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Title

Rates and risks factors for relapse among children recovered from severe acute malnutrition: a multi-country, prospective cohort study in Mali, South Sudan, and Somalia

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ABSTRACT

Background
Community-based Management of Acute Malnutrition (CMAM) is an effective treatment model for children with severe acute malnutrition (SAM). However, little evidence exists regarding post-discharge outcomes and the sustainability of recovery achieved under this model.

Methods
This multi-country prospective cohort study followed children recovered from SAM (i.e., post-SAM) and non-malnourished controls in parallel for six-months in Mali, South Sudan, and Somalia. Nutritional status was assessed monthly to determine the proportion of post-SAM children remained non-malnourished, measure the relative risk of developing acute malnutrition (AM) between the two groups, and determine associated risk factors. A total of 2,935 children were enrolled (1,821 post-SAM and 1,114 control) between April 2021 and July 2022.

Findings
After six months of follow-up, 31% (95% CI 26-35), 47% (95% CI 43-51), and 5% (95% CI 4-7) of post-SAM children in Mali, South Sudan, and Somalia, respectively, relapsed to AM or died. Post-SAM children were between three to five times more likely to experience AM or death compared to controls. Higher anthropometric measurements at discharge were identified as protective. Few individual and household-factors were associated.

Interpretation
Following initial recovery, post-SAM children are at significant risk of relapsing within six months, with almost half failing to sustain recovery in one of the three countries. Although absolute relapse rates differ contextually, relative risk varies little. The higher relative risk of relapse underscores the vulnerability of this population and failures of current approaches to prevent children from experiencing repeated AM episodes.

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RESEARCH IN CONTEXT

Evidence before this study

A small body of evidence and anecdotal observations from healthcare workers indicate that children receiving treatment for severe acute malnutrition (SAM) in public health and nutrition programmes are often readmitted for repeated treatments even after successfully completing treatment and achieving an initial recovery. However, there has been limited research to quantify the post-discharge relapse rate in a systematic way in different populations and operational programmes. In 2018 and 2019, two systematic reviews on post-discharge follow-up of children aged 6-59 months recovered from SAM found critical gaps in the evidence-base, including: a limited understanding of post-treatment outcomes, a lack of standard definitions for relapse, and inconsistent methodology for quantifying post-discharge outcomes. This led the Council of Research and Technical Advice on Acute Malnutrition (CORTASAM) in 2018 to outline the pressing need for more research to estimate rates of post-treatment relapse in different settings with standardized definitions and measurement.

Added value of this study

This is the first multi-country prospective cohort study to estimate relapse rates and associated risk factors using a standardized approach of collecting monthly anthropometry measurements on children recovered from uncomplicated SAM treated in the community ("post-SAM" children) and to compare them to community matched controls. We provide new and important evidence on the burden of relapse and its determinants. We show that children who recover from SAM, although they are clinically deemed 'not malnourished', are more nutritionally vulnerable than their non-previously malnourished peers. Furthermore, this vulnerability persists for at least six months following initial recovery. Relapse rates in the three country contexts varied greatly, likely due to differences in access to healthcare services, CMAM programme design, and other contextual and environmental risk factors. However, the risk ratios of relapse were similar for the three very different contexts, thus allowing us to generalize relapse risk more broadly in humanitarian settings. In view of current gaps in the SAM relapse evidence, our study provides new evidence on the extent of relapse among children discharged from CMAM programmes in three different high burden settings and shows relapse risk factors are likely to be as multifactorial and interconnected as risk factors for acute malnutrition itself.

Implication of all the available evidence

Our study highlights the need to consider post-discharge relapse as an indicator of the performance of SAM treatment programmes. Additionally, our results suggest the need for specific strategies to prevent relapse post discharge and to include relapse as a fundamental targeting criterion for interventions and assistance. More fundamentally, our findings emphasize the importance of stronger prevention strategies to ensure children do not initially become wasted and enter the harmful cycle of relapse.

TEXT

Introduction

The prevalence of acute malnutrition (AM) in young children remains high with only 34% of countries on track to meet the Sustainable Development Goals wasting targets.[1] In 2022, approximately 45 million children under the age of five suffered from AM, with 13·7 million children affected by severe acute malnutrition (SAM).[1] AM in children aged 6-59 months is defined by the World Health Organization (WHO) as having a low weight-for-height z-score (WHZ) <-2SD and/or a low mid-upper arm circumference (MUAC) <125mm and/or bilateral pitting oedema. SAM, defined by the lowest range of these anthropometric measures (WHZ <-3SD and/or MUAC <115mm) and/or when oedema is present, has severe consequences, including increased risk of infections and mortality.[2,3]

Community-based management of acute malnutrition (CMAM) is the standard treatment for SAM children in low-resource settings. The WHO-endorsed model comprising outpatient treatment using specially formulated foods and medication has proven effective in temporarily reversing nutritional deterioration.[4] Nevertheless, evidence suggests children frequently relapse after recovery, jeopardizing their health.[5-15]

Relapse rates after SAM recovery have been documented in a small number of studies ranging from 0-37%.[16] However, many studies lack longitudinal follow-up or control groups, leading to gaps in estimating and understanding post-discharge risk.[17,18] Inconsistent methods for reporting post-discharge outcomes limit comparisons across contexts and hamper an accurate quantification of the relapse problem.

High levels of relapse negate much of the impact of SAM treatment and waste limited humanitarian assistance by treating the same children multiple times. Relapse likely increases the risk of poor health outcomes and death, as children linger in a cycle of malnutrition. Preventing relapse is critical, yet fundamental evidence gaps exist regarding factors associated with relapse to inform what interventions could prove most effective.[19]

The study's primary objective was to estimate the cumulative incidence and risk of relapse within six months following children's recovery from SAM treatment as compared to their non-malnourished peers in three countries with high burden of SAM and identify potential risk-factors.

Methods

Study design and participants

This study was conducted in 16 CMAM programme sites in Mali, South Sudan, and Somalia, using a prospective cohort design to assess the cumulative incidence of relapse after recovery from SAM treatment and the associated risk factors. A detailed description of the study protocol and sample size calculations was previously published.[20]

Study sites were selected based on high SAM caseloads, established CMAM programmes, and accessibility by data collectors. Post-SAM children (those discharged as recovered after uncomplicated SAM treatment) and community-matched control children were enrolled and followed for six months. Children eligible for enrollment were those discharged from CMAM as recovered from SAM between the ages of 6-47 months. Controls were matched to post-SAM children on age, sex, and location and required to be without an episode of AM in the year prior to enrollment and to be within three months (for children aged 6-11 months) or six months (for children aged 12-47 months) of the post-SAM child's age.

Ethical approval was provided by Solutions Institutional Review Board (#20200310), the London School of Hygiene and Tropical Medicine's (LSHTM) Research Ethics Committee (#18059), the Ministry of Health and Human Services of Somalia (MOH&HS/DGO/0429/03/202), the Université Des Sciences, Des Techniques Et Des Technologies De Bamako (2020/202/CE/FMOS/FAPH)) in Mali, and the Ministry of Health of South Sudan (MOH/ERB6/2020). Written informed consent was obtained from all participants' caregivers. The study adheres to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines (Annex I).[21]

Data collection
Post-SAM children were enrolled at discharge from treatment and control children were enrolled within two weeks of the matched post-SAM child's enrollment. Data collection was identical across groups.

Participants were assessed monthly in clinics, with seven rounds of data collection (one at enrollment and six follow-up visits). At each visit a survey was completed, and children were evaluated anthropometrically (MUAC, WHZ, and oedema). AM-identified children were referred for treatment and remained in the study. CMAM services were available for any cases of SAM and moderate acute malnutrition (MAM), defined as MUAC 115-124mm and/or WHZ ≥-3SD - <-2SD without oedema. Treatment data, including medical care, co-morbidities, and length of treatment, were collected. Survey data covered an array of individual child-level and household-level covariates including child feeding practices, health history, maternal survival status, and number of siblings. Food insecurity was assessed via the Household Hunger Scale (HHS).[22]

Data was collected electronically or via paper forms, double-entered into electronic databases and stored on secure servers. Quality checks were conducted upon entry to identify data entry errors, irregularities, or incompleteness.

Definition of primary outcome measures
The primary outcome was the cumulative incidence of AM or all-cause death (AM+death) over the full six-month observational period. In additional analyses, results were further disaggregated as distinctly SAM, MAM, or all-cause death. When a child experienced more than one outcome (e.g., SAM then death), the most severe outcome was chosen as the final outcome (e.g., death). Secondary outcomes included the incidence rate, point prevalence, and relative risk of AM+death (and disaggregated SAM, MAM, and all-cause death) in both post-SAM and control cohorts. For the post-SAM cohort, these outcomes are considered relapses. Thus, the definition of relapse is relapse to AM+death, with further disaggregation of relapse distinctly to SAM, MAM, or all-cause death. Detailed tertiary outcomes are defined in the published protocol.[20]

Nutritional status at each follow-up visit was classified at clinic sites, with z-score dependent indicators confirmed using the WHO's 2006 Child Growth Standards via the *zscore06* Stata package.[23, 24] Any discrepancies were resolved based on the calculated scores. Missing height, weight, and MUAC measurements were imputed by averaging observations prior to and after a missing measurement, excluding visits once children were lost to follow-up. Imputed data remained comparable to non-imputed data, with no significant differences when excluding and including imputed values (Supplementary Table 1).

Some aspects of CMAM implementation differed in the three contexts (Supplementary Table 2). Variations applied to the application of MUAC and WHZ admission and discharge criteria, maximum length of stay, transfers from OTP to supplementary feeding programmes (SFP) during treatment, and type of specialized nutritious foods provided (ready-to-use therapeutic food (RUTF), and ready-to-use supplementary food (RUSF.

Statistical analyses
We calculated cumulative incidence of AM+death, defined as all new and pre-existing cases of AM during a given period divided by the total population during the same period who were not lost to follow-up in that round, for each time point across the observational period. The cumulative incidence of AM+death constitutes the relapse rates in the post-SAM group and initial incidence in the control group.

To compare child characteristics at enrollment and outcomes between the control and post-SAM groups, we used a proportion z-test for binary variables and Student's t-test for continuous variables. To calculate risk ratios, we used a Poisson regression model with robust error variance,[25] including both a crude model with the independent variable (post-SAM vs control) only and an adjusted model with an added matrix of covariates, including age, sex, and WHZ of child at admission and clinic the child was admitted to.

In the post-SAM cohort, we ran the same Poisson regression to identify factors associated with relapse across different countries and outcomes. For each model we ran a crude regression with only one driver, and then an adjusted model

controlling for child sex, child age at admission, length of stay, whether child is currently breastfed, whether the mother is alive, mothers education, whether child is a twin, number of siblings, HHS, Morris Index, and access to improved water source and improved sanitation. Given the strong correlation between different anthropometric indicators, we only included one indicator at a time for each model (WHZ, WAZ, HAZ, and MUAC at admission and at discharge, and the rate of weight change).

To understand the overall risk ratio for outcomes in all three countries, we ran a random-effects meta-analysis using the log of the risk ratio as the effect size. The analysis was run separately for three binary outcomes: AM+death vs not, SAM vs. not, and MAM vs. not. Weights were applied using the inverse variance of the log risk ratios.

Kaplan-Meier survival curves were run for post-SAM and control groups on whether the child survived without AM over the six-month observational period. Curves were compared using the log-rank test. A p-value of less than 0·05 was considered significant.

Role of funding source

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Results

Participants were enrolled between April 2021 and July 2022, with data collection concluding in November 2022. A total of 2,895 children were enrolled, including 1,821 and 1,114 post-SAM and control children, respectively. Forty children were excluded from final analysis due to incorrect eligibility criteria. Loss to follow-up was low with data available for the full six-month period for 2,760 (95%) participants. The severity of SAM upon admission to treatment in the CMAM programme did not differ in the three countries, when comparing children's anthropometric measurement at admission and according to the measure upon which they were admitted (Table 1). At discharge, 95 (16%) post-SAM children in South Sudan and 29 (4%) in Somalia were considered recovered per programme discharge criteria, yet their WHZ, which was not considered a part of the discharge criteria, was below -2SD.

In all countries, post-SAM children had significantly lower anthropometric measurements than the control children. Severe stunting (height-for-weight z-score <-3SD) and severe underweight (weight-for-age z-score <-3SD) were more than twice as prevalent in the post-SAM groups (Table 1).

At six months post-discharge, the cumulative incidence of post-SAM relapse to AM+death was 31% (95% CI 26-35), 47% (95% CI 43-51), and 5% (95% CI 4-7) for Mali, South Sudan, and Somalia, respectively (Table 2). In Mali and South Sudan, episodes of AM mostly consisted of MAM rather than SAM (Mali: 15% MAM vs. 4% SAM p<0.0001; South Sudan: 29% MAM vs. 6% SAM p<0·0001). Mortality remained low in all countries, never exceeding 1% in the six-month period. The cumulative incidence of AM+death was significantly higher in the post-SAM group than the control group by the end of six months (Mali: 31% vs. 9%, p<0·0001; South Sudan: 47% vs. 10%, p<0·0001; Somalia: 5% vs. 2%, p=0·014) and at nearly all follow-up points.

In all countries, post-SAM children had a significantly greater risk of experiencing AM+death than control children with the overall risk ratio of 3·8, 95% CI [2·89, 5·01] (Figure 1). Even higher was the overall relative risk of developing SAM (RR:7·8, 95% CI [2·89, 21·03]). After controlling for covariates in adjusted models, including anthropometry at enrollment, these elevated risks remained statistically significant (Supplementary Table 3). Models were run with the outcomes including and excluding death and results were similar with no significant differences (results not shown).

Regarding the timing of relapse, Figure 2 shows that point prevalence of AM was evenly distributed across all follow-up periods for the Mali and Somalia cohorts, with a slight peak occurring at three months in South Sudan. The incidence rate of relapse was also calculated at three- and six-months post-discharge: at three months post-discharge, the AM incidence rate was 8 per 100 child-months, 14 per 100 child-months, and 1 per 100 child-months for Mali,

South Sudan, and Somalia, respectively. At six-months post-discharge, the AM incidence rate was 6 per 100 child-months, 11 per 100 child-months, and 1 per 100 child-months, in Mali, South Sudan, and Somalia, respectively.

In comparing the average time to first occurrence of AM+death, post-SAM children fared worse than control children, who sustained their healthy survival status longer than the post-SAM group. (Mali: p<0·0001; South Sudan: p<0·0001; Somalia: p<0·0001) (Figure 3). Median time to first episode of AM+death in the post-SAM cohort (2·3 [IQR: 2·9], 2·0 [IQR: 2·5], and 2·8 [IQR: 3·4] months in Mali, South Sudan, and Somalia, respectively) was approximately one month less than that of the control group (3.0 [IQR: 2·7]; 3·0 [IQR: 3·1]; and 3·8 [IQR: 4·5] months in Mali, South Sudan, and Somalia, respectively).

As variations in CMAM programmes across the three countries might have influenced post-discharge outcomes, separate analyses were conducted in which each of the three different CMAM programme criteria were applied to each country's datasets to calculate simulated cumulative incidence and risk ratios for AM+death. Results of this simulation demonstrate that relapse rates are highest when CMAM programmes defined AM using both WHZ and/or MUAC and lowest when using MUAC only. Cumulative incidence fluctuated 14-20 percentage points depending on the CMAM programme criteria applied. For example, if we applied to Somalia's data a MUAC and/or WHZ criterion instead of a MUAC-only criterion, post-SAM relapse to AM+death would increase from 5% to 23%. Similarly, if we applied to Mali's dataset a MUAC-only criterion instead of a MUAC and/or WHZ criteria, post-SAM relapse to AM+death would decrease from 31% to 17% (Table 3).

Among the post-SAM cohort, multiple factors related to child initial SAM treatment and household were explored to identify potential risk factors for post-discharge relapse to AM+death in unadjusted (Supplementary Table 4) and adjusted models (Table 4). While lower anthropometry at both admission and discharge is associated with relapse, after adjusting for co-factors, discharge anthropometry has a stronger and more consistent association with relapse than admission anthropometry. Of all the discharge anthropometrics, WAZ was the most consistently associated with relapse. Protective factors included being female or under 24 months in Mali. In Somalia, children whose households experienced severe huger or were in the lowest wealth quartile saw an increased risk of relapse. Few other household-level risk factors were associated with relapse.

Discussion

Our multi-country prospective cohort study shows that relapse rates among post-SAM children can be extremely high with up to nearly half of post-SAM children relapsing within six months after being discharged as recovered. Overall, post-SAM children are 3·8 times as likely to become acutely malnourished or die, and 7·8 times as likely to redevelop SAM compared to their peers without a recent history of AM. Children with lower anthropometric measurements during their initial treatment are most susceptible to relapse.

Contextual factors likely play a significant role in the observed range (5% to 47%) of absolute relapse rates among CMAM programmes. With few individual and household-level factors associated with relapse, relatively higher relapse rates (31% and 47% for Mali and South Sudan, respectively) were observed in rural areas where access to healthcare, cash, or other assistance is limited. In contrast, the lower relapse rate (5%) in Somalia's densely populated urban IDP camps is likely impacted by the high availability of humanitarian assistance, including healthcare, cash, food distributions, and other services. This urban-rural distinction is also seen in a 2020 Ethiopia study where the odds of relapse were two to three times higher for children in rural districts compared to urban areas.[18,35] Additionally, Somalia's CMAM programme with low relapse rates applied a MUAC-only criterion for wasting diagnosis which led to a lower cumulative incidence overall; whereas Mali and South Sudan, with relatively higher relapse rates, included both WHZ and MUAC criteria for wasting. Nonetheless, when simulating consistent CMAM criteria across country datasets, the difference in absolute relapse rates did not change drastically, suggesting that context remains a driving factor.

The range of cumulative incidence for relapse specifically to SAM in this study (1% to 7%) falls on the lower end of previously reported SAM relapse spanning 2% to 33%.[17,18,26-33] Studies observing high absolute SAM relapse rates occurred in contexts where MAM treatment programmes did not exist.[17,30] However, in our study, we provided treatment when a child was identified as having (or relapsing to) MAM, which likely prevented more children from

relapsing to SAM—the more severe form of malnutrition—and underestimating the true burden of relapse to SAM and ultimately death.

Similar to our results, other longitudinal studies observed that among children who relapse to AM, the proportion of those who relapse to MAM is higher than SAM.[27,29,31,34] This is likely due to: 1) the natural trajectory of recovery may not encompass a constant increase in weight and body size, but rather a ponderal growth that oscillates across the MAM threshold as status gradually improves; and/or 2) children who relapse to SAM will naturally "regress through" MAM, where they may be treated before ever reaching SAM.

Unlike the difference in the cumulative incidence of relapse, the relative risk of developing AM+death for post-SAM children compared to controls is consistent in all three countries. This highlights that despite varying contextual factors, all post-SAM children are at elevated risks for poor outcomes. Two other cohort studies similarly found children recently recovered from SAM at excess risk of developing AM.[17,27] In a 2020 study in Nigeria, where MAM management was not available, post-SAM children were 52 times more likely to develop SAM compared to controls.[17] Likewise, results for a 2022 study in Ethiopia found post-SAM children had a risk of developing SAM 14 times higher than that of controls.[27] Risk ratios are higher for SAM in these other studies compared to the current study likely because of the absence of MAM programming.

Even though post-SAM children are deemed "recovered" and clinically classified in the same nutritional category as their non-previously malnourished peers (i.e., not acutely malnourished), post-SAM children are more vulnerable. In contexts where children's progression through initial SAM treatment is tracked by one anthropometric criterion (either MUAC or WHZ), between 4-16% of post-SAM children continue to have the other indicator (MUAC or WHZ) still low at the point of discharge. But still, even in contexts where children *are* discharged with both anthropometric criteria reaching recovery levels, they remain nutritionally vulnerable, a finding consistent across the literature.[18,27,29,30] This vulnerable post-SAM population should be viewed as a priority for targeting interventions aimed at reducing malnutrition.

In Mali and Somalia, the timing of relapse remained relatively even across the entire six-month post-discharge period. These results align with findings from another study in Mali that found the incidence of relapse to AM in the first three months of follow-up as similar to the incidence in the final three months (5·3 per 100 child-months vs. 4·4 per 100 child-months).[29] Studies from Ethiopia and Malawi with a twelve-month follow-up also saw relapse occurring throughout the post-discharge period.[27,36] In South Sudan, there was a slight peak in prevalence of post-discharge relapse to AM around three months. Also, in other studies with six-month follow-up periods, the median time to relapse was often less than three months.[17,29,30,32]

In this study and others, the most consistent risk factor for relapse is having relatively lower anthropometric measurements during SAM treatment.[14,17,26,29,30] A strong continuum of care through full SAM recovery, reaching recovery of both WHZ and MUAC, or higher discharge cut-offs may be considered for improving sustained recovery. When comparing our findings with other studies, child sex is inconsistently associated with relapse, requiring additional context-specific investigation.[17,35] Also inconsistent is food security, with severe household hunger predicting relapse in neither Mali nor South Sudan but doing so in Somalia and other studies in Nigeria and Ethiopia.[17,35] A more nuanced measure of food security may reveal greater consistency in its relationship with relapse, as a 2023 study found the indicator lacked sensitivity in certain contexts.[37] Other studies have shown that favorable CMAM programme quality indicators may also mirror favorable post-discharge outcomes.[29,38] This finding is consistent with our results as Somalia experienced the highest recovery rate and lowest relapse rate.

This study has several limitations. The study was originally designed to include a twelve-month observational period, but the COVID-19 pandemic necessitated to shorten the length of follow-up. A full year of follow-up would provide a more comprehensive understanding. The intensive monitoring in the study follow-up procedures likely led to an underestimation of post-discharge mortality. The study included children with nutritional oedema, but the low prevalence of oedema limits the generalizability of our results to populations with higher kwashiorkor.

Post-SAM children have a high likelihood of failing to sustain recovery; therefore, practitioners can realistically expect large proportions of recovered SAM children to relapse, depending on the context and CMAM programme design. Highest rates are expected to be found in rural or remote areas and lowest rates in urban areas with good access to healthcare and other multisectoral support. Furthermore, CMAM programmes with a MUAC-only admission criterion are likely to observe lower relapse than those that include two anthropometric admission criteria (MUAC or WHZ) for wasting.

Addressing relapse should be a key consideration in the management of AM programmes and guidelines. Given the high-risk of post-SAM children for poor outcomes, having a prior episode of SAM should be considered as a targeting criterion for assistance interventions. Additionally, rigorous clinical trials are needed to provide definitive guidance on effective interventions to reduce relapse among post-SAM children. Where feasible, recently recovered SAM children should be monitored for six months post-discharge to ensure timely intervention among those that relapse.

Contributors
HS conceived and designed the study. EY supported provision of study resources. HS, SK, AM, LDG, OC, and IT developed study protocol and data collection processes. HS, SK, and LDG developed tools, databases, and oversaw implementation. SK, SMC, FM, NGL, LDG, KA, AO, and BA coordinated and participated in data collection. AM led the statistical analysis. HS, AM, SK, and LDG contributed to analysis and interpretation of results. SK wrote the first manuscript draft. All authors had full access to all data in the study, participated in critical revision of the manuscript and had final responsibility for the decision to submit for publication.

Data Sharing
The study's deidentified dataset is available from the corresponding author upon reasonable request.

Declaration of interests
The authors declare no competing interests.

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Disclaimer
The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the US Centers for Disease Control and Prevention.

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TABLES

Table 1: Comparison of study participant characteristics from Mali, South Sudan, and Somalia

	Comparison of Post-SAM and Control cohorts within each country									Comparison of Post-SAM cohorts between countries		
	Mali			South Sudan			Somalia			Mali vs. South Sudan	Mali vs. Somalia	Somalia vs. South Sudan
Characteristic	Post-SAM n = 403	Control n = 402	p-value	Post-SAM n = 612	Control n = 278	p-value	Post-SAM n = 800	Control n = 400	p-value	p-value	p-value	p-value
Sex and age												
Female	230 (57%)	229 (57%)	0·98	317 (52%)	144 (52%)	0·99	449 (56%)	219 (55%)	0·65	0·30	1·0	0·32
Age, months	15·7 (7·3)	16·8 (7·3)	0·32	21·0 (9·0)	21·8 (9·4)	0·19	14·6 (5·5)	15·9 (5·9)	0·0002	<0·0001	0·022	<0·0001
< 24 months	350 (87%)	331 (82%)	0·076	406 (66%)	175 (63%)	0·33	722 (90%)	347 (87%)	0·067	<0·0001	0·41	<0·0001
Initial treatment characteristics[i]	***n = 403***			***n = 573***			***n = 800***					
MUAC at admission (mm)												
All children	115·5 (5·7)	··		115·4 (5·9)	··		110·9 (2·6)	··		1·0	<0·0001	<0·0001
Children admitted with MUAC <115	110·8 (3·7)	··		111·0 (2·9)	··		110·7 (2·4)	··		1·0	1·0	0·39
WHZ at admission												
All children	-3·2 (0·7)	··		-3·2 (1·0)	··		-2·2 (1·0)	··		1·0	<0·0001	<0·0001
Children admitted with WHZ <-3SD	-3·.6 (0·5)	··		-3·7 (0·5)	··		-3·5 (0·5)	··		0·009	0·12	<0·0001
Oedema at admission	5 (1%)	··		13 (2%)	··		0	··		0·33	0·13	<0·0001
Average length of stay (days)	50·2 (22·7)	··		105·3 (33·8)	··		79·9 (29·6)	··		<0·0001	<0·0001	<0·0001
Study enrollment (i.e., point of recovery and initial CMAM discharge for post-SAM cohorts) anthropometry												
MUAC (mm) at enrollment	131·0 (5·1)	139·8 (9·5)	<0·0001	129·9 (4·4)	144·3 (9·3)	<0·0001	127·2 (2·4)	137·5 (8·9)	<0·0001	<0·0001	<0·0001	<0·0001
WHZ at enrollment	-1·1 (0·5)	-0·6 (0·8)	<0·0001	-1·4 (0·9)	-0·6 (0·9)	<0·0001	-0·4 (1·0)	-0·5 (1·0)	0·030	<0·0001	<0·0001	<0·0001
Stunting at enrollment												
HAZ ≥ -3 to < -2	113 (28%)	56 (14%)	<0·0001	161 (26%)	42 (13%)	<0·0001	192 (24%)	78 (19%)	0·08	1·0	0·39	1·0
HAZ < -3	103 (26%)	42 (10%)	<0·0001	224 (36%)	17 (5%)	<0·0001	387 (48%)	60 (15%)	<0·0001	0·001	<0·0001	<0·0001
Underweight at enrollment												
WAZ ≥ -3 to < -2	144 (36%)	49 (12%)	<0·0001	253 (41%)	45 (14%)	<0·0001	274 (34%)	62 (16%)	<0·0001	0·24	1·0	0·50
WAZ < -3	38 (9%)	12 (3%)	0·0002	131 (21%)	3 (1%)	<0·0001	72 (9%)	18 (5%)	0·005	<0·0001	1·0	<0·0001
Post-discharge follow-up												
Loss to follow-up	21 (5%)	9 (2%)	0·026	28 (5%)	12 (4%)	0·86	25 (3%)	40 (10%)	<0·0001	1·0	0·25	0·52

Data are n (%) or mean (SD). CMAM=community-based management of acute malnutrition. MUAC=mid-upper arm circumference. WHZ=weight-for-height z-score. HAZ=height-for-age z-score. WAZ=weight-for-age z-score.

[i] *Initial CMAM treatment does not include control children as they were healthy and did not require treatment prior to study enrollment.*

Table 2: Cumulative incidence of sustained recovery, acute malnutrition or death, as well as moderate acute malnutrition, severe acute malnutrition, and death by post-SAM versus control and months post-discharge for Mali, South Sudan, and Somalia

		Months Post-discharge											
		0-1		0-2		0-3		0-4		0-5		0-6	
		Post-SAM	Control	Post-SAM	Control	Post-SAM	Control	Post-SAM	Control	Post-SAM	Control	Post-SAM	Control
Mali	Sustained recovery	90% [87-93]	98% [96-99]***	83% [79-87]	96% [94-98]***	78% [74-82]	95% [93-97]***	74% [70-78]	93% [90-95]	72% [68-76]	92% [89-95]***	69% [65-74]	91% [88-94]***
	AM+death[t]	10% [7-13%]	2% [1-4%]***	17% [13-20%]	4% [2-6]***	22% [17-26]	5% [3-7]***	26% [22-30]	7% [5-10]***	28% [24-33]	8% [5-11]***	31% [26-35]	9% [6-12]***
	MAM	8% [5-11]	2% [1-4]***	13% [10-17]	4% [2-6]***	17% [13-20]	5% [3-7]***	19% [15-23]	7% [4-9]***	21% [17-25]	8% [5-10]***	23% [18-27]	8% [6-11]***
	SAM	2% [0-3]	0% [0-0]*	3% [1-4]	0% [0-0]***	4% [2-6]	0% [0-0]***	7% [4-9]	0% [0-0]***	7% [4-9]	0% [0-1]***	7% [5-10]	0% [0-1]***
	Death	0% [0-1]	0% [0-0]	1% [0-1]	0% [0-0]	1% [0-1]	0% [0-1]	1% [0-1]	0% [0-1]	1% [0-1]	0% [0-1]	1% [0-2]	0% [0-1]
	Sample size	399	401	397	401	395	401	395	398	389	396	385	394
South Sudan	Sustained recovery	84% [82-87]	99% [97-100]***	74% [70-77]	97% [95-99]***	65% [60-69]	95% [92-97]***	62% [58-66]	93% [90-96]***	58% [54-62]	91% [88-95]**	53% [49-57]	90% [86-93]***
	AM+death[t]	16% [13-18]	1% [0-3]***	26% [23-30]	3% [1-5]***	35% [31-39]	5% [3-8]***	38% [34-42]	7% [4-10]***	42% [38-46]	9% [5-12]***	47% [43-51]	10% [7-14]***
	MAM	14% [11-16]	1% [0-3]***	23% [19-26]	3% [1-5]***	30% [26-33]	5% [2-8]***	32% [28-36]	6% [3-9]***	35% [32-39]	7% [4-10]***	39% [35-43]	9% [5-12]***
	SAM	2% [1-3]	0% [0-0]*	4% [2-5]	0% [0-0]**	5% [4-7]	0% [0-1]***	6% [4-8]	1% [0-2]***	6% [5-8]	1% [0-3]**	7% [5-10]	2% [0-3]***
	Death	0% [0-0]	0% [0-0]	0% [0-0]	0% [0-0]	0% [0-1]	0% [0-0]	0% [0-1]	0% [0-0]	1% [0-1]	0% [0-0]	1% [0-1]	0% [0-0]
	Sample size	610	278	609	278	607	276	606	276	604	275	594	266
Somalia	Sustained recovery	98% [98-99]	99% [99-100]	98% [97-99]	99% [98-100]*	97% [96-98]	99% [98-100]*	96% [95-98]	99% [98-100]**	96% [94-97]	98% [97-100]*	95% [93-97]	98% [97-99]*
	AM+death[t]	2% [1-2]	1% [0-1]	2% [1-3]	1% [0-2]*	3% [2-4]	1% [0-2]*	4% [2-5]	1% [0-2]**	4% [3-6]	2% [0-3]*	5% [4-7]	2% [1-4]*
	MAM	1% [0-2]	0% [0-1]	1% [0-1]	0% [0-1]	1% [1-2]	0% [0-1]	2% [1-2]	0% [0-1]*	2% [1-3]	1% [0-1]	2% [1-3]	1% [0-1]
	SAM	1% [0-1]	0% [0-0]	1% [1-2]	0% [0-1]	2% [1-3]	0% [0-1]*	2% [1-3]	0% [0-1]*	2% [1-3]	0% [0-1]*	2% [1-3]	0% [0-1]*
	Death	0% [0-0]	0% [0-1]	0% [0-0]	0% [0-1]	0% [0-1]	1% [0-1]	0% [0-1]	1% [0-1]	1% [0-1]	1% [0-2]	1% [0-2]	1% [0-2]
	Sample size	799	400	798	400	795	399	795	397	791	390	777	360

AM=acute malnutrition. MAM=moderate acute malnutrition. SAM=severe acute malnutrition.
** alpha<0·05, **alpha<0·01, ***alpha<0·001.*

[t] *AM+death is the summation of moderate acute malnutrition, severe acute malnutrition, and death.*

Table 3: Cumulative incidence of acute malnutrition or death at six months post-discharge in the post-SAM vs. control group and overall risk ratio, by country and using different outcome definitions

		Treatment and Outcome Definitions		
		Mali's criteria	**South Sudan's criteria**	**Somalia's criteria**
CMAM Program	**Admission**	Admitted on either low WHZ or low MUAC	Admitted on either low WHZ or low MUAC	Admitted on low MUAC only
	Discharge	Discharged with both WHZ and MUAC above recovery threshold	Discharged with one indicator, either WHZ or MUAC, above recovery threshold	Discharged by MUAC above recovery threshold, regardless of WHZ
Re-admittance to treatment relapse definition	**Post-SAM**	AM defined using either MUAC or WHZ	AM defined using one indicator, either MUAC only or WHZ only, matching with the indicator upon which the child was initially discharged	AM defined using MUAC only
	Control	AM defined using either MUAC or WHZ	AM defined using either MUAC or WHZ	AM defined using MUAC only

		Post-SAM	**Control**	**Relative risk[t]**	**Post-SAM**	**Control**	**Relative risk[t]**	**Post-SAM**	**Control**	**Relative risk[t]**
Mali's dataset	Sample size	385	394	779	385	394	779	186	392	578
	AM+death	31% [26-36]	9% [6-12]	3·45[2·43-4·90]***	23% [19-28]	9% [6-12]	2·63 [1·83-3·79]***	17% [12-23]	5% [3-8]	3·37 [1·98-5·74]***
South Sudan's dataset	Sample size	501	266	859	594	266	860	351	298	649
	AM+death	64% [60-68]	10% [7-14]	7·67 [4·38-9·08]***	47% [43-52]	10% [7-14]	4·68 [3·23-6·76]***	44% [39-50]	1% [0-3]	32·90 [12·32-87·76]***
Somalia' dataset	Sample size	752	348	1100	777	348	1125	777	360	1137
	AM+death	23% [20-26]	21% [17-26]	1·09 [0·86-1·39]	5% [4-7]	21% [17-26]	0·23 [0·16-0·34]***	5% [4-7]	2% [1-4]	2·58 [1·16-5·72]*

AM=acute malnutrition. MUAC=mid-upper arm circumference. WHZ=weight-for-height z-score. Gray shading indicates outcome related to country-specific definition used throughout the report.
*alpha<0·05, **alpha<0·01, ***alpha<0·001.
[t]Poisson model.

Table 4: Adjusted risk ratios for anthropometry at admission and discharge associated with relapse to acute malnutrition (AM) or death among the post-SAM cohort by country and using different outcome definitions

		Mali's Outcome Criteria						South Sudan's Outcome Criteria						Somalia's Outcome Criteria					
		Mali		South Sudan		Somalia		Mali		South Sudan		Somalia		Mali		South Sudan		Somalia	
		crude	*adj*	*crude*	*adj*	*crude*	*adj*	*crude*	*adj*	*crude*	*adj*	*crude*	*adj*	*crude*	*adj*	*crude*	*adj*	*crude*	*adj*
	n	385	344	467	437	751	735	385	344	555	514	776	760	385	167	310	282	776	760
Admission	**MUAC**	1·01 [0·97-1·04]	1·00 [0·96-1·03]	1·00 [0·98-1·02]	0·99 [0·96-1·02]	1·03 [0·97-1·09]	1·03 [0·96-1·08]	1·04* [1·00-1·08]	1·03 [0·99-1·08]	1·00 [0·98-1·02]	1·00 [0·97-1·03]	1·10 [0·97-1·24]	1·16* [1·01-1·34]	1·01 [0·97-1·04]	0·97 [0·87-1·07]	0·98 [0·94-1·02]	0·97 [0·91-1·03]	1·10 [0·97-1·24]	1·16* [1·01-1·34]
	WHZ	0·69** [0·53-0·89]	0·98 [0·71-1·36]	0·96 [0·85-1·08]	0·96 [0·84-1·10]	0·70*** [0·60-0·82]	0·76** [0·64-0·90]	0·67** [0·50-0·91]	1·03 [0·71-1·52]	1·04 [0·92-1·17	1·03 [0·90-1·17]	1·07 [0·79-1·44]	1·12 [0·80-1·59]	0·69** [0·53-0·89]	1·44 [0·81-2·56]	1·06 [0·91-1·23]	0·99 [0·83-1·18]	1·07 [0·.79-1·44]	1·12 [0·80-1·59]
	WAZ	0·72** [0·59-0·88]	0·96 [0·74-1·23]	0·96 [0·85-1·08]	0·94 [0·82-1·08]	0·85* [0·72-1·00]	0·97 [0·82-1·15]	0·65*** [0·51-0·82]	0·91 [0·68-1·21]	0·98 [0·87-1·11]	0·92 [0·80-1·07]	0·87 [0·62-1·22]	0·92 [0·63-1·33]	0·72** [0·59-0·88]	0·65 [0·39-1·06]	0·98 [0·83-1·15]	0·84 [0·68-1·04]	0·87 [0·62-1·22]	0·92 [0·63-1·33]
	HAZ	0·86* [0·76-0·98]	0·.99 [0·85-1·14]	0·99 [0·92-1·07]	0·97 [0·89-1·06]	1·02 [0·93-1·13]	1·08 [0·99-1·19]	0·81** [0·70-0·94]	0·95 [0·80-1·13]	0·97 [0·90-1·05]	0·92 [0·84-1·01]	0·90 [0·73-1·11]	0·93 [0·74-1·16]	0·86* [0·76-0·98]	0·64** [0·46-0·89]	0·96 [0·86-1·06]	0·88 [0·77-1·01]	0·90 [0·73-1·11]	0·93 [0·74-1·16]
Discharge	**MUAC**	0·98 [0·95-1·02]	0·95* [0·90-1·00]	0·98 [0·95-1·01]	0·96* [0·93-1·00]	0·86*** [0·78-0·94]	0·84*** [0·77-0·93]	0·98 [0·94-1·02]	0·93* [0·88-0·99]	0·94*** [0·91-1·11]	0·93*** [0·89-0·96]	0·82 [0·67-1·01]	0·83 [0·68-1·02]	0·98 [0·95-1·02]	0·89 [0·78-1·01]	0·87*** [0·81-0·93]	0·83*** [0·76-0·92]	0·82 [0·67-1·01]	0·83 [0·83-1·02]
	WHZ	0·29*** [0·19-0·45]	0·37** [0·20-0·66]	0·86 [0·74-1·01]	0·86 [0·72-1·03]	0·49*** [0·40-0·60]	0·53*** [0·43-0·65]	0·32*** [0·19-0·52]	0·46* [0·24-0·90]	0·95 [0·83-1·09]	0·91 [0·78-1·06]	0·96 [0·70-1·33]	0·93 [0·65-1·33]	0·29*** [0·19-0·45]	0·65 [0·24-1·75]	1·01 [0·85-1·18]	0·88 [0·73-1·07]	0·96 [0·70-1·33]	0·93 [0·65-1·33]
	WAZ	0·60*** [0·45-0·75]	0·76* [0·58-1·00]	0·90 [0·79-1·03]	0·89 [0·76-1·05]	0·75** [0·63-0·89]	0·83 [0·69-1·01]	0·54*** [0·42-0·70]	0·72* [0·52-0·99]	0·86* [0·76-0·99]	0·80** [0·68-0·94]	0·84 [0·59-1·19]	0·78 [0·53-1·15]	0·60*** [0·48-0·75]	0·33** [0·17-0·65]	0·83* [0·69-0·99]	0·68** [0·53-0·86]	0·84 [0·59-1·19]	0·78 [0·53-1.15]
	HAZ	0·85* [0·74-0.98]	0·97 [0·83-1·13]	0·98 [0·91-1·06]	0·98 [0·89-1·08]	1·09 [0·98-1·20]	1·12* [1·01-1·23]	0·79** [0·67-0·92]	0·93 [0·78-1·11]	0·92* [0·85-1·00]	0·90* [0·81-0·99]	0·91 [0·73-1·14]	0·.91 [0·72-1·13]	0·85* [0·74-0·98]	0·62** [0·44-0·87]	0·88* [0·79-0·98]	0·84* [0·73-0·97]	0·91 [0·73-1·14]	0·91 [0·72-1·13]
	weight change rate	0·93 [0·87-1]	0·90* [0·81-0·98]	0·96 [0·88-1·05]	0·96 [0·87-1·06]	0·89* [0·79-0·99]	0·84* [0·75-0·95]	0·90* [0·83-0·99]	0·89 [0·80-1·00]	0·92 [0·83-1·01]	0·92 [0·82-1·03]	0·89 [0·72-1·11]	0·89 [0·70-1·14]	0·93 [0·87-1·00]	0·84 [0·68-1·03]	0·89 [0·76-1·03]	0·91 [0·76-1·08]	0·89 [0·72-1·11]	0·89 [0·70-1·14]

MUAC=mid-upper arm circumference. WHZ=weight-for-height z-score. WAZ=weight-for-age z-score. HAZ=height-for-age z-score.

*** p-value<0·001, ** p-value<0·01, * p-value<0·05

FIGURES

Figure 1: Forest plot of meta-analysis with random effects for the risk ratio of acute malnutrition (AM) or death, moderate acute malnutrition (MAM), and severe acute malnutrition (SAM) by country for the post-SAM versus control groups

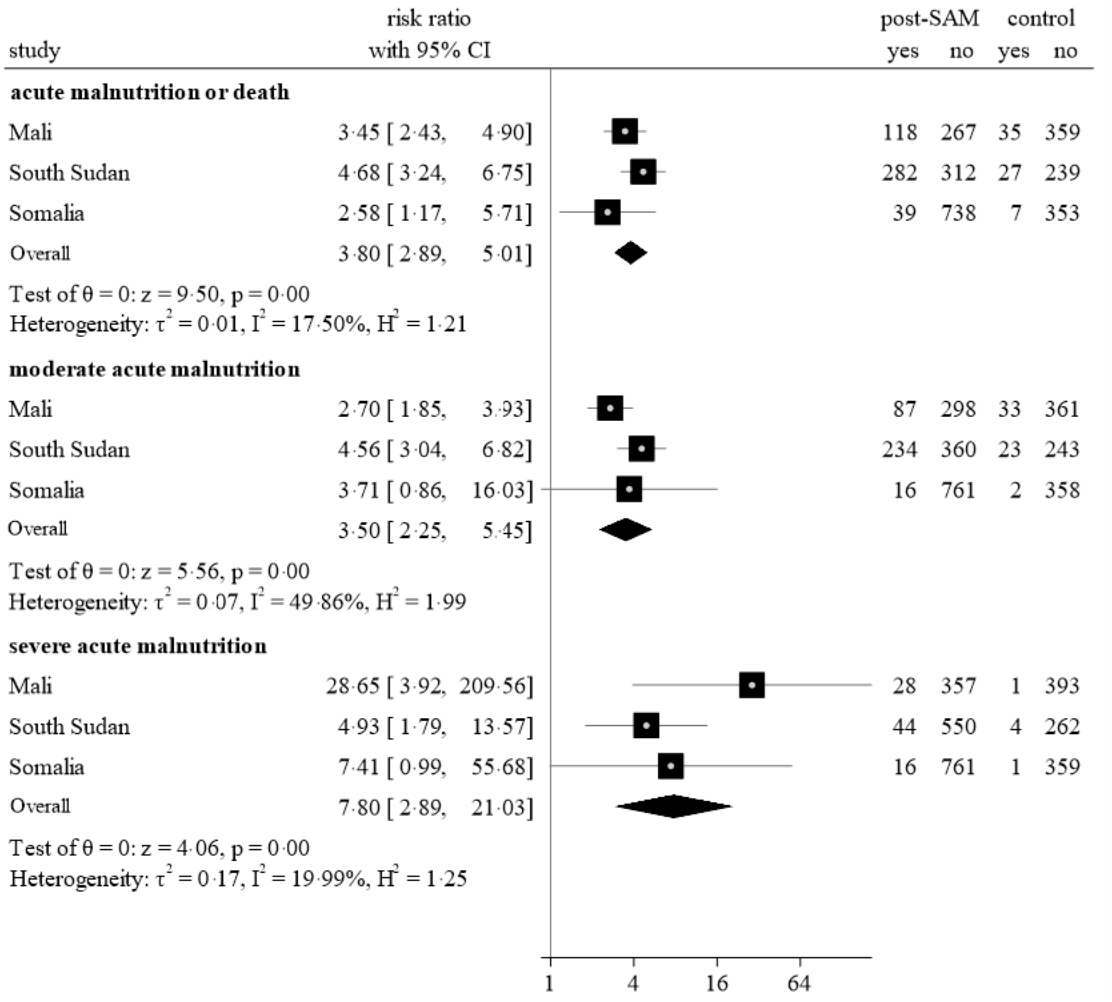


Figure 2: Point prevalence of moderate acute malnutrition (MAM), severe acute malnutrition (SAM), and death by months post-discharge by country for the control vs. post-SAM groups

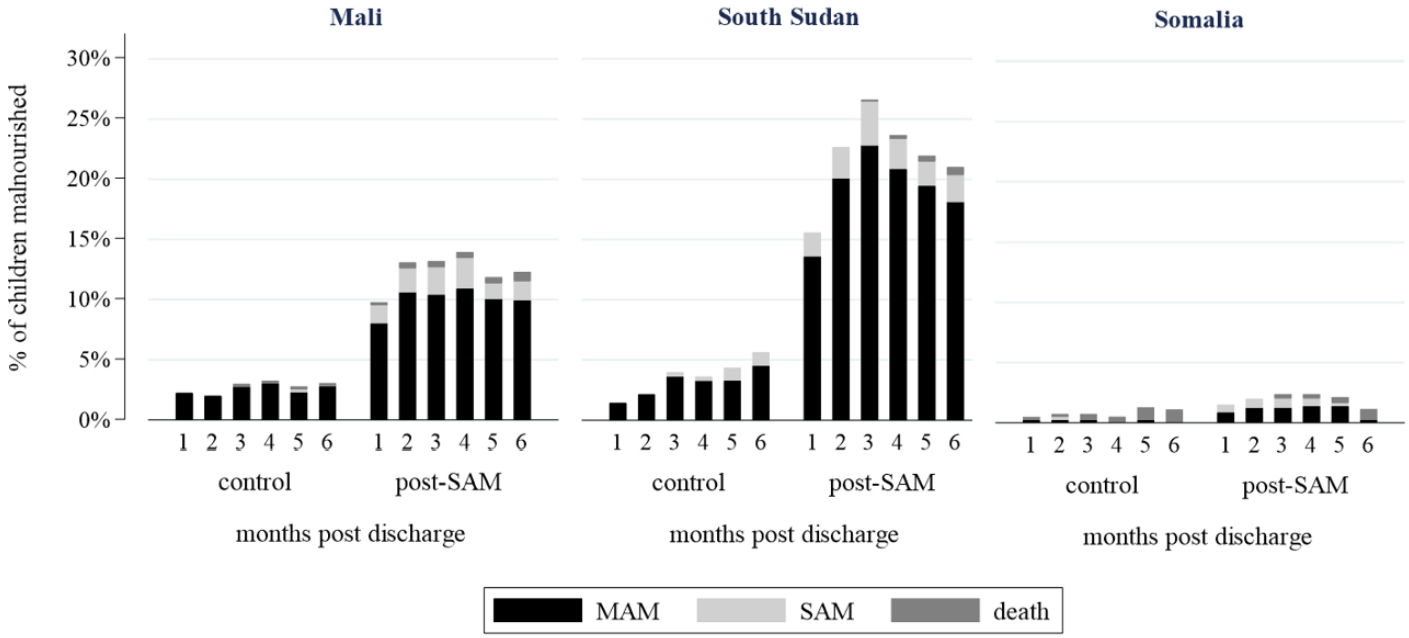
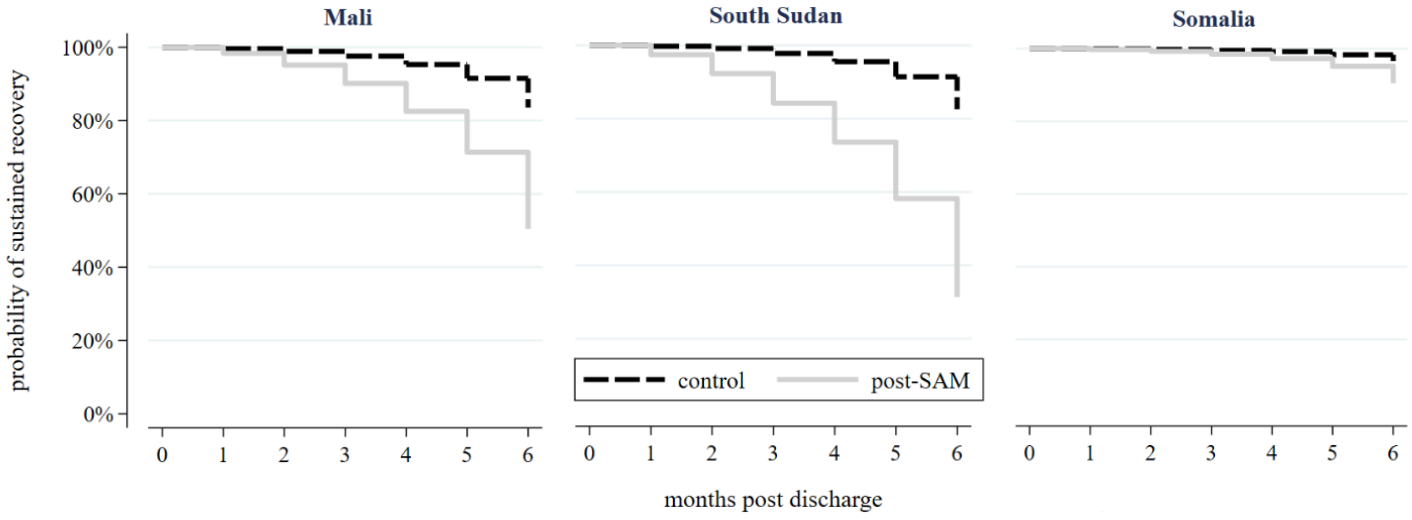


Figure 3: Probability of sustained recovery versus acute malnutrition (AM) or death for control and post-SAM group by country and months post-discharge



Number at risk

control	402	401	401	401	398	396	394	278	278	278	276	276	275	266	400	400	400	399	397	390	360
post-SAM	403	399	397	395	395	389	385	612	610	609	607	606	604	594	800	799	798	795	795	791	777

SUPPLEMENTARY TABLES

Supplementary Table 1: Comparison of imputed versus non-imputed variables.

	Mali						South Sudan						Somalia					
		Non-Imputed		All Values[i]				Non-Imputed		All Values[i]				Non-Imputed		All Values[i]		
	% Missing	n	mean (SD)	n	mean (SD)	p-value	% Missing	n	mean (SD)	n	mean (SD)	p-value	% Missing	n	mean (SD)	n	mean (SD)	p-value
Follow-up Visit 1																		
MUAC (mm)	1%	793	137 (9·0)	799	136 (9·0)	0·98	2%	866	135 (10·2)	888	135 (10·2)	0·97	6%	1122	134 (8·0)	1198	133 (7·9)	0·71
Weight (kg)	1%	792	8.8 (1·6)	799	8·8 (1·6)	0·95	2%	865	9·1 (1·8)	886	9·1 (1·8)	0·81	6%	1122	8·4 (1·4)	1198	8·4 (1·4)	1·0
Height (cm)	1%	792	75·3 (7·1)	799	75·3 (7·2)	0·94	2%	865	78·1 (7·9)	886	78·1 (7·9)	0·82	6%	1122	72·3 (6·5)	1198	73 (6·6)	0·91
Follow-up Visit 2																		
MUAC (mm)	2%	778	138 (9·1)	796	138 (9·0)	0·91	4%	854	135 (10·7)	886	135 (10·7)	0·87	6%	1121	135 (8·2)	1197	135 (8·3)	0·92
Weight (kg)	3%	776	9·0 (1·6)	796	9·0 (1·6)	0·85	3%	854	9·2 (1·8)	884	9·2 (1·8)	0·84	6%	1121	8·6 (1·5)	1197	8·6 (1·5)	1·0
Height (cm)	3%	776	76·1 (7·2)	796	76·0 (7·1)	0·84	3%	854	78·7 (7·9)	884	78·8 (7·9)	0·92	6%	1121	73·1 (6·6)	1197	73·0 (6·6)	0·88
Follow-up Visit 3																		
MUAC (mm)	2%	777	139 (9·2)	792	139 (9·2)	1·0	3%	852	136 (11·3)	880	136 (11·2)	0·86	6%	1122	136 (8·3)	1189	136 (8·3)	0·96
Weight (kg)	2%	776	9·2 (1·6)	792	9·2 (1·6)	0·92	3%	852	9·3 (1·8)	878	9·4 (1·8)	0·82	6%	1122	8·7 (1·5)	1189	8·7 (1·5)	0·86
Height (cm)	2%	776	76·7 (7·1)	792	76·7 (7·1)	0·91	3%	852	79·3 (7·8)	878	79·4 (7·8)	0·86	6%	1123	73·7 (6·5)	1189	73·7 (6·6)	0·89
Follow-up Visit 4																		
MUAC (mm)	1%	779	141 (9·5)	789	141 (9·5)	0·89	1%	865	136 (11·3)	878	137 (11·2)	0·94	5%	1131	137 (8·6)	1187	137 (8·5)	0·80
Weight (kg)	1%	779	9·4 (1·6)	789	9·4 (1·6)	0·9	1%	865	9·6 (1·8)	876	9·6 (1·8)	0·92	5%	1131	8·9 (1·5)	1187	8·8 (1·5)	0·74
Height (cm)	1%	779	77·4 (7·2)	789	77·4 (7·2)	0·92	1%	866	80 (7·8)	876	80 (7·8)	0·91	5%	1131	74·4 (6·6)	1187	74·3 (6·6)	0·71
Follow-up Visit 5																		
MUAC (mm)	1%	774	142 (9·7)	780	142 (9·7)	0·97	1%	864	137 (11·3)	873	137 (11·3)	0·93	3%	1138	138 (8·3)	1173	138 (8·3)	0·92
Weight (kg)	1%	773	9·6 (1·6)	780	9·6 (1·6)	0·97	1%	864	9·7 (1·8)	871	9·7 (1·8)	0·95	3%	1138	9·0 (1·5)	1173	9·0 (1·5)	1·0
Height (cm)	1%	773	78·0 (7·3)	780	78·0 (7·2)	0·98	1%	864	80·7 (7·8)	871	80·7 (7·8)	0·98	3%	1138	74·9 (6·7)	1173	74·9 (6·6)	0·95

MUAC=mid-upper arm circumference. Values were only imputed when a measure occurred prior to and following the missing value; values were not imputed for enrollment or the final follow-up visit.
[i]All values includes non-imputed values plus imputed values.

Supplementary Table 2: Country context, treatment protocols and outcome definitions

		Mali	South Sudan	Somalia
Context	**Location**	Rural	Rural	Urban
	Population	Majority permanent residents	Majority permanent residents	Majority internally displaced population
Initial SAM Treatment in CMAM Programme	**No. of facilities**	9	6	1
	Operated by	Ministry of Health	Action Against Hunger	Ministry of Health & Action Against Hunger
	Admission Anthropometric Criteria[i]	WHZ (<-3), MUAC (<115mm), and/or bi-lateral pitting oedema	WHZ (<-3), MUAC (<115mm), and/or bi-lateral pitting oedema	MUAC (<115mm) and/or bi-lateral pitting oedema
	Anthropometric criteria used to monitor at intermediate follow-up visits[i]	Both WHZ and MUAC	Either WHZ or MUAC according to which indicator was used for admission; if both met admission criteria, then MUAC was used to track progress	MUAC
	Discharge Anthropometric Criteria[i]	Both WHZ (≥-1.5) and MUAC (≥125mm) (and no oedema) for two consecutive visits	Either WHZ (≥-2) or MUAC (≥125mm) (and no oedema) for two consecutive visits, determined by monitoring criteria	MUAC (≥125mm) (and no oedema) for two consecutive visits
	Transfer from OTP to SFP?	No. Treated in OTP for duration of stay	Yes. Transferred from OTP to TSFP when nutrition status changed from SAM to MAM	Yes. Transferred from OTP to TSFP when nutrition status changed from SAM to MAM
	Follow-up visit frequency	Weekly	Weekly for OTP Fortnightly for TSFP	Weekly for OTP Fortnightly for TSFP
	Products Used	RUTF for OTP	RUTF for OTP RUSF/CSB++ for TSFP[ii]	RUTF for OTP RUSF for TSFP
	Maximum Length of Stay	Three months	Six months	Eight Months
Post-Discharge	**Definition of Relapse to AM / Re-admission Criteria for Treatment: Post-SAM Cohort**[i]	WHZ (<-2) and/or MUAC (<125mm), or oedema	WHZ (<-2) or MUAC (<125mm), whichever was initially used for CMAM monitoring and discharge, or oedema	MUAC (<125mm) or oedema
	Admission Criteria for Treatment: Control Cohort[i]	WHZ (<-2) and/or MUAC (<125mm), or oedema	WHZ (<-2) and/or MUAC (<125mm), or oedema	MUAC (<125mm) or oedema

AM=acute malnutrition. CMAM=community-based management of acute malnutrition. CSB++=super cereal. MAM=moderate acute malnutrition. MUAC=mid-upper arm circumference. OTP=outpatient therapeutic programme. RUSF=ready-to-use supplementary food. RUTF=ready-to-use therapeutic food. SAM=severe acute malnutrition. TSFP=therapeutic supplementary feeding programme. WHZ=weight-for-height z-score.

[i] *Oedema was an admission criterion in all CMAM programs. Children must have had no oedema for two consecutive visits to be discharged.*

[ii] *CSB++ was only used in TSFP when RUSF stockouts occurred.*

[iii] *Control children technically did not relapse because they were not previously malnourished. Therefore, if a control child becomes acutely malnourished and is eligible for admission, this would be a first admission.*

Supplementary Table 3: Relative risk of relapse for children who are post-SAM vs in the control group for acute malnutrition and death (AM+death), moderate acute malnutrition (MAM), and severe acute malnutrition (SAM) by country, after adjustment for age of the child (in months) at admission, sex of the child, WHZ at admission, and clinic[t]

			Model Variables				
Country	**Outcome**	**Model**	**Post-SAM**	**Age (months) at admission**	**Female**	**WHZ at admission**	**Constant**
Mali n=779	AM+death	crude	3·45 [2·43-4·90]***				0·09 [0·06-0·12]***
		adjusted	2·69 [1·89-3·59]***	0·99 [0·98-1·02]	0·70 [0·52-0·94]*	0·34 [0·25-0·47]***	0·05 [0·03-0·12]***
	MAM	crude	2·69 [1·85-3·93]***				0·08 [0·06-0·12]***
		adjusted	2·00 [1·42-2·81]***	0·99 [0·97-1·02]	0·71 [0·50-1·01]	0·3 [0·2-0·43]***	0·04 [0·02-0·11]***
	SAM	crude	28·65 [3·91-209·83]**				0·00 [0·00-0·02]***
		adjusted	24·72 [3·37-181·63]**	1·03 [0·99-1·08]	0·73 [0·34-1·56]	0·57 [0·25-1·30]	0·01 [0·00-0·05]***
	Death	crude	3·07 [0·32-29·43]				0·00 [0·00-0·02]***
		adjusted	2·62 [0·32-21·38]	0·87 [0·74-1·02]	0·24 [0·04-1·40]	0·72 [0·19-2·68]	0·00 [0·00-0·00]***
South Sudan n=860	AM+death	crude	4·67 [3·23-6·76]***				0·10 [0·07-0·15]***
		adjusted	4·21 [2·86-6·22]***	0·99 [0·98-0·99]**	1·18 [0·99-1·38]	0·86 [0·78-0·96]**	0·06 [0·03-0·10]***
	MAM	crude	4·56 [3·04-6·82]***				0·09 [0·06-0·13]***
		adjusted	3·92 [2·56-6·01]***	0·99 [0·98-0·99]*	1·17 [0·97-0·92]	0·81 [0·72-0·92]**	0·04 [0·02-0·08]***
	SAM	crude	4·92 [1·79-13·58]**				0·02 [0·01-0·04]***
		adjusted	5·01 [1·69-14·82]**	0·99 [0·95-1·02]	1·04 [0·60-1·80]	1·04 [0·74-1·46]	0·01 [0·00-0·05]***
	Death	crude	3·1e+06 [1e+06-8e+06]***				0·00 [0·00-0·00]***
		adjusted	9e+06 [3e+06-2e+07]***	0·77 [0·59-0·99]*	2e+07 [4e+06-5e+07]	1·55 [1·13-2·12]**	0·00 [0·00-0·00]***
Somalia n=1137	AM+death	crude	2·58 [1·16-5·72]*				0·02 [0·01-0·04]***
		adjusted	2·69 [1·22-5·93]*	1·01 [0·96-1·07]	1·5 [0·79-2·78]	0·84 [0·60-1·18]	0·01 [0·00-0·04]***
	MAM	crude	3·71 [0·86-16·04]				0·01 [0·85-16·04]***
		adjusted	4·22 [1·01-17·75]*	1·05 [0·98-1·14]	1·63 [0·56-4·81]	0·63 [0·34-1·18]	0·00 [0·00-0·01]***
	SAM	crude	7·41 [0·98-55·73]				0·00 [0·00-0·02]***
		adjusted	7·04 [0·92-53·79]	0·93 [0·85-1·02]	1·18 [0·44-3·16]	0·87 [0·5-1·5]	0·01 [0·00-0·09]***
	Death	crude	0·81 [0·24-2·75]				0·01 [0·00-0·03]***
		adjusted	0·81 [0·24-2·68]	1·03 [0·95-1·12]	2·01 [0·52-7·68]	1·26 [0·81-1·95]	0·01 [0·00-0·03]***

AM=acute malnutrition. MAM=moderate acute malnutrition. SAM=severe acute malnutrition. WHZ=weight-for-height z-score.

[t] While we controlled for clinic in the regression model, we did not include the clinic level output in the table. All clinics were controlled for in Mali and South Sudan. All children came from the same clinic in Somalia.

*alpha<0·05, **alpha<0·01, ***alpha<0·00

Supplementary Table 4: Unadjusted risk ratios for individual and household-level factors associated with relapse to acute malnutrition or death (AM+death) among the post-SAM cohort for Mali, South Sudan, and Somalia[1]

	Mali				South Sudan				Somalia			
Characteristic	All	Relapsed to AM or death	Risk Ratio	p-value	All	Relapsed to AM or death	Risk Ratio	p-value	All	Relapsed to AM or death	Risk Ratio	P-value
N or n (%)	385	118 (31)			594	282 (47)			777	39 (5)		
Sex and age												
Female	220 (58)	46 (39)	0·48 [0·3, 0·7]	0·000	306 (52)	156 (55)	1·17 [0·9, 1·5]	0·202	434 (56)	24 (62)	1·26 [0·7, 2·4]	0·476
Age at admission (mos)	14·2 ± 6·5	15·2 ± 7·9	1·02 [1·0, 1·1]	0·075	17·4 ± 9·0	16·7 ± 8·7	0·99 [1·0, 1·0]	0·205	11·9 ± 5·6	12·5 ± 6·9	1·02 [1·0, 1·1]	0·516
< 24 mos	355 (93)	104 (88)	0·56 [0·3, 1·0]	0·036	428 (77)	214 (80)	1·18 [0·9, 1·6]	0·287	754 (97)	37 (95)	0·56 [0·1, 2·3]	0·431
Initial CMAM Treatment												
Admission Anthropometrics												
MUAC (mm)	115·6 ± 5·8	115·8 ± 6·0	1·01 [1·0, 1·0]	0·715	115·5 ± 5.9	115·5 ± 5·5	1·00 [1·0, 1·0]	0·938	110·9 ± 2·6	111·4 ± 3·0	1·10 [1·0, 1·2]	0·155
MUAC<115 (mm)	182 (48)	57 (48)	1·04 [0·7, 1·5]	0·822	298 (54)	139 (52)	0·93 [0·7, 1·2]	0·527	760 (98)	35 (90)	0·20 [0·1, 0·6]	0·002
MUAC<110 (mm)	29 (8)	7 (6)	0·77 [0·4, 1·7]	0·511	51 (9)	19 (7)	0·75 [0·5, 1·2]	0·236	156 (20)	6 (15)	0·72 [0·3, 1·7]	0·466
WHZ	-3·2 ± 0·7	-3·4 ± 0·7	0·69 [0·5, 0·9]	0·005	-3·2 ± 1·0	-3·2 ± 1·1	1·04 [0·9, 1·2]	0·548	-2·2 ± 1·0	-2·2 ± 0·9	1·07 [0·8, 1·4]	0·680
WHZ<-3	367 (96)	257 (218)	0·67 [0·3, 1·4]	0·282	445 (80)	216 (81)	1·03 [0·8, 1·4]	0·864	200 (26)	11 (28)	1·13 [0·6, 2·3]	0·725
WHZ<-3.5	101 (27)	43 (36)	1·61 [1·1, 2·3]	0·013	217 (39)	102 (38)	0·96 [0·7, 1·2]	0·727	55 (7)	0 (0)	0 [0, 0]	0·987
HAZ	-1·9 ± 1·4	-2·2 ± 1·5	0·86 [0·8, 1·0]	0·022	-2·1 ± 1·6	-2·2 ± 1·5	0·97 [0·9, 1·0]	0·433	-2·4 ± 1·6	-2·7 ± 1·8	0·90 [0·7, 1·1]	0·345
HAZ<-2	177 (46)	62 (53)	1·30 [0·9, 1·9]	0·153	286 (52)	143 (53)	1·08 [0·8, 1·4]	0·550	507 (65)	26 (67)	1·07 [0·5, 2·1]	0·853
HAZ<-3	81 (22)	40 (34)	1·92 [1·3, 2·8]	0·001	148 (27)	77 (29)	1·11 [0·9, 1·4]	0·445	295 (38)	20 (51)	1·72 [0·9, 3·2]	0·091
WAZ	-3·3 ± 0·9	-3·5 ± 0·9	0·72 [0·6, 0·9]	0·002	-3·4 ± 1·0	-3·4 ± 1·0	0·98 [0·9, 1·1]	0·807	-3·0 ± 1·0	-3·1 ± 0·9	0·87 [0·6, 1·2]	0·422
WAZ<-2	363 (95)	114 (97)	1·73 [0·6, 4·7]	0·283	507 (91)	245 (91)	1·01 [0·7, 1·5]	0·969	660 (85)	34 (87)	1·21 [0·5, 3·1]	0·696
WAZ<-3	233 (61)	85 (72)	1·68 [1·1, 2·5]	0·011	376 (68)	186 (69)	1·08 [0·8, 1·4]	0·562	395 (51)	22 (56)	1·25 [0·7, 2·4]	0·487
Kwashiorkor/Bi-lateral Edema	5 (2)	0 (0)	-	-	12 (2)	3 (1)	0·52 [0·2, 1·6]	0·255	0 (0)	-	-	-
Both low MUAC & low WHZ	164 (43)	49 (42)	0·96 [0·7, 1·4]	0·814	196 (35)	88 (33)	0·89 [0·7, 1·2]	0·384	190 (24)	7 (18)	0·68 [0·3, 1·5]	0·348
Discharge Anthropometrics												
MUAC (mm)	131 ± 5·1	130·6 ± 4·9	0·98 [0·9, 1·0]	0·391	129·8 ± 4·3	128·9 ± 3·8	0·94 [0·9, 1·0]	0·000	127·2 ± 2·4	126·5 ± 1·7	0·82 [0·7, 1·0]	0·063
MUAC<130 (mm)	170 (45)	48 (41)	0·87 [0·6, 1·3]	0·447	359 (60)	204 (72)	1·71 [1·3, 2·2]	0·000	688 (89)	36 (92)	1·55 [0·5, 5·0]	0·464
MUAC<128 (mm)	114 (30)	38 (32)	1·13 [0·8, 1·7]	0·538	249 (42)	149 (53)	1·55 [1·2, 2·0]	0·000	523 (67)	30 (77)	1·62 [0·8, 3·4]	0·205
WHZ	-1·1 ± 0·5	-1·3 ± 0·5	0·29 [0·2, 0·4]	0·000	-1·4 ± 0·9	-1·4 ± 0·9	0·95 [0·8, 1·1]	0·499	-0·4 ± 1·0	-0·4 ± 1·0	0·96 [0·7, 1·3]	0·816
WHZ<-1.5	75 (20)	45 (38)	2·55 [1·8, 3·7]	0·000	280 (47)	148 (53)	1·24 [1·0, 1·6]	0·072	88 (11)	5 (13)	1·15 [0·5, 2·9]	0·768
WHZ<-2	0 (0)	-	-	-	95 (16)	44 (16)	0·97 [0·7, 1·3]	0·859	29 (4)	1 (3)	0·68 [0·1, 4·9]	0·702
WHZ<-3	0 (0)	-	-	-	12 (2)	8 (3)	1·42 [0·7, 2·9]	0·332	3 (0)	0 (0)		
HAZ	-2·1 ± 1·3	-2·4 ± 1·4	0·85 [0·7, 1·0]	0·024	-2·5 ± 1·4	-2·6 ± 1·4	0·92 [0·8, 1·0]	0·048	-2·8 ± 1·5	-3·0 ± 1·6	0·91 [0·7, 1·1]	0·409
HAZ<-2	208 (55)	70 (59)	1·24 [0·9, 1·8]	0·249	372 (63)	193 (69)	1·30 [1·0, 1·7]	0·043	564 (73)	28 (72)	0·96 [0·5, 1·9]	0·912
HAZ<-3	99 (26)	41 (35)	1·54 [1·1, 2·2]	0·026	216 (36)	115 (41)	1·21 [1·0, 1·5]	0·123	378 (49)	22 (56)	1·37 [0·7, 2·6]	0·334
WAZ	-1·9 ± 0·8	-2·3 ± 0·8	0·6 [0·5, 0·8]	0·000	-2·3 ± 0·9	-2·4 ± 0·9	0·86 [0·8, 1·0]	0·030	-1·8 ± 0·9	-2·0 ± 1·0	0·84 [0·6, 1·2]	0·329
WAZ<-2	174 (46)	73 (62)	1·97 [1·4, 2·9]	0·000	369 (62)	191 (68)	1·28 [1·0, 1·6]	0·052	338 (44)	22 (56)	1·68 [0·9, 3·2]	0·108
WAZ<-3	37 (10)	21 (18)	2·04 [1·3, 3·3]	0·003	125 (21)	70 (25)	1·24 [0·9, 1·6]	0·120	72 (9)	5 (13)	1·44 [0·6, 3·7]	0·447
Growth												
Total MUAC change (mm)	15·4 ± 6·3	14·8 ± 7·0	0·99 [1·0, 1·0]	0·312	14·2 ± 5·4	13·2 ± 4·8	0·97 [0·9, 1·0]	0·004	16·3 ± 3·3	15·1 ± 3·0	0·88 [0·8, 1·0]	0·019

Total WHZ change	2·1 ± 0·7	2 ± 0·7	0·83 [0·6, 1·1]	0·177	1·8 ± 1·0	1·8 ± 1·1	0·95 [0·8, 1·1]	0·345	1·9 ± 1·0	1·9 ± 1·2	0·94 [0·7, 1·3]	0·682
Total HAZ change	-0·3 ± 0·4	-0·2 ± 0·3	1·22 [0·8, 2·0]	0·409	-0·4 ± 0·8	-0·5 ± 0·7	0·87 [0·7, 1·0]	0·082	-0·5 ± 0·7	-0·5 ± 0·7	0·92 [0·6, 1·5]	0·734
Total WAZ change	1·3 ± 0·5	1·3 ± 0·5	0·72 [0·5, 1·0]	0·084	1·1 ± 0·7	1·0 ± 0·7	0·84 [0·7, 1·0]	0·049	1·2 ± 0·7	1·2 ± 0·7	1·01 [0·6, 1·6]	0·976
Weight change (g/kg/d)	5·3 ± 2·9	4·8 ± 2·6	0·93 [0·9, 1·0]	0·062	2·4 ± 1·4	2·2 ± 1·3	0·92 [0·8, 1·0]	0·094	3·1 ± 1·5	2·8 ± 1·4	0·89 [0·7, 1·1]	0·291
Weight change after 2 wks (g/kg/d)	6·8 ± 4·3	6·0 ± 4·5	0·96 [0·9, 1·0]	0·056	3·9 ± 6·1	4·0 ± 4·8	1·00 [1·0, 1·0]	0·791	4·1 ± 3·1	4·7 ± 3·7	1·06 [1·0, 1·2]	0·247
Length of Stay												
Average length of stay (days)	50·8 ± 22·9	52·3 ± 20·4	1·00 [1·0, 1·0]	0·473	105·6 ± 34·1	107·2 ± 31·2	1·00 [1·0, 1·0]	0·447	80 ± 29·6	88·8 ± 29·6	1·01 [1·0, 1·0]	0·062
Discharged late	166 (44)	38 (32)	0·63 [0·4, 0·9]	0·018	164 (30)	69 (26)	0·83 [0·6, 1·1]	0·173	48 (6)	2 (5)	0·82 [0·2, 3·4]	0·786
Discharged early	13 (4)	7 (6)	1·80 [0·8, 3·9]	0·130	91 (16)	54 (20)	1·29 [1·0, 1·7]	0·098	588 (76)	34 (87)	2·19 [0·9, 5·6]	0·103
Infant and Young Child Feeding												
Ever breastfed	360 (96)	110 (95)	0·87 [0·4, 2·0]	0·731	571 (97)	269 (96)	0·81 [0·4, 1·5]	0·503	723 (93)	37 (95)	1·30 [0·3, 5·4]	0·714
Currently breastfed	286 (81)	85 (78)	0·88 [0·6, 1·4]	0·578	344 (59)	172 (63)	1·17 [0·9, 1·5]	0·208	321 (42)	10 (26)	0·49 [0·2, 1·0]	0·049
Drink introduced after 6 mos	27 (8)	13 (11)	1·64 [0·9, 2·9]	0·094	98 (16)	51 (18)	0·96 [0·8, 1·1]	0·566	4 (1)	1 (3)	5·09 [0·7, 37]	0·108
Food introduced after 6 mos	2 (1)	2 (2)	1·15 [0·7, 1·8]	0·543	216 (36)	95 (34)	0·93 [0·8, 1·1]	0·473	162 (21)	11 (28)	1.49 [0.7, 3·0]	0·261
Caregiver												
Mother alive	369 (97)	115 (98)	2·18 [0·5, 8·8]	0·274	584 (99)	278 (99)	1·27 [0·4, 4·0]	0·681	726 (94)	37 (95)	1·27 [0·3, 5·3]	0·739
Maternal schooling (yrs)	2·2 ± 3·4	2·8 ± 3·6	1·05 [1·0, 1·1]	0·070	1·5 ± 2·8	1·4 ± 2·6	0·99 [0·9, 1·0]	0·563	0·05 ± 0·5	0·03 ± 0·2	0·88 [0·3, 2·4]	0·795
Household												
Child is a twin	18 (5)	8 (7)	1·48 [0·7, 3·0]	0·282	52 (9)	30 (11)	1·24 [0·8, 1·8]	0·264	28 (4)	1 (3)	0·70 [0·1, 5·1]	0·729
No. of siblings	2·7 ± 2·2	2·5 ± 2·2	0·95 [0·9, 1·0]	0·274	3·3 ± 2·1	3·5 ± 2·1	1·04 [1·0, 1·1]	0·166	4·6 ± 2·6	4·9 ± 2·6	1·05 [0·9, 1·2]	0·399
HHS score at enrollment	0·1 ± 0·4	0·1 ± 0·6	1·22 [0·9, 1·7]	0·249	2·9 ± 7·3	3·6 ± 10·2	1·01 [1·0, 1·0]	0·156	1·8 ± 8·8	4·4 ± 15·9	1·02 [1·0, 1·0]	0·096
HHS category at enrollment												
Little to no hunger	370 (99)	112 (97)	0·40 [0·1, 1·3]	0·121	245 (42)	112 (41)	0·95 [0·7, 1·2]	0·681	544 (71)	21 (57)	0·54 [0·3, 1·0]	0·060
Moderate hunger	2 (1)	1 (1)	1·63 [0·2, 11·7]	0·626	152 (26)	72 (26)	1·01 [0·8, 1·3]	0·953	140 (18)	5 (14)	0·70 [0·3, 1·8]	0·456
Severe hunger	2 (1)	2 (2)	3·29 [0·8, 13·3]	0·095	187 (32)	91 (33)	1·05 [0·8, 1·3]	0·704	82 (11)	11 (30)	3·53 [1·7, 7·1]	0·000
Wealth scale	-0·3 ± 2·1	0 ± 2·1	1·06 [1·0, 1·2]	0·164	-0·4 ± 1·9	-0·5 ± 1·9	0·97 [0·9, 1·0]	0·283	0·1 ± 2·0	-0·2 ± 1·6	0·92 [0·8, 1·1]	0·374
Wealth Quartiles												
Q1	108 (29)	26 (22)	0·72 [0·5, 1·1]	0·147	174 (29)	93 (33)	1·19 [0·9, 1·5]	0·174	158 (20)	13 (33)	1·96 [1·0, 3·8]	0·048
Q2	107 (28)	72 (61)	1·10 [0·7, 1·6]	0·651	162 (27)	76 (27)	0·98 [0·8, 1·3]	0·903	175 (23)	8 (21)	0·89 [0·4, 1·9]	0·764
Q3	94 (25)	32 (27)	1·15 [0·8, 1·7]	0·495	153 (26)	64 (23)	0·85 [0·6, 1·1]	0·240	230 (30)	8 (21)	0·61 [0·3, 1·3]	0·218
Q4	76 (20)	25 (21)	1·09 [0·7, 1·7]	0·693	105 (18)	49 (17)	0·98 [0·7, 1·3]	0·895	214 (28)	10 (26)	0·91 [0·4, 1·9]	0·791

AM=acute malnutrition. HAZ = height-for-age z-score. HHS=Household Hunger Score. WAZ=weight-for-age z-score. WHZ=weight-for-height z-score. MUAC=mid-upper arm circumference. Gray shading indicates outcome related to country-specific definition used throughout the report.
[1]Crude logistic regression