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Effect of caregiver training on knowledge and confidence of at-home clinical and anthropometric surveillance of children with uncomplicated severe acute malnutrition: analysis of a cross-over cluster randomised trial in Sokoto, Nigeria

Nazia Binte Ali ,[1,2] Matt DT Hitchings,[3] Fatou Berthé,[4] Philip Aruna,[5] Ibrahim Shehu,[4] Siméon Nanama,[6] Chizoba Steve-Edemba,[6] Rebecca F Grais,[7] Sheila Isanaka [1,8]

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For numbered affiliations see end of article.

Correspondence to
Dr Sheila Isanaka;
sisanaka@hsph.harvard.edu

ABSTRACT

Introduction Patient-centred task-shifting models may be a promising strategy in the community-based management of severe acute malnutrition (SAM) to alleviate pressure on health systems and increase access to treatment in low-resource settings. The engagement of caregivers in clinical and anthropometric surveillance has not been evaluated.

Objectives We examined the effect of caregiver training on their knowledge and confidence in at-home clinical and anthropometric surveillance of children with uncomplicated SAM in Sokoto, Nigeria.

Methods We used data from a cross-over cluster-randomised trial (n clusters=10) comparing a monthly follow-up schedule with caregiver training to standard weekly follow-up for the outpatient management of children 6–59 months with uncomplicated SAM. Caregivers in the monthly follow-up group received a one-time training on at-home clinical surveillance and mid-upper arm circumference (MUAC) measurement. Intention-to-treat analyses assessed mean differences in knowledge and confidence scores within the monthly follow-up group and between groups at enrolment, post-training, programme discharge and 3 months post-discharge. Accuracy of MUAC measurement and classification was compared in the monthly follow-up group to study staff at enrolment post-training, programme discharge and 3 months post-discharge.

Results Of 3945 enrolled children, 96% were followed to programme discharge and 91% to 3 months post-discharge. Caregivers' knowledge and confidence scores in clinical surveillance increased significantly in the monthly follow-up group post-training and remained elevated at programme discharge and 3 months post-discharge, compared with pretraining. Agreement in MUAC classification between caregiver and study staff was high (>92% agreement at all time points). Caregivers' knowledge and confidence scores in clinical surveillance were significantly greater in the monthly follow-up group compared with the weekly follow-up group at all time points.

Discussion These findings confirm caregiver training increases knowledge and confidence in at-home clinical

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Patient-centred task-shifting models have been used in various healthcare settings, allowing for more efficient use of healthcare workforce by redistributing tasks from highly skilled professionals to less-trained healthcare workers.

⇒ These models of care can improve access to care in resource-limited settings by addressing workforce shortages, potentially reducing costs and enhancing patient satisfaction by providing timely care while ensuring quality standards are maintained through proper training.

⇒ Since 2007, the community-based management of acute malnutrition has allowed children with uncomplicated severe acute malnutrition (SAM) to be treated on an outpatient basis with weekly or biweekly follow-up visits at local health facilities with skilled healthcare professionals.

⇒ Studies have shown that community health workers may be able to deliver care in the community and caregivers are able to conduct anthropometric surveillance using measurement of mid-upper arm circumference (MUAC).

⇒ Caregivers' ability to conduct at-home clinical and anthropometric surveillance between routine facility visits with skilled healthcare professionals is not known.

⇒ To date, no randomised controlled trials have evaluated the effect of caregiver training on caregiver knowledge and confidence in at-home clinical and anthropometric surveillance of children with uncomplicated SAM.

WHAT THIS STUDY ADDS

- ⇒ This study provides the first evidence from a large randomised controlled trial on the effect of caregiver training on their knowledge, confidence and skills in conducting at-home clinical and anthropometric surveillance of children with uncomplicated SAM receiving community-based treatment for SAM in Sokoto, Nigeria.
- ⇒ Results show that with minimal training, caregivers' knowledge and confidence in identifying clinical danger signs and their skills in MUAC measurement significantly improved from pretraining levels.
- ⇒ The improvement in caregiver's knowledge and skills was sustained for 3 months post-discharge.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ These findings support further consideration of patient-centred task-shifting models for the community-based management of SAM with caregiver training for at-home clinical and anthropometric surveillance of children with uncomplicated SAM in low-resource settings.
- ⇒ Caregiver training models should be adapted and tested according to the local context and population.

and anthropometric surveillance in the management of children with uncomplicated SAM, encouraging the continued consideration for task-shifting models in the community-based management of SAM in similar settings.

Trial registration number NCT03140904.

INTRODUCTION

Since 2007, Community-based Management of Acute Malnutrition programmes have successfully treated children with severe acute malnutrition (SAM) with high rates of recovery and low mortality.[1–3] These programmes use standardised medical and nutritional protocols that allow children with uncomplicated SAM (eg, those with no clinical complications requiring inpatient care and with sufficient appetite) to be treated on an outpatient basis with weekly or biweekly follow-up visits at local health facilities by skilled healthcare professionals. Despite the proven effectiveness of these programmes, programme coverage remains low:[4] globally, only 39% of children with SAM received treatment in 2023.[5] Key demand-side barriers to accessing treatment include the distance to healthcare facilities and cost of care, while supply-side challenges include inadequate facility readiness and a shortage of healthcare personnel.[4 6] Alternative delivery models for the outpatient management of uncomplicated SAM are needed to address these barriers and improve coverage of this life-saving intervention.

Task-shifting, defined as the transfer of tasks typically performed by health professionals to lower-level health workers or trained community members, is an effective strategy to improve coverage of various health and nutrition interventions in many low- and middle-income countries (LMICs).[7–9] Evidence shows that community health workers (CHWs) can effectively provide standard care for children with SAM, and this approach is included in WHO guidelines for the treatment of wasting in specific settings.[10–12] Further decentralising care to the household level may be another promising approach, especially in areas with shortages of trained CWHs or CWHs with excessive workloads. By involving caregivers in the treatment of uncomplicated SAM through at-home clinical and anthropometric surveillance, programmes can reduce the demands on healthcare staff, minimise the time and resources families spend on frequent visits to health facilities and encourage early detection of life-threatening complications at home. Previous studies have shown that, with brief training, mothers can diagnose SAM using measurement of mid-upper arm circumference (MUAC) as accurately as CHWs.[13 14] While caregiver involvement in at-home clinical and anthropometric surveillance for SAM appears promising, caution is warranted given the risk associated with delayed care-seeking for clinical complications, which could slow recovery and increase mortality risk.[15] Before implementation, it is essential to assess the effect of caregiver training to support at-home clinical and anthropometric surveillance for children with uncomplicated SAM.

We conducted a cluster randomised trial to estimate the effectiveness of monthly versus standard weekly follow-up schedules in children aged 6–59 months with uncomplicated SAM. Caregivers in the monthly follow-up group received a one-time training for at-home clinical and anthropometric surveillance of their children between monthly visits at a local health facility by skilled healthcare professionals. In this paper, we present the effect of caregiver training on their knowledge and confidence in at-home clinical and anthropometric surveillance and accuracy of MUAC measurement. These results are intended to provide evidence on the effectiveness of a new task-shifting model that directly engages caregivers in the community-based management of children with uncomplicated SAM.

METHODS

Study setting

The trial was conducted in 10 outpatient health facilities in the rural area of Sokoto state of Northwestern Nigeria. The area had a high burden of undernutrition among children under 5 years of age with the prevalence of stunting (height for age z score <–2) of 34% and wasting (weight for height z score <–2) of 7% in 2023.[5] The female literacy rate among women 15 years of age and older was 53%, and the prevalence of severe food insecurity was 21.3% in 2021.[16 17] The community-based treatment of SAM was provided free of charge in all 10 study sites by the Sokoto State Ministry of Health, with support from UNICEF.

Study design

The parent trial was a cluster randomised trial with a crossover design to examine the effect of monthly versus weekly follow-up schedules for outpatient treatment of uncomplicated SAM among children aged 6–59 months (ClinicalTrials.gov ID: NCT03140904). Details of the study design have been published previously.[15] In summary, 10 health facilities in the Binji and Wamako Local Government Areas were stratified based on size (±500 admissions per site per year). Within each stratum, the facilities were randomly assigned in 1:1 ratio by lottery to either a monthly follow-up schedule with caregiver training for at-home clinical and anthropometric surveillance or standard weekly follow-up schedule without training. All children enrolled within a health facility received the same follow-up schedule. Given the nature of the intervention, neither the investigators nor the participants were blinded. Due to lower-than-expected enrolment, after 11 months of intervention, a crossover was executed to increase study power. The crossover was a two-period, two-treatment cross-sectional design: facilities assigned to the monthly follow-up schedule switched to weekly follow-up schedules for all new admissions from that time forward, and vice versa. There was no washout period at the time of crossover; children who were already under follow-up at the time of the crossover continued with the facility's originally assigned schedule until discharge. The study was suspended 3 weeks before the planned end date due to the COVID-19 pandemic, when the outcome assessment at 3 months post-discharge was incomplete for 1.9% (n=72) children. Nutritional recovery was lower in the monthly follow-up group compared with the weekly group (52.4% vs 58.8%) and non-inferiority was not demonstrated with a margin of 10% (lower bound of the CI was −11.5%).[15]

Study population

Children aged 6–59 months newly admitted for treatment of uncomplicated SAM at the study facilities between January 2018 and November 2019 were included. According to the national protocol, children were eligible for outpatient SAM management if they weighed at least 3.5 kg, had a MUAC of less than 115 mm and/or had grade 1 or 2 oedema with no illness requiring inpatient care. Additional study eligibility criteria included living within the catchment area of one of the study facilities and obtaining written informed consent from a parent or legal guardian. Children who had previously been successfully treated and discharged as cured but returned with a new episode of acute malnutrition within 2 months were also eligible, as were those transferred from inpatient to outpatient care. However, children were excluded if they had missed three consecutive visits before recovery during previous treatment, had been transferred from another outpatient site or had a reported allergy to peanuts or any other condition that in the field investigator's judgement could interfere with protocol adherence or informed consent.

Intervention

The parent trial was designed to evaluate two follow-up schedules in the outpatient treatment of uncomplicated SAM: (1) the standard approach according to the national protocol involving weekly follow-up visits to a health facility until programme discharge and (2) a monthly follow-up schedule with caregiver training for at-home clinical and anthropometric surveillance and scheduled visits to a health facility at 4, 8, 10 and 12 weeks until programme discharge. The additional visit at week 10 was included with the aim to reduce participant burden and programme costs among children eligible for discharge before the next monthly visit at week 12. Distribution of therapeutic foods and facility-based clinical and anthropometric surveillance by trained healthcare workers was conducted at all scheduled facility visits in both groups.

Caregivers in the monthly follow-up group received a small-group training session at the time of programme enrolment, which lasted <30 min and presented information to complete at-home clinical surveillance of nine clinical danger signs, three signs of respiratory distress, five steps for the assessment of nutritional oedema and four steps for measuring MUAC for at-home anthropometric surveillance. The nine clinical danger signs included convulsions, diarrhoea, oedema, fever, persistent cough, poor appetite, respiratory distress, lethargy and vomiting. Signs of respiratory distress included rapid breathing, difficulty speaking or eating, chest retractions during inhalation and abnormal breathing sounds. Steps in assessing nutritional oedema included examining both feet, gently pressing the tops of both feet with thumbs for three seconds, removing fingers and checking for an indent in the skin; if an indent was present on both feet, bringing the child to a health centre. Steps of MUAC measurement included measuring at the left arm, band midway between elbow and shoulder, band properly tightened and eyes levelled to the arm and band when reading. Training was delivered using illustrated flipcharts developed in the local language, which were previously pilot tested in Niger (see online supplemental materials 1 and 2).[18] Caregivers were given a water-resistant, postcard-sized copy of the illustrations and a colour-coded MUAC tape marked in 1 mm increments for home use, with no further training provided during the follow-up period.

Regardless of the assigned intervention of their treatment site, all children received standard medical care according to national guidelines. Additionally, they received an unannounced home safety visit within 2 weeks of study enrolment. Children exhibiting any clinical danger signs during the home safety visit were referred to the nearest health facility for immediate care. All children were asked to return to the health facility 3 months after programme discharge for a final clinical and anthropometric assessment at 3 months post-discharge.

Outcomes

The primary outcome of the parent trial was nutritional recovery, as previously published.[15] In this analysis, we presented the secondary outcomes of caregiver knowledge and confidence in at-home clinical and anthropometric surveillance and accuracy in MUAC measurements.

Caregiver knowledge and confidence in clinical surveillance were evaluated using a standardised questionnaire, administered pretraining at enrolment, post-training at enrolment, programme discharge and 3 months after programme discharge. Caregivers were asked to list clinical danger signs that require facility-based care (convulsions, diarrhoea, oedema, fever, persistent cough, poor appetite, respiratory distress, lethargy and vomiting), signs of respiratory distress (rapid breathing, difficulty speaking or eating, chest retractions during inhalation and abnormal breathing sounds), steps in assessing nutritional oedema (examining both feet, gently pressing the tops of both feet with thumbs for 3 s, removing fingers and checking for a dent in the skin; if a dent is present on both feet, bringing the child to a health centre) and steps of MUAC measurement (measured at left arm, band midway between elbow/shoulder, band properly tightened and eyes fixed to band when reading). Understanding these specific signs and steps for clinical and anthropometric assessment was considered crucial for caregivers to engage in at-home surveillance and appropriate care-seeking behaviour if the child became ill. Caregiver confidence in their assessment of clinical danger signs, signs of respiratory distress, nutritional oedema assessment steps and MUAC measurement steps was also assessed using a Likert scale ranging from 1 to 5, where one represented the least confidence and five the most confidence. Caregivers were additionally presented with 20 clinical case scenarios and asked to determine whether the situation required facility-based care.[18] These scenarios assessed how well caregivers could apply their theoretical knowledge to hypothetical care-seeking decisions. Study staff not involved in the training sessions administered the questionnaires.

Among caregivers in the monthly follow-up group, accuracy in measuring MUAC was assessed by comparing caregiver measurements to those taken by study staff at enrolment post-training, programme discharge and 3 months post-discharge. Caregivers and study staff independently measured each child's MUAC in mm one time and determined the colour of their MUAC measurements (red: MUAC <115 mm; yellow: MUAC=115–124 mm and green: MUAC ≥125 mm) at each time point.

Statistical analysis

We created composite scores for the knowledge subdomains by summing the number of correct responses in each subdomain during the interview. The subdomain scores ranged from 0 to 9 for clinical danger signs, 0 to 3 for signs of respiratory distress, 0 to 5 for signs of nutritional oedema and 0 to 4 for MUAC measurement. Scores for clinical case studies ranged from 0 to 20, reflecting the accuracy of interpretations of the 20 clinical case scenarios presented during the interview. Confidence subdomain scores ranged from 1 to 5 (ordinal scales), where 1 indicated no confidence and 5 indicated strong confidence.

We assessed sociodemographic characteristics and the clinical profile of children at enrolment using means and SD for continuous variables and frequencies and percentages for binary and categorical variables. To compare group differences in the sociodemographic characteristics and child clinical profile at enrolment, we used log-binomial regression for the binary variables and linear regression for the continuous variables.

We examined changes in mean knowledge and confidence subdomain scores pretraining and post-training in the monthly follow-up group, as well as mean differences in knowledge and confidence subdomain scores between the weekly and monthly follow-up groups over time (pretraining, programme discharge and 3 months post-discharge). We used log-binomial regression for knowledge subdomain scores and an ordinal logistic regression model for confidence subdomain scores. Additionally, we calculated the mean differences and 95% CIs between caregiver-measured and study staff-measured MUAC using linear regression. Per cent agreement between the MUAC colour determinations (red, yellow, green) of caregivers versus study staff was calculated as well as Cohen's kappa to finally compare MUAC group classifications at post-training, programme discharge and 3 months post-discharge.

All analyses were intent-to-treat and conducted at the individual level. To account for clustering in outcomes at the site level, we used generalised estimating equations with an exchangeable correlation structure, allowing individuals attending the same clinic to have correlated outcomes. To account for the crossover design, regression models included a fixed effect term for 'period' (ie, after the crossover vs before the crossover).[19 20] Statistical significance was defined as p value <0.05, and no adjustments were made for multiple comparisons. Data entry was performed using Epi Info V.7.2.2.2, and sample size calculations and analyses were performed using SAS V.9.3 (SAS Institute, Cary, North Carolina, USA) and R V.4.0.2.

RESULTS

Between 23 January 2018 and 30 November 2019, 3945 children were enrolled in the study, of which 1875 were from facilities randomised to standard weekly follow-up schedules and 2070 were from facilities randomised to monthly follow-up with caregiver training for at-home clinical and anthropometric surveillance (online supplemental figure 1). In the weekly follow-up group, 1802 children (96%) completed assessments at programme discharge and 1721 (92%) at 3 months post-discharge, compared with 1976 (95%) children in the monthly follow-up group who completed assessments at programme discharge and 1873 (90%) children at 3 months post-discharge. Study exclusions due to protocol violations were related to confirmation of caregiver residence outside of the study

Table 1 Characteristics of the study population at study enrolment

Characteristic	Total (N=3945)	Weekly follow-up group (n=1875)	Monthly follow-up group (n=2070)	P value*
Sociodemographic characteristics:				
Mother's age in years, mean (SD)	26.18 (6.51)	26.43 (6.8)	25.95 (6.22)	0.004
Mother's education (any), n (%)	225 (5.73)	113 (6.06)	112 (5.43)	0.91
Mother's number of pregnancies, mean (SD)	4.25 (2.56)	4.2 (2.52)	4.29 (2.59)	0.45
Time to health facility by foot (minutes), mean (SD)	57.32 (39.04)	55.25 (35.38)	59.18 (41.98)	0.91
Child characteristics:				
Age in months, mean (SD)	15.75 (7.12)	15.74 (7.09)	15.77 (7.16)	0.81
Female sex, n (%)	2097 (53.16)	962 (51.31)	1135 (54.83)	0.057
Currently breastfeeding, n (%)	2616 (66.33)	1228 (65.53)	1388 (67.05)	0.42
Anthropometric data, mean (SD)				
Weight-for-height z-score, mean (SD)	−3.75 (1.15)	−3.78 (1.19)	−3.73 (1.11)	0.44
Height-for-age z-score, mean (SD)	−3.52 (1.45)	−3.53 (1.51)	−3.5 (1.4)	0.44
Weight-for-age z-score, mean (SD)	−4.51 (0.83)	−4.53 (0.84)	−4.49 (0.82)	0.080
MUAC, mm, mean (SD)	105.77 (6.01)	105.67 (6.05)	105.85 (5.98)	0.50

*P values for binary outcomes from generalised estimating equations with an exchangeable correlation structure and a log-binomial distribution. P values for continuous outcomes from generalised estimating equations with an exchangeable correlation structure with a normal distribution.
MUAC, mid-upper arm circumference.

catchment area and illness requiring inpatient care at admission or interfering with protocol adherence.

Participants' characteristics

Table 1 describes the sociodemographic characteristics and clinical profile of children at study enrolment. Groups did not differ in terms of the sociodemographic and clinical profile of children. Overall, 6% of mothers received any education, with an average (SD) fertility rate of 4.3 (2.6). The mean (SD) age of children at enrolment was 15.8 (7.1) months. The mean (SD) MUAC at enrolment was 105.8 mm (6.0). Children presented with a variety of mild clinical danger signs at enrolment, the most prevalent including dehydration and coughing.

Difference in caregiver knowledge and confidence in at-home clinical and anthropometric surveillance over time in the monthly follow-up group

We compared changes in caregiver knowledge and confidence within the monthly follow-up group over time (table 2). Across all subdomains, knowledge scores significantly increased from pretraining to all post-training assessments. At pretraining, mean (SD) knowledge scores for clinical danger signs were 3.61 (1.47) out of 9 total, for signs of respiratory distress were 1.16 (0.83) out of 3 total, nutritional oedema assessment steps were 0.19 (0.87) out of 5 total, for MUAC measurement steps were 0.14 (0.67) out of 4 total and for clinical case studies were 10.01 (4.01) out of 20 total. At post-training at enrolment, knowledge scores for clinical danger signs increased significantly to 8.27 (1.02), signs of respiratory distress to 2.74 (0.52), nutrition oedema assessment steps to 4.66 (0.73), MUAC measurement steps to 3.84 (0.53) and case studies for care-seeking to 14.13 (2.09). Caregiver knowledge scores remained significantly higher than pretraining scores at programme discharge and 3 months post-discharge. Caregiver knowledge scores for the assessment of nutritional oedema and MUAC measurement were significantly different between programme discharge and 3 months post-discharge; however, the magnitude of these differences was small. Caregiver knowledge scores at programme discharge and 3 months post-discharge were lower compared with scores at post-training at enrolment. Similar trends were observed in caregiver confidence scores over time in the monthly follow-up group (table 2). Confidence scores for all subdomains, measured on a 1–5 scale, increased significantly from pretraining to all post-training assessments and remained elevated throughout follow-up to 3 months post-discharge.

Difference in caregiver knowledge and confidence in at-home clinical and anthropometric surveillance over time between groups

We further assessed mean differences in caregiver knowledge and confidence scores between groups pretraining at enrolment, programme discharge and 3 months post-discharge (figures 1 and 2). There were no between-group differences in knowledge and confidence scores pretraining. Both at programme discharge and 3 months post-discharge, caregivers in the monthly follow-up group had significantly higher knowledge and confidence scores than the caregivers in the weekly follow-up

Table 2 Caregiver knowledge and confidence within the monthly follow-up group over time

	Pretraining at enrolment Mean (SD)	Post-training at enrolment Mean (SD)	At programme discharge Mean (SD)	At 3 months post-discharge Mean (SD)
N	1976	1975	1763	1695
Caregiver knowledge*				
Clinical danger signs (total: 9)	3.61 (1.42)	8.27 (1.02)†	6.85 (1.6)†‡	6.74 (1.61)†‡
Signs of respiratory distress (total: 3)	1.16 (0.83)	2.74 (0.52)†	2.08 (0.85)†‡	2.1 (0.84)†‡
Steps of nutritional oedema assessment (total: 5)	0.19 (0.87)	4.66 (0.73)†	4.38 (1.2)†‡	4.29 (1.34)†‡§
Steps of MUAC measurement (total: 4)	0.14 (0.67)	3.84 (0.53)†	3.65 (0.85)†‡	3.56 (0.99)†‡§
Clinical case studies (total: 20)	10.01 (4.07)	14.13 (2.09)†	13.58 (2.17)†‡	13.57 (2.51)†‡
Caregiver confidence to assess (scale 1–5)				
Clinical danger signs	2.86 (0.89)	4.84 (0.41)†	4.22 (0.8)†‡	4.25 (0.79)†‡
Signs of respiratory distress	3.55 (1.23)	4.75 (0.56)†	4.57 (0.7)†‡	4.49 (0.77)†‡
Steps of nutritional oedema assessment	2.01 (0.88)	4.26 (0.97)†	3.4 (1.24)†‡	3.39 (1.21)†‡
Steps of MUAC measurement	3.28 (1.41)	4.72 (0.59)†	4.51 (0.79)†‡	4.47 (0.82)†‡

*The intracluster correlation coefficient of caregiver knowledge outcomes at programme discharge ranged from 0.001 to 0.04.
†Score significantly different from the pretraining score at enrolment.
‡Score significantly different from the post-training score at enrolment.
§Score significantly different from programme discharge score.
MUAC, mid-upper arm circumference.

groups. At 3 months post-discharge, the mean (SD) knowledge score for clinical danger signs was 6.74 (1.61) in the monthly follow-up group versus 4.73 (1.49) in the weekly follow-up group (p value for mean difference between groups<0.001), for signs of respiratory distress, scores were 2.10 (0.84) vs 1.44 (0.89) (p<0.001), for steps

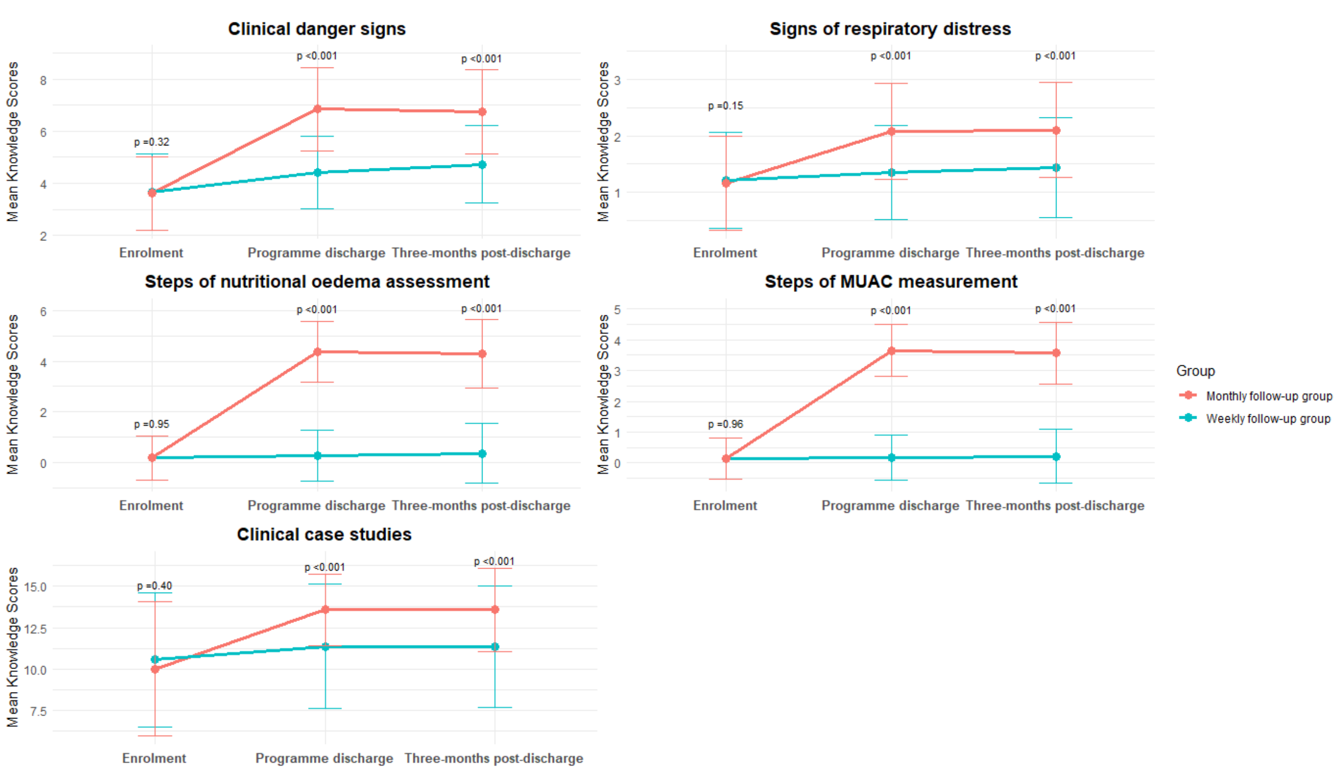

Figure 1 Caregiver knowledge scores among the weekly and monthly follow-up groups at enrolment, programme discharge and 3 months post-discharge. P values from generalised estimating equations, with exchangeable correlation structure and a log-binomial distribution comparing mean differences in the knowledge scores between weekly and monthly follow-up groups at enrolment, programme discharge and 3 months post-discharge. MUAC, mid-upper arm circumference.

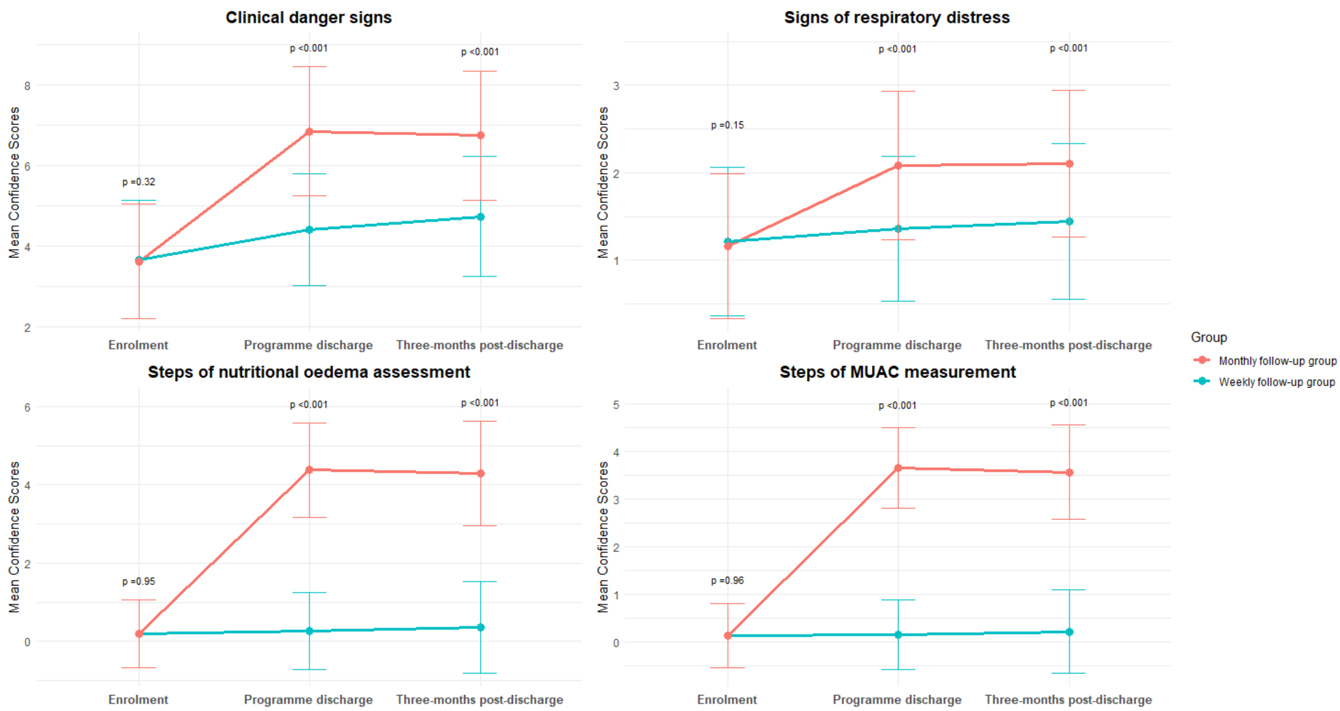

Figure 2 Caregiver confidence scores among weekly and monthly follow-up groups at enrolment, programme discharge and 3 months post-discharge. P values generalised estimating equations, with exchangeable correlation structure and an ordinal logistic model comparing mean differences in the knowledge scores between weekly and monthly follow-up groups at enrolment, programme discharge and 3 months post-discharge. MUAC, mid-upper arm circumference.

to assess nutritional oedema, scores were 4.29 (1.34) vs 0.36 (1.18) (p<0.001), for steps for MUAC measurement, scores were 3.56 (0.99) vs 0.22 (0.88) (p<0.001) and for clinical case studies, care seeking scores were 13.57 (2.51) vs 11.35 (3.68) (p<0.001) (figure 1). Similarly, at 3 months post-discharge, the mean (SD) confidence scores in the monthly follow-up group were significantly higher than the weekly follow-up group (figure 2).

Accuracy of MUAC measurement and classification by caregivers in the monthly follow-up group

Caregivers measured MUAC 0.4 mm higher than study staff post-training at enrolment (105.9 (6.0) mm vs 106.3 (5.9) mm; mean difference 95% CI: 0.3 to 0.6) and 0.1 mm lower than study staff at programme discharge (125.3 (9.7) mm vs 125.2 (9.7) mm; mean difference 95% CI: 0.03 to 0.3). At 3 months post-discharge, there was no difference in MUAC measurements between caregivers and study staff (127.1 (11.5) mm vs 127.0 (11.1); mean difference −0.1 mm, 95% CI: −0.2 to 0.1). When classifying MUAC according to colour categories, agreement was high between caregivers and study staff at all follow-up time points (98% agreement post-training, 92% at programme discharge and 93% at 3 months post-discharge, table 3). We estimated Cohen's Kappa, which measures inter-rater reliability while accounting for the underlying distribution of the condition, revealing that there was low agreement between caregivers and staff post-training due to the high proportion of children in the red category and the small number of caregivers who graded their children as yellow (κ=0.00, 95% CI −0.01 to 0.00) while agreement was very strong at programme discharge (κ=0.86, 95% CI 0.84 to 0.88) and 3 months post-discharge (κ=0.87, 95% CI 0.84 to 0.89).

DISCUSSION

Our study examined the effect of caregiver training on knowledge and confidence to conduct at-home clinical and anthropometric surveillance of children with uncomplicated SAM. We found that a short, one-time training improved caregiver knowledge and confidence scores in at-home clinical surveillance and conducting MUAC measurements. Improved caregiver knowledge and confidence remained elevated compared with pretraining throughout treatment and up to 3 months post-discharge. Caregivers demonstrated high agreement in MUAC measurement when compared with measurements of study staff, both post-training at enrolment and at all follow-up points thereafter.

The parent trial evaluated a reduced schedule of follow-up model for the community-based management of uncomplicated SAM, in which a monthly follow-up schedule with caregiver training was compared with a standard weekly follow-up schedule without training for the outpatient management of children aged 6–59 months with uncomplicated SAM in rural Nigeria. This monthly follow-up strategy relied on caregivers' ability to monitor clinical and anthropometric indicators between scheduled health facility visits with healthcare workers. Our

Table 3 Comparison of colour-coded MUAC classification between caregivers in the monthly follow-up group and study staff

Caregiver classification	N	Study staff classification Green n (%)	Yellow n (%)	Red n (%)	Agreement n (%)
At enrolment	1957				
Green*		0 (0)	0 (0)	0 (0)	
Yellow		0 (0)	0 (0)	28 (1)	
Red		0 (0)	3 (0)	1926 (98)	1926 (98.42)
At programme discharge	1699				
Green		1039 (61)	14 (1)	2 (0)	
Yellow		59 (3)	341 (20)	28 (2)	
Red		3 (0)	19 (1)	194 (11)	1574 (92.64)
At 3 months post-discharge	1595				
Green		964 (61)	37 (2)	2 (0)	
Yellow		42 (3)	365 (24)	17 (1)	
Red		1 (0)	13 (1)	154 (9)	1483 (92.97)

*Colour category system for classifying MUAC: green (MUAC ≥125 mm), yellow (MUAC between 115 and 125 mm), red (MUAC <115 mm).
MUAC, mid-upper arm circumference.

analyses here showed that a short, one-time training can improve caregivers' knowledge and confidence in recognising clinical danger signs and that gains were sustained during treatment and up to 3 months after programme discharge. This aligns with findings from an earlier feasibility study conducted in Niger, where caregivers of children with SAM showed improved awareness of nine clinical danger signs up to 28 days post-training.[18] Other health education approaches have been successful in improving caregivers' knowledge of clinical danger signs in children across various community-based health and nutrition programmes in several LMICs such as Nigeria, Zambia and Pakistan.[21–23] A pre–post study on video-based caregiver training for the Integrated Management of Newborn and Childhood Illnesses in Nigeria reported a reduction in the proportion of mothers unable to recognise newborn danger signs from 47% before training to 1.5% 3 months afterward.[21] Another quasi-experimental study on malaria home management for children in Nigeria found that caregiver knowledge of referral signs and symptoms increased by 52% following training in the intervention group compared with 0.2% in the comparison group.[22] Our findings similarly support the potential for task-shifting models that engage caregivers to be effective in supporting at-home clinical surveillance of children with uncomplicated SAM.

Our results also demonstrated that caregivers receiving a short, one-time training could measure MUAC with similar accuracy as study staff. Previous quasi-experimental studies have shown that caregivers can reliably measure MUAC and diagnose SAM using MUAC following training, with accuracy comparable to that of health or CHW.[13 14 24] A non-randomised study conducted in two rural villages in Niger assessed the effect of caregiver education on detecting SAM using MUAC compared with CHWs.[13] The results showed that caregivers identified SAM with high sensitivity (>73%) and high specificity (>98%) compared with CHWs. In another large-scale pragmatic, non-randomised intervention study in Niger, 12 893 mothers and 36 CHWs were trained to screen for SAM using colour-coded MUAC tapes.[24] Agreement on MUAC measurements with facility staff was higher in areas where caregivers were trained compared with CWH-led areas (75% agreement vs 40%). Also, cases of SAM were detected earlier, with a median MUAC at admission 1.6 mm higher in caregiver-led areas than in CHW-led areas. These findings collectively support the caregiver's ability to monitor anthropometric status between facility visits, which would be important for shifting surveillance for SAM from facilities to the household level and thereby reduce the burden on the health systems while promoting early identification of complications. Retaining these skills over time and even after programme discharge can be crucial, considering 6–37% children with SAM can have a relapse within 6 months of programme recovery.[25–27]

While our results support the effectiveness of training on caregiver knowledge and confidence and the potential for scalability of a short, small-group education session, we note that training and support for at-home clinical surveillance should be adapted to the specific context. Training materials should be tailored to the disease burden and risk factors for complications and mortality of the setting, as well as care seeking behaviours and educational background of caregivers. In our study setting, diarrhoea and pneumonia were leading causes of hospitalisation and death among children with SAM[15] and clinical danger signs for these morbidities were included in our training. Although we saw retention of knowledge and confidence for clinical and anthropometric surveillance during treatment and even up to 3 months post-discharge compared with pretraining, we also observed some non-significant decline in caregiver knowledge and confidence at programme discharge and 3 months post-discharge. Programmes may consider repeating the training or providing abbreviated refreshers to encourage sustained knowledge retention. Given the high risk of complications and relapse among children with SAM, training initially provided once at enrolment could be reinforced throughout and after treatment to promote longer term benefits.[25 26]

Our study has several strengths and limitations. Interpretation of our study findings is strengthened by the large, randomised controlled study design and low loss to follow-up. A crossover study design was also employed to improve power with a smaller number of clusters and reduced confounding due to between-cluster variability as each cluster delivered both interventions.[28] Time period effects were accounted for in the statistical analysis to consider seasonal or secular trends that could have influenced the intervention effect. Several limitations should be recognised as well.[28] Generalisability may be limited, and study findings should be contextualised with consideration for the specific study setting, which has been characterised by low literacy levels, low care-seeking practices and the presence of clinical complications at enrolment.[15] The study design did not include direct at-home observation of clinical and anthropometric surveillance, and low levels of literacy among participants complicated participant recording of at-home practice; we therefore do not have information on at-home practice to support our interpretation of findings on caregiver knowledge and confidence. Further, we are unable to disentangle the effect of training from the reduced frequency of follow-up on caregiver knowledge and confidence. It is possible that the less frequent, monthly follow-up among caregivers who received training alone empowered them to assume greater responsibility for and confidence with at-home clinical and anthropometric surveillance, but our findings more broadly relate to the combined effect of caregiver training with a reduced schedule of follow-up. Finally, it is important to note that the parent trial found the monthly schedule of follow-up with caregiver training to be less effective than the standard weekly follow-up in terms of nutritional recovery among children with SAM.[15] This suggests that, despite improved caregiver knowledge and confidence in detecting complications achieved with a short training, inconsistent practice of at-home clinical and anthropometric surveillance and delayed care-seeking associated with a reduced or monthly follow-up schedule may contribute to poorer outcomes. Future research may consider further assessment of feasibility and acceptability of at-home clinical and anthropometric surveillance among caregivers to better understand at-home practice. Future adaptations of a reduced follow-up schedule for the community-based management of children with uncomplicated SAM may need to provide additional support beyond caregiver training and explore additional strategies to encourage regular practice of at-home clinical and anthropometric surveillance presented during training and improved care-seeking behaviours. Involving key stakeholders such as fathers in training sessions and integrating additional home visits by CWH between routine facility-based follow-ups could be considered, given the success of these approaches in improving care-seeking for common childhood illnesses in other LMIC settings.[29 30]

In conclusion, our trial showed that a short, one-time training significantly improved caregivers' knowledge and confidence in at-home clinical and anthropometric surveillance, and these gains were sustained up to 3 months post-discharge. These findings provide valuable insights into scalable interventions that can be used to support caregivers' ability to recognise complications between health facility visits, a lynchpin to patient-centred task-shifting models for the community-based management of SAM. Given the variations in disease epidemiology, sociodemographic factors, care-seeking behaviours and health system capacity, future adaptations of caregiver training models should be tailored to local contexts and populations.

Author affiliations
[1]Department of Global Health and Population, Harvard T H Chan School of Public Health, Boston, Massachusetts, USA
[2]Maternal and Child Health Division, International Centre for Diarrhoeal Disease Research Bangladesh, Dhaka, Bangladesh
[3]Biology, University of Florida, Gainesville, Florida, USA
[4]Epicentre Niger, Niamey, Niger
[5]Operations, Médecins Sans Frontières Operational Centre Amsterdam, Amsterdam, The Netherlands
[6]UNICEF West and Central Regional Office, Dakar, Senegal
[7]Epicentre, Paris, France
[8]Department of Nutrition, Harvard T H Chan School of Public Health, Boston, Massachusetts, USA

Contributors Study conceptualisation (SI and RFG); funding acquisition (SI); project administration (FB, PA, MH, SN, CS-E); data curation (MH, FB and IS); data analysis (MH); drafted the manuscript (NBA and SI). All authors reviewed and contributed to the finalisation of the manuscript. SI had access to the data and accepts responsibility for the accuracy of the data analysis and the decision to submit the manuscript for publication. SI is responsible for the overall content as guarantor.

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ORCID iDs
Nazia Binte Ali http://orcid.org/0000-0001-5010-9563
Sheila Isanaka http://orcid.org/0000-0002-4503-2861

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