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Original Article

Low-dose RUTF protocol and improved service delivery lead to good programme outcomes in the treatment of uncomplicated SAM: a programme report from Myanmar

Philip T. James*†, Natalie Van den Briel*, Aurélie Rozet*, Anne-Dominique Israël*, Bridget Fenn† and Carlos Navarro-Colorado‡

**Expertise and Advocacy Department, Action Contre la Faim (ACF), Paris, France, †Faculty of Epidemiology & Population Health, London School of Hygiene & Tropical Medicine, London, UK, and ‡Emergency Response and Recovery Branch, Division of Global Disease Protection, Center for Global Health, US Centers for Disease Control and Prevention, Atlanta, Georgia, USA*

Abstract

The treatment of uncomplicated severe acute malnutrition (SAM) requires substantial amounts of ready-to-use therapeutic food (RUTF). In 2009, Action Contre la Faim anticipated a shortfall of RUTF for their nutrition programme in Myanmar. A low-dose RUTF protocol to treat children with uncomplicated SAM was adopted. In this protocol, RUTF was dosed according to beneficiary's body weight, until the child reached a Weight-for-Height *z*-score of ≥−3 and mid-upper arm circumference ≥110 mm. From this point, the child received a fixed quantity of RUTF per day, independent of body weight until discharge. Specific measures were implemented as part of this low-dose RUTF protocol in order to improve service quality and beneficiary support. We analysed individual records of 3083 children treated from July 2009 to January 2010. Up to 90.2% of children recovered, 2.0% defaulted and 0.9% were classified as non-responders. No deaths were recorded. Among children who recovered, median [IQR] length of stay and weight gain were 42 days [28; 56] and 4.0 g kg^{-1} day^{-1} [3.0; 5.7], respectively. Multivariable logistic regression showed that children older than 48 months had higher odds of non-response to treatment than younger children (adjusted odds ratio: 3.51, 95% CI: 1.67–7.42). Our results indicate that a low-dose RUTF protocol, combined with specific measures to ensure good service quality and beneficiary support, was successful in treating uncomplicated SAM in this setting. This programmatic experience should be validated by randomised studies aiming to test, quantify and attribute the effect of the protocol adaptation and programme improvements presented here.

Keywords: severe acute malnutrition, health service delivery, community-based, therapeutic feeding, programme evaluation, undernutrition.

Correspondence: Ms Natalie Van den Briel, Action Contre la Faim (ACF), 14-16 Boulevard Douaumont, Paris Cedex 17, Paris 75854, France. E-mail: natalievandenbriel@gmail.com

Introduction

Worldwide, 52 million children under 5 are suffering from acute malnutrition, of which 19 million are suffering from severe acute malnutrition (SAM) at any point in time (Black *et al*. 2013). Acute malnutrition can manifest over a short period of time when the body does not receive adequate amounts of energy or micronutrients, either as a result of insufficient dietary intake or through malabsorption of nutrients and loss of appetite due to illness. Acute malnutrition increases the risk of infection through suppressing immunity (Tomkins & Watson 1989), and is recognised as an underlying factor in child mortality (Black *et al*. 2003; Müller & Krawinkel 2005). An estimated 53% of the preventable causes of death in children

aged under 5 can be attributed to malnutrition (Black *et al*. 2003). Acute malnutrition also has negative implications for morbidity, long-term growth, cognitive and behavioural development, and work capacity among survivors (Martorell 1999; Alderman 2006). Symptoms of acute malnutrition include either marasmus (wasting), kwashiorkor (nutritional oedema) or both, and diagnosis at population level is primarily through anthropometric tests (Young & Jaspars 2006). SAM is defined as a weight-for-height ratio less than three standard deviations below the median reference population, a low mid-upper arm circumference (MUAC) or the presence of nutritional oedema. Current protocols for the treatment of children with uncomplicated SAM recommend ambulatory care through the distribution of ready-to-use therapeutic food (RUTF), standardised medical treatment and regular beneficiary follow-up (WHO *et al.* 2007).

Action Contre la Faim (ACF) has implemented nutrition programmes for children with SAM in Myanmar since 2003. In 2009, ACF was operational in outpatient treatment programmes (OTPs) located in densely populated coastal areas in Northern Rakhine State, where Rohingyas are the dominant group. A nutrition survey conducted in the area in 2009 using SMART methodology indicates that global acute malnutrition (GAM, defined as weight-for-height <–2 *z*-score; Young & Jaspars 2006) and SAM (defined as weight-for-height <–3 *z*-score or presence of bilateral oedema; WHO *et al.* 2007) among children under 5 were 20.8% and 2.6%, respectively. The main causes of acute malnutrition have been identified as poor access to food and health services, inadequate child care practices, and poor sanitation and hygiene (ACF 2010). Local livelihoods consist mainly of fishing and subsistence farming and these coastal areas face regular cyclones and floods, as well as food price volatility. The target population for the nutrition programme was within 30 km of the OTPs, and access was by foot, rickshaw or boat.

In April 2009, ACF anticipated a procurement shortfall of the RUTF supply due to importation difficulties. In order to maintain the running of the nutrition programme, ACF developed a low-dose RUTF protocol in consultation with experts that would reduce the overall RUTF demands, enabling ACF to treat all children who presented with SAM. This protocol was implemented until January 2010 when adequate amounts of RUTF could be imported and treatment under the standard protocol was resumed. The programme took place during the annual hunger gap (June–September) when food security is poor, commodity prices rise and malnutrition rates increase.

This paper reports the programme outcomes of two OTP sites that implemented the low-dose RUTF protocol for the treatment of uncomplicated SAM in children aged 6–59 months, and explores implications for future research and programming.

Materials and methods

Description of the low-dose RUTF protocol

Children eligible for the low-dose RUTF protocol included all children 6–59 months of age with SAM defined as weight-for-height *z*-score (WHZ) < –3 and/or MUAC < 110 mm[1]), without oedema and no

[1]At the time of implementation, ACF Myanmar was transitioning from National Center for Health Statistics (NCHS) to World Health Organization (WHO) growth standards. Weight-for-height cut-off was defined per WHO WHZ and MUAC was still defined per NCHS.

Key messages

- Within this context, children with severe acute malnutrition were effectively treated through a low-dose RUTF protocol when additional inputs were provided to increase programme quality and beneficiary support.
- The low-dose RUTF protocol reached Sphere Minimum Standards with 90.2% recovery, 2% of children defaulted and 0% died.
- Further research on the viability of such approach within different context and revised dosage is needed.

medical complications (i.e. absence of anorexia, open lesions, respiratory infection, severe anaemia, dehydration, fever or apathy).

The low-dose RUTF protocol consisted of two treatment stages. During stage 1, RUTF[2] was dosed according to the child's body weight from admission until the child reached a MUAC ≥ 110 mm and a WHZ ≥ –3 [plus an additional safety margin of 200 g (children < 65 cm) or 300 g (children ≥ 65 cm)]. At this point, the child's treatment changed to stage 2, whereby the RUTF was dosed at one sachet per day (92 g or 500 kcal day^{-1}), regardless of weight, until completion of treatment. This differs from the standard (international) protocol where RUTF is given according to body weight throughout the treatment until discharge.

During treatment stage 1, the child's caregiver was advised to feed the child only with RUTF and provide clean drinking water with it. In contrast, during stage 2, caregivers were encouraged to provide home-cooked food to supplement the RUTF dose. It was advised to provide four non-spicy family meals per day and to prioritise RUTF consumption prior to these meals. Sharing of RUTF with family members was strongly discouraged. Lactating mothers were encouraged to continue breastfeeding at all times. Each child's caregiver received an individual care practice education session at the start of stage 2.

All children received medical treatment according to the standard international protocol; broad spectrum antibiotics (amoxicillin) over 7 days, vitamin A supplementation and deworming (WHO *et al.* 2007). They were also followed up weekly at OTP level to assess treatment compliance and nutritional evolution (i.e. anthropometry) and were screened for medical complications. Each OTP team consisted of nutrition workers who received frequent training on the nutrition protocol and anthropometric measurement and a trained nurse for the medical screening and care.

Owing to the non-standard nature of the RUTF dosage, the protocol included detailed criteria on how to respond to any child found to be deteriorating or in need of additional support. In stage 2, any child not gaining weight, or losing less than 5% of admission weight, and with a WHZ ≥ –3, was sent to a day care centre to receive treatment according to stage 1 together with psychosocial support. These beneficiaries and caretakers were welcomed by trained psychosocial and nutrition ACF staff in two day care centres. Children whose nutrition status deteriorated during stage 2 (i.e. WHZ < –3 or MUAC < 110 mm or weight loss >5%) were moved back to stage 1 in the OTP if he/she presented no medical complications, and to the inpatient stabilisation centre for medical care and milk-based therapeutic treatment if he/she did. Trained nurses provided 24-h medical care to those beneficiaries. These movements between stages were considered an integral part of the protocol, rather than a violation of it, and were intended to ensure fast, appropriate action if nutritional treatment was insufficient.

The service quality improvement and beneficiary support components of the low-dose RUTF protocol consisted of: (1) the opening of two day care centres to provide psychosocial support to mothers on child feeding and care practices; (2) additional training of ACF staff on the facilitation of group discussions, health care awareness creation and management training; (3) strengthening of early referral by the community through enhanced community awareness sessions and refresher training for community volunteers; (4) support of caregivers to provide home-cooked food to complement the low-dose RUTF; (5) a dedicated protocol was developed with actions to be undertaken for children whose response to treatment was suboptimal, including individual counselling sessions, reinforcing the system of returning RUTF sachets, re-explaining the treatment course and its components, and proposing more frequent OTP visits for beneficiaries in the neighbourhood of the OTP for better follow-up; and (6) streamlining of programme delivery processes (e.g. crowd control).

Procedures and participants

We analysed individual records of children 6–59 months of age treated through the low-dose RUTF protocol in two OTP sites (in Maungdaw and

[2]RUTF provided in the programme in 2009 was Plumpy' Nut® by Nutriset, Malaunay, France.

Buthidaung towns) from July 2009 to January 2010. Available data from the OTP records were collected weekly using standard methods. Age was recorded to the nearest month, estimated through an interview with the caregiver, using dental charts and a seasonal calendar. Children were weighed to the nearest 0.1 kg in minimal clothing on a portable hanging spring balance 25 kg scale. Recumbent length (for children <87 cm) and standing height (for those ≥87 cm) were recorded to the nearest 0.1 cm using a locally manufactured wooden height board. MUAC was measured on the left arm, midway between shoulder and elbow, to the nearest millimetre using numbered MUAC measuring tapes. Presence of bilateral oedema was assessed by applying thumb pressure on both feet and assessing whether any indentations remained after 3 second.

Recovery from SAM was recorded when a child presented with at least 15% weight gain from admission on two consecutive weighings, plus a MUAC ≥ 110 mm (if length >65 cm) and WHZ ≥ −2. Other final outcomes of treatment were classified as follows: died (confirmed by home visit); defaulter (child missed 2 consecutive weeks but was alive as confirmed by a home visit); non-responder (child did not reach the discharge criteria after 10 weeks); medical transfer (child was transferred to a hospital); and unconfirmed defaulter (child missed 2 consecutive weeks but survival could not be confirmed by a home visit).

The outcome reported by the clinics for each child was verified by recalculation of weight gain, WHZ and MUAC at discharge. Children who were initially classified as cured at the clinic, but whose anthropometric indicators could not be verified through recalculation, were reclassified as 'unconfirmed recovered'. Those who were discharged by the clinics but whose discharge measurements were not complete were reclassified as 'missing discharge criteria'.

Data analysis methods

Data for individual beneficiary cards were entered into a Microsoft Office Excel 2003 worksheet by ACF staff in Myanmar. All statistical analyses were carried out on cleaned data in STATA version 11. Anthropometric *z*-scores were calculated using the 2006 World Health Organisation (WHO) growth standards (WHO_ANTHRO, version 3.1). Following WHO recommendations for cleaning potential erroneous data (WHO Multicentre Growth Reference Study Group 2006), data from children with height-for-age *z*-score (HAZ) below −6 or above +6, weight-for-age *z*-score (WAZ) below −6 or above +5, or WHZ below −5 or above +5 were excluded from analysis (Fig. 1). The total length of stay was calculated in days for all children included in the programme as the period between the date of discharge and admission. Weight gain (g kg^{-1} day^{-1}) was calculated as the difference between discharge and admission weight, in grams, over the admission weight, in kilograms, divided by the number of days of stay in the programme.

Final outcomes from the low-dose RUTF protocol were compared with the Sphere Minimum Standards for Therapeutic Care (i.e. recovery rate >75%, death rate <10% and defaulter rate <15%) as outlined under 'Management of acute malnutrition and micronutrient deficiencies standard 2: Severe acute malnutrition' of the Sphere handbook (Sphere Project 2011).

MUAC, WHZ, HAZ, length of stay and weight gain were treated as continuous variables in the descriptive analysis. Age was treated as an ordered categorical variable. We used the Wilcoxon rank sum test to compare medians for continuous variables, chi-squared tests for binary variables (e.g. sex), and chi-squared tests for trend (or the Fisher's exact test for small sample sizes) for categorical variables. We analysed the medians of continuous variables by age category using a non-parametric test for trend (Kruskal–Wallis). Logistic regression was used to identify predictors of recovery, defaulting and non-response to treatment in three separate models. Continuous variables were converted into binary variables as they were not normally distributed (age < 12 months, age > 48 months, WHZ < −3.5, HAZ < −4, MUAC < 110 mm, sex = female; using cut-off points for each variable; Sadler 2009). In each model, the outcome of interest was compared with all other outcomes, with exclusion of children that had been reclassified as

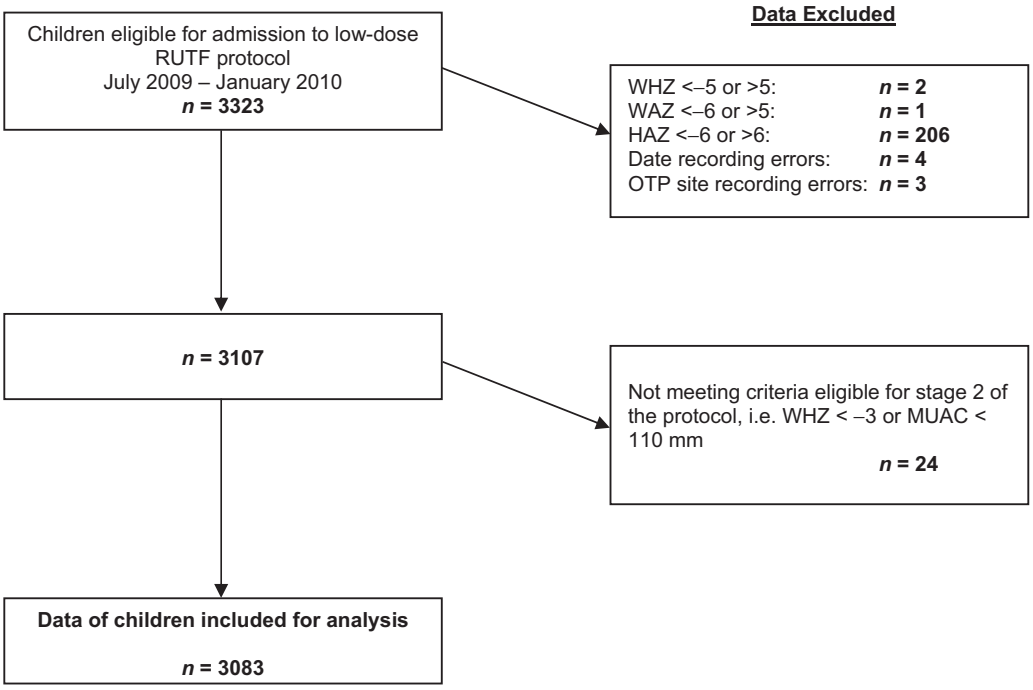

Fig. 1. Flowchart of data inclusion and exclusion criteria. HAZ, height-for-age *z*-score; MUAC, mid-upper arm circumference; OTP, outpatient therapeutic programme; SAM, severe acute malnutrition; WAZ, weight-for-age *z*-score; WHZ, weight-for-height *z*-score.

'uncertain' for that outcome (i.e. unconfirmed defaulters, unconfirmed recovered or missing discharge criteria). Univariable results generating a *P*-value of <0.1 for the odds ratio were carried forward into a model using multivariable backwards stepwise logistic regression to estimate adjusted odds ratios. The best fit of the data was assessed using Maximum Likelihood Ratio tests. Robust standard errors were used to account for any effects of clustering by OTP site.

Ethical approval

All the data were collected as part of routine nutritional care and programme monitoring activities. No specific consent was sought for data extraction and analysis. No personal identifiers were entered in the dataset. Ethical approval for analysis was provided by the MSc Research Ethics Committee of the London School of Hygiene & Tropical Medicine on 22 June 2010 (Ref. 009/487). This was a retrospective analysis of historical data and therefore pre-study approval was waived by the Ethics Committee.

ACF analysed the data every month in real time to monitor the quality of recovery and to provide the basis for a decision to stop the implementation of the low-dose RUTF protocol had it not performed to standards.

Results

Data from 3083 children treated under the low-dose RUTF protocol were available for analysis. Median (IQR) age at admission was 30 months [18; 46]; median MUAC 118 mm [114; 122], median WHZ –3.3 [–3.5; –3.2] and median HAZ –3.2 [–4.2; –2.2]. As shown in Table 1, 2782 (90.2%) children recovered under the low-dose RUTF protocol, 62 (2.0%) defaulted from the programme, 28 (0.9%) were classified as non-responders, 2 (0.07%) were transferred to the hospital for medical reasons, and 33 (1.1%) were classified as unconfirmed defaulter. No death

Table 1. Outcomes of children in the low-dose RUTF protocol compared with the Sphere Minimum Standards

	Programme results		Sphere Minimum Standards	Sphere Minimum Standards met?
	N	%		
Recovered	2782	90.2	>75%	Yes
Died	0	0.0	<10%	Yes
Defaulted (confirmed)	62	2.0	<15%	Yes
Non-responders	28	0.9	NA	NA
Medical transfer cases	2	0.1	NA	NA
Unconfirmed defaulter	33	1.1	NA	NA
Unconfirmed recovered	141	4.6	NA	NA
Missing discharge criteria	35	1.1	NA	NA
Total	3083	100.0		

NA, not applicable.

Table 2. Outcomes of children in the low-dose RUTF protocol by treatment pattern

	Uninterrupted treatment on stage 2		Interrupted treatment on stage 2	
	N	%	*N*	%
Recovered	2595	91.66	187	74.21
Defaulted (confirmed)	39	1.38	23	9.13
Non-responders	14	0.49	14	5.56
Medical transfer cases	1	0.04	1	0.4
Unconfirmed defaulter	25	0.88	8	3.17
Unconfirmed recovered	123	4.34	18	7.14
Missing discharge criteria	34	1.20	1	0.40
Total	2831	100.0	252	100.0

Movements between stages were considered an integral part of the protocol and were intended to ensure fast and appropriate action if nutritional treatment was insufficient. A total of 2831 children completed their treatment on stage 2 with no interruptions whereas 252 children experienced an interruption during stage 2 treatment by returning once or twice to stage 1 at some point.

was recorded during the studied period. For 141 (4.6%), the outcome recorded in their clinical records could not be verified with their clinical data, and were labelled as 'unconfirmed recovered'. Thirty-five children (1.1%) had missing discharge criteria and were classified as such.

The majority of children, 91.8% (2831), remained on stage 2 of the treatment without returning to stage 1 at OTP, stabilisation centre or day care centre. Among the 252 (8.2%) children who were sent back to stage 1, a total of 187 (74.2%) recovered from SAM, 23 (9.1%) defaulted from the programme, 8 (3.2%) were classified as unconfirmed defaulters, 14 (5.6%) were classified as non-responders, and 18 (7.1%) were reclassified as 'unconfirmed recovered'. One child (0.4%) was transferred for medical reasons and one (0.4%) had missing data on anthropometry at discharge (Table 2). Out of the 252 children, 49 finished treatment at the stabilisation centre, 56 children at the day care centre and 147 children at OTP level.

The length of stay from admission to discharge for all children under the low-dose RUTF protocol was 42 days [28; 56] with a median of 14 days [13; 21] on stage 1 and 21 days [14; 35] on stage 2. The 2783 children who recovered under the low-dose RUTF protocol had a median length of stay of 42 days [28; 56]. Median weight gain for recovered children during this period was 4.0 g kg^{-1} day^{-1} [3.0; 5.7]. The children who defaulted from the programme had a median

length of stay of 68.5 days [54; 77] with a median weight gain of 1.0 g kg^{-1} day^{-1} [0.5–1.5]. Children who did not respond to treatment stayed in the programme for 77.5 days [70; 89] and had a median weight gain of 0.7 g kg^{-1} day^{-1} [0.4; 0.9]. Unconfirmed defaulters had a median length of stay of 42 days [36; 68] and a median weight gain of 1.7 g kg^{-1} day^{-1} [1.1; 2.5]. The group of children who were reclassified as 'unconfirmed recovered' had a median length of stay of 49 days [35; 56] and a median weight gain of 3.5 g kg^{-1} day^{-1} [2.7; 5.3]. Children with missing discharge criteria had a median length of stay of 39 days [21; 57] and a median weight gain of 4.0 g kg^{-1} day^{-1} [1.0; 6.9].

Older age groups present a lower recovery rate ($P = 0.015$) and higher non-response to treatment rate ($P = 0.001$) (Table 3). The percentage of medical transfers, confirmed and unconfirmed defaulters did not vary with age group ($P = 1.000$, $P = 0.573$ and $P = 0.460$, respectively). Total length of stay increased with age group ($P = 0.001$) and median weight gain decreased ($P = 0.001$).

A WHZ less than −3.5 was associated with lower odds for recovery ($P < 0.001$) (Table 4, model 1). In this model, age was not found to be associated with recovery after controlling for WHZ, despite the significant trend, presented in Table 3. A HAZ below −4 was associated with lower odds of defaulting ($P = 0.001$) (Table 4, model 2). The multivariable model for non-response (Table 4, model 3) identified a positive association between age >48 months and the odds for non-responding ($P = 0.001$).

Discussion

We have reported the treatment results of an outpatient programme for the treatment of uncomplicated SAM in which the dose of RUTF provided during stage 2 of the treatment was reduced in order to face shortages in RUTF supply, and where additional inputs were provided to increase programme quality and beneficiary support. During the implementation of the low-dose RUTF protocol, ACF was able to provide nutritional treatment to all children presenting with SAM, which would not have been the case with the standard protocol due to the expected shortage of RUTF. Based on this and the treatment results presented here, we conclude that the programme was successful at both meeting the objective of providing treatment for children with SAM by reducing the overall consumption of RUTF in the programme and for the number of children who recovered.

Despite the reduced provision of RUTF, this low-dose RUTF protocol obtained programme performance rates that are considered successful under the Sphere Minimum Standards for recovery, death and defaulting rates. Median weight gain and median length of stay in treatment were in line with reported results from programmes that use standard protocols. For example, in a review of 30 OTP programmes that used standard protocols, only two had a shorter duration of stay for recovered patients than the one observed with our protocol (Collins *et al*. 2006).

In addition, most children were able to complete treatment in stage 2 of the protocol and 74.2% of children who were sent back into stage 1 of the protocol because of lack of weight gain ended up recovering. The diligence of the programme to identify children who were not responding to treatment, to assess their evolution and address them with appropriate treatment or support also emphasises the importance of weekly follow-up, including a thorough evaluation of child compliance with treatment, nutritional evolution and clinical status. This may have contributed to the good results observed in this project.

In order to reduce the misclassification that is frequent in secondary data from real-life programmes like this, we recalculated the anthropometric indicators at discharge for all children. This resulted in a number of recovered children who were reclassified as 'unconfirmed recovered' and others who were reclassified as 'missing discharge criteria'. Additionally, some defaulters who were not found during a subsequent home visit were considered as 'unconfirmed defaulters' and analysed separately, since they could have represented children who had died. Although this uncertainty around some of the treatment outcomes may have affected our conclusions, we think that this may not be the case: Even if all the 'unconfirmed defaulters' (1.1%) had in fact died, the

Table 3. Outcomes of children in the low-dose RUTF protocol by age category

Outcome	Total $n = 3083$		Age category (months)										*P*-value
			6–11 $n = 224$		12–23 $n = 881$		24–35 $n = 651$		36–47 $n = 561$		48–59 $n = 766$		
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	
Recovered	2782	90.2	203	90.6	821	93.2	573	88.0	506	90.2	679	88.6	0.015*
Defaulted	62	2.0	6	2.7	14	1.6	13	2.0	15	2.7	14	1.8	0.573†
Medical transfer	2	0.1	0	0.0	1	0.1	0	0.0	0	0.0	1	0.1	1.000†
Non-responder	28	0.9	1	0.4	1	0.1	5	0.8	6	1.1	15	2.0	0.001†
Unconfirmed defaulter	33	1.1	1	0.4	9	1.0	9	1.4	3	0.5	11	1.4	0.460†
Unconfirmed recovered	141	4.6	12	5.4	27	3.1	44	6.8	27	4.8	31	4.1	0.014†
Missing discharge criteria	35	1.1	1	0.5	8	0.9	7	1.1	4	0.7	15	2.0	0.210†
Outcome	Total $n = 3050$		6–11 $n = 223$		12–23 $n = 874$		24–35 $n = 644$		36–47 $n = 557$		48–59 $n = 752$		*P*-value
	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR	Median	IQR	
Total length of stay (days)	42	28, 56	35	28, 49	38	28, 53	40.5	28, 55	42	28, 56	49	35, 63	**0.001**‡
Weight gain (g kg^{-1} day^{-1})	3.9	2.8, 5.6	4.5	3.2, 6.4	4.2	3.1, 6.0	4.2	3.0, 5.8	3.7	2.9, 5.4	3.4	2.5, 4.6	**0.001**‡

*Chi-squared test for trend. †Fisher's exact test. ‡Kruskal–Wallis equality-of-populations rank test.

Table 4. Predictors of outcomes in the low-dose RUTF protocol: univariable and multivariable analysis

Dependent variable	Risk factors		Univariable analysis			Multivariable analysis		
		n†	Crude OR	95% CI	p value*	Adjusted OR	95% CI	p value*
MODEL 1:	Age <12 months	3083	1.05	0.66–1.67	0.839	–	–	–
Recovered	Age >48 months	3083	0.79	0.61–1.03	0.087	–	–	–
	WHZ <–3.5	3083	0.21	0.16–0.26	<0.001	0.21	0.16–0.27	<0.001
	HAZ <–4	3083	1.01	0.77–1.31	0.954	–	–	–
	MUAC <110 mm	2886	0.60	0.38–0.93	0.022	–	–	–
	Sex = female	3083	1.32	1.04–1.67	0.024	–	–	–
MODEL 2:	Age <12 months	3050	1.37	0.58–3.21	0.471	–	–	–
Defaulted	Age >48 months	3050	0.88	0.49–1.61	0.689	–	–	–
	WHZ <–3.5	3050	0.94	0.51–1.74	0.839	–	–	–
	HAZ <–4	3050	0.22	0.09–0.54	0.001	0.22	0.09–0.54	0.001
	MUAC <110 mm	2885	0.54	0.13–2.24	0.396	–	–	–
	Sex = female	3050	0.91	0.55–1.50	0.703	–	–	–
MODEL 3:	Age <12 months	2942	0.47	0.06–3.51	0.465	–	–	–
Non-responder	Age >48 months	2942	3.52	1.66–7.43	0.001	3.51	1.67–7.42	0.001
	WHZ <–3.5	2942	2.08	0.93–4.62	0.073	–	–	–
	HAZ <–4	2942	0.56	0.21–1.49	0.246	–	–	–
	MUAC <110 mm	2613	No sample	–	–	–	–	–
	Sex = female	2942	0.49	0.23–1.08	0.076	–	–	–

*Two-tailed Z-test for odds ratio

†Recovered has all beneficiaries, except models including MUAC (197 observations less). Model 2 excludes 33 observations that were unconfirmed defaulters. Model 3 excludes 141 observations that were unconfirmed recovered.

death rate in the programme would still be similar to that found in nutrition programmes implementing standard protocols and below Sphere Minimum Standards. If, on the other hand, they were all true defaulters, the total defaulter rate would add up to 3.1%, still well below Sphere Minimum Standards.

The opposite may in fact be true: The fact that many children were 'unconfirmed recovered' (4.3%) was probably due to poor record keeping and early discharge. The average weight gain at the time of their last measurement available was only slightly lower than that in the recovery group, although their length of stay in the programme was longer. The 'unconfirmed recovered' group certainly represents a mix of children who were in fact recovered and others who were not. Therefore, it is possible that the results presented are a conservative estimate of the true recovery rate.

Being anthropometrically recovered and discharged from the OTP without complications only captures part of the child's health status. This project did not evaluate the evolution of the children after discharge (e.g. susceptibility to infectious disease) or the rate of SAM relapse among them, both of which could have theoretically been affected by the lower nutrient replenishment resulting from the use of the low-dose RUTF protocol. This should be evaluated in future research.

The objective of the subgroup analysis presented in the logistic regression models was to determine if all children had benefited equally from the low-dose RUTF protocol and identify subgroups of beneficiaries who may not have benefited from it. Being admitted with a WHZ below –3.5 was seen to lower the chances of recovery. This could reflect the fact that the more wasted a child is, the more catch-up growth is required to reach anthropometric criteria for recovery, as well as their higher vulnerability to complications, including secondary infection (Black *et al*. 2008; Alcoba *et al*. 2013). Similarly, children older than 48 months of age were more likely to become non-responders. This may in turn be related to their higher total energy and nutrient requirements (i.e. as opposed to needs per body mass), and therefore a bigger gap than in younger children between energy and nutrient requirements and the amount provided

by one sachet of RUTF per day (500 kcal). When reconsidering the low-dose RUTF protocol presented here, special attention should be given to these two groups, perhaps by increasing the dietary amounts provided to the children with lowest WHZ and to older children, even in stage 2 of treatment.

We interpret the low defaulting rate as an indication of the acceptability of the programme to the families of the children enrolled in the programme, despite the reduced RUTF quantity received halfway during treatment. The best predictor of defaulting was having a HAZ below –4 (i.e. severe stunting), an indicator of poverty, a factor that may influence programme attendance and access in multiple ways.

Standard protocols for the treatment of SAM aim at covering all the energy and nutrient needs of the child until recovery. The low-dose RUTF protocol departed from this: It assumed that most nutrient replenishment would have happened in stage 1 of treatment and expected the families to cover the gap in energy needs left by the reduced RUTF dose during stage 2. Because of high food insecurity and the annual hunger gap, the ability of the household to provide additional food for the malnourished child was uncertain upon protocol development. Despite this uncertainty, the food intake to cover this gap at household level was not measured. The fact that older (i.e. bigger) children were more likely to become non-responders may support the fact that some households were not able to cover this gap. However, being a young child (<12 months) was not associated with non-response. Although successful in this setting, this approach relied on the families' ability to provide additional food for the malnourished child, despite the uncertain food security level. We have published elsewhere a list of factors that may have contributed to the feasibility of this approach in Myanmar (Cosgrove *et al*. 2012). In addition to efforts to assess and reinforce food security, a revision of the dosage in stage 2 is needed in order to cover energy and micronutrient requirements in those settings where it is not possible to rely on household food security to support child recovery in stage 2 of treatment.

The implementation of the low-dose RUTF protocol in Myanmar was accompanied by improvements in service quality and beneficiary support at the OTP sites that may have played a major role in its success. These improvements included implementation of day care centres to provide support for children not recovering as expected, individual counselling and education, additional training of staff, early referral of cases from the community, enhanced weekly monitoring of children attending the OTP sites, and changes in service delivery (see Methods). Although these improvements were introduced in Myanmar OTP sites as a safeguard against the uncertainty of implementing a new protocol, their implementation should be recommended in all programmes. This requires inputs in human resources and management that may offset the economic savings of using less RUTF, and that may not be available in all settings, but their return in terms of programme results may certainly be worthwhile.

Although the experience presented here was not conceived as a study to compare the low-dose RUTF protocol to standard protocols, the results obtained suggest the possibility that the low-dose RUTF protocol may be a viable approach in similar contexts. Some adaptations to the protocol suggested above may include providing additional inputs to children with very low WHZ and children above 48 months of age, selection of settings with appropriate baseline food security, and/or assessment and reinforcement of food security levels and implementation of service quality improvements and beneficiary support. The performance results of the low-dose RUTF protocol described in this paper provide a foundation for a large randomised trial study to test its efficacy against standard protocols and evaluate the contribution of its individual programme components. Such a study should include follow-up of children after discharge to determine if the children treated under a low-dose RUTF protocol present more complications after treatment or more relapse. It should also evaluate the cost-effectiveness of the proposed protocol, to estimate the potential savings involved, and consider its development into new and better adapted strategies for the treatment of acute malnutrition.

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Conflicts of interest

The authors declare that they have no conflicts of interest. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Contributions

PTJ contributed to the data analysis and interpretation and writing of the manuscript. NVDB contributed to the data interpretation and writing of the manuscript. AR did the follow-up of protocol implementation and data collection; provided technical inputs for the manuscript draft. A-DI contributed to the conception of the protocol and the study follow-up; provided technical inputs for the manuscript draft. BF contributed in drafting the manuscript and provided statistical support. CN-C contributed to the conception of the protocol and the study; contributed to project follow-up, data interpretation and writing of the manuscript.

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