The Journal of Nutrition
Community and International Nutrition

Preventive Effects of Long-Term Supplementation with 2 Nutritious Food Supplements in Young Children in Niger[1–3]

Jessica Sayyad-Neerkorn,[4]* Céline Langendorf,[4] Thomas Roederer,[4] Stéphane Doyon,[5] Abdoul-Aziz Mamaty,[6] Lynda Woi-Messe,[6] Mahamane L Manzo,[7] Souley Harouna,[8] Saskia de Pee,[9,10] and Rebecca F Grais[4]

[4]Epicentre, Paris, France; [5]Doctors without Borders (MSF), Paris, France; [6]Epicentre, Niamey, Niger; [7]Regional Department of the Ministry of Public Health, Maradi, Niger; [8]Niger Health Forum (FORSANI), Niamey, Niger; [9]Nutrition Division, World Food Programme, Rome, Italy; and [10]Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA

Abstract

Background: In nutritional crises, large-scale preventive distributions of specialized nutritious foods are recommended to prevent acute and chronic malnutrition in young children. Among the available specialized nutritious foods, the World Food Programme and UNICEF recommend lipid-based nutrient supplements (LNSs) and Super Cereal Plus (SC+). Although the effectiveness of short-term distributions for prevention of severe acute malnutrition (SAM) is well documented, evidence for long-term strategies and the role of distribution of specialized nutritious foods for prevention of stunting is weaker.

Objective: The objective of this study was to compare long-term supplementation of LNSs and SC+ on the incidence of acute malnutrition and stunting in young children.

Methods: We conducted two 15-mo-long supplementation interventions with the use of LNSs (500 kcal/d) and SC+ (810 kcal/d) and half rations during 5 mo of the nonlean season, for the prevention of acute malnutrition and stunting in children aged 6–23 mo. The study was designed as a prospective cohort in 11 villages in Madarounfa, Niger. We compared the incidence of acute malnutrition and stunting with the use of Cox proportional hazards models and report on sharing and use of these food supplements.

Results: Characteristics of children at baseline were similar across groups. A total of 1967 children were included in the analysis (845 in the SC+ group and 1122 in the LNS group). No significant differences in the incidence of moderate acute malnutrition (SC+ compared with LNS: adjusted HR: 0.79; 95% CI: 0.61, 1.02) or SAM (HR: 0.84; 95% CI: 0.52, 1.34) were found. No difference in the incidence of stunting (HR: 1.08; 95% CI: 0.95, 1.24) or severe stunting (HR: 0.94; 95% CI: 0.71, 1.22) over the follow-up period were found.

Conclusions: These findings in young children in Niger suggest that both products should be considered when planning preventive distributions and choice of long-term supplementation should be guided by context-specific factors such as acceptability, cost, and operational feasibility, among others. Additional research is essential to improving child health. The study was registered at clinicaltrials.gov as NCT01828814. *J Nutr* 2015;145:2596–603.

Keywords: child malnutrition, prevention, acute malnutrition, stunting, Super Cereal Plus, lipid-based nutrient supplements, Niger

Introduction

Malnutrition is highly prevalent in low- and middle-income countries, and has a significant morbidity and mortality burden and deleterious impact on child cognitive development (1). Acute malnutrition (wasting) or chronic malnutrition (stunting) are classified according to WHO growth standards (2).

Malnutrition is an underlying cause of death in an estimated 45% of children <5 y of age (3), either directly or indirectly because of deficiencies in micronutrients such as vitamin A and zinc, inappropriate breastfeeding practices, wasting, and stunting.

[1] Doctors without Borders and the World Food Programme funded this study. Epicentre receives core funding from Doctors without Borders. Authors from Doctors without Borders and the World Food Programme participated in the conception of this study and preparation of the manuscript.

[2] Author disclosures: J Sayyad-Neerkorn, C Langendorf, T Roederer, S Doyon, A-A Mamaty, L Woi-Messe, ML Manzo, S Harouna, S de Pee, and RF Grais, no conflicts of interest. None of the authors received a specific salary from the funders for this project and publication.

[3]Supplemental Tables 1 and 2 are available from the ''Online Supporting Material'' link in the online posting of the article and from the same link in the online table of contents at http://jn.nutrition.org.

*To whom correspondence should be addressed. E-mail: jessica.sayyad@epicentre.msf.org.

Manuscript received March 4, 2015. Initial review completed April 2, 2015. Revision accepted September 8, 2015.
First published online September 30, 2015; doi:10.3945/jn.115.213157.

Sub-Saharan Africa remains highly affected, and the Sahelian region has one of the highest burdens (4). Despite recent improvements in child health indicators (5), the nutritional situation in Niger remains fragile (6), with children aged 6–23 mo remaining particularly vulnerable. A wasted child may be classified as either moderately or severely acutely malnourished based on body measurements. Mid-upper arm circumference (MUAC)[11] and weight-for-length *z* score (WLZ) are the indicators used to classify wasting in young children. Based on WHO Child Growth Standards, moderate acute malnutrition (MAM) is defined as having a WLZ between −2 and −3 *z* scores. Severe acute malnutrition (SAM) is defined as having a MUAC <11.5 cm and/or WLZ <−3 and/or bilateral pitting edema. Global acute malnutrition (GAM) is the sum of MAM and SAM at the population level. Stunting is defined as having a length-for-age *z* score (LAZ) <−2; severe stunting is defined as having a LAZ <−3, based on the WHO Child Growth Standards.

Over the past 3 y, an estimated 1 million children have been treated for SAM in community-based or in-patient therapeutic programs in Niger (7). Malnutrition is present throughout the year, but peaks before the harvest, from May to October, a period known as the lean season. According to a Niger Ministry of Health survey in 2011 (8), children aged 6–23 mo accounted for a large share of the nutritional burden, with 1 in 5 children affected by GAM and 3.1% by SAM. The survey reported as well that one-half of the children aged 6–23 mo in Niger were stunted and 1 in 5 was severely stunted.

UNICEF and the World Food Programme (WFP) recommend large-scale distributions of specialized nutritious foods targeting young children during the lean season to prevent seasonal wasting (9, 10). Both lipid-based nutrient supplements (LNSs) and Super Cereal Plus (SC+), a type of fortified blended flours (FBFs), are among the recommended products. These 2 products are different types (ready-to-eat paste compared with flour for making a porridge) and differ in ingredients, energy density, packaging, taste, preparation, and cost.

LNSs are ready-to-use foods that are typically composed of peanuts, milk powder, sugar, vegetable oil, and micronutrients. Two different LNSs with different amounts of energy and concentration of micronutrients were specifically designed to treat MAM or prevent seasonal wasting (11): lipid-based nutrient supplement–large quantity (LNS-LQ, or ready-to-use supplementary food) products, providing 500 kcal/d (e.g., Supplementary Plumpy), and lipid-based nutrient supplement–medium quantity (LNS-MQ) products, providing 250 kcal/d (e.g., Plumpy'Doz). These products are well accepted (12, 13), especially because they do not require preparation and can be fed directly to the child.

Preventive distributions with LNSs when malnutrition increases seasonally have been shown to reduce the incidence and prevalence of SAM in young children (14). They also have been shown to reduce the incidence and prevalence of MAM and reduce other morbidities because of improved micronutrient intake (15–18). LNS-LQs and LNS-MQs may also have an impact on stunting and severe stunting (19, 20).

Another type of specialized nutritious food, FBFs, are blends of partially precooked and milled cereals, in addition to soy beans or legumes fortified with micronutrients (vitamins and minerals). They are prepared as porridge by adding water and boiling for 5–10 min. SC+ is an FBF to which dry skimmed milk (8%), sugar (9%), and oil (3%) have been added during production and then packaged in 1.5 kg bags. SC+ has a higher energy density than the common FBF (also known as Super Cereal). LNSs and SC+ have been compared previously in other settings and the 2 products showed similar effects on MAM treatment (21–23) and have proven effective in preventing acute malnutrition (15, 16, 24).

As a result of the development of these products (SC+ and LNSs), considerable progress has been made in treating SAM and MAM, but little is known about whether one of these supplements could be more beneficial in preventing undernutrition, including stunting, wasting, and micronutrient deficiencies. The first 1000 d after conception are increasingly recognized as the pivotal time for nutritional interventions (25). Although the evidence base for short-term distribution of supplementary foods is well developed, long-term strategies have been less studied and optimal choice of foods and duration for prevention of undernutrition remain open questions. Building upon the success of short-term distributions, we hypothesized that acute malnutrition and stunting could be mitigated through continuous supply of specialized nutritious foods to children over a longer period and not only during the lean season. We were specifically interested in the relative benefits of SC+ compared with LNSs.

We compared LNSs (LQ, 500 kcal/d during lean season, and MQ, 250 kcal/d the rest of the year) and SC+ (820 kcal/d during lean season and 410 kcal/d the rest of the year) on the incidence of acute malnutrition and stunting in young children over 15 mo of follow-up through large-scale monthly distribution covering 2 lean seasons.

Methods

Starting in August 2011, 4514 children measuring 60–80 cm (as a proxy for age 6–23 mo) were enrolled in a prospective intervention trial to examine the effectiveness of supplementation strategies that included distribution of nutritious supplementary foods, with or without additional household support (family food ration or cash transfer), and cash transfer only. Details of the study design have been published previously (26). Although 7 different supplementation strategies were evaluated from August to December 2011, 2 arms continued over another 10 mo period overlapping a second lean season, until the end of October 2012. The long-term interventions included either SC+ or LNSs.

We did not include a formal control group (without any additional support) for ethical considerations, because previous studies in the same context have shown the effectiveness of large-scale distributions of supplementary foods (15, 16).

Study area and participants. Our study was conducted in Madarounfa district in the region of Maradi, along the southern border of Niger with Nigeria, an area that recurrently records a high prevalence of early childhood wasting and stunting (8).

Each year up to one-third of the national burden of cases of SAM are treated in the region of Maradi. This region has faced several nutritional crises, particularly in 2005 and 2007, when up to 60,000 children with SAM were admitted to therapeutic feeding centers (TFCs). In 2011, prevalence of GAM was estimated at 21% and SAM was estimated at 4% in children aged 6–23 mo; around 60% of them were stunted and one-third were severely stunted (8). In collaboration with the Ministry of Public Health of Niger, the nongovernmental organizations Doctors without Borders and Niger Health Forum supported primary health care centers and nutritional interventions.

Only villages located in a rural area of Madarounfa district and within 15 km of a health care facility supported by Doctors without Borders (MSF) and Niger Health Forum (FORSANI) were eligible for

[11] Abbreviations used: FBF, fortified blended flour; GAM, global acute malnutrition; LAZ; length-for-age *z* score; LNS, lipid-based nutrient supplement; LNS-LQ, lipid-based nutrient supplement–large quantity; LNS-MQ, lipid-based nutrient supplement–medium quantity; MAM, moderate acute malnutrition; MUAC, mid-upper arm circumference; SAM, severe acute malnutrition; SC+, Super Cereal Plus; TFC, therapeutic feeding center; WFP, World Food Programme; WHZ, weight-for-height *z* score; WLZ, weight-for-length *z* score.

inclusion. As described previously (26), 7 different groups of geographically close villages were created, each group with 500–800 children aged 6–23 mo, to receive 7 different initial interventions. Group assignment was random for 4 intervention groups, including the 2 long-term interventions evaluated here, and group assignment was nonrandom for 3 other interventions, which built on interventions that were already ongoing in these groups of villages.

All children residing in the study villages measuring >60 to ≤80 cm (27) were eligible irrespective of their nutritional status. Because precise age is usually unknown, it is common practice in large-scale nutritional interventions to use length as a proxy (14, 15, 27). Because of the high prevalence of stunting, we selected 60.0 cm and 80.0 cm as the proxy lengths for ages 6 and 23 mo, respectively. For 1064 children (50.7%), age was determined by the date of birth provided by the caretaker. For the remaining children, we estimated child age to the nearest month with the use of a local calendar listing special events in the community. Children meeting admission criteria for SAM at the initial visit were referred for care to TFCs. At each monthly distribution, new children were included when they reached 60 cm, and then were followed until they reached 80.1 cm. Rations distributed followed WFP recommendations during the 2011 lean season, August–December (800 kcal/d for SC+ and 500 kcal/d for LNS-LQs) and were reduced by one-half thereafter to take into account the higher availability of food locally, with the goal of reducing intervention costs. Rations were increased again, to the same amount as during the previous lean season, during June–October 2012.

Ethical considerations. The study was approved by the National Ethical Committee of Niger's Ministry of Public Health and by the Committee for Protection of Persons (ERB) "Ile-de-France XI," France.

Before the beginning of the study, the head of each study village gave his or her approval to participate.

Written informed consent was obtained from all eligible participant representatives. Participation in the study was not a precondition for receiving free medical services or for accessing preventive distributions. It was clearly stated to the participants' representatives that they could withdraw from the study at any time.

Intervention. Two intervention groups received either LNSs or SC+ and were followed from August 2011 to October 2012 (**Supplemental Table 1**). One group received LNS-LQs 500 kcal/d (92 g/d of Supplementary Plumpy; Nutriset) from August 2011 to December 2011, LNS-MQs 250 kcal/d (325 g/wk of Plumpy'Doz; Nutriset) from January to May 2012, and LNS-LQs again during the second lean season from June to October. The second group received SC+ 820 kcal/d (1.5 kg/wk; Michiels) during the first lean season, then SC+ 410 kcal/d (1.5 kg/2 wk), and finally SC+ 820 kcal/d again during the second lean season. The SC+ ration included allocation for sharing in the daily ration as recommended by the WFP. The energy and nutrient content of a daily ration of each supplement are provided in **Supplemental Table 2**.

Before each monthly distribution, mothers received education and information sessions on correct use of the nutritious food distributed, as well as health, hygiene, and nutrition. For 15 mo, the 2 groups of young children were followed up monthly. Follow-up visits coincided with the monthly distributions. At each visit, the children's anthropometric measurements were taken (weight, length, and MUAC) twice by 2 different nutrition assistants with the use of standardized methods and calibrated instruments (26). If the 2 values deviated by ± 0.5 cm for length and MUAC or ± 0.2 kg for weight, a third nutrition assistant took measurements, and the mean of the 2 closest values was used. In addition, a quality control was conducted every 2 mo by an independent team on a randomly selected sample of 10% of the children. Children who were classified as severely wasted were referred to a TFC and resumed follow-up once they recovered.

Village health workers sought children who missed scheduled visits at their homes within 10 d. If a child had died, a medical staff member subsequently visited the home to conduct a verbal autopsy to determine the probable cause of death (28).

Sample size and data analysis. The sample size was calculated, and a minimal sample size of 500 children per study group was required to detect a 20% difference in mean WLZ. A post hoc calculation confirmed that the study was sufficiently powered to detect this same difference for time-to-first-event of MAM and stunting between the LNS and SC+ groups over 15 mo.

Our primary outcomes included events of MAM, SAM, stunting, and severe stunting, as well as multiple events of MAM and SAM. Secondary outcomes included mortality and mean monthly gain in MUAC, WLZ, and LAZ for children. For mortality, we included all reports for which the cause of absence at the distribution site was death of the child as reported by a family member after a home visit by a study team member. Mean monthly gain in MUAC and WLZ was calculated for children included at baseline. Mean monthly change in LAZ was calculated for children receiving a minimum of 10 distributions. We also evaluated the reported use and consumption of distributed food over 15 mo according to caretaker answers to the questionnaire on a monthly basis.

Data analysis. Summary enrollment characteristics were calculated as means ± SDs for continuous measures and as n (%) for categorical variables. Anthropometric indexes were calculated with the use of the WHO 2006 growth standards (2). Baseline characteristics were compared with the use of generalized estimating equations to adjust SEs for clustering at the village level. We then compared supplementation strategy on the incidence of acute malnutrition, stunting, and mortality in children included in the cohort over the 15 mo of the intervention.

We used survival analysis to calculate the incidence of MAM and SAM among children free of SAM at enrollment for SAM incidence and free of MAM and SAM at enrollment for MAM incidence. We also explored the association between supplementation strategies and stunting in children free from the outcome at enrollment. Incidences and mortality rates were estimated per 100 child-months (person-time) for first and multiple events.

In children free from the outcome at enrollment, we estimated HRs and 95% CIs by using Cox proportional hazards models with time from enrollment to the event (acute malnutrition, stunting, or death) as the outcome and by using calendar month as the time scale. All 95% CIs used robust estimates of the variance to account for clustering at the village level. Children contributed person-time to the analysis from enrollment (August 2011) until the first occurrence of the outcome or the end of the study (October 2012). HRs were adjusted with the use of multivariate methods for sex, breastfeeding status, size of the household, child length, and WLZ at enrollment as potential confounding factors.

We defined multiple events as repeated episodes of SAM or MAM separated by at least 2 successive follow-up visits to attempt to identify new episodes and not relapses, and we estimated HRs and 95% CIs with the use of a Cox proportional hazards model.

Mean monthly changes were determined by calculating the average change per month for children enrolled at baseline over the study period and per group. In children receiving at least 10 distributions, mean monthly LAZ at baseline was compared with mean monthly LAZ at the end of follow-up. Comparisons of continuous variables were made with the use of Student's t test and potential differences between groups were determined with the use of a linear model adjusted for clustering, sex, child, breastfeeding status, size of household, length, and WLZ at baseline.

Proportions of ration consumption and main consumers were compared with the use of a chi-square test for proportions.

All data were collected on standardized forms and double-entered into EpiData version 2.1. Analyses were conducted with the use of STATA version 13 based on an intention-to-treat principle. All analyses were considered significant at $P < 0.05$.

Results

A total of 2214 children were recruited over the 15 mo study period; 1164 were included at baseline (660 in the LNS group and 504 in the SC+ group) and 1050 were gradually included in the cohort (575 in the LNS group and 475 in the SC+ group) as they reached 60 cm. A total of 762 left the cohort (422 in the LNS group and 340 in the SC+ group) when they reached 80.1 cm.

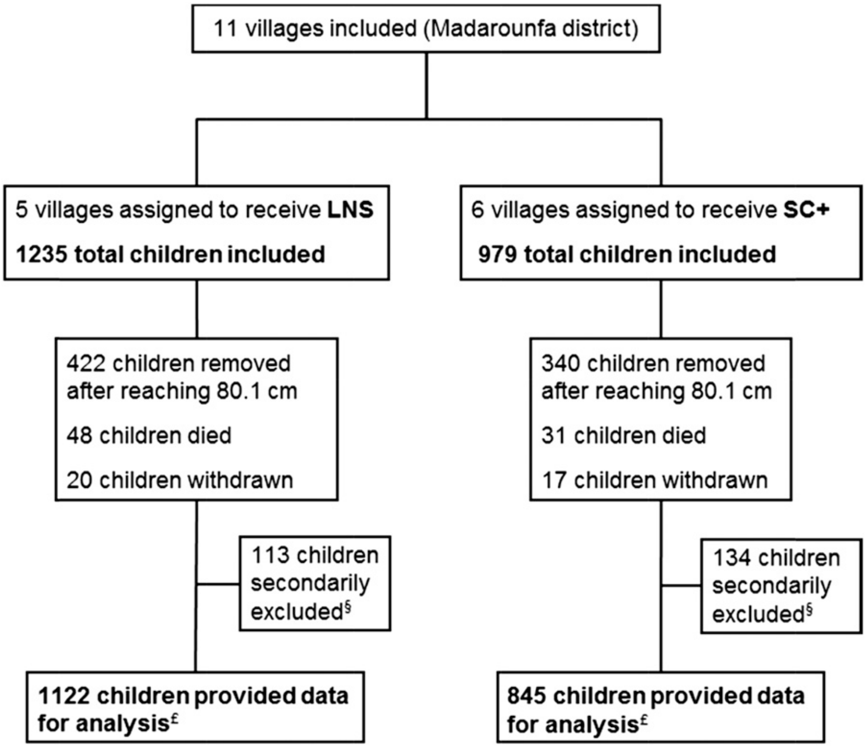

FIGURE 1 Intervention assignment and study flow of participants. §Did not meet the inclusion criteria (were not living in a study village or were not the child initially enrolled). £All included children minus secondarily excluded children. LNS, lipid-based nutrient supplement; SC+, Super Cereal Plus.

Over the study period, 37 children withdrew, 79 died, and 247 were secondarily excluded after it was discovered that they did not meet the inclusion criteria (were not living in the study village or were not the child initially enrolled). A total of 1967 children provided data for analysis (**Figure 1**).

Overall, the 2 groups were comparable at baseline in the prevalence of MAM, SAM, GAM, stunting, age, and sex ratio, with the exception of a higher proportion of children reported being breastfed in the LNS group (64% compared with 58%, P = 0.01) (**Table 1**).

At the first distribution in August, the prevalence of GAM was 35.1% in the LNS group and 32.6% in the group receiving SC+; the prevalence of SAM was ~6% in the 2 groups. The prevalence of stunting was ~60% in the 2 groups, with one-half of them severely stunted (Table 1).

Because we followed an open cohort and participation in distributions was voluntary, not all children participated in all distributions. Children who were eligible throughout the duration of the intervention could have attended a total of 15 distributions. The median number of distributions received per child, including children who entered or exited based on eligibility criteria, was 8 (IQR 4, 12), and this did not differ across groups. The majority of children did not miss any distribution they were eligible to receive, missing a median of 1 distribution (IQR 1, 1).

Adjusted risks were similar to those unadjusted and no difference was found between groups in the incidence of SAM and MAM, although there was a tendency toward a greater preventive effect from LNSs for the incidence of first event of MAM (P = 0.07) and from SC+ for the incidence of multiple events of MAM (P = 0.07) (**Table 2**). In children having multiple episodes, 80% had 2 episodes.

In children enrolled at the first distribution (n = 1104) and over their respective follow-ups, those who received LNSs had a mean monthly gain in MUAC of 0.012 ± 0.14 cm, whereas the children who received SC+ had a monthly mean MUAC decline of −0.010 ± 0.14 cm (P = 0.019). With respect to WLZ, the LNS group had a mean monthly gain of 0.108 ± 0.16, whereas the SC+ group had a mean monthly decline of 0.015 ± 0.18 (P = 0.022). No difference was found between groups when comparing the mean monthly change in LAZ (−0.70 ± 0.09 in the LNS group and −0.66 ± 0.09 in the SC+ group; P = 0.27).

TABLE 1 Characteristics of participants at baseline, August 2011[1]

Characteristics of children	SC+ (n = 504)	LNS (n = 660)
Age, mo	17.4 [11.3–21.8]	15.2 [10.3–22.3]
<6	26 (5.2)	43 (6.5)
6 to <12	120 (23.8)	173 (26.2)
12–24	273 (54.2)	325 (49.2)
>24	85 (16.9)	117 (17.7)
Female	257 (51.0)	324 (49.1)
Weight, kg	7.9 ± 1.3	7.7 ± 1.3
Length, cm	72.2 ± 5.6	71.8 ± 5.6
MUAC, cm	13.2 ± 1.1	13.1 ± 1.0
WLZ	−1.2 ± 1.1	−1.3 ± 1.0
GAM	164 (32.6)	232 (35.1)
MAM	129 (25.6)	192 (29.2)
SAM	35 (6.9)	40 (6.1)
Stunting	306 (60.6)	403 (61.1)
Severe stunting	159 (31.4)	200 (30.3)
Breastfeeding[2]	293 (58.3)	420 (64.2)
Caregiver's age, y	26 [22–30]	26 [21–30]
Household size	5.4 ± 1.8	5.3 ± 1.7

[1] Values are means ± SDs, medians [IQRs], or n (%). GAM, global acute malnutrition; LNS, lipid-based nutrient supplement; MAM, moderate acute malnutrition; MUAC, mid-upper arm circumference; SAM, severe acute malnutrition; SC+, Super Cereal Plus; WLZ, weight-for-length z score.

[2] Difference between groups for breastfeeding (P = 0.01) with the use of generalized estimating equations to adjust SEs for clustering at the village level.

TABLE 2 Incidence of SAM, MAM, and stunting and adjusted risks of MAM and SAM, August 2011–October 2012[1]

	SC+	LNS	*P* value
Incidence of first episodes			
SAM			
Number of first events/child-months at risk	55/4436	77/5627	
Incidence rate per 100 child-months (95% CI)	1.37 (1.09, 1.71)	1.24 (0.95, 1.61)	
Unadjusted HR (95% CI)	1.00 (reference)	0.95 (0.63, 1.42)	0.80
Adjusted HR (95% CI)	1.00 (reference)	0.84 (0.52, 1.34)	0.47
MAM			
Number of first events/child-months at risk	234/3416	264/4511	
Incidence rate per 100 child-months (95% CI)	6.84 (6.02, 7.78)	5.85 (5.18, 6.60)	
Unadjusted HR (95% CI)	1.00 (reference)	0.80 (0.63, 1.02)	0.07
Adjusted HR (95% CI)	1.00 (reference)	0.79 (0.61, 1.02)	0.07
Stunting			
Number of first events/child-months at risk	190/2081	260/2645	
Incidence rate per 100 child-months (95% CI)	9.12 (7.9, 10.52)	9.82 (8.7, 11.1)	
Unadjusted HR (95% CI)	1.00 (reference)	1.10 (0.95, 1.28)	0.20
Adjusted HR (95% CI)	1.00 (reference)	1.08 (0.95, 1.24)	0.20
Severe stunting			
Number of first events/child-months at risk	173/4110	233/5600	
Incidence rate per 100 child-months (95% CI)	4.21 (3.63, 4.88)	4.15 (3.66, 4.73)	
Unadjusted HR (95% CI)	1.00 (reference)	0.95 (0.74, 1.23)	0.72
Adjusted HR (95% CI)	1.00 (reference)	0.94 (0.71, 1.22)	0.63
Incidence of multiple episodes			
SAM, >1 episode			
Number of multiple events/child-months at risk	29/6222	35/8527	
Incidence rate per 100 child-months at risk	0.47 (0.32, 0.67)	0.41 (0.29, 0.57)	
Unadjusted HR (95% CI)	1.00 (reference)	0.87 (0.51, 1.46)	0.60
Adjusted HR (95% CI)	1.00 (reference)	0.94 (0.56, 1.56)	0.83
MAM, >1 episode			
Number of multiple events/child-months at risk	126/5049	203/6815	
Incidence rate per 100 child-months at risk	2.49 (2.09, 2.98)	2.98 (2.59, 3.41)	
Unadjusted HR (95% CI)	1.00 (reference)	1.19 (0.96, 1.48)	0.11
Adjusted HR (95% CI)	1.00 (reference)	1.21 (0.98, 1.49)	0.07

[1] From Cox proportional hazards models; time is calendar month, and predictors included intervention groups, sex, length at admission, WLZ at admission, size of household, and breastfeeding. SAM is defined as WLZ <−3 and/or MUAC <11.5 cm and/or bipedal edema. MAM is defined as WLZ <−2 and ≥−3 and/or MUAC <12.5 cm and ≥11.5 cm. Stunting and severe stunting are defined as LAZ <−2 and LAZ <−3, respectively. LAZ, length-for-age *z* score; LNS, lipid-based nutrient supplement; MAM, moderate acute malnutrition; MUAC, mid-upper arm circumference; SAM, severe acute malnutrition; SC+, Super Cereal Plus; WLZ, weight-for-length *z* score.

In children receiving a minimum of 10 distributions (n = 1008) over the study period, mean age at enrollment was 13.9 ± 6.7 mo for the SC+ group and 13.2 ± 6.3 mo for the LNS group; these numbers were 24.1 ± 7.1 mo and 23.8 ±6.8 mo, respectively, at the end of follow-up. Mean length was 69.2 ± 4.5 cm for SC+ and 69.0 ± 4.4 cm for LNSs at enrollment and 76.5 ± 3.4 cm and 76.4 ± 3.5 cm, respectively, at the end of follow-up. In this subpopulation, mean LAZ declined in both groups during the study follow-up (**Figure 2**). Between enrollment and the last follow-up visit, the mean LAZ declined from −2.17 to −2.94 (P = 0.002) in the SC+ group and from −2.19 to −2.92 (P = 0.001) in the LNS group. There were no groupwise differences in mean LAZ at enrollment (P = 0.81) or at last follow-up visit (P = 0.84). As indicated by the decline in LAZ, the proportion of stunted children increased from 62.7% to 79.1% in the SC+ group and from 63.0% to 79.9% in the LNS group between enrollment and last follow-up visit.

We recorded 79 deaths across the 2 groups, representing 0.45 per 100 child-months (31 deaths) in the SC+ group and 0.51 per 100 child-months (48 deaths) in the LNS group. The deaths occurred mainly between August and September, both in 2011 and in 2012. These months are the months of high malaria morbidity prevalence; there was no seasonal malaria-chemo-prophylaxis preventive treatment for malaria for the children, but all of them had access to free care for malaria during the study period. The mean age of children who died was 17.3 ± 8.1 mo, with a minimum age of 6.3 mo and a maximum age of 37.3 mo.

Of the 79 deaths, 73 (92.4%) were documented by verbal autopsy; for the others, probable cause of death could not be documented because the families had either traveled or moved. The most commonly reported cause before death was fever (75.3%), followed by diarrhea (42.5%) and vomiting (32.9%). Of the 73 documented deaths, 30 (41.1%) were reported as having occurred at home, whereas 38 deaths (52.8%) took place at a health care facility and 5 (6.8%) on the way from home to the health care facility. Most families (90.4%) reported having sought care before the death of the child.

According to caretakers, the vast majority (94.2% for LNSs and 93.0% for SC+) of the nutritious supplementary food ration distributed over the 15 mo period was consumed within the nuclear family of the beneficiary child and did not vary with time (**Table 3**). A small proportion was reported to have been sold or

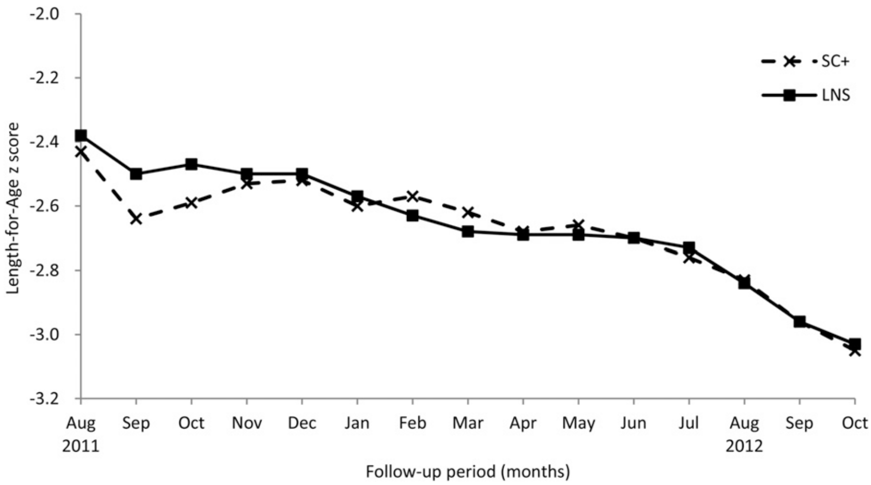

FIGURE 2 Mean LAZ by type of supplement for children receiving at least 10 distributions over the study period, August 2011–October 2012. SC+ mean: −2.94 (range: −5 to 0.5); LNS mean: −2.92 (range −5 to 0.49). The mean monthly change in LAZ did not differ between groups (P = 0.27). LAZ, length-for-age z score; LNS, lipid-based nutrient supplement; SC+, Super Cereal Plus.

exchanged, with significantly more in the LNS group (1.0%) than in the SC+ group (0.1%) (P < 0.001). There was no difference between the groups in terms of portion of ration consumed within the household outside of the nuclear family (P = 0.2).

Within the nuclear family, the child included in the study was reported to be the main consumer of the supplementary food in both groups. However, the child was more often the only consumer of LNSs (72.9%) than of SC+ (60.1%) (P < 0.001) (Table 3). LNSs were more often consumed by children <5 within the household (including the targeted child) than SC+ (P < 0.001), which was shared among other family members. In general, caretakers reported that SC+ was more frequently shared among adults (P < 0.001) and children >5 (P < 0.001) than LNSs. SC+ was reported to be consumed more frequently by women (mothers, pregnant women, or breastfeeding mothers) than LNSs (P < 0.001).

Discussion

This prospective cohort compared 2 types of nutritious supplements to prevent acute and chronic malnutrition in children aged 6–23 mo in Madarounfa district, under standardized conditions for 15 mo, including 2 lean seasons.

Preventive distributions have proven effective to reduce acute malnutrition (14, 17, 24), particularly in countries affected by regular hunger gaps and with a high prevalence of malnutrition. The results of this study suggest that there was no difference between the preventive effects of LNSs and SC+ distributed over 15 mo on incidence of acute malnutrition and stunting. However, there was a tendency toward a greater preventive effect of LNSs for the incidence of MAM (P = 0.073).

Mean monthly MUAC and WLZ gains were greater in the LNS group than in the SC+ group over 15 mo, although of small magnitude, questioning the nutritional significance. No differences in LAZ over time in children receiving a minimum of 10 distributions were found between the groups. Further, LAZ declined in both groups, which likely is due to the impact of the lean season known to be concomitant with a high prevalence of malaria, diarrhea, and other comorbidities.

Our findings suggest that the choice of a specific type of nutritious supplementary food among those recommended by the WFP and UNICEF (LNS-LQs, LNS-MQs, or SC+) could be less important in terms of effectiveness in preventing acute and chronic malnutrition than factors such as acceptability, preparation, cost, availability, and sustainability.

In this context, results confirmed a good acceptability of LNSs by children and families, as reported by previous studies

TABLE 3 Use of nutritious supplementary foods within households as reported by caregivers, August 2011–October 2012[1]

	SC+	LNS	P value
Proportion of nutritious supplementary foods			
Consumed within nuclear family	94.2	93.7	0.006
Consumed within household, beyond nuclear family	3.1	2.9	0.20
Stored	0.08	0.03	<0.001
Given away outside household	2.6	2.4	0.051
Sold or exchanged	0.1	1.0	<0.001
Main consumers of nutritious supplementary foods within households[2]			
Targeted child only[2]	3932 (60.1)	6549 (72.9)	<0.001
Targeted child and other consumers (nonexclusive categories)[3]			
Other children <5 y within households only	828 (12.7)	976 (10.8)	<0.001
Mothers, breastfeeding mothers, or pregnant women	1443 (22.1)	1205 (13.4)	<0.001
Children >5 y and adults	448 (6.8)	356 (3.9)	<0.001

[1] Values are percentages or n (%). LNS, lipid-based nutrient supplement; SC+, Super Cereal Plus.
[2] The total sample size represents the total number of caregivers responding over all distributions.
[3] A caregiver could respond positively to all categories.

suggesting good acceptance (13, 29); moreover, LNSs do not seem to replace the consumption of other foods or breast milk (30). Another recent study conducted in Malawi compared acceptability and feeding practices of SC+ and LNS-LQs and concluded that there were no differences in acceptance of the 2 products (31). Despite differences in taste, texture, packaging, and preparation, acceptability seemed high for both products.

Most of the supplement distributed was consumed solely by the children enrolled in the study or shared with other children in the nuclear family, which is consistent with previous studies (22, 31). SC+ was reported by caretakers to be shared more, which likely is due to the high bulk of the porridge represented by one ration (1.5 kg/wk provides for 250 mL porridge 4 times/d) and leftovers, which are then consumed by other siblings and the mother. However, the impact of ration sharing did not seem to affect prevention of acute and chronic malnutrition. This might be due to the higher amount of energy provided by SC+ daily rations compared with LNS daily rations (32).

In addition to the results of this study, there are several additional differences between the 2 supplements with respect to preparation, shelf life, and cost. LNSs can be consumed directly and require no preparation, whereas SC+ needs to be cooked as porridge with the use of water. This is an important difference between the 2 products and may be most relevant in situations without access to potable water. Further, LNSs have a shelf life of 24 mo, whereas the shelf life of SC+ is 18 mo. Both products can be stored at relatively high ambient temperatures; LNSs before consumption and SC+ before preparation are resistant to bacterial growth. With respect to cost, although this was not prospectively assessed, we are able to provide some indicative information on the 2 supplements. The monthly average cost per child over 15 mo was estimated to be €9.10 (US$10.32) for the LNS strategy and €7.12 (US$8.07) for SC+. These rough estimates, which would vary greatly depending on transport costs and context, also highlight the need for well-designed cost-effectiveness studies.

It is important to note several limitations of this study. First, findings could be due to unmeasured confounding factors or bias linked to anthropometric measures (26, 33). However, measures to minimize bias, including ongoing staff training, systematic double measurements, and external quality control, were implemented. We also used a local calendar of events to limit bias relating to misclassification of children's ages, which may have affected LAZ estimation, thereby limiting the possibility of detecting a difference between groups. It is also important to note that because we followed children enrolled in the previously cited study, there was insufficient power to assess impact on SAM and mortality because of the rarity of these events.

Second, no objective assessment of the quantity of food actually consumed by the children was made, and the answers to the questionnaire about food usage were not formally consolidated with on-site observations of feeding behavior. Use and sharing were only reported by caregivers; as such, they are subject to social desirability bias. However, this is likely to be equally present in both groups.

Third, the need for and outcomes of large-scale distribution remain highly dependent on the health and socioeconomic status of the population of the study area. In this study, consistent and free access to pediatric and nutritional care was assured. Results may be different in an area with less access to comprehensive care. Moreover, the study population was familiar with nutritious supplementary foods targeting young children, which may have increased acceptability of the foods that were provided.

Implementing large-scale trials in settings such as Niger are challenging. Finally, although the methodologic limitations of observational cohorts are clear, observational studies (33, 34) produce important evidence needed to evaluate large-scale nutritional interventions as part of program evaluation assessments (35).

In conclusion, both supplements, i.e., LNSs and SC+, should be considered when planning large-scale distribution for prevention of wasting, stunting, and micronutrient interventions, including during lean seasons. Supplements should be chosen according to the local context, considering familiarity and preference of consumers, possibility of cooking (SC+), local availability, and cost, among others. Furthermore, nutritious supplementary food distributions should be part of a comprehensive package that includes nutrition-sensitive interventions such as water and sanitation, primary health care, antenatal and maternal care, and education (29). Moreover, in contexts of low dietary diversity, it may be important to consider distribution of special nutritious foods outside of the lean season. This may be particularly important to address micronutrient and essential FA deficiencies, which persist outside of the lean season. Additional research on these issues and cost-effectiveness analyses are necessary to confirm these results and help guide policies, strategies, and program design.

Acknowledgments

We wish to thank Denise Brown on behalf of the World Food Programme Niger. We also wish to thank Nassirou Ousmane on behalf of the Division of Nutrition, Ministry of Health, Niger. CL, TR, SD, SdP, and RFG designed the research; A-AM, LW-M, MLM, and SH conducted the research; JS-N, CL, TR, and RFG analyzed the data or performed the statistical analysis; JS-N, CL, SD, SdP, and RFG wrote the paper; and JS-N, CL, and RFG had primary responsibility for the final content. All authors read and approved the final manuscript.

References

1. 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 2013;382:427–51.
2. World Health Organization, United Nations Children's Fund. WHO child growth standards and identification of severe acute malnutrition in infants and children. A joint statement of the World Health Organization and the United Nations Children's Fund. Geneva (Switzerland): World Health Organization; 2009.
3. Caulfield LE, de Onis M, Blössner M, Black RE. Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. Am J Clin Nutr 2004;80:193–8.
4. United Nations Children's Fund. UNICEF-WHO-World Bank joint child malnutrition estimates. New York: United Nations Children's Fund, Geneva (Switzerland): World Health Organization, Washington (DC): The World Bank. 2012.
5. Amouzou A, Habi O, Bensaid K, The Niger Countdown Case Study Working Group. Reduction in child mortality in Niger: a Countdown to 2015 country case study. Lancet 2012;380:1169–78.
6. Wuehler SE, Biga Hassoumi A. Situational analysis of infant and young child nutrition policies and programmatic activities in Niger. Matern Child Nutr 2011;7 Suppl 1:133–56.
7. Burki TK. Malaria and malnutrition: Niger's twin crises. Lancet 2013;382:587–8.
8. National Institute of Statistics and the Nutrition Department of the Ministry of Health in Niger. National survey report. Nutrition surveys on children aged 6 to 59 months. 2011.

9. World Food Programme. Interventions Nutrition at the World Food Programme. Programming for Nutrition-Specific interventions. Rome (Italy): WFP; 2012.
10. World Health Organization, United Nations Children's Fund, World FoodProgramme, United Nations High Commissioner for Refugees. Follow-up meeting of the joint WHO/UNICEF/WFP/UNHCR consultation on the dietary management of moderate malnutrition. Geneva (Switzerland): WHO; 2010.
11. Dewey KG, Arimond M. Lipid-Based Nutrient Supplements : How Can They Combat Child Malnutrition? PLoS Med 2012;9:e1001314.
12. Matilsky DK, Maleta K, Castleman T, Manary MJ. Supplementary feeding with fortified spreads results in higher recovery rates than with a corn/soy blend in moderately wasted children. J Nutr 2009;139: 773–8.
13. Cohuet S, Marquer C, Shepherd S, Captier V, Langendorf C, Ale F, Phelan K, Manzo ML, Grais RF. Intra-household use and acceptability of Ready-to-use-supplementary-foods distributed in Niger between July and December 2010. Appetite 2012;59:698–705.
14. Defourny I, Minetti A, Harczi G, Doyon S, Shepherd S, Tectonidis M, Bradol J-H, Golden M. A large-scale distribution of milk-based fortified spreads: evidence for a new approach in regions with high burden of acute malnutrition. PLoS One 2009;4:e5455.
15. Grellety E, Shepherd S, Roederer T, Manzo ML, Doyon S, Ategbo E-A, Grais RF. Effect of mass supplementation with ready-to-use supplementary food during an anticipated nutritional emergency. PLoS One 2012;7:e44549.
16. Isanaka S, Nombela N, Djibo A, Poupard M, Van Beckhoven D, Gaboulaud V, Guerin PJ, Grais RF. Effect of preventive supplementation with ready-to-use therapeutic food on the nutritional status, mortality, and morbidity of children aged 6 to 60 months in Niger: a cluster randomized trial. JAMA 2009;301:277–85.
17. Isanaka S, Roederer T, Djibo A, Luquero FJ, Nombela N, Guerin PJ, Grais RF. Reducing wasting in young children with preventive supplementation: a cohort study in Niger. Pediatrics 2010;126:e442–50.
18. Huybregts L, Houngbe F, Ait-aissa M, Kolsteren P. The effect of adding ready-to-use supplementary food to a general food distribution on child nutritional status and morbidity: a cluster-randomized controlled trial. PLoS Med 2012;9:e1001313.
19. Phuka JC, Maleta K, Thakwalakwa C, Cheung YB, Briend A, Manary MJ, Ashorn P. Postintervention growth of Malawian children who received 12-mo dietary complementation with a lipid-based nutrient supplement or maize-soy flour. Am J Clin Nutr 2009;89: 382–90.
20. Phuka JC, Maleta K, Thakwalakwa C, Cheung YB, Briend A, Manary MJ, Ashorn P. Complementary feeding with fortified spread and incidence of severe stunting in 6- to 18-month-old rural Malawians. Arch Pediatr Adolesc Med 2008;162:619–26.
21. LaGrone LN, Trehan I, Meuli GJ, Wang RJ, Thakwalakwa C, Maleta K, Manary MJ. A novel fortified blended flour, corn-soy blend "plus-plus," is not inferior to lipid-based ready-to-use supplementary foods for the treatment of moderate acute malnutrition in Malawian children. Am J Clin Nutr 2012;95:212–9.
22. Ackatia-Armah RS, McDonald CM, Doumbia S, Erhardt JG, Hamer DH, Brown KH. Malian children with moderate acute malnutrition who are treated with lipid-based dietary supplements have greater weight gains and recovery rates than those treated with locally produced cereal-legume products: a community-based, cluster-randomized trial. Am J Clin Nutr 2015;113:069807.
23. Nikièma L, Huybregts L, Kolsteren P, Lanou H, Tiendrebeogo S, Bouckaert K, Kouanda S, Sondo B, Roberfroid D. Treating moderate acute malnutrition in first-line health services: an effectiveness cluster-randomized trial in Burkina Faso. Am J Clin Nutr 2014;100:241–9.
24. Ruel MT, Menon P, Habicht J-P, Loechl C, Bergeron G, Pelto G, Arimond M, Maluccio J, Michaud L, Hankebo B. Age-based preventive targeting of food assistance and behaviour change and communication for reduction of childhood undernutrition in Haiti: a cluster randomised trial. Lancet 2008;371:588–95.
25. Adair LS, Fall CHD, Osmond C, Stein AD, Martorell R, Ramirez-Zea M, Sachdev HS, Dahly DL, Bas I, Norris SA, et al. Associations of linear growth and relative weight gain during early life with adult health and human capital in countries of low and middle income: findings from five birth cohort studies. Lancet 2013;382:525–34.
26. Langendorf C, Roederer T, de Pee S, Brown D, Doyon S, Mamaty A-A, Touré LW-M, Manzo ML, Grais RF. Preventing acute malnutrition among young children in crises: A prospective intervention study in Niger. PLoS Med 2014;11:e1001714.
27. Hall A, Oirere M, Thurstans S, Ndumi A, Sibson V. The practical challenges of evaluating a blanket emergency feeding programme in northern Kenya. PLoS One 2011;6:e26854.
28. World Health Organization, John Hopkins School of Hygiene and Public Health TLS of H and TM. A standard verbal autopsy method for investigating causes of death in infants and children. Geneva. World Health Organization.1999.
29. Adu-Afarwuah S, Lartey A, Brown KH, Zlotkin S, Briend A, Dewey KG. Home fortification of complementary foods with micronutrient supplements is well accepted and has positive effects on infant iron status in Ghana. Am J Clin Nutr 2008;87:929–38.
30. Flax VL, Thakwalakwa C, Phuka J, Ashorn U, Cheung YB, Maleta K, Ashorn P. Malawian mothers' attitudes towards the use of two supplementary foods for moderately malnourished children. Appetite 2009;53:195–202.
31. Wang RJ, Trehan I, LaGrone LN, Weisz AJ, Thakwalakwa CM, Maleta KM, Manary MJ. Investigation of food acceptability and feeding practices for lipid nutrient supplements and blended flours used to treat moderate malnutrition. J Nutr Educ Behav 2013;45:258–63.
32. Chaparro CM, Dewey KG. Use of lipid-based nutrient supplements (LNS) to improve the nutrient adequacy of general food distribution rations for vulnerable sub-groups in emergency settings. Matern Child Nutr 2010;6 Suppl 1:1–69.
33. Kerac M, Seal A. Preventing acute malnutrition in young children: improving the evidence for current and future practice. PLoS Med 2014;11:e1001715.
34. Black N. Why we need observational studies to evaluate the effectiveness of health care. BMJ 1996;312:1215–8.
35. Victora CG, Habicht J-P, Bryce J. Evidence-based public health: moving beyond randomized trials. Am J Public Health 2004;94:400–5.