Adequacy of Nutrient Intakes of Severely and Acutely Malnourished Children Treated with Different Doses of Ready-To-Use Therapeutic Food in Burkina Faso

Victor Nikièma,[1,2] Suvi T. Kangas,[3] Cécile Salpéteur,[3] Abdoulaye Ouédraogo,[4] Carl Lachat,[5] Nestor H I Bassolé,[6] and Nadia F Fogny[2]

[1]Nutrition and Health Department, Action contre la Faim, Ouagadougou, Burkina Faso; [2]School of Nutrition and Food Sciences and Technologies, Faculty of Agronomic Sciences, University of Abomey-Calavi, Benin; [3]Expertise and Advocacy Department, Action contre la Faim, Paris, France; [4]Food Security and Livelihoods Department, Action contre la Faim, Ouagadougou, Burkina Faso; [5]Department of Food Technology, Safety, and Health, Faculty of Bioscience Engineering, Ghent University, Belgium; and [6]Department of Biochemistry and microbiology, Joseph KI-ZERBO University, Ouagadougou, Burkina Faso

ABSTRACT

Background: Ready-to-use therapeutic foods (RUTF) are designed to cover the daily nutrient requirements of children with severe acute malnutrition (SAM). However, with the transfer of uncomplicated SAM care from the hospital environment to the community level, children will be able to consume complementary and family foods (CFF) in addition to RUTF, and this might decrease the quantity of RUTF needed for recovery.

Objectives: Using an individually randomized clinical trial, we investigated the effects of a reduced RUTF dose on the daily energy and macronutrient intakes, the proportion of energy coming from CFF, and the mean probability of adequacy (MPA) of intake in 11 micronutrients of 516 children aged 6–59 mo who were treated for SAM in Burkina Faso.

Methods: The data were collected using a single 24-h multipass dietary recall, 1 mo after starting treatment, from December 2016 to August 2018, repeated on a subsample of 66 children. Differences between children receiving the reduced RUTF (intervention arm) and those receiving standard RUTF (control arm) were assessed by linear mixed models.

Results: Daily energy intake was lower ($P < 0.01$) in the intervention arm (mean $\pm$ SD 1321 $\pm$ 339 kcal) than in the control arm (1467 $\pm$ 319 kcal). CFF contributed to 40% of the daily energy intake in the intervention and 35% in the control arm. The MPA for 11 micronutrients was 0.89 $\pm$ 0.1 in the intervention arm and 0.95 $\pm$ 0.07 in the control arm ($P = 0.06$).

Conclusions: Reducing the dose of RUTF during SAM treatment had a negative impact on daily energy intake of the children. Despite this, children covered their recommended energy intake. The energy intake coming from CFF was similar between arms, suggesting that children's feeding practices did not change due to the reduction in RUTF in this context. This trial was registered at the IRSCTN registry as ISRCTN50039021. *J Nutr* 2021;00:1–10.

Keywords: children with severe acute malnutrition, ready-to-use therapeutic food, complementary feeding, energy and micronutrient adequacy, Burkina Faso

Introduction

Undernutrition includes stunting, wasting, and micronutrient deficiencies (1). Nearly 47 million children aged <5 y were wasted in 2019, of which 14 million were severely wasted (2). Malnutrition including wasting plays a causal role in more than half of the deaths that occur in children aged <5 y, and severe acute malnutrition (SAM) is responsible of 500,000 deaths each year (3). In addition to acute malnutrition, deficiencies in micronutrients such as vitamin A, folate, iron, and zinc are common in developing countries among young children,

resulting mainly from inadequate micronutrient intakes from poor-quality diets (1).

In Burkina Faso, malnutrition is characterized by endemicity of stunting, underweight, acute malnutrition, iodine, iron, vitamin A deficiency, and very poor food diversification in children <5 y of age. In 2016, the prevalence of global acute malnutrition was 8.5% (of which 1.7% was severe) at the national level and 8.6% (2.4% severe cases) in the East region (4). Approximately 50% of children were breastfed exclusively up to 6 mo of age in the Eastern region compared with 55% for

the national level and 88% of children started complementary feeding at the age of 6–8 mo (4).

In children 6 to 59 mo of age, SAM is defined as a mid–upper arm circumference (MUAC) <115 mm, a weight-for-height/length z-score (WHZ) <−3 (5), or the presence of bilateral edema (6). Children with SAM without medical complications at admission are treated as outpatients in the community and return to health centers 1 time per wk for treatment. SAM treatment consists of a systematic antibiotic regimen, as well as RUTF prescribed according to the weight of the child and continued until the end of treatment (5). RUTFs are highly fortified, energy-dense pastes designed to fulfil all nutritional requirements of children during the recovery from SAM, and the recommendation is to give no foods other than RUTFs and breastmilk to these children (7). However, given that the treatment is home based, sharing of food and drinks seems to occur (8) within families, and treated children might be complementing their prescribed diet with family foods. Considering this, an assessment of the effect of reducing the RUTF dose on the dietary adequacy is warranted.

In 2009 in Myanmar, a retrospective analysis was undertaken looking at a Community-based Management of Acute Malnutrition (CMAM) program that reduced the RUTF dose to 1 sachet per d once children with SAM reached moderate acute malnutrition (MAM) criteria (9). In this study, caregivers were encouraged to provide home-cooked foods to supplement the RUTF dose, to continue breastfeeding at all times, to prioritize RUTF consumption prior to these meals, and not to share RUTF with family members. The cure rate (children who reached recovery according to discharge criteria) was 90.2% (9). In 2015 in Sierra Leone, a cluster-randomized trial evaluated the effectiveness of a reduced RUTF dose once children were classified as MAM according the MUAC criterion. In this study, mothers were advised on a variety of child nutrition and health issues, including improving breastfeeding practices. Eighty-three percent of children recovered (10). These studies, however, have not assessed the nutritional contribution of complementary feeding to program outcomes or overall

nutritional intake. Reducing the dose of RUTF could be offset by undocumented family food intakes contributing to positive treatment outcomes.

This study is part of the Modelling an Alternative Nutrition Protocol Generalizable to Outpatient (MANGO) project. MANGO is a randomized controlled clinical trial testing the noninferiority of a reduced RUTF dose compared with a standard dose in the management of uncomplicated SAM in children aged 6–59 mo. The main results from the trial show that a reduced RUTF dose is not inferior to standard RUTF dose in terms of response to treatment, whether weight-gain velocity or recovery rate (11). This suggests that the 2 groups of children had similar daily energy intake or that both covered all their estimated energy requirements. However, we did find a difference in linear growth velocity between the 2 groups, which could be explained by a difference in the intake of certain micronutrients involved in growth (11). The present substudy is essentially exploratory and is designed to assess the effect of a reduced RUTF dose on the daily energy and nutrient intakes, the proportion of energy and nutrients coming from complementary feeding, and the adequacy of intake in 11 micronutrients among children treated for SAM aged 6–59 mo 1 mo after the start of SAM treatment. The primary outcome of the study is the daily energy intake of children.

Methods

Study design: the MANGO original study

The MANGO trial was performed in accordance with the principles in the Declaration of Helsinki. The research protocol was approved by the national ethics committee (Comité d'éthique pour la Recherche en Santé) and the clinical trials board (Direction Générale de la Pharmacie, du Médicament et des Laboratoires) of Burkina Faso and was registered at the IRSCTN registry (http://www.isrctn.com/ISRCTN50039021). At the time of registration, the aim of the dietary intake substudy was to estimate energy intake and dietary diversity. In this paper we focus on energy and nutrient intakes. The findings on dietary diversity will be presented separately.

The MANGO study was conducted in the Fada N'Gourma health district, 220 km from the capital, Ouagadougou, in the Eastern region of Burkina Faso, where the prevalence of wasting (WHZ <−2) was 10% in 2016 (4) and coverage for SAM treatment was estimated at 48% in 2014 (12). The health district of Fada N'Gourma was in a balanced cereal production situation during the 2014–2015 agricultural season, with a cereal-needs coverage of 97% (13). Study participants were recruited from children presenting with SAM at the 10 participating health centers. A total of 802 SAM children 6–59 mo of age were enrolled according to the admission criteria as defined by national and WHO protocols (MUAC <115 mm and/or WHZ <−3) (5, 14). These children successfully passed the appetite test and did not have medical complications or bilateral pitting edema. After eligibility was confirmed and parental consent was obtained, children were randomly assigned individually in each of the 10 health centers to reduced RUTF dose or standard RUTF dose. Thus, the children were randomly assigned into 2 arms in each of 10 health centers: the intervention group, which received the reduced dose of RUTF, and the standard arm, which received the standard dose of RUTF. The team leader gave each child a unique identifier, and only the food distributor had access to the codes for distributing the correct RUTF dose. Other team members who made decisions about a child's recovery, referral, and clinical status did not have access to the random assignment list.

SAM treatment followed the Burkina national CMAM guidelines (14) except for the RUTF dose: from the third treatment week onward, 402 children were randomly assigned to the intervention arm and received either 1 or 2 sachets per d if they weighed <7 kg or ≥7 kg, respectively. A sample of 400 children were randomly assigned to the control arm and received the standard RUTF dose throughout

TABLE 1 Number of RUTF sachets per week in reduced and standard dose groups in MANGO trial[1]

| | Sachets/wk | | | Reduction of RUTF dose (%) |
| | Standard RUTF dose | Reduced RUTF dose | | |
Weight (kg)	Admission to discharge	Week 1–2	Week 3 to discharge	From week 3 to discharge
3.0–3.4	8	8	7	13
3.5–4.9	10	10	7	30
5.0–6.9	15	15	7	53
7.0–9.9	20	20	14	30
10.0–14.9	30	30	14	53

[1]Table from previous publication (11). MANGO, Modelling an Alternative Nutrition Protocol Generalizable to Outpatient; RUTF, ready-to-use therapeutic foods.

treatment (Table 1) (11). All admitted children received 7 d of amoxicillin at admission and children ≥12 mo of age received albendazole at the second treatment visit. In addition, children who were not up to date with their immunization schedule were referred to health workers at the health center for catch-up, and vitamin A supplementation campaigns were organized every 6 mo. Children were treated until they reached the discharge criteria, and recovered children were followed up every 2 weeks for 12 weeks after discharge.

At admission, data were collected about the sociodemographic characteristics, anthropometry, and 2-wk retrospective morbidity of the child and a clinical examination was performed. Anthropometric data were collected in duplicate and concerned weight, length (in children <2 y old), height (in children >2 y old), and MUAC, as previously described (11). In this paper, we have used height to refer to both length and height. The Household Food Insecurity Access Scale (HFIAS) was assessed at admission for the past 4 wk (15). Weekly treatment visits consisted of a clinical examination and anthropometric measurements to follow the child's health and nutritional status and declare recovery when the child met the predefined anthropometric criteria without illness. Per national SAM treatment protocol, key messages were delivered to all mothers/caregivers irrespective of study arm at every weekly visit. These messages included recommendations not to share the RUTF with other members of household, not give complementary food to the child if he/she was still hungry after eating the RUTF, and not to give breastmilk at all times on demand. Research teams were responsible for treating the children and collecting data in the 10 health centers each week.

Sample for the dietary intake survey

The dietary intake study started 2 mo after launch of the main study. The substudy was nested within the main trial and took place 1 mo after the admission of the children to the treatment, precisely at visit 4 and/or 5. The substudy followed the same randomized controlled design, except it was not bound to the noninferiority principle. Every child included in the MANGO study was eligible for the dietary intake study in the same arm if he was still in treatment at the time of the 24-h multipass dietary recall (24HDR; visits 4 and/or 5). The children who were discharged (recovered, defaulted, death, referral) were not eligible for a 24HDR because they were no longer subject to random assignment and allocation of the amount of RUTF according to the arm. Also, the children discharged before the 24HDR period (visit 4 and/or 5) or children who did not receive the RUTF treatment during the 24HDR period (absent consecutively at visits 4 and 5) were not eligible for the substudy, in order to avoid potential bias due to the nonconsumption of RUTF. A total of 527 children (66% of the MANGO main study sample) were included in this study and were considered for the 24HDR, including 11 children who were excluded for surveys carried out after discharge (5 in the reduced RUTF and 6 from the standard RUTF) (**Supplemental Figure 1**).

Dietary intake assessment

Data on children's food intake were collected using a single 24HDR (16) at week 4 or 5 (if caregiver was not available at week 4), matched with

weekly visit days Monday to Friday, from December 2016 to August 2018. A second nonconsecutive 24HDR was repeated with a subsample of 12.5% (66 recalls) for the probability of micronutrient adequacy (PA) and overall mean probability of micronutrient adequacy (MPA) (17).

The 24HDR was conducted as a face-to-face interview. The trained investigators asked caregivers to recall and describe all foods and beverages consumed by their child during the previous 24 h as well as all the ingredients of each food. In practice, 1 wk before the recall, the investigators distributed standard bowls to caregivers and encouraged them to follow the child's diet before the next visit and to memorize the amount of each food item consumed. The investigators used the standard bowls with other common kitchen utensils (scoop, cup, spoon, etc.) to help quantify the different foods the child consumed. The foods consumed, their volume in household units, and the ingredients used in the preparation were noted and recorded together with the number of RUTF sachets consumed. The average recipe method (16) was used to convert amounts consumed from household units to grams. For this, each food recipe was prepared by at least 3 mothers/caregivers who participated in the 24HDR in the presence of the investigators. During the preparation, the weight of each ingredient before cooking and the final weight of the cooked food were measured by the investigators. Weight was measured with a TANITA KD electronic kitchen scale (model KD-400SV, Tanita Corporation, precision 1 g, maximum load 5 kg). The study was not able to quantify the amount of breastmilk consumed because a reliable quantification requires sophisticated methods such as isotopes. This was beyond the scope of our study. Nonetheless, we recognize that this lack would affect our findings.

Data analysis

All preparation and statistical analyses were performed using Stata 15 (Stata Corp.). Rainy season was defined as June to October and dry season as November to May. Morbidity was defined as the presence of fever and/or diarrhea during the last wk. A safe source of drinking water was defined as water from taps, boreholes, and protected wells. The urban living environment was defined as the caregivers/mothers living <30 min from the town of Fada on foot. Caregivers/mothers were considered to have formal education when they had at least attended formal primary school. Anthropometric z-scores were calculated using the 2006 WHO growth standards (18). Three household food security categories were created from the HFIAS scores: food secure, mildly food insecure, and moderately or severely food insecure (15). CFFs were foods consumed by children outside of RUTF. These foods were either prepared at the children's homes or purchased by family caregivers.

Foods consumed were converted to nutrients using a food composition database (FCDB) compiled for the study from 3 sources: the FCDB developed contained 162 food components, 82% of which came from the West African Food Composition Table (19), 15% from the Burkina Faso Table (20), and 3% from the manufacturing labels on the food products. The dietary recalls and the compiled FCDB were entered into Lucille software (Ghent University) to calculate individual nutrient intake. In the FCDB, the vitamin A content of a food was expressed in retinol activity equivalents, taking into account the content

of retinol, β-carotene, and other carotenoids (21). To account for the bioavailability of nutrients such as calcium, iron, and zinc, we applied coefficients to estimate intake. For iron bioavailability, we applied 5% absorption according to the WHO and FAO recommendations for developing countries for diets typically based on plant foods (22). For calcium bioavailability, we applied 25% for grains, roots, tubers, and legumes, 45% for fruits and vegetables, and 32% for other foods (23). For zinc bioavailability, we applied 25% on the basis of an unrefined cereal-based diet (24).

Intake distributions were generated by using the Multiple Source Method (25) on the basis of 1 dietary recall per child for energy, macronutrient, and micronutrient intake and 2-d recall for adequacy of 11 micronutrient intakes. No covariate was added to the model. First, the nutrient intakes, which were skewed, were transformed to approximate normal distribution using a Box-Cox transformation for energy and each nutrient. Then, the within- and between-person variances were calculated for the transformed intake variables. Finally, using these variances, the best linear unbiased predictor (BLUP) of the intake for each nutrient and for each child was calculated. The BLUP were also used to calculate the probability of adequacy for each of 11 key micronutrients: vitamin A, vitamin C, thiamin, riboflavin, niacin, vitamin B-6, vitamin B-12, folate, zinc, calcium, and iron (26–29).

The PA of micronutrient intake was assessed using the estimated average requirements (EAR) approach (17, 30). The EAR was back calculated from recommended nutrient intake (RNI) of children with MAM proposed by Golden (31) using RNI = EAR + 2SD (17). During the 24HDR, approximately 80% of the children had reached MAM status. Thus, we used the RNIs for MAM children that have been proposed by Golden (31). Using the RNIs proposed by the WHO/FAO (17, 22), which concern healthy children, the micronutrient adequacy might be overestimated because these estimates for healthy children are lower than those for MAM children. The SD was calculated using the CV of the requirements and the EAR, as SD = CV × EAR/100 (17). The CV was 12.5% for Zn (24); 15% for niacin; 10% for vitamins C, B-6 and B-12, thiamin, riboflavin, niacin, and folate; and 20% for vitamin A (17, 22, 30) and Ca (32). The PA for each nutrient (x) was calculated by the algorithm:

$$PA\ (x)\ =\ NORM[\tfrac{estimated\ child\ intake\ (x)-EAR(x)}{SD(x)}]$$ (17, 30), in which NORM is the statistical function in STATA software that calculates the probability that a child's intake is above the EAR and SD(x) = $\sqrt{Vr\ +\ (Vwithin/n)}$; ($n$ = number of repeated recall, n = 2); V_r denotes the variance of the distribution of requirements in the group; and V_{within} denotes the variance in day-to-day intakes of the nutrient. Both variances are computed as the square of the corresponding SD for nutrient (x). The MPA for each child was averaged from the PA for the 11 micronutrients in the analysis, ranging from 0 to 1. The mean PA per child and mean MPA for all children were then calculated based on 2-d 24HDR.

Statistical analysis

The baseline characteristics of the study population were summarized as percentages and means ± SDs. The analyses for daily energy intake were done both by intention to treat and per protocol in accordance with the analysis recommendations for non inferiority randomized clinical trials (33, 34). The proportion of energy coming from complementary feeding, as well as the PA and MPA, were presented by intention-to-treat only. A significance level of 5% was used to determine statistical significance for all analyses. The data analyzed in the intention to treat concerned 516 children, including 243 in the reduced RUTF and 273 in the standard RUTF dose. Per protocol was defined here as the children who were correctly randomly assigned in the initial arm. Thus, 16 children, 7 from the intervention arm and 9 from the standard arm, were excluded from the per protocol analyses for allocation not in accordance with the initial groups.

Differences between intervention and control arms were assessed using mixed linear model with study site (health center) as a random effect. Unadjusted and adjusted models for sex, age, weight, breast-feeding status, morbidity, caregiver's education level, urban compared with rural setting, and food security status were used to estimate differences between daily energy and macronutrients intakes. The differences in energy and macronutrient intakes by source (RUTF and complementary feeding) between intervention and control arms were estimated only with the adjusted model. For PA and MPA separate results were obtained with and without adjusting for total energy intake. Data are reported as means ± SDs or proportions (%).

Results

Children's characteristics at enrolment and at recall

At admission into the MANGO study, children's mean age was 13 mo; 52% were girls, mean weight was 6 kg, and 87% were breastfed. Mothers/caregivers were, on average, 28 y of age; 76% had no formal education. Up to 85% of households were categorized as food secure. Approximately 58% of children were stunted at admission. At the time of the 24HDR, the mean age of children was 14 mo and nearly 90% of them were >2 y old, mean weight was 7.0 kg, and 85% of children were still breastfed. SAM was still present in <20% of children at the 24HDR time, with most already classified as having MAM. There were no differences in anthropometric and other characteristics between children receiving the reduced and standard RUTF dose at admission and at the time of the dietary assessment (Table 2).

Energy and macronutrient intakes

Daily energy and macronutrient intakes were significantly different ($P < 0.01$) between the 2 arms in both unadjusted and adjusted models for sex, age, weight, breastfeeding status, morbidity, caregiver's educational level, urban compared with rural setting, and food security status (Table 3). Children receiving the reduced RUTF had lower energy and nutrient intakes compared with those receiving the standard RUTF. The energy balance between proteins, carbohydrates, and fats intakes in the 2 groups of children was within the recommended range according to the acceptable macronutrient distribution range (30). The 2 groups of children covered their recommended energy intake: 157% for reduced RUTF dose and 182% for standard dose.

Contribution of CFF to daily energy and nutrient intakes

Concerning the source of intake, there were no significant differences in energy or macronutrient intakes from CFF between the 2 groups of children ($P > 0.05$). The family diet contributed considerably more to energy intake than micronutrient intake. More than a third of the energy came from family diet in the 2 groups of children: nearly half of the total carbohydrate intake and <20% of total lipid intake. CFF contributions to micronutrient intake varied from 2% to 25%: For total daily intakes, iron, zinc, and vitamin A represented 2% to 5%; riboflavin and vitamin B-12 intakes 6% to 10%; calcium, thiamine and folate intakes of 10% to 20%; and niacin and vitamin B-6 intakes represented 20% to 25% (Table 4).

Probability of adequacy of micronutrient intake

The intake of all 11 measured micronutrients was significantly lower among children in the reduced RUTF dose arm than among those in the control arm. Unadjusted MPA was lower for children receiving a reduced RUTF dose and those receiving a standard dose ($P = 0.01$). When controlling for energy intake, the MPA did not differ more between children receiving

TABLE 2 Characteristics of children with severe acute malnourished aged 6–59 mo at admission and during the 24HDR (n = 516)[1]

	Characteristics of children					
	At admission			During 24HDR (1 mo after admission)		
Variables	Reduced RUTF (n = 243)	Standard RUTF (n = 273)	P value	Reduced RUTF (n = 243)	Standard RUTF (n = 273)	P value
Age, mo	13.2 ± 8.5	13.3 ± 8.6	0.87	14.2 ± 8.5	14.3 ± 8.6	0.92
Children age range, % (n)						0.64
6–11 mo, % (n)				53.5 (130)	54.2 (148)	
12–23 mo, % (n)				36.6 (89)	33.7 (92)	
24–59 mo, % (n)				9.88 (24)	12.1 (33)	
Girls, % (n)	52.3 (127)	53.8 (147)	0.72			
Morbidity, % (n)	48.6 (118)	52.4 (143)	0.39	15.6 (38)	20.9 (57)	0.13
Breastfeeding, % (n)	87.7 (213)	86.8 (237)	0.78	85.2 (207)	84.6 (231)	0.86
Weight, kg	6.24 ± 1.20	6.24 ± 1.37	0.96	6.97 ± 1.33	6.99 ± 1.48	0.83
Height, cm	69.2 ± 7.32	69.2 ± 8.05	0.99	70.3 ± 7.2	70.3 ± 7.9	0.99
MUAC, mm	113 ± 6.38	113 ± 6.86	0.72	123 ± 7.08	123 ± 8.10	0.60
WHZ	− 3.08 ± 0.69	− 3.06 ± 0.69	0.77	− 2.13 ± 0.76	− 2.08 ± 0.84	0.51
Height for Age, Z-score	− 2.31 ± 1.24	− 2.35 ± 1.32	0.74	− 1.87 ± 1.23	− 1.90 ± 1.32	0.74
WAZ	− 3.48 ± 0.75	− 3.50 ± 0.83	0.77	− 2.58 ± 0.81	− 2.57 ± 0.89	0.92
Stunted, % (n)	59.3 (144)	57.1 (156)	0.63			
Mothers/caregiver's age, y	28.1 ± 7.27	27.2 ± 7.48	0.18			
Mothers, no formal education, % (n)	76.5 (186)	74.0 (202)	0.50			
Residence, Urban, % (n)	17.3 (42)	15.4 (42)	0.56			
Open defecation, % (n)	74.9 (182)	75.5 (206)	0.88			
Access to safe source of drinking water, % (n)	86.4 (210)	83.5 (228)	0.36			
HFIAS category, % (n)			0.76			
Food security, % (n)	84.4 (205)	86.4 (236)				
Mild food insecurity, % (n)	11.9 (29)	9.89 (27)				
Moderate and severe food insecurity, % (n)	3.70 (9)	3.66 (10)				
Recall during rainy season, % (n)				39.5 (96)	38.5 (105)	0.81
SAM at recall, % (n)				17.7 (43)	20.5 (56)	0.42

[1]Data are means ± SDs unless otherwise indicated. HFIAS, Household Food Insecurity Access Scale; MUAC, mid-upper arm circumference; RUTF, ready-to-use therapeutic food; SAM, severe acute malnutrition; WAZ, weight-for-age z-score; WHZ, weight-for-height z-score; 24HDR, 24-h dietary recall.

a reduced RUTF dose and those receiving a standard dose (P = 0.06) (Table 5). The PAs of iron, vitamin A, thiamin, riboflavin, folates, and vitamin B-12 were significantly different between the groups for the 2 models (unadjusted and adjusted by energy intake). In the adjusted model the PAs of calcium, zinc, vitamin C, niacin, and vitamin B-6 did not differ (P > 0.05) between children receiving a reduced or standard RUTF dose. Only the PA of niacin was <70% in reduced RUTF. PAs of calcium and vitamin B-6 were between 70% and 80% in reduced RUTF. The PA of vitamin A in reduced RUTF was between 80% and 90%. PAs of calcium, niacin, and vitamin B-6 were between 80% and 90% in the standard RUTF arm. Other micronutrients had adequacy between 90% and 100% in the 2 groups.

Discussion

This study was the first to assess the diet of children with SAM under RUTF treatment. The primary outcome of the present analysis was the daily energy intake of children. The reduction in the dose of RUTF had a negative impact on the daily energy intake. The difference in total energy intake came from the difference in the consumption of RUTF between the 2 groups: children who received the standard RUTF had a daily difference of 160 kcal in energy intake compared with those who received the reduced RUTF dose. The difference in the dose of RUTF prescribed was not equivalent to the difference in energy intake

(160 kcal), which corresponded to one-third of the sachet of RUTF. This difference in the energy intake also suggests that the 2 groups of children did not consume their full amount of prescribed RUTF.

The MANGO study previously showed a significant difference in weight gain velocity after week 2 of treatment: 2.3 g·kg⁻¹·d⁻¹ with reduced RUTF compared with 2.7 g·kg⁻¹·d⁻¹ with standard RUTF (11). The difference in daily energy intake observed between the 2 arms could explain the difference in weight gain velocity observed after reducing the RUTF dose starting from the third week of treatment.

The energy intake observed in the current study is higher than that reported among MAM children in Burkina Faso in a cash transfer program (35) and in nonmalnourished children of similar age in different contexts (20, 26). This higher energy intake is probably driven by the nutritional needs for the rapid catch-up growth during recovery from SAM and the consumption of RUTFs that are very energy dense. Also, in this study, RUTF was the main source of energy, contrary to previous studies in which children did not receive therapeutic foods, but mainly CFF, which contained less energy than RUTF. In this study, RUTF alone provided 794 kcal of energy in children receiving the reduced dose and 955 kcal for those receiving the standard RUTF dose, which roughly matches the estimated energy requirements of normally nourished children <2 y of age. CFF contributions of ≥500 kcal are considerable in both groups, especially considering that according to the current recommendations, children are supposed to consume

TABLE 3 Total daily energy and nutrient intakes among children aged 6–59 mo receiving a reduced or standard RUTF dose during outpatient SAM treatment (*n* = 516)[1]

			Total daily energy and macronutrient intakes			
			Unadjusted		Adjusted[2]	
Outcomes	Reduced RUTF (*n* = 243)	Standard RUTF (*n* = 273)	Difference (95% CI)	*P* value	Difference (95% CI)	*P* value
Energy, kcal/d						
ITT	1321 ± 339	1467 ± 319	−150 (−204, −96)	<0.001*	−148 (−194, −101)	<0.001*
PP	1316 ± 336	1468 ± 319	−157 (−212, −102)	<0.001*	−157 (−204, −110)	<0.001*
RNI[3] for MAM	673[4]/958[5]/1242[6]					
Protein						
ITT, g/d	39.0 ± 10.8	42.9 ± 9.59	−4.06 (−5.75, −2.37)	<0.001*	−3.95 (−5.47, −2.42)	<0.001*
Energy, %	11.8	11.7	0.08 (−0.10, 0.25)	0.39	0.09 (−0.08, 0.26)	0.32
AMDR,[7] min, max	5.00, 20.0					
Carbohydrates						
ITT, g/d	159 ± 46.4	171 ± 43.3	−13.7 (−20.9, −6.45)	<0.001*	13.5 (−19.8, −7.23)	<0.001*
Energy, %	47.8	46.5	1.24 (0.49, 1.99)	<0.001*	1.21 (0.46, 1.95)	<0.001*
AMDR,[7] min, max	45.0, 65.0					
Fats						
ITT, g/d	58.1 ± 15.4	66.7 ± 14.4	−8.65 (−11.2, −6.12)	<0.001*	−8.48 (−10.8, −6.20)	<0.001*
Energy, %	39.8	41.1	−1.28 (−1.98, −0.57)	<0.001*	−1.26 (−1.95, −0.56)	<0.001*
AMDR,[7] min, max	30.0, 40.0					

[1] Data are means ± SDs or proportion (%) unless otherwise indicated. *Significant difference with *P* < 0.01. AMDR, acceptable macronutrient distribution range for normal children; ITT, intention to treat; PP, per protocol; RNI, recommended nutrient intake for MAM children (31); RUTF, ready-to-use therapeutic-food; SAM, severe acute malnutrition.
[2] Analyzed by using mixed linear model with study site as random effects and adjusting for sex, age, weight, breastfeeding status, morbidity, caregiver's educational level, urban compared with rural setting, and food security status.
[3] RNI of energy for moderate acute malnutrition children proposed by Golden (31).
[4] For children aged 6–11 mo.
[5] For children aged 12–23 mo.
[6] For children aged 24–36 mo.
[7] AMDR from Institute of medicine (30).

only RUTF. Energy intakes therefore exceeded the nutritional recommendations for children.

The energy and macronutrients intakes in the 2 groups were above the RNIs proposed by Golden (31) for children with MAM, which were from 673 to 1242 kcal for energy and between 17 and 32 g/d for protein in children aged 6–59 mo (31).The 2 groups of children covered their RNI. When considering the energy coming from RUTF only, children receiving the standard RUTF covered fully their RNI (123%), whereas those receiving the reduced RUTF dose reached only 92% coverage. CFF enabled the reduced RUTF dose group to cover its RNI. We observed a considerable contribution of CFF to daily energy intake and macronutrient intakes in the 2 groups of children: CFF contributed 40% of daily energy intake in children receiving the reduced RUTF compared with 35% in children receiving the standard RUTF dose. Also, CFF contributed ∼40% of the daily protein intake in the 2 groups: 50% of daily carbohydrate intake and >18% of daily lipids intake. This strong contribution demonstrates that during the treatment of children with SAM, the caregivers/mothers continued to give complementary and family foods to their children. The nondifference observed in energy intake from CFF in both groups shows that children's feeding practices did not change despite the reduction in the RUTF dose. This could be explained by the fact that the majority of households were food secure. The reality was that children on RUTF treatment did not match with the recommendation not to give any other food besides RUTF. Caregivers tried to vary their diet during treatment beyond RUTF, which remained the main food.

When adjusted for the difference in energy intake, the MPAsno longer differed among the 2 arms. This indicates that the difference in micronutrient intake is predominantly carried by the difference in quantity of energy and not a difference in quality of diet. In addition, CFF contributed <10% of the intakes in zinc, vitamin A, vitamin C, and riboflavin; between10% and 20% of the intakes in calcium, thiamine, folate, and vitamin B-12; and between 20% and 30% of the intakes of niacin and vitamin B-6 in the 2 groups of children. However, the MPA of both groups of children was higher than the MPA reported in previous studies on nonmalnourished children due to the high contribution of RUTF to the micronutrient intake of treated children (20, 26). The coverage of recommended energy intake combined with a similar overall micronutrient adequacy could partly explain the similar programmatic results (weight and MUAC gain velocity, recovery proportion, and length of stay in treatment) previously found in the MANGO study (11). Nevertheless, the significant differences between arms for intake and probability of adequate intake of iron, vitamins C and B-6, folate, and vitamin B-12 could explain the previous observation of a lower hemoglobin concentration at discharge among children in the reduced dose arm (36).

In the present study, the PAs of vitamin A and iron were lower compared with those of other micronutrients. This corroborates our previous findings. We previously reported a high rate of anemia (55%), iron deficiency (35%), and vitamin A deficiency (9%) at the end of treatment in both groups (36). This shows that deficiencies persist and remain unresolved during treatment and suggests that there

TABLE 4 Contribution of CFF to daily energy and nutrient intakes among children aged 6–59 mo receiving a reduced or standard RUTF dose during outpatient SAM treatment (n = 516)[1]

Outcomes	Nutrient intakes from CFF source				Contribution of CFF source to daily nutrient intakes, %			
	Reduced RUTF (n = 243)	Standard RUTF (n = 273)	Difference[2] (95% CI)	P value	Reduced RUTF (n = 243)	Standard RUTF (n = 273)	Difference[2] (95% CI)	P value
Energy, kcal/d	533 ± 237	511 ± 200	21.1 (−11.2, 53.3)	0,20	39.8	34.6	5.13 (3.27, 6.98)	<0.001*
Protein, g/d	17.6 ± 9.42	17.0 ± 7.66	0.59 (−0.76, 1.94)	0,39	43.4	38.7	4.80 (2.53, 7.07)	<0.001*
Carbohydrates, g/d	86.1 ± 39.0	82.5 ± 35.2	3.05 (−2.44, 8.54)	0,28	52.9	46.9	5.94 (3.92, 7.95)	<0.001*
Fats, g/d	12.1 ± 9.04	11.6 ± 6.55	0.65 (−0.63, 1.93)	0,32	20.4	17.5	3.02 (1.17, 4.88)	0.001*
Available calcium,[3] mg/d	93.3 ± 116	91.1 ± 102	1.55 (−16.2, 19.3)	0,86	12.7	10.8	1.80 (−0.21, 3.80)	0.08
Available iron,[3] mg/d	0.56 ± 0.51	0.51 ± 0.48	0.04 (−0.04, 0.12)	0,29	3.16	2.49	0.66 (0.19, 1.12)	0.005*
Available zinc,[3] mg/d	0.78 ± 0.46	0.74 ± 0.40	0.04 (−0.03, 0.11)	0,27	4.16	3.38	0.77 (0.37, 1.17)	<0.001*
Vitamin A, μg RAE/d	91.3 ± 337	66.3 ± 85.1	25.1 (−15.6, 65.8)	0,23	4.60	3.73	0.86 (−0.37, 2.09)	0.17
Vitamin C, mg/d	9.82 ± 23.8	7.10 ± 7.66	2.70 (−0.19, 5.60)	0,07	5.85	4.45	1.37 (0.22, 2.52)	0.020*
Thiamin, mg/d	0.27 ± 0.12	0.26 ± 0.11	0.01 (−0.01, 0.03)	0,39	15.5	13.1	2.43 (1.38, 3.48)	<0.001*
Riboflavin, mg/d	0.28 ± 0.30	0.27 ± 0.22	0.01 (−0.04, 0.05)	0,71	7.50	6.36	1.15 (0.23, 2.07)	0.01*
Niacin, mg/d	3.61 ± 2.54	3.26 ± 2.05	0.36 (−0.01, 0.74)	0,06	25.1	20.3	4.83 (2.70, 6.96)	<0.001*
Vitamin B-6, mg/d	0.33 ± 0.27	0.31 ± 0.21	0.02 (−0.02, 0.06)	0,34	22.0	18.5	3.52 (1.49, 5.54)	0.001*
Folate, μg/d	67.8 ± 78.3	61.6 ± 60.4	6.34 (−5.09, 17.8)	0,28	12.7	10.2	2.42 (0.64, 4.20)	0.008
Vitamin B-12, μg/d	0.41 ± 0.67	0.45 ± 0.72	− 0.03 (−0.15, 0.09)	0,60	9.60	9.05	0.56 (−1.49, 2.62)	0.59

[1] Data are means ± SDs unless otherwise indicated. CFF, complementary and family foods; RAE, retinol activity equivalents; RUTF; ready-to-use therapeutic foods; SAM, severe acute malnutrition.

[2] Analyzed by using mixed linear model with study site as random effects and adjusting for sex, age, weight, breastfeeding status, morbidity, caregiver's education, urban compared with rural setting, food security status, and season of interview.

[3] To calculate nutrient intake, we applied coefficient of bioavailability for calcium, zinc, and iron. For calcium, we applied 25% for grains, roots, tubers, and legumes, 45% for fruits and vegetables and 32% for other foods (23). For zinc bioavailability, we applied 25% on the basis of an unrefined cereal-based diet (24). For iron, we used the low bioavailability assumption of 5% (22).

*Significant difference with P < 0.05.

is potentially a need to revise the level of fortification of RUTF for certain micronutrients including vitamin A, iron, and zinc or to test complementary approaches to ensure that children recover a normal micronutrient status. Regarding the family diet, the messages must be more oriented toward the consumption of more diversified foods that will contribute to the intake of micronutrients beyond the intake of energy.

The lower micronutrient intakes for all 11 micronutrients and the lower PAs reported for zinc, iron, and vitamin A in children with reduced RUTF could explain the previous lower length gained in children receiving reduced RUTF (11). Combined zinc and iron supplementation appear to have a modest effect on the linear growth of deficient populations (37). The positive effect on growth seems particularly clear among initially stunted subjects, such as those included in the current trial, supplemented with zinc and iron or zinc, iron, and vitamin A (38).

This study was done in a context of somewhat stable food security with a complete research team that gave awareness messages and administered appropriate care to children. The stable food security status of households could explain the high contribution of family food to total daily energy and nutrient intakes. The study covered a full 2 y, taking into account both seasons (dry and rainy) in terms of food availability and variety. This allows data to be generalized throughout the year. The study was done with 85% of the children still breastfed; however, we were unable to quantitatively assess the nutritional intake from breastfeeding. Thus, breastfeeding was not taken into account in the energy and nutrient intakes, which could be underestimated. Despite the fact that there was a similar proportion of children being breastfed in the

2 groups of children, we could expect a greater contribution of energy and nutritional intakes from breast milk in children receiving reduced RUTF, which would further increase their daily energy and nutritional intakes. In addition, about 90% of the children who participated in the study were under 2 y old, which limits generalization to malnourished children over 2 y old. Another limitation to this study is that the adequacy in 11 micronutrients intakes was estimated in only 12.5% of study children due to the availability of double 24HDR and limits generalization to all children. The use of RNI for MAM children to calculate probability of adequacy of micronutrient may underestimate or overestimate the present study EAR of the children because the requirements of malnourished children are not well known, and more research work could better estimate the needs of moderately and severely malnourished children. Another limitation of this study is that we did not apply retention factors due to cooking; this could lead to an overestimation on the intake of vitamins A, C, thiamine, and folate, which are very sensitive to some culinary processes.

In conclusion, reducing the dose of RUTF during SAM treatment had a negative impact on total energy intake. Despite this, the children covered their recommended energy intake. The overall micronutrient adequacy appears to be similar between the 2 groups of children. The energy intake coming from family foods was similar between arms, suggesting that children's feeding practices did not change due to the reduction in RUTF. Complementary foods contribute significantly to the energy and nutrient intake of children with SAM regardless of the RUTF dose they receive. These results suggest that children with SAM under RUTF treatment continue to consume family food in their household. Thus, the recommendation to

TABLE 5 Total micronutrient intakes, PA, and overall mean PA among children receiving a reduced or standard RUTF dose during outpatient SAM treatment (n = 66)[1]

| | | Total daily intake (mean for 2 recalls) | | Probability of adequacy | | | | | |
| | | | | Unadjusted[2] | | | | Controlling for energy | |
Outcomes	EAR[3]	Reduced RUTF (n = 32)	Standard RUTF (n = 34)	Reduced RUTF (n = 32)	Standard RUTF (n = 34)	Difference (95% CI)	P value	Difference (95% CI)	P value
Available calcium,[4] mg/d	400 ± 80.0	623 ± 177	750 ± 157	0.79 ± 0.20	0.89 ± 0.14	−0.11 (−0.19, −0.03)	0.01*	−0.08 (−0.16, 0.00)	0.06
Available iron,[4] mg/d	10.0 ± 1.00	17.4 ± 3.97	21.0 ± 3.68	0.91 ± 0.14	0.97 ± 0.05	−0.06 (−0.11, −0.01)	0.02*	−0.05 (−0.10, −0.00)	0.04*
Available zinc,[4] mg/d	8.70 ± 2.20	18.3 ± 4.18	22.1 ± 3.91	0.95 ± 0.09	0.98 ± 0.04	−0.04 (−0.07, −0.00)	0.03*	−0.03 (−0.06, 0.00)	0.06
Vitamin A, μg RAE/d	0.91 ± 0.18	1.46 ± 0.33	1.76 ± 0.31	0.85 ± 0.17	0.93 ± 0.11	−0.08 (−0.15, −0.02)	0.01*	−0.07 (−0.14, −0.00)	0.04*
Vitamin C, mg/d	50.0 ± 5.00	135 ± 36.5	162 ± 30.4	0.99 ± 0.03	1.00 ± 0.01	−0.01 (−0.02, −0.00)	0.03*	−0.01 (−0.02, 0.00)	0.07
Thiamin, mg/d	0.60 ± 0.10	1.64 ± 0.37	1.99 ± 0.35	1.00 ± 0.01	1.00 ± 0.00	−0.00 (−0.00, −0.00)	0.005*	−0.00 (−0.00, −0.00)	0.03*
Riboflavin, mg/d	1.00 ± 0.10	3.44 ± 0.83	4.18 ± 0.78	1.00 ± 0.00	1.00 ± 0.00	−0.00 (−0.00, −0.00)	0.002*	−0.00 (−0.00, −0.00)	0.01*
Niacin, mg/d	9.20 ± 1.40	12.6 ± 3.54	15.0 ± 2.87	0.69 ± 0.23	0.84 ± 0.19	−0.14 (−0.24, −0.05)	0.003*	−0.09 (−0.18, 0.01)	0.07
Vitamin B-6, mg/d	1.00 ± 0.10	1.34 ± 0.34	1.57 ± 0.31	0.71 ± 0.26	0.82 ± 0.24	−0.12 (−0.23, −0.01)	0.04*	−0.06 (−0.18, 0.05)	0.26
Folate, μg/d	200 ± 20.0	474 ± 113	563 ± 105	0.98 ± 0.03	1.00 ± 0.01	−0.01 (−0.02, −0.00)	0.01*	−0.01 (−0.02, −0.00)	0.03*
Vitamin B-12, μg/d	1.50 ± 0.10	3.54 ± 1.02	4.30 ± 1.01	0.92 ± 0.09	0.98 ± 0.04	−0.05 (−0.08, −0.02)	0.001*	−0.04 (−0.08, −0.01)	0.01*
MPA[5]	—	—	—	0.89 ± 0.10	0.95 ± 0.07	−0.06 (−0.10, −0.02)	0.01*	−0.04 (−0.08, 0.00)	0.06

[1] Data are means ± SDs unless otherwise indicated. *Significant difference with P < 0.05. EAR, estimated average requirement; ITT, intention to treat; MPA, mean probability of adequacy across for 11 micronutrients; RAE, retinol activity equivalents; RNI, recommended nutrient intake; RUTF, ready-to-use therapeutic foods; SD, SD of requirement.

[2] Analyzed by using mixed linear model with study site as random effect.

[3] The EAR was calculated using RNI proposed by Golden [31] for moderate acute malnutrition children: RNI = EAR + 2SD, [17]. The SDs of requirements were calculated using the CV of requirement and the EAR; the CVs were 12.5% for zinc (ref); 20% for vitamin A, 15% for niacin, and 10% for vitamins C, B-6, B-12, thiamin, riboflavin, and folate [17, 22, 30]. The CV of calcium was 20% [32].

[4] To calculate nutrient intake, we applied coefficient of bioavailability for calcium, zinc, and iron. For calcium, we applied 25% for grains, roots, tubers, and legumes, 45% for fruits and vegetables, and 32% for other foods [23]. For zinc bioavailability, we applied 25% on the basis of an unrefined cereal-based diet [24]. For iron, we used the low bioavailability assumption of 5% [22].

[5] MPA across 11 micronutrients in intention to treat.

not eat other foods apart RUTF during treatment could be reconsidered.

Acknowledgements

References

1. Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, Mathers C, Rivera J. Maternal and child undernutrition: global and regional exposures and health consequences. Lancet [Internet] 2008 [cited 2020 Jun 1];371(9608):243–60. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0140673607616900.

2. UNICEF, WHO, & World Bank Group. Levels and trends in child malnutrition: Joint Child Malnutrition Estimates key findings of the 2020 edition. pdf [Internet] [cited 2020 Apr 21]. Available from https://www.who.int/publications/i/item/jme-2020-edition. 2020.

3. Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, Ezzati M, Grantham-McGregor S, Katz J, Martorell R, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet [Internet] 2013 [cited 2020 Jun 1];382(9890):427–51. Available from: https://linkinghub.elsevier.com/retrieve/pii/S014067361360937X.

4. Ministère de la Santé. Enquête nutritionnelle nationale SMART 2016 Burkina Faso. pdf [Internet] [cited 2020 Jun 2]. Available from https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/documents/files/smart_2016.pdf. 2016.

5. World Health Organization (WHO). Guideline. Updates on the management of severe acute malnutrition in infants and children [Internet] [cited 2020 Apr 21]. Available from https://www.who.int/publications/i/item/9789241506328. 2013.

6. OMS. Normes de croissance OMS et identification de la malnutrition aiguë sévère chez l'enfant [Internet] [cited 2020 Apr 21]. Available from https://www.who.int/nutrition/publications/severemalnutrition/9789241598163/fr/. 2009.

7. WHO, WFP & UNICEF. Community-based management of severe acute malnutrition: a joint statement [Internet] [cited 2020 Apr 21]. Available from https://apps.who.int/iris/handle/10665/44295. 2007.

8. Tadesse E, Berhane Y, Hjern A, Olsson P, Ekström E-C. Perceptions of usage and unintended consequences of provision of ready-to-use therapeutic food for management of severe acute child malnutrition. A qualitative study in Southern Ethiopia. Health Policy Plan [Internet] 2015 [cited 2020 Apr 22];30(10):1334–41. Available from: https://academic.oup.com/heapol/article-lookup/doi/10.1093/heapol/czv003

9. James PT, Van den Briel N, Rozet A, Israël A-D, Fenn B, Navarro-Colorado C. Low-dose RUTF protocol and improved service delivery lead to good programme outcomes in the treatment of uncomplicated SAM: a programme report from Myanmar: Low-dose RUTF protocol. Matern Child Nutr [Internet] 2015 [cited 2020 Apr 22];11(4):859–69. Available from: http://doi.wiley.com/10.1111/mcn.12192.

10. Maust A, Koroma AS, Abla C, Molokwu N, Ryan KN, Singh L, Manary MJ. Severe and moderate acute malnutrition can be successfully managed with an integrated protocol in Sierra Leone. J Nutr [Internet] 2015 [cited 2020 Apr 21];145(11):2604–9. Available from: https://academic.oup.com/jn/article/145/11/2604/4585811.

11. Kangas ST, Salpéteur C, Nikièma V, Talley L, Ritz C, Friis H, Briend A, Kaestel P. Impact of reduced dose of ready-to-use therapeutic foods in children with uncomplicated severe acute malnutrition: a randomised non-inferiority trial in Burkina Faso. Persson LÅ, editor. PLoS Med [Internet] 2019 [cited 2020 May 13];16(8):e1002887. Available from: https://dx.plos.org/10.1371/journal.pmed.1002887

12. Action contre la Faim (ACF). Rapport d'evaluation squeac district sanitaire de fada n'gourma. pdf [Internet] [cited 2020 May 13]. Available from https://www.coverage-monitoring.org/wp-content/uploads/2014/05/ACF-SQUEAC-BF-GOURMA-2014-VF.pdf. 2014.

13. Ministère de l'Agriculture. Résultats définitifs de la campagne agricole 2014/2015 et perspectives de la situation alimentaire et nutritionelle. 2015.

14. Ministère de Santé. Protocol national prise en charge integree de la malnutrition aiguë. pdf [Internet] [cited 2016 Jan 11]. Available from https://www.humanitarianresponse.info/fr/operations/burkina-faso/document/burkina-faso-protocole-national-pcima-2014.

15. Coates J, Swindale A, Bilinsky P. Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide: version 3: (576842013-001) [Internet]. American Psychological Association; 2007 [cited 2020 Aug 7]. Available from: http://doi.apa.org/get-pe-doi.cfm?doi = 10.1037/e576842013-001.

16. Gibson RS, Ferguson EL, Gibson RS, Ferguson EL, 2008. An interactive 24-hour recall for assessing the adequacy of iron and zinc intakes in developing countries. Washington (DC): International Food Policy Research Institute (IFPRI) and International Center for Tropical Agriculture (CIAT). ISBN 978-0-9818176-1-3. 2008, 160.

17. Dietary Reference Intakes: applications in dietary assessment [Internet]. Washington (DC): National Academies Press; 2000 [cited 2020 May 13]. Available from: http://www.nap.edu/catalog/9956

18. World Health Organization (WHO), editor. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age; methods and development. Geneva: WHO Press; 2006. 312p.

19. Stadlmayr B. West African food composition table = Table de composition des aliments d'Afrique de l'Ouest [Internet] [cited 2020 May 14]. Available from http://www.fao.org/3/i2698b/i2698b00.pdf. Rome: Food and Agriculture Organization of the United Nations; 2012.

20. Arsenault JE, Nikiema L, Allemand P, Ayassou KA, Lanou H, Moursi M, De Moura FF, Martin-Prevel Y. Seasonal differences in food and nutrient intakes among young children and their mothers in rural Burkina Faso. J Nutr Sci [Internet] 2014 [cited 2020 Apr 28];3:e55. Available from: https://www.cambridge.org/core/product/identifier/S2048679014000536/type/journal_article

21. Food and Agricultural Organization (FAO), International Network of Food Data Systems (INFOODS). Directives FAO/INFOODS relatives à la conversion d'unités, de dénominateurs et d'expressions, version 1.0. FAO, Rome, 2015. Population (French Edition) [Internet] 2015 [cited 2020 Aug 7];5(4):764. Available from: https://www.jstor.org/stable/1523706?origin =.

22. World Health Organization (WHO), Food and Agricultural Organization (FAO), editors. Vitamin and mineral requirements in human nutrition. 2nd ed. Geneva: World Health Organization and Food and Agriculture Organization of the United Nations; 2004. 341 p.

23. Kennedy G, Nantel G. Basic guidelines for validation of a simple dietary diversity score as an indicator of dietary nutrient adequacy for non-breastfeeding children 2–6 years. 2006, 25.

24. Christine Hotz and Kenneth H. Brown, guest editors (2004). Assessment of the risk of zinc deficiency in populations and options for its control.pdf. Internationl Zinc Nutrition Consultative Group (IZiNCG) technical document #1.

25. Harttig U, Haubrock J, Knüppel S, Boeing H. The MSM program: web-based statistics package for estimating usual dietary intake using the Multiple Source Method. Eur J Clin Nutr [Internet] 2011 [cited 2020 Aug 7];65(S1):S87–91. Available from: http://www.nature.com/articles/ejcn201192.

26. Arsenault JE, Yakes EA, Islam MM, Hossain MB, Ahmed T, Hotz C, Lewis B, Rahman AS, Jamil KM, Brown KH. Very low adequacy of micronutrient intakes by young children and women in rural Bangladesh is primarily explained by low food intake and limited diversity. J Nutr [Internet] 2013 [cited 2020 Apr 28];143(2):197–203. Available from: https://academic.oup.com/jn/article/143/2/197/4569839.

27. Food and Agriculture Organization (FAO). On choosing a standard operational indicator of women's dietary diversity. ISBN 978_92_5_108883_8 Rome.pdf. 2015.

28. Henjum S, Torheim LE, Thorne-Lyman AL, Chandyo R, Fawzi WW, Shrestha PS, Strand TA. Low dietary diversity and micronutrient adequacy among lactating women in a peri-urban area of Nepal. Public Health Nutr [Internet] 2015 [cited 2020 Apr 20];18(17):3201–10. Available from: https://www.cambridge.org/core/product/identifier/S1368980015000671/type/journal_article

29. Mak T-N, Angeles-Agdeppa I, Lenighan YM, Capanzana MV, Montoliu I. Diet diversity and micronutrient adequacy among Filipino school-age children. Nutrients [Internet] 2019 [cited 2020 Apr 20];11(9):2197. Available from: https://www.mdpi.com/2072-6643/11/9/2197

30. Otten JJ, Hellwig JP, Meyers LD , editors. DRI, Dietary Reference Intakes: the essential guide to nutrient requirements. Washington (DC): National Academies Press; 2006. 543 p.

31. Golden MH. Proposed recommended nutrient densities for moderately malnourished children. Food Nutr Bull [Internet] 2009 [cited 2020 May 13];30(3_suppl3):S267–342. Available from: http://journals.sagepub.com/doi/10.1177/15648265090303S302

32. Institute of Medicine (IOM), editor. Dietary Reference Intakes: calcium, vitamin D. Washington (DC): National Academies Press; 2011. 536p.

33. Christensen E. Methodology of superiority vs. equivalence trials and non-inferiority trials. J Hepatol [Internet] 2007 [cited 2020 Aug 10];46(5):947–54. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0168827807001328

34. Schumi J, Wittes JT. Through the looking glass: understanding non-inferiority. Trials [Internet] 2011 [cited 2020 Aug 10];12(1):106. Available from: https://trialsjournal.biomedcentral.com/articles/10.1186/1745-6215-12-106

35. Tonguet-Papucci A, Houngbe F, Huybregts L, Ait-Aissa M, Altare C, Kolsteren P, Huneau JF. Unconditional seasonal cash transfer increases intake of high-nutritional-value foods in young Burkinabe children: results of 24-hour dietary recall surveys within the Moderate Acute Malnutrition Out (MAM'Out) randomized controlled trial. J Nutr [Internet] 2017 [cited 2020 Apr 20];147(7):1418–25. Available from: https://academic.oup.com/jn/article/147/7/1418-1425/4743659

36. Kangas ST, Salpéteur C, Nikièma V, Talley L, Briend A, Ritz C, Friis H, Kaestel P. Vitamin A and iron status of children before and after treatment of uncomplicated severe acute malnutrition. Clin Nutr [Internet] 2020 Mar [cited 2020 May 19];S0261561420301333. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0261561420301333

37. Bhandari N, Bahl R, Taneja S. Effect of micronutrient supplementation on linear growth of children. Br J Nutr [Internet] 2001 [cited 2020 Jun 8];85(S2):S131. Available from: http://www.journals.cambridge.org/abstract_S0007114501001027

38. Fahmida U, Rumawas JS, Utomo B, Patmonodewo S, Schultink W. Zinc-iron, but not zinc-alone supplementation, increased linear growth of stunted infants with low haemoglobin. Asia Pac J Clin Nutr 2007;9:301–9.