Reducing Wasting in Young Children With Preventive Supplementation: A Cohort Study in Niger

WHAT'S KNOWN ON THIS SUBJECT: The effectiveness of RUTF in the treatment of severe wasting has led to the development of new, targeted ready-to-use spreads, including RUSF. The effectiveness of RUSF relative to RUTF in the prevention of malnutrition in children has not been evaluated.

WHAT THIS STUDY ADDS: Study results suggest that the performance of two supplementation strategies depended on receipt of a previous nutritional intervention. The choice of dose and duration of supplementation should be guided by the effectiveness and cost-effectiveness of the overall strategy according to the context.

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KEY WORDS

ready-to-use supplementary foods, ready-to-use therapeutic foods, prevention, wasting, child malnutrition, Niger

ABBREVIATIONS

RUTF—ready-to-use therapeutic food
RUSF—ready-to-use supplementary food
MSF—Médecins Sans Frontières
NCHS—National Center for Health Statistics
WHZ—weight-for-height *z* score
HAZ—height-for-age *z* score
HR—hazard ratio
CI—confidence interval

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abstract

OBJECTIVE: To compare the incidence of wasting, stunting, and mortality among children aged 6 to 36 months who are receiving preventive supplementation with either ready-to-use supplementary foods (RUSFs) or ready-to-use therapeutic foods (RUTFs).

SUBJECTS AND METHODS: Children aged 6 to 36 months in 12 villages of Maradi, Niger, ($n = 1645$) received a monthly distribution of RUSFs (247 kcal [3 spoons] per day) for 6 months or RUTFs (500-kcal sachet per day) for 4 months. We compared the incidence of wasting, stunting, and mortality among children who received preventive supplementation with RUSFs versus RUTFs.

RESULTS: The effectiveness of RUSF supplementation depended on receipt of a previous preventive intervention. In villages in which a preventive supplementation program was previously implemented, the RUSF strategy was associated with a 46% (95% confidence interval [CI]: 6%–69%) and 59% (95% CI: 17%–80%) reduction in wasting and severe wasting, respectively. In contrast, in villages in which the previous intervention was not implemented, we found no difference in the incidence of wasting or severe wasting according to type of supplementation. Compared with the RUTF strategy, the RUSF strategy was associated with a 19% (95% CI: 0%–34%) reduction in stunting overall.

CONCLUSION: We found that the relative performance of a 6-month RUSF supplementation strategy versus a 4-month RUTF strategy varied with receipt of a previous nutritional intervention. Contextual factors will continue to be important in determining the dose and duration of supplementation that will be most effective, acceptable, and sustainable for a given setting. *Pediatrics* 2010;126:e442–e450

In recent years, ready-to-use therapeutic foods (RUTFs) have transformed the treatment of child malnutrition. These energy-dense micronutrient spreads often made of peanuts, oil, sugar, and milk powder have been shown effective in the treatment of severe wasting in children and have made large-scale community-based care and treatment possible.[1–5] The acceptability and effectiveness of RUTFs have led to the development of a variety of new, targeted ready-to-use spreads, including ready-to-use supplementary foods (RUSFs). RUSFs were developed to serve as a supplement to traditional complementary foods and were specifically designed for the prevention of malnutrition among children aged 6 to 36 months. Compared with RUTFs, which provide large quantities of energy and the micronutrients needed by children with severe wasting, RUSFs provide lower energy and the recommended daily allowance of micronutrients when combined with the local diet in a small daily dose of spread (Table 1). The RUSF formulation developed for use in prevention, rather than treatment, and the lower cost relative to RUTFs have contributed to an increasing interest in the use of RUSFs within nutritional programs.

In April 2007, Médecins Sans Frontières (MSF) (Doctors Without Borders) initiated a preventive program in which supplementation with the new RUSF formulation was offered to children aged 6 to 36 months during the months preceding the harvest season throughout the district of Guidan Roumdji, Niger.[6] To assess the effectiveness of preventive supplementation with RUSFs versus RUTFs, we used data collected in 6 villages in Guidan Roumdji that received RUSFs through the district-wide program and in 6 villages in the district of Madarounfa that received preventive supplementation with RUTFs. In this study, we present a comparison of the incidence of wasting, stunting, and mortality during 12 months of follow-up among children aged 6 to 36 months who received preventive supplementation with either RUSFs or RUTFs.

TABLE 1 Nutritional Composition of RUTFs and RUSFs Per Unit Energy and Study Dose

Component	Per 1000 kcal		Per Study Dose	
	RUTFs	RUSFs	RUTFs	RUSFs
Quantity, g	—	—	92	46.3
Energy, kcal	1000	1000	500	247
Protein, g	25	24	12.5	5.9
Protein, % kcal	9.5	9.5	9.5	9.5
Lipid, g	65.6	64.8	32.8	16
Lipid, % kcal	58.2	58.2	58.2	58.2
Potassium, mg	2044	1255	1022	310
Magnesium, mg	170	243	85	60
Phosphorus, mg	550	1113	275	275
Zinc, mg	20	16	10	4
Calcium, mg	590	1567	295	387
Selenium, μg	55.2	68.8	27.6	17
Iron, mg	21.2	36.4	10.6	9
Iodine, μg	184	364	92	90
Copper, mg	3.3	1.2	1.65	0.3
Manganese, mg	—	0.7	—	0.17
Thiamine, mg	1.2	2.0	0.6	0.5
Riboflavin, mg	3.4	2.0	1.7	0.5
Niacin, mg	10	24	5	6
Pantothenic acid, mg	5.6	8.1	2.8	2
Pyridoxine, mg	1.2	2.0	0.6	0.5
Folic acid, μg	386	648	193	160
Vitamin B_{12}, μg	3.4	3.6	1.7	0.9
Vitamin C, mg	96	121	48	30
Vitamin A, μg	1680	1619	840	400
Vitamin E, mg	36.8	24.3	18.4	6
Linoleic acid, g	9.1	8	4.8	2
α-Linolenic acid, g	0.9	1.2	0.5	0.3

The study dose was 1 sachet per day of RUTFs and 3 spoons per day of RUSFs.

METHODS

Starting in August 2006, 3533 children aged 6 to 60 months were enrolled in a cluster-randomized trial to examine the effectiveness of short-term supplementation of RUTFs in the prevention of wasting. Details of the trial design have been published.[7] Briefly, nonmalnourished children with a weight-for-height ratio of ≥80% of the National Center for Health Statistics (NCHS) reference median in 6 randomly selected villages in the Maradi region of Niger (3 in the Madarounfa district and 3 in the Guidan Roumdji district) received a monthly distribution of RUTFs (1 sachet per day of 92 g [500 kcal]) (Plumpy'nut [Nutriset, Malaunay, France]) for 3 months preceding the harvest (August to October). Children in 6 other villages (3 in the Madarounfa district and 3 in the Guidan Roumdji district) received no preventive supplementation. Surveillance activities, including anthropometric measurements and physical examinations, were conducted on a monthly basis by field teams in each of the 12 study villages. In April 2007, after 8 months of follow-up, the trial was interrupted because of the observed benefit of supplementation with RUTFs to reduce the incidence of wasting.

With the successful implementation of a community-based prevention program using RUTFs and the development of products specifically designed for prevention in young children, MSF, in collaboration with the Ministry of Health, initiated a district-wide preventive program in Guidan Roumdji using the new RUSF formulation. In the preventive program, all children 60 to 85 cm tall (aged 6–36 months) were eligible for participation in a monthly distribution of RUSFs (3 spoons per day of 46.3 g [247 kcal]) (Plumpy'doz [Nutriset]) from May to October 2007 (6 months, Fig 1). Children aged 6 to 36 months were targeted for supplementation with RUSFs because this formulation was specifically developed for children of this age, according to the manufacturer. Monthly distributions of RUSFs were made in 325-g pots (1 pot is 1 weekly ration per child) at sites located within walking distance from each village. At the time of RUSF distribution through the preventive program, nutrition assistants also screened children in attendance for midupper arm circumference of <110 mm or edema and referred children to the MSF nutritional treatment program when indicated.

To allow for a comparison of the RUSF supplementation strategy being implemented in Guidan Roumdji versus

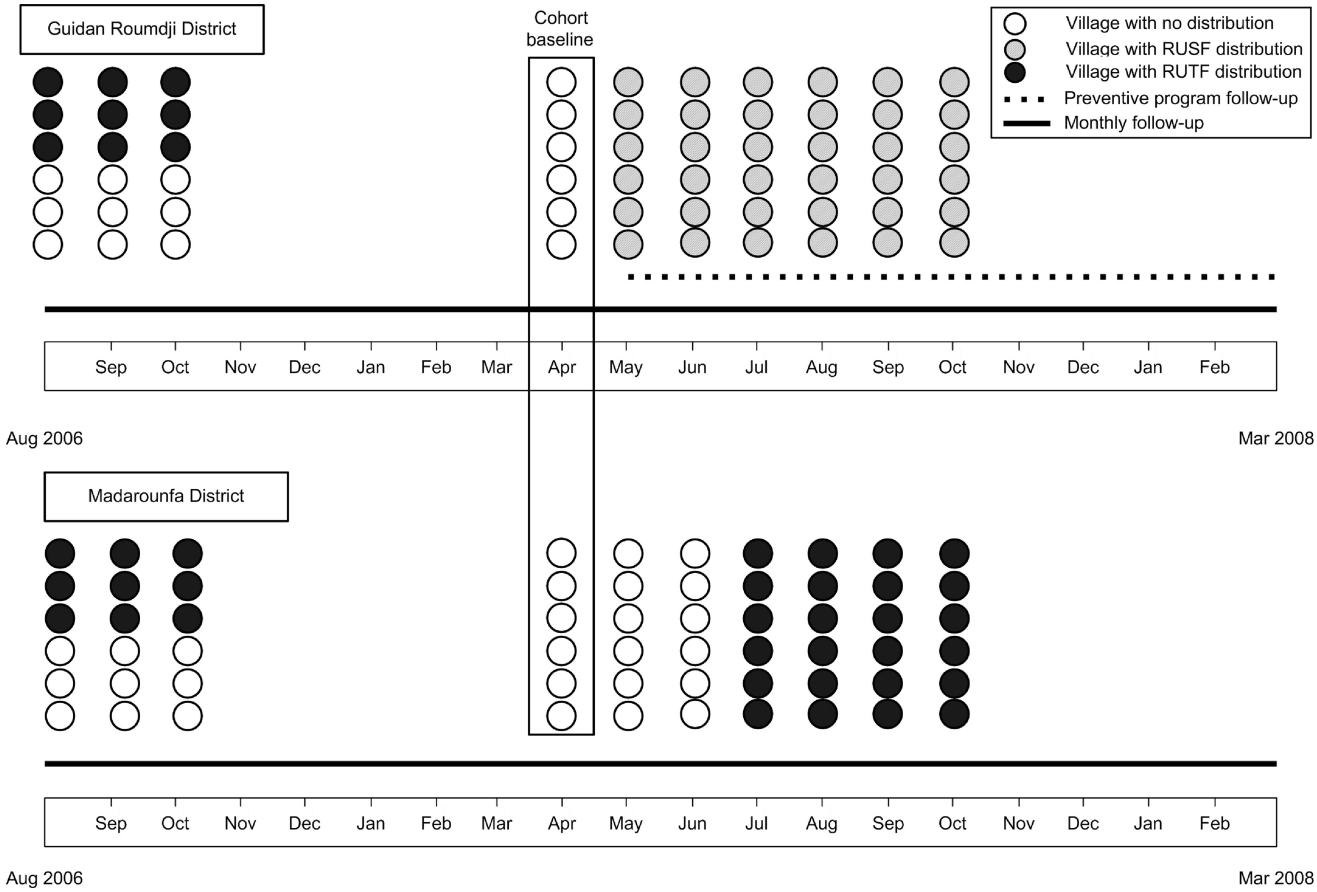

FIGURE 1

As part of the parent trial, RUTFs (500 kcal [1 sachet] per day) were distributed in 6 villages (3 villages in Madarounfa and 3 villages in Guidan Roumdji) for 3 months from August to October 2006 to children aged 6 to 60 months with a weight-for-height ratio of ≥80% of the NCHS reference median. During this time, no supplements were distributed in 6 other study villages (3 villages in Madarounfa and 3 villages Guidan Roumdji). Subsequently, RUSFs (247 kcal [3 spoons] day) were distributed in the 6 study villages of Guidan Roumdji for 6 months from May to October 2007 to all children aged 6 to 36 months as part of district-wide preventive program. RUTFs (500 kcal [1 sachet] per day) were distributed in the 6 study villages of Madarounfa for 4 months from July to October 2007 to all nonmalnourished children aged 6 to 60 months. Because the preventive supplementation strategies were determined at the village level, children were eligible to receive only 1 type of preventive supplementation, and there was no overlap between the RUSF and RUTF strategies. In villages in which RUTFs were distributed as part of the previous trial, 79.4% of children in the RUSF group and 77.5% of children in the RUTF group would have been eligible by the age criterion to receive the previous nutrition intervention for at least 1 month between August and October 2006. Monthly follow-up was conducted in all 12 study villages by nutritional assistants and research nurses from August 2006 to March 2008, with follow-up from April 2007 to March 2008 included in this cohort analysis. During monthly follow-up visits from April 2007 to March 2008, all children aged 0 to 60 months received a physical examination and anthropometric assessment and were referred to treatment if their WHZ was less than −3 (weight-for-height ratio of <70% of the NCHS reference median in April 2007) or edema. In addition, at the site of RUSF distributions, children in attendance were screened for midupper arm circumference of <110 mm or edema by nutritional assistants; children were referred to the MSF nutritional treatment program when indicated.

RUTFs, we continued monthly follow-up activities in the 12 study villages of the previous trial (6 in Guidan Roumdji and 6 in Madarounfa) and continued the preventive distribution of RUTFs to children aged 6 to 60 months from July to October 2007 (4 months) in the 6 study villages of Madarounfa. Monthly distributions of RUTFs were made in individual sachets (1 sachet is 1 daily ration per child) and took place at the same location and time as monthly follow-up activities. Because the preventive supplement strategy was determined at the village level, children were eligible to receive only 1 type of preventive supplementation, and there was no overlap between the 2 interventions. Supplement distributions were made directly to caregivers with instructions to ensure that the target child consumed the amount prescribed by the study per day (eg, 1 sachet of RUTFs or 3 spoons of RUSFs). Actual intake by the target child was not directly observed.

All children aged 60 months or younger in the 12 study villages were followed on a monthly basis from April 2007 to March 2008. At monthly follow-up visits, trained nutrition assistants conducted anthropometric measurements with the use of standardized methods and calibrated instruments. Child height (recumbent

length if <85 cm) was measured to the nearest 0.1 cm by using a wooden measurement board. Weight was measured to the nearest 0.1 kg by using a hanging Salter (Salter Brecknell Weighting Products, Fairmont, MN) scale. Any child found with a weight-for-height *z* score (WHZ) of less than −3 of the World Health Organization growth standards (weight-for-height ratio < 70% of the NCHS reference median in April 2007) or with medical complications at a follow-up visit was referred to the nutritional program or neighboring governmental health facility, respectively, for treatment provided at no cost. In 2007, there were 6 nutritional outpatient centers operated by MSF in Guidan Roumdji and 2 in Madarounfa. If a child did not present for the monthly follow-up visit in the village, the head of village provided the cause of absence. If a child had died, the cause of death was provided by a family member or the head of village.

Statistical Analysis

Children aged 6 to 36 months at baseline in the 12 study villages comprised the cohort in which we compared the RUSF supplementation strategy (247 kcal [3 spoons] per day for 6 months) with the RUTF supplementation strategy (500 kcal [1 sachet] per day for 4 months) with regards to the incidence of wasting, stunting, and mortality during 12 months. Our end points specifically included wasting (WHZ < −2), severe wasting (WHZ < −3), stunting (height-for-age *z* score [HAZ] < −2), and severe stunting (HAZ < −3) according to World Health Organization growth standards,[8] and mortality. Mortality events included all reports for which the cause for absence from surveillance visits was reported by a family member or the head of village to be death.

We examined the distribution of baseline (April 2007) characteristics by supplementation strategy by using generalized estimating equations to adjust standard errors for clustering at the village level. Next, we explored the association between supplementation strategy and the incidence of wasting, stunting, and mortality among children aged 6 to 36 months at baseline. Among children free from the outcome at baseline, we estimated hazard ratios (HRs) and 95% confidence intervals (CIs) by using marginal Cox proportional hazards models with time from recruitment to the event (wasting, 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 baseline (April 2007) until the first occurrence of the outcome or the end of study (March 2008).

Propensity score adjustment was used to assess the effect of potential confounders.[9–11] We estimated the propensity score in the full cohort by using a logistic regression in which we estimated the probability of receiving the RUSF supplementation strategy given the baseline characteristics that were considered a priori to be potential confounders or were associated with the supplementation strategy in univariate analyses at $P < .20$.[12] This included the child's age at baseline (6–11, 12–23, or 24–36 months), gender, baseline WHZ and HAZ (continuous), previous episode of malnutrition as reported by the mother at the time of recruitment (yes or no), child's sleeping under a bed net as reported by the mother at the time of recruitment (yes or no), malaria diagnosis at previous visit (yes or no), being breastfed for 6 months or longer (yes or no), maternal age (13–19, 20–29, or ≥30 years), maternal education (yes or no), maternal BMI (<18.5, 18.5–24.9, or ≥25), parity, more than 1 co-spouse in the household (yes or no), and the number of children in household younger than 5 years (0–1, 2–3, or ≥4) (*c* statistic = 0.71). Indicators for quartile categories of the propensity score were included as independent variables in each outcome model. When considering the potentially confounding effects of child's age, gender, and baseline WHZ and HAZ, there was no difference when using traditional multivariate or propensity score adjustment. In models for stunting, severe stunting, and mortality, we also adjusted for intervention status from the previous trial.

In the cohort analysis reported here, we considered that the performance of the RUSF strategy may be modified by receipt of the previous nutritional intervention,[7] because of differences in nutritional status, food security environment, or use of the supplement within the household associated with the previous intervention experience. To assess the potential interaction between the previous intervention in the randomized trial and subsequent preventive strategy using RUSFs or RUTFs, we compared Cox models with and without a cross-product term for previous and subsequent supplementation strategies by using a partial likelihood ratio test for the wasting and stunting outcomes. The interaction was not assessed for mortality because of limited power. $P \leq .05$ was considered statistically significant. Analyses were conducted by using SAS 9.1 (SAS Institute Inc, Cary, NC).

The study protocol was approved by the government of Niger and the Comité de Protection des Personnes, "Ile-de-France XI," France, and the study was authorized by the Ministry of Health of Niger. Approval from all heads of villages was received before the start of the study, and the objectives of the study and study protocol were explained to heads of

households with eligible children before inclusion. An informed-consent statement was read aloud in the local dialect before being signed or fingerprinted by the head of household or child caregiver.

RESULTS

A total of 1645 children, corresponding to 1151 households, were included in the analysis. Nineteen percent of the children were younger than 12 months at baseline, and 40% were aged between 12 and 23 months. The mean age of children's mothers was 25.7 years (SD: ±6.4), and educational attainment was low, with a minority of mothers (4%) ever attending school. On average, children who received RUSFs were slightly older ($P = .03$) and had lower WHZs at baseline ($P = .05$) (Table 2). The prevalence of stunting and presence of morbidities did not significantly differ according to supplementation strategy at baseline. During the 12-month surveillance period, children contributed a total of 19 234 months to follow-up for the survival end point, with a median of 12 visits per child (mean: 11.2 ± 2.1). The number of children with anthropometric measurements in April, July, and October 2007 and January 2008 was 772, 754, 754, and 725 within the RUSF strategy and 873, 868, 854, and 846 within the RUTF strategy, respectively. More children in the RUSF strategy than in the RUTF strategy were in villages that received the previous nutritional intervention (50.3% vs 43.9%). On average, children had higher WHZs (−0.76 ± 1.07 vs −0.93 ± 1.10) and HAZs (−2.24 ± 1.04 vs −2.56 ± 1.15) at baseline in villages in which the nutritional intervention was previously implemented.

We found that the previous nutritional intervention modified the association between subsequent preventive strategy and the risk of wasting (*P* for interaction = .002) and severe wasting (*P* for interaction = .05). In villages that did not receive the previous intervention, we found no difference in the incidence of wasting (adjusted HR: 1.31 [95% CI: 0.59–2.91]) or severe wasting (adjusted HR: 1.21 [95% CI: 0.69–2.14]) according to supplementation strategy (Table 3). On the other hand, in villages that received the previous intervention, the RUSF strategy was associated with a lower risk of wasting (adjusted HR: 0.54 [95% CI: 0.31–0.94]) and severe wasting (adjusted HR: 0.41 [95% CI: 0.20–0.83]) when compared with the RUTF strategy.

Among those children not stunted at baseline, there were fewer stunting events associated with the RUSF strategy compared with the RUTF strategy.

TABLE 2 Participant Characteristics in April 2007 According to Supplementation Strategy

	RUTFs	RUSFs	*P*[a]
No. of villages	6	6	
No. of children	873	772	
Person time, mo	10 268	8966	
Child characteristics, *N* (%)[b]			
Child age, mo			.01
6–11	187 (21.4)	128 (16.6)	
12–23	347 (39.8)	315 (40.8)	
24–36	339 (38.8)	329 (42.6)	
Gender			.25
Male	432 (49.5)	405 (52.5)	
Female	441 (50.5)	367 (47.5)	
Wasting			
WHZ, mean (±SD)	−0.7 (1.1)	−1.0 (1.1)	.01
Wasting (WHZ less than −2)	99 (11.8)	122 (16.4)	.05
Severe wasting (WHZ less than −3)	27 (3.2)	27 (3.7)	.61
Stunting			
HAZ, mean (±SD)	−2.4 (1.1)	−2.4 (1.1)	.97
Stunting (HAZ less than −2)	543 (64.6)	483 (65.8)	.89
Severe stunting (HAZ less than −3)	268 (31.9)	197 (26.8)	.37
Any previous malnutrition episode at entry	151 (17.7)	143 (18.8)	.81
Breastfed for ≥6 mo	625 (72.8)	386 (50.9)	<.0001
Child sleeps under bed net	501 (57.7)	360 (47.1)	.38
Health status in April 2007			
Hospitalized during last month	0 (0.0)	0 (0.0)	—[c]
Malaria diagnosis[d]	13 (1.6)	0 (0.0)	—[c]
Diarrhea diagnosis	3 (0.3)	4 (0.5)	.51
Respiratory infection diagnosis	4 (0.5)	3 (0.4)	.61
Maternal characteristics, *N* (%)[b]			
Maternal age, y			.58
13–19	131 (15.6)	92 (13.1)	
20–29	489 (58.3)	426 (60.8)	
≥30	219 (26.1)	183 (26.1)	
Ever attended school	16 (1.9)	41 (5.5)	.01
No. of co-wives			.52
0	0 (0.0)	3 (0.4)	
1	367 (42.7)	297 (39.4)	
≥2	493 (57.3)	453 (60.2)	
Maternal BMI, mean ± SD, kg/m^2	21.9 ± 7.9	21.2 ± 4.4	.01
Household characteristics, *N* (%)[b]			
No. of children younger than 5 y at home			.06
1	98 (11.4)	114 (15.2)	
2	227 (26.5)	251 (33.5)	
3	222 (25.9)	187 (25.0)	
≥4	311 (36.3)	197 (26.3)	

[a] *P* from generalized estimating equations to adjust SE for clustering at the village level.
[b] Sums may not add up to totals because of missing values.
[c] Not estimable because of low frequency of events.
[d] Determined by rapid-finger stick assay.

TABLE 3 Effect of Supplementation Strategy on Wasting, Stunting, and Mortality

	RUTF Strategy	RUSF Strategy
Wasting		
Village without previous nutritional intervention[a]		
N[b]	427	320
Number of events per child-year	85/359	83/247
Incidence rate per child-year	0.24	0.34
Unadjusted HR (95% CI)	1.00	1.34 (0.67–2.67)
Adjusted HR (95% CI)[c]	1.00	1.31 (0.59–2.91)
Village with previous nutritional intervention[a]		
N[b]	347	330
Number of events per child-year	70/290	36/282
Incidence rate per child-year	0.24	0.13
Unadjusted HR (95% CI)	1.00	0.52 (0.32–0.84)
Adjusted HR (95% CI)[c]	1.00	0.54 (0.31–0.94)
Severe wasting		
Village without previous nutritional intervention[a]		
N[b]	476	366
Number of events per child-year	33/436	34/317
Incidence rate per child-year	0.08	0.11
Unadjusted HR (95% CI)	1.00	1.35 (0.84–2.16)
Adjusted HR (95% CI)[c]	1.00	1.21 (0.69–2.14)
Village with previous nutritional intervention[a]		
N[b]	370	379
Number of events per child-year	14/345	8/340
Incidence rate per child-year	0.04	0.02
Unadjusted HR (95% CI)	1.00	0.57 (0.29–1.11)
Adjusted HR (95% CI)[c]	1.00	0.41 (0.20–0.83)
Stunting		
N[b]	330	289
Number of events per child-year	165/216	127/183
Incidence rate per child-year	0.76	0.69
Unadjusted HR (95% CI)	1.00	0.89 (0.72–1.11)
Adjusted HR (95% CI)[c]	1.00	0.81 (0.66–1.00)
Severe stunting		
N[b]	605	575
Number of events per child-year	144/495	130/454
Incidence rate per child-year	0.29	0.29
Unadjusted HR (95% CI)	1.00	0.95 (0.69–1.32)
Adjusted HR (95% CI)[c]	1.00	0.99 (0.76–1.30)
Mortality		
N[b]	873	772
Number of events per child-year	25/856	10/747
Incidence rate per child-year	0.03	0.01
Unadjusted HR (95% CI)	1.00	0.46 (0.31–0.68)
Adjusted HR (95% CI)[c]	1.00	0.49 (0.23–1.01)

Wasting and severe wasting were defined as a WHZ less than −2 and WHZ less than −3, respectively. WHZ was not calculated for children with edematous malnutrition ($n = 4$). These observations, therefore, were not included in analyses of the incidence of wasting or severe wasting. Stunting and severe stunting were defined as an HAZ less than −2 and HAZ less than −3, respectively.

[a] Previous nutritional intervention consisted of a monthly distribution of RUTFs (500 kcal [sachet] per day) from August to October 2006 to children aged 6 to 60 months with a weight-for-height ratio of ≥80% of the NCHS reference median.

[b] No. of children contributing to unadjusted analysis.

[c] From marginal Cox proportional hazards models, in which the outcome variable is time until first event, and time metameter is calendar month. Predictors in the adjusted model included supplementation strategy and indicators for quartiles of the estimated propensity score. The propensity score was estimated by using logistic regression in which the probability of receiving the RUSF supplementation strategy was predicted given the child's age at baseline (6–11, 12–23, or 24–36 months), gender, baseline WHZ and HAZ (continuous), previous episode of malnutrition as reported by mother at recruitment (yes or no), child's sleeping under bed net as reported by mother at recruitment (yes or no), malaria diagnosis at previous visit (yes or no), being breastfed for 6 months or longer (yes or no), maternal age (13–19, 20–29, or ≥30 years), maternal education (yes or no), maternal BMI (<18.5, 18.5–24.9, or ≥25), parity, more than 1 co-spouse in the household (yes or no), and number of children in household younger than 5 (0–1, 2–3, or ≥4). Models for stunting, severe stunting, and mortality were additionally adjusted for previous intervention status. Only children who did not have the outcome at baseline were included in the analyses.

After adjustment, the RUSF strategy was associated with a 19% (95% CI: 0% to 34%) reduction in the incidence of stunting. We found no difference in the incidence of severe stunting by supplementation strategy, and no interaction with the previous intervention was observed for the incidence of stunting (P for interaction = .36) or severe stunting (P for interaction = .49). We found no difference in mortality between supplementation strategies.

DISCUSSION

In this study we examined differences in the incidence of wasting, stunting, and mortality among children aged 6 to 36 months who received preventive supplementation with either RUSFs or RUTFs. To our knowledge, this is the first study to provide information on the relative performance of preventive supplementation strategies in young children using RUSFs versus RUTFs to reduce the occurrence of malnutrition and mortality. This study draws from an extensive surveillance database that included a relatively large number of children and high rates of follow-up (<4% of follow-up visits missed). The application of propensity score methods to control for confounding by a number of measured factors allows the use of these unique data to inform the ongoing discussion on the use of RUSFs within nutritional programs while randomized trial data become available.

However, this study has several limitations. In addition to the dose, the 2 preventive strategies under comparison differed in important ways, including the duration of supplementation, mode and time of initiation of distributions, as well as the age of children eligible for supplementation. The frequency of anthropometric screening also differed according to strategy; children who received the RUSF strategy were screened twice as often as

those who received the RUTF strategy, because of screening at both the RUSF distribution sites and monthly follow-up visits. As a result, our conclusions relate to the relative performance of the 2 preventive strategies overall rather than to the individual products. In addition, this comparison involves children from different districts. The study districts may have differed with respect to baseline nutritional status, malaria endemicity, frequency of additional food aid distributions (eg, corn-soy blend and oil), proximity to medical and nutritional care, and other unmeasured factors that influence the health and survival of children. Although we are unable to ensure the comparability of children between districts owing to the nonrandomized nature of the study, we do have information on a number of potential confounders. Adjustment for baseline anthropometry and other measured factors did not substantially alter our conclusions. Finally, we do not have complete data on compliance or supplement use within the household and, thus, cannot know if the supplement was consumed as intended by the target child.

We found that the effectiveness of preventive supplementation varied with the village experience with a previous nutritional intervention. The mechanisms underlying this interaction are unclear, but they are more likely related to contextual factors related to the village experience with the previous intervention than to individual factors associated with intake, such as baseline nutritional status. Children in villages in which the previous nutritional intervention was implemented were of better nutritional status (measured by higher WHZs), and it is plausible that duration of supplementation may have contributed more to improvements in weight gain than did dose among children of better nutritional status. However, the effect of the supplementation strategy on the incidence of wasting or severe wasting was not modified by baseline WHZ or HAZ in supplemental analyses (data not shown). The interaction by previous intervention also persisted in the subgroup of children who were not eligible for the previous intervention because of their young age, again indicating that village-level, rather than individual-level, factors associated with the previous intervention may have contributed to the observed interaction.

In villages with previous experience with RUTF supplementation, RUTFs may have been used as a replacement (as opposed to a complement) to habitual family meals or breast milk or shared with other household members. Either scenario could have contributed to lower energy intake with RUTFs in villages where the previous intervention was implemented. Increased energy intake has previously been associated with increased weight gain,[13,14] and the energy provided by RUSF is within the range (200–300 kcal/day, assuming average breast milk intake) that older infants require from complementary foods.[15] Previous evaluations of RUSFs supplementation have been consistent in demonstrating improved weight gain in a variety of study populations and against a range of comparator products, including micronutrient-fortified flours and porridge.[16–18]

We found that the 6-month RUSF strategy was related to a reduction in the incidence of stunting relative to the 4-month RUTF strategy. It is possible that the duration, rather than the dose, of supplementation may contribute more to the maintenance of linear growth associated with the RUSF strategy. Although the impact of previous complementary feeding interventions on linear growth has been inconsistent,[19–22] the findings of our study are consistent with the limited evidence specific to RUSFs. RUSFs were related to greater length gain compared with micronutrient-fortified flour among children aged 6 to 18 months in Malawi,[17] a micronutrient-only supplement among older infants in Ghana,[13] and an unfortified spread among stunted children aged 3 to 6 years in Algeria.[23]

Owing to the interruption of the earlier trial, we compared the performance of 2 preventive strategies in the context of whether a nutritional intervention was implemented in the previous year. The finding that previous intervention can modify the effectiveness of a nutritional program underscores that contextual factors should be considered early in program development, because the most effective dose and duration of supplementation may depend on the particular context of the program setting. Our findings suggest that there may be some settings in which there is no appreciable difference in the prevention of wasting between strategies that provide lower energy for longer duration and those that provide higher energy for shorter periods. However, the nonsignificant trend toward an increased risk of both wasting and severe wasting among children who received the RUSF strategy in villages without the previous intervention is of concern and should be confirmed in other studies.

Randomized trials that allow for direct estimation of the preventive effect of RUSFs on the anthropometric and micronutrient status of young children are warranted. Because age and nutritional status continue to be important predictors of nutritional outcomes, studies designed to compare the effectiveness of RUSF according to age and nutritional status are also needed to identify groups in which supplementation is most effective and could be targeted. Finally, cost-effectiveness stud-

ies are required to help guide the choice of the strategy according to the context. Although preventive strategies that use RUSFs for longer durations may be appropriate in some settings because of its lower costs ($0.19 per dose per day for RUSFs vs $0.37 per dose per day for RUTFs) (Stéphane Doyon, MSF, written communication, February 2009), the extended duration of such strategies will have additional cost and programmatic implications.

CONCLUSIONS

We found that the relative performance of a 6-month RUSF supplementation strategy versus a 4-month RUTF strategy varied with receipt of a previous nutritional intervention. Contextual factors will continue to be important in determining the dose and duration of supplementation that will be most effective, acceptable, and sustainable for a given setting. As we continue to better understand the implications of supplementation with ready-to-use foods, their targeted use in community-based preventive programs could contribute to important improvements in child nutrition.

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