW)	OW	91	1.6	1.3	1.9
Overweight or obesity (OW) with high weigh for age (HW)	OWHW	27	0.5	0.3	0.7

Table 4: Proportions and confidence limits (95%) of nutritional status categories in RGT children.

Condition	Nutritional status category	Number of children	Proportion (%)	Lower CL	Upper CL
Normal	NN	810	61.8	59.1	64.4
Malnutrition Anthropometric Index (MAI)	-	501	38.2	35.6	40.9
Malnutrition due to Deficiency (MAD)	-	450	34.3	31.8	37
Wasting only (WS)	WS	47	3.6	2.7	4.8
Wasting (WS) with low weight for age (LW)	WSLW	78	5.9	4.8	7.4
Wasting (WS) with stunting (ST) and low weight for age (LW)	STWSLW	35	2.7	1.9	3.7
Stunting (ST) with low weight for age (LW)	STLW	124	9.5	8	11.2
Stunting only (ST)	ST	146	11.1	9.5	13
Low weight for age only (LW)	LW	20	1.5	1	2.4
Malnutrition due to Dual Burden (MADB)	-	33	2.5	1.8	3.6
Stunting (ST) with overweight or obesity (OW) and low weight for age (LW)	STOWLW	0	0	0	0.4
Stunting (ST) with overweight or obesity (OW)	STOW	33	2.5	1.8	3.6
Stunting (ST) with overweight or obesity (OW) and high weight for age (HW)	STOWHW	0	0	0	0.4
Malnutrition due to Excess (MAE)	-	18	1.4	0.8	2.2
High weight for age only (HW)	HW	2	0.2	0	0.6
Overweight or obesity only (OW)	OW	12	0.9	0.5	1.6
Overweight or obesity (OW) with high weigh for age (HW)	OWHW	4	0.3	0.1	0.8

Table 5: Proportions and confidence limits (95%) of nutritional status categories in UBF children.

versus 2.0% (95% CI from 1.5% to 2.5%) in urban Guatemala as depicted by Tables 3 and 4.

The magnitude of malnutrition in Burkina Faso was slightly lower in urban children and lower in rural children than in Guatemala. The urban-rural gap was higher in Guatemala than in Burkina Faso.

In urban Burkina Faso the MAI was 38.2% with a MAD of 34.3%, a MAE of 1.4% and a MADB of 2.5%; while in rural Burkina Faso the MAI was circa 15% points higher (53.8%) with a MAD of 49.9%, and MAE and MADB of the same magnitude respectively.

Surprisingly children living in remote rural villages of bordering municipalities from El Salvador, Guatemala, Honduras and Nicaragua in 20013-2015 showed higher normal nutritional conditions with prevalence of 48.8% and 95% confidence interval from 44.0% to 53.7% (Table 2) than those living in rural areas of Guatemala 2008-2009 with prevalence of 36.8% and 95% confidence interval from 35.6% to 38.0% (Table 4).

Malnutrition conditions due to excess were higher in Central America populations (RCA, UGT and RGT) than in Burkina Faso; however malnutrition conditions due to dual burden were similar. On the other hand, malnutrition due to dual burden and excess were similar in urban and rural children in Burkina Faso.

Figures 2-6 show details of structural composition of the sub-indices of malnutrition (MAD, MAE and MADB). Figures 2-4 show predominant MAD components in RCA of three fourths (31.9%) due

Condition	Nutritional status category	Number of children	Proportion (%)	Lower CL	Upper CL
Normal	NN	2115	46.2	44.7	47.6
Malnutrition Anthropometric Index (MAI)	-	2466	53.8	52.4	55.3
Malnutrition due to Deficiency (MAD)	-	2286	49.9	48.4	51.4
Wasting only (WS)	WS	207	4.5	3.9	5.2
Wasting (WS) with low weight for age (LW)	WSLW	246	5.4	4.7	6.1
Wasting (WS) with stunting (ST) and low weight for age (LW)	STWSLW	174	3.8	3.3	4.4
Stunting (ST) with low weight for age (LW)	STLW	772	16.9	15.8	18
Stunting only (ST)	ST	800	17.5	16.4	18.6
Low weight for age only (LW)	LW	87	1.9	1.5	2.3
Malnutrition due to Dual Burden (MADB)	-	115	2.5	2.1	3
Stunting (ST) with overweight or obesity (OW) and low weight for age (LW)	STOWLW	8	0.2	0.1	0.4
Stunting (ST) with overweight or obesity (OW)	STOW	107	2.3	1.9	2.8
Stunting (ST) with overweight or obesity (OW) and high weight for age (HW)	STOWHW	0	0	0	0.4
Malnutrition due to Excess (MAE)		65	1.4	1.1	1.8
High weight for age only (HW)	HW	8	0.2	0.1	0.4
Overweight or obesity only (OW)	OW	34	0.7	0.5	1
Overweight or obesity (OW) with high weigh for age (HW)	OWHW	23	0.5	0.3	0.8

Table 6: Proportions and confidence limits (95%) of nutritional status categories in RBF children.

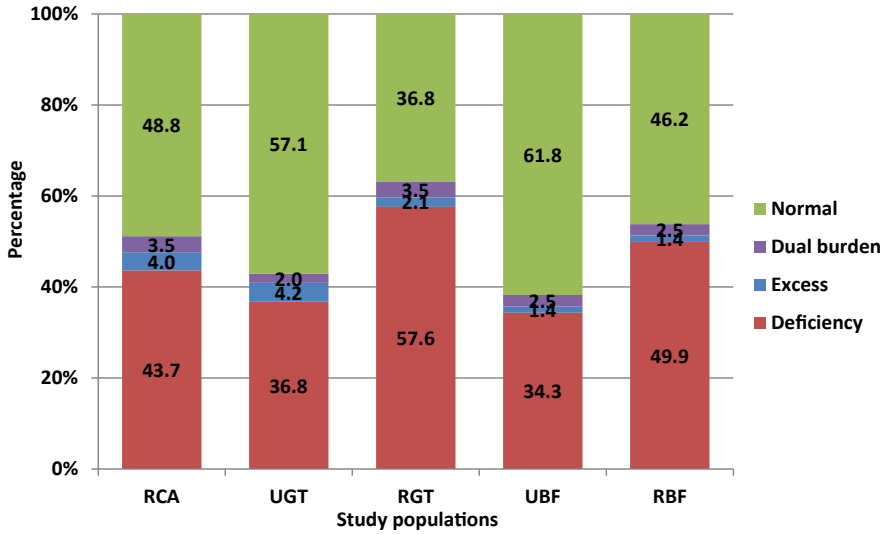

Figure 1: Classification of the nutritional status of children in rural Central America 2013-2015 (RCA), urban and rural Guatemala 2008-2009 (UGT and RGT respectively) and rural and urban Burkina Faso 2010 (UBF and RBF respectively).

to stunting alone and one fourth (10.8%) to stunting with low weight for age, in urban Guatemala three fourths (27.4%) due to stunting alone and one fourth (8.7%) to stunting with low weight for age, the MAE was 4.2%, mainly due to overweight or obesity alone (3.0%) and the MADB was 2.0%, mainly due to stunting and overweight or obesity (2.0%); and in rural Guatemala three fourths (40.2%) due to stunting alone and one fourth (16.3%) to stunting with low weight for age; the MAE was 2.1%, mainly due to overweight or obesity alone (1.6%) and the MADB was 3.5%, mainly due to stunting and overweight or obesity (3.4%).

Both MAE and MADB may become a public nutrition problem in Central America, in particular overweight or obesity alone or with stunting. The MAE were 4.0%, 4.2% and 2.1% in RCA, UGT and RGT respectively, mainly due to overweight or obesity alone (2.8%, 3.0% and 1.6% respectively); while the MADB were 3.5%, 2.0% and 3.5% respectively, mainly due to stunting with overweight or obesity (3.1%, 2.0% and 3.4% respectively).

Figures 5-6 show that the structural compositions for children in rural and urban Burkina Faso 2010 were similar but very different from those study populations in Central America. Figure 5 shows that the MAD structural composition of deficiency conditions was less predominant and complex than that observed in Central America populations.

For children in urban Burkina Faso the MAD was comprised by many malnutrition conditions. Stunting alone (11.1%), stunting with low weight for age (9.5%), wasting with low weight for age (6.0%) and wasting alone (3.6%) among others, and in rural children higher with stunting alone (17.5%), stunting with low weight for age (16.9%),

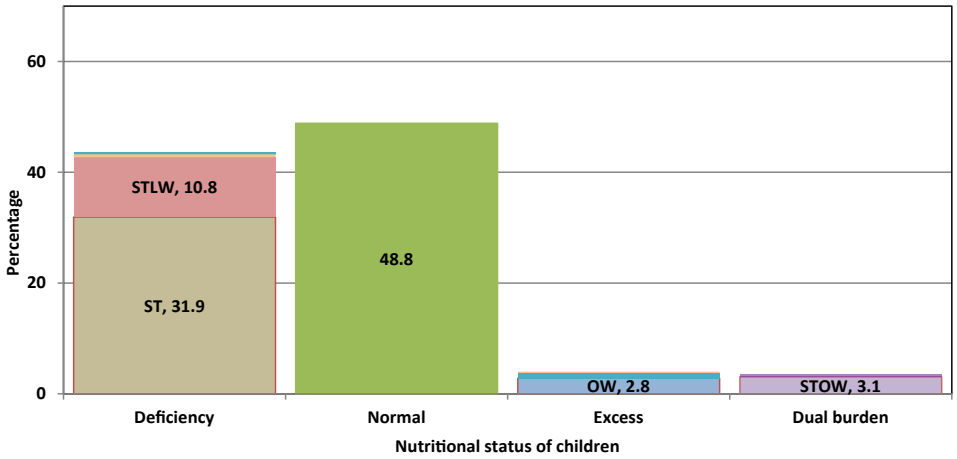

Figure 2: Classification of the nutritional status of children in rural communities of bordering territories in El Salvador, Guatemala, Honduras and Nicaragua 2013-2015.

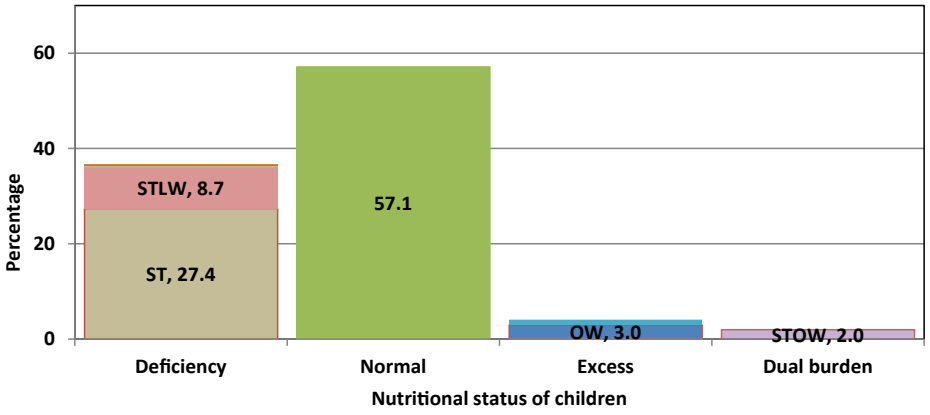

Figure 3: Classification of the nutritional status of children in urban Guatemala 2008-2009.

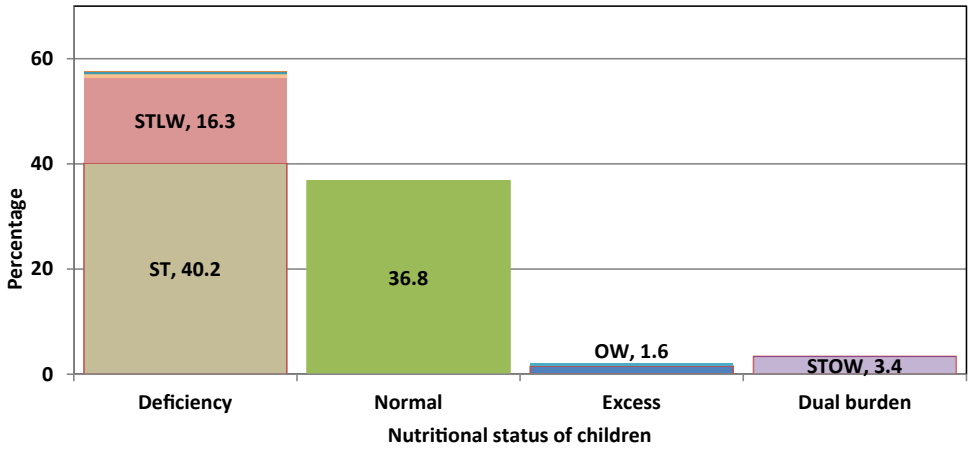

Figure 4: Classification of the nutritional status of children in rural Guatemala 2008-2009.

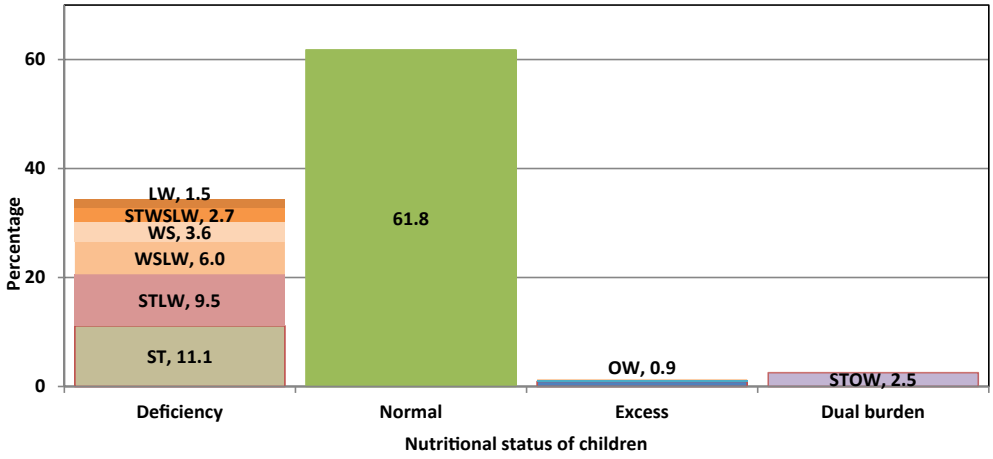

Figure 5: Classification of the nutritional status of children in urban Burkina Faso 2010.

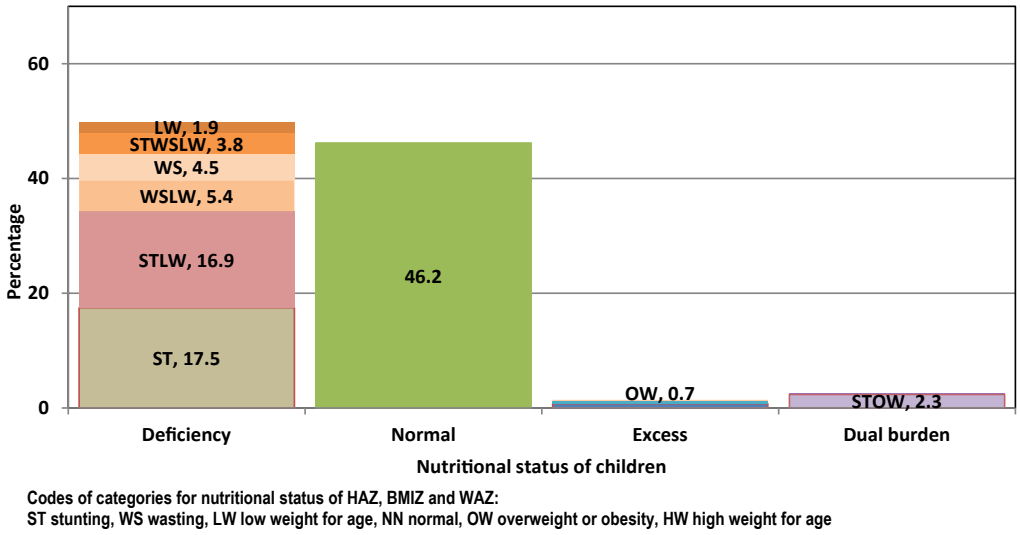

Figure 6: Classification of the nutritional status of children in rural Burkina Faso 2010.

wasting with low weight for their age (5.4%), and wasting alone (4.5%) among others.

The MAE and MADB were lower than in Central America study populations. The MAE was in urban and rural children mainly due to overweight or obesity alone (0.9% and 0.7% respectively) and the MADB due to stunting with overweight or obesity (2.5% and 2.3% respectively).

Conclusions

Malnutrition due to deficiencies as well as excess and dual burden should be assessed for a better guide to policy designers and decision makers of strategies, programmes, projects and actions with impact on the food and nutrition security of populations.

Policy-design implications for urban and rural populations may be different depending on malnutrition conditions due to deficiencies, to families of children facing dual burden stunting and overweight or obesity, and to families of children facing stunting alone to avoid overweight or obesity.

Discussion

Although we have limited our analysis to a small number of study populations for illustration purposes, this type of analysis is very useful for untangling the malnutrition assessment into deficiency, excess and dual burden in children based on traditional standardized Z scores of anthropometric indices and without adding collected information in the household surveys. For example, highlighting that urban children with higher MAE than rural children and the opposite with respect to MADB provides better knowledge for action in Guatemala.

Using the proposed approach the percentage of children in normal nutrition may be better estimated by considering malnutrition due to excess and dual burden, in particular in developing societies.

The existence of not only malnutrition due to excess but also dual

burden of malnutrition requires special attention in the kind of policies and actions needed to address emerging malnutrition problems.

Recommendations

Expand country reports in the WHO database (WHO, 2016) at including the percentages of children suffering deficiencies, excess and both using the sub-indices MAD, MAE and MADB.

Use MAI, sub-indices MAD, MAE and MADB as well as their components in the analysis of results from anthropometric surveys in children for monitoring and evaluation purposes in actions and policies with impact on food and nutrition security.

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