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

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Summary

Background Community-based management of acute malnutrition is an effective treatment model for severe acute malnutrition. However, sparse evidence exists on post-discharge outcomes and the sustainability of recovery. This study aimed to evaluate the risk and determinants of relapse following severe acute malnutrition recovery in high-burden settings.

Methods This multi-country prospective cohort study followed children who had recovered from severe acute malnutrition and their non-malnourished peers in parallel for 6 months in Mali (nine sites), South Sudan (six sites), and Somalia (one site). Nutritional status was assessed by research staff at nutrition clinics monthly to obtain the proportion of children exposed to severe acute malnutrition who relapsed to acute malnutrition and the relative risk of developing acute malnutrition for exposed versus non-exposed (ie, previously non-malnourished) children. Exposed children were eligible if they had been discharged from community-based management of acute malnutrition programmes while aged 6–47 months. Non-exposed children were eligible if they had not had an episode of acute malnutrition in the previous year; non-exposed children were matched to exposed children by age, sex, and community. Acute malnutrition was defined as having a mid-upper arm circumference of less than 125 mm, a weight-for-height Z score of less than –2, or nutritional oedema. The primary outcome was the cumulative incidence of acute malnutrition at 6 months in the exposed and non-exposed cohorts. Relapse was defined as an episode of acute malnutrition among exposed children during the 6-month follow-up period.

Findings Between April 9, 2021, and June 2, 2022, 2749 children were enrolled (1689 exposed and 1060 non-exposed). After 6 months, 30% (95% CI 25–34) of children previously exposed to severe acute malnutrition relapsed in Mali, 63% (95% CI 59–67) in South Sudan, and 22% (95% CI 19–25) in Somalia. Depending on the context, exposed children were 1·2–6·2 times more likely to have acute malnutrition compared with non-exposed children. Higher anthropometric measurements at discharge were protective against relapse; however, few other child-level or household-level factors at the time of discharge were associated with subsequent relapse. After discharge, children experiencing food insecurity or morbidity at time of follow-up were more likely to relapse than those who were not experiencing these factors.

Interpretation Following severe acute malnutrition recovery, children have a significant risk of relapsing within 6 months, highlighting the particular vulnerability of this population. Although the community-based management of acute malnutrition model proves highly effective in saving lives, high relapse indicates the need for additional services during and following treatment to better sustain recovery.

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See **Comment** page e6

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Introduction

Acute malnutrition in young children remains a global problem, with only 34% of countries on track to meet the UN Sustainable Development Goals' wasting targets.[1] In 2022, 45 million children younger than 5 years had acute malnutrition at any given time, including 13·7 million children with severe acute malnutrition.[1] Acute malnutrition in children aged 6–59 months is defined by WHO as having a weight-for-height Z score (WHZ) of less than –2 SD than the median of WHO child growth standards, a mid-upper arm circumference (MUAC) less than 125 mm, or nutritional bilateral oedema. Severe acute malnutrition, defined by more severe measurements for these anthropometric measures (WHZ less than –3 SD or MUAC <115 mm) or oedema, includes increased risk of morbidity and mortality.[2,3]

Community-based management of acute malnutrition (CMAM) is the standard treatment for children with severe acute malnutrition in low-resource settings. The WHO-endorsed model comprises outpatient treatment using

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Research in context

Evidence before this study

A growing body of evidence and anecdotal observations from health-care workers indicate that children who recover after being treated for severe acute malnutrition are often readmitted for repeated treatments. To identify existing evidence, we used multiple methods to search the literature including a systematic review on PubMed using terms such as "acute malnutrition", "community-based management of acute malnutrition", "post-discharge", "relapse", and "sustained acute malnutrition recovery". The search captured primary studies and systematic reviews published between Jan 1, 2018, and Aug 31, 2023, and was restricted to English language publications. Systematic reviews from 2018 and 2019 on post-discharge follow-up of children aged 6–59 months who had recovered from severe acute malnutrition identified crucial gaps in the evidence-base, including: an insufficient understanding of post-treatment outcomes, an absence 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 to outline the pressing need for more research to estimate rates of post-treatment relapse in different settings with standardised definitions and measurement.

Added value of this study

This multi-country prospective cohort study is the first to estimate relapse rates and associated risk factors using a standardised approach of collecting monthly anthropometry measurements on children recovered from uncomplicated severe acute malnutrition (referred to as exposed children) treated in the community and comparing them with community matched peers (referred to as non-exposed children). We provide new and important evidence on the burden of post-severe acute malnutrition relapse and its risk factors. Previously, only a few studies had systematically followed up children after discharge. Therefore, results could not be compared across contexts, leaving a gap in the overall understanding of the burden of relapse and its main drivers. In view of these current gaps, our study provides new evidence on the extent of relapse among children discharged from community-based management of acute malnutrition programmes in three different high-burden settings and shows that outside of anthropometry at discharge, few household and individual-level factors are consistently significant, underscoring the need to look more broadly at systemic and community-level drivers, as is done for acute malnutrition.

Implications of all the available evidence

This study highlights that treatment for acute malnutrition continues to leave some children vulnerable to relapse and that the current recovery definitions might be insufficient to consider a child as nutritionally well. These findings suggest the need for specific strategies to prevent relapse following initial recovery from severe acute malnutrition and to include severe acute malnutrition exposed children as a targeting criterion for interventions to reach this vulnerable population. Fundamentally, our findings emphasise the need to consider improving or adding to the community-based management of acute malnutrition model to ensure children are not left highly susceptible upon discharge to repeated acute malnutrition episodes and to link treatment and prevention services.

specially formulated foods and antimicrobial therapy and has proven effective in temporarily reversing nutritional deterioration.[4] Nevertheless, emerging evidence suggests that children relapse frequently after recovery.[5]

Relapse rates have been documented in various studies with a range of 0–37%.[6–10] However, most studies do not have longitudinal follow-up and non-malnourished comparison groups, leading to gaps in estimating and understanding post-discharge risk.[9,10] Inconsistent methods for reporting post-discharge outcomes limit comparisons across contexts and hamper accurate quantification of the problem.

See Online for appendix 1

High rates of relapse could highlight shortcomings in the current CMAM model, suggesting that limited resources might be being used inefficiently to repeatedly treat the same children. Preventing relapse is crucial, yet our understanding of the size and drivers of the problem is incomplete.[11,12]

In this study, the primary objective was to estimate the cumulative incidence and risk of relapse within 6 months following children's recovery from severe acute malnutrition as compared with their non-malnourished peers in three countries and to identify potential risk factors for relapse.

Methods

Study design and participants

In this prospective cohort study, 16 clinics were purposefully selected as they had high severe acute malnutrition caseloads and accessible community-based management of acute malnutrition programmes: nine in Mali, six in South Sudan, and one in Somalia (appendix 1 p 6). The clinics in Mali and South Sudan served rural non-displaced populations and had few assistance programmes available with limited funding, while the clinic in Somalia served the urban Banadir internally displaced persons camp with more assistance programmes available. Exposed children (discharged as recovered from uncomplicated severe acute malnutrition) and non-exposed children (who had not previously been diagnosed as malnourished) were enrolled on a rolling basis and followed up for 6 months. The study was originally designed to have 1 year follow-up, but this was decreased to 6 months due to the COVID-19 pandemic.

Children were enrolled between April 9, 2021, and June 2, 2022. Exposed children were eligible for enrolment upon discharge from CMAM programmes; they had to be discharged as recovered from severe acute malnutrition while aged 6–47 months. This age range was selected to maintain consistent anthropometric criteria for diagnosing acute malnutrition and to ensure that children would remain eligible for CMAM programmes for the full planned year of follow-up, which was later shortened to 6 months. Non-exposed children were matched to exposed children on age, sex, and clinic catchment area and without an episode of acute malnutrition in the previous year. Each country's programme had distinct criteria for admission and discharge (appendix 1 p 6). To standardise study enrolment criteria across the countries, all children included in the final analysis were required to have a MUAC of 125 mm or greater, a WHZ of –2 SD or greater, and no nutritional oedema at enrolment. Children who received inpatient care before CMAM admission or with a chronic or congenital disease or disability were ineligible. Recruitment occurred at select nutrition clinics and associated catchment areas, with non-exposed children referred from the community by trained research staff when matching parameters were met. Written informed consent was obtained from all participants' caregivers. For caregivers who were illiterate, informed consent was obtained orally, with a witness signing to confirm each caregiver's consent.

A detailed description of the study protocol has previously been published.[13] Ethical approval was provided by Solutions Institutional Review Board (reference number #20200310), London School of Hygiene & Tropical Medicine's Research Ethics Committee (#18059), Ministry of Health 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). This study adheres to the STROBE guidelines (appendix 1 p 3).[14]

Procedures

Exposed children were enrolled at the point of discharge from severe acute malnutrition treatment and non-exposed children were enrolled within 2 weeks of the matched exposed child. Data collection procedures were identical across sites, using the same study tools and carried out by research staff specific to each site.

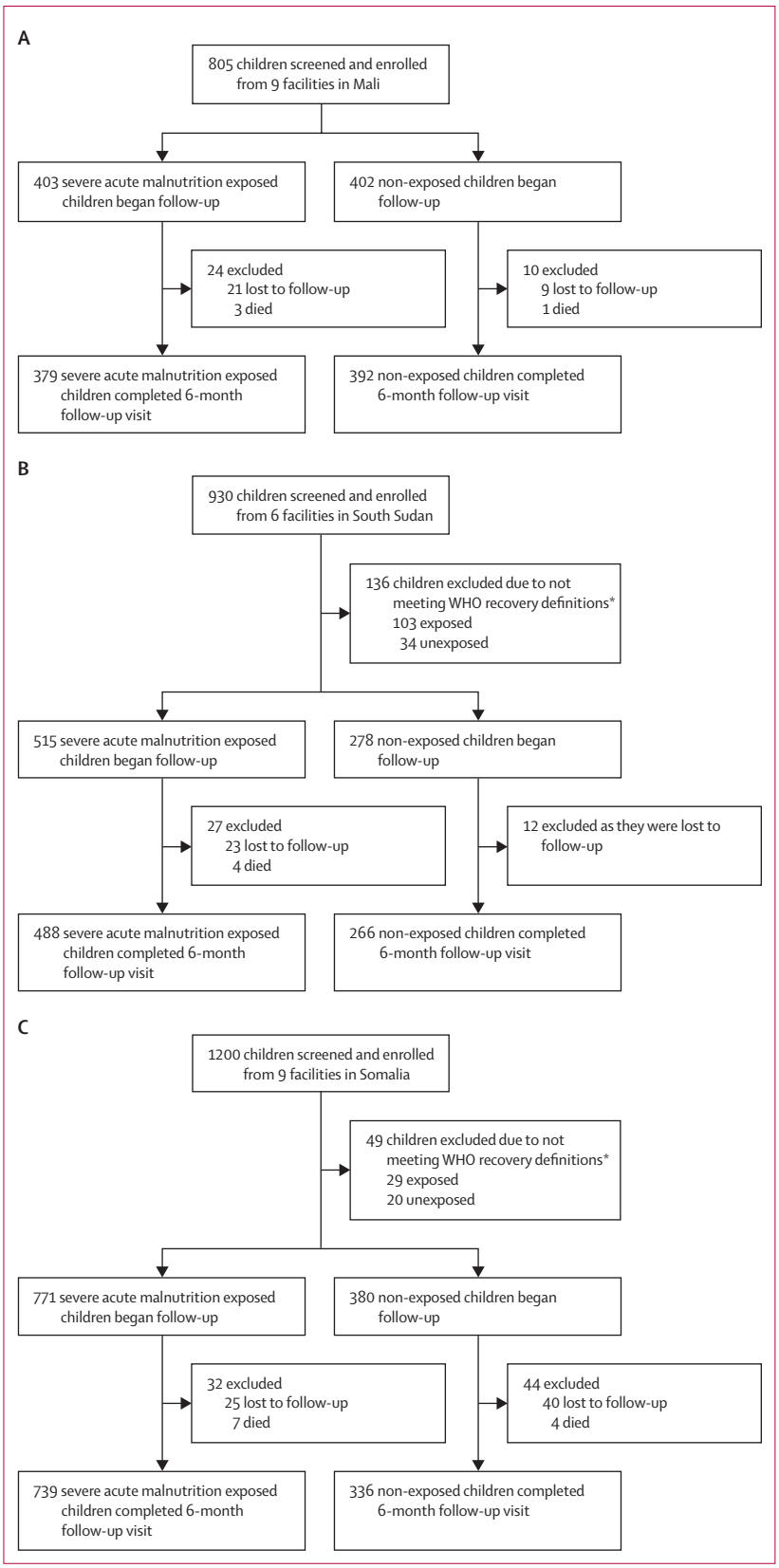
Research staff, trained on the same data collection protocol, assessed participants in clinics at enrolment and at the follow-up visits, which occurred monthly for 6 months. A month was defined as 4 weeks to align with clinic schedules. At each visit, a survey was completed by research staff to collect individual child-level and household-level covariates, and children were evaluated anthropometrically (ie, for MUAC, WHZ, and oedema). Children were classified as either without acute malnutrition (MUAC ≥125 mm, WHZ of –2 SD or greater, and without oedema), moderate acute malnutrition (MUAC 115–124 mm or WHZ more than –3 SD to –2 SD, without severe acute malnutrition), severe acute malnutrition (MUAC <115 mm, WHZ less than –3 SD, or oedema), dead, or missed a visit (incomplete follow-up visit within 3 weeks after the scheduled date). Each child's stunting and underweight status was classified for each visit, with underweight defined as a weight-for-age Z score (WAZ) less than –2 SD and stunting as a height-for-age Z score (HAZ) less than–2 SD. Severe underweight was classified as a WAZ less than –3 SD, and severe stunting was classified as a HAZ less than –3 SD. Underweight and stunting can indicate nutritional deficits and risks that might influence post-discharge outcomes.

Throughout follow-up, any child identified with moderate or severe acute malnutrition was referred for treatment at the same clinic and remained in the study. Research staff collected reported death data from caregivers monthly. All caregivers were provided either in-kind or financial compensation for their time at each visit. Treatment data, including medical care, comorbidities, and length of stay, were collected. Surveys gathered data on individual child-level and household-level covariates including self-reported child sex (with the options of female or male), child feeding, illness symptoms, maternal survival status, and number of siblings. Food insecurity was assessed via the Household Hunger Scale, which measures experiential food insecurity over the past month.[15] The wealth quartile for each household was assessed against other households in the same country using the first component of principal component analysis on the following binary variables related to asset ownership and quality: mattress, mobile phone, fridge, television, radio, table, chair, torch, bicycle, car, motorbike, donkey cart, shoes, chickens, ducks, pigs, cattle, goats, sheep, horses, dogs, cats, other animals, kitchen, access to a bank, electricity, good construction material of the floor, wall, and roof.

Research staff performed supervision and data verification. Data were collected electronically or via paper, double-entered into electronic databases, and stored on secure servers. Quality checks were conducted upon entry and errors were corrected by referral to original forms.

Outcomes

The primary outcome was the cumulative incidence of acute malnutrition at 6 months, defined as the proportion of children experiencing an acute malnutrition event by month 6 over the total number of children in their cohort who remained in the study for the full 6 months without death or loss to follow-up.[16] Cumulative incidence was calculated for each country separately and as an all-country pooled value, weighed by the inverse of each



country's sample size. A child was considered to have acute malnutrition if they had a MUAC less than 125 mm, a WHZ less than –2 SD, or nutritional oedema. Relapse was defined as an episode of acute malnutrition among exposed children.

Secondary outcomes include the cumulative incidence of acute malnutrition, moderate acute malnutrition, and severe acute malnutrition at each follow-up visit and the relative risk (RR) of acute malnutrition, moderate acute malnutrition, and severe acute malnutrition at month 6 for exposed children compared with non-exposed children (excluding all children who died or were lost to follow-up). Additional ad-hoc secondary outcomes included the binary outcome of acute malnutrition status at each month for temporal analyses, the number of months that a child had acute malnutrition out of the 6 months, and change in WHZ and MUAC from enrolment to month 6.

Additional secondary outcomes that account for participants with incomplete follow-up (ie, death and loss to follow-up) were calculated including: point prevalence of acute malnutrition (disaggregated by moderate and severe), death, and loss to follow-up at each month; incidence rate of acute malnutrition at month 6; and survival without acute malnutrition across the 6 months using the Kaplan–Meier method. For both the incidence rate of acute malnutrition at month 6 and survival, children who developed acute malnutrition, died, or were lost to follow-up were censored at subsequent months.

Nutritional status was classified at clinics for Z score-dependent indicators and confirmed using WHO's 2006 Child Growth Standards via the zscore06 Stata package.[17,18] For any children who missed a follow-up visit during months 2–5, we used proximal linear interpolation between non-missing data points for height, weight, and MUAC measurements. This approach incorporates maximum individual level variation similar to more sophisticated methods, while remaining conceptually straightforward.[19]

Statistical analysis

The sample size was calculated to detect an RR of at least 2·3 in each country and a pooled RR of 1·7 given an α of 0·05, a power of 80%, adjusting for clinic-level clustering in Mali and South Sudan using a rho of 0·007, a maximum loss to follow-up of 5%, 6 months of follow-up, and a 2:1 exposed to non-exposed ratio. Slow enrolment in Mali prompted a change to a 1:1 ratio to increase analytical power, leading to a delayed enrolment of the non-exposed cohort. After these ad-hoc

Figure 1: **Study inclusion profile**
(A) Mali. (B) South Sudan. (C) Somalia. *To be included in analysis, children were required to have a mid-upper arm circumference of ≥125 mm, a weight-for-height z-score of –2 standard deviations or more, and no bilateral pitting oedema at the start of study follow-up.

	Mali			South Sudan			Somalia			All country pooled			Mali and South Sudan pooled		
	Exposed (n=403)	Non-exposed (n=402)	p value	Exposed (n=515)	Non-exposed (n=278)	p value	Exposed (n=771)	Non-exposed (n=380)	p value	Exposed (n=1689)	Non-exposed (n=1060)	p value	Exposed (n=918)	Non-exposed (n=680)	p value
Sex and age															
Female	230 (57·1%)	229 (57·0%)	0·98	279 (54·2%)	144 (51·8%)	0·52	444 (57·6%)	211 (55·5%)	0·51	950 (56·2%)	583 (55·0%)	0·54	509 (55·4%)	373 (54·9%)	0·81
Male	173 (42·9%)	173 (43·0%)	0·98	236 (45·8%)	134 (48·2%)	0·52	327 (42·4%)	169 (44·5%)	0·51	739 (43·8%)	477 (45·0%)	0·54	409 (44·6%)	307 (45·2%)	0·81
Age (months)	15·7 (6·5)	16·8 (7·3)	0·032	20·8 (9·0)	21·9 (9·5)	0·10	14·4 (5·4)	15·9 (5·8)	<0·0001	17·0 (7·7)	18·0 (8·0)	0·0020	18·6 (8·4)	18·9 (8·6)	0·48
Younger than 24 months	350 (86·9%)	331 (82·3%)	0·076	348 (67·6%)	175 (63·0%)	0·19	704 (91·3%)	331 (87·1%)	0·026	1379 (81·7%)	826 (77·9%)	0·021	697 (75·9%)	505 (74·3%)	0·46
Study enrolment anthropometrics															
MUAC (mm)	131·0 (5·1)	139·8 (9·5)	<0·0001	130·1 (4·4)	144·3 (9·3)	<0·0001	127·2 (2·4)	137·7 (8·9)	<0·0001	129·3 (4·3)	140·5 (9·7)	<0·0001	130·5 (4·7)	141·7 (9·7)	<0·0001
MUAC <130 mm	177 (43·9%)	42 (10·5%)	<0·0001	301 (58·5%)	12 (4·3%)	<0·0001	677 (87·8%)	54 (14·2%)	<0·0001	1105 (65·4%)	103 (9·7%)	<0·0001	479 (52·2%)	54 (7·9%)	<0·0001
MUAC <128 mm	118 (29·3%)	17 (4·2%)	<0·0001	200 (38·8%)	5 (1·8%)	<0·0001	512 (66·4%)	21 (5·5%)	<0·0001	786 (46·5%)	41 (3·9%)	<0·0001	318 (34·6%)	22 (3·2%)	<0·0001
WHZ	−1·1 (0·5)	−0·6 (0·8)	<0·0001	−1·2 (0·8)	−0·6 (0·9)	<0·0001	−0·3 (0·9)	−0·4 (0·9)	0·092	−0·8 (0·9)	−0·6 (0·9)	<0·0001	−1·1 (0·7)	−0·6 (0·8)	<0·0001
WHZ less than −1·5	78 (19·4%)	43 (10·7%)	0·0010	188 (36·5%)	43 (15·5%)	<0·0001	60 (7·8%)	48 (12·6%)	0·0080	357 (21·1%)	134 (12·6%)	<0·0001	267 (29·1%)	86 (12·7%)	<0·0001
HAZ	−2·1 (1·3)	−1·0 (1·6)	<0·0001	−2·5 (1·4)	−0·9 (1·5)	<0·0001	−2·8 (1·4)	−1·3 (1·7)	<0·0001	−2·5 (1·4)	−1·1 (1·6)	<0·0001	−2·3 (1·4)	−1·0 (1·6)	<0·0001
HAZ less than −2	216 (53·6%)	98 (24·4%)	<0·0001	324 (62·9%)	57 (20·5%)	<0·0001	560 (72·6%)	135 (35·5%)	<0·0001	1081 (64·0%)	280 (26·4%)	<0·0001	540 (58·8%)	155 (22·8%)	<0·0001
HAZ less than −3	103 (25·6%)	42 (10·5%)	<0·0001	194 (37·7%)	17 (6·1%)	<0·0001	375 (48·6%)	58 (15·3%)	<0·0001	650 (38·5%)	112 (10·6%)	<0·0001	298 (32·4%)	59 (8·7%)	<0·0001
WAZ	−1·9 (0·8)	−1·0 (1·1)	<0·0001	−2·2 (0·8)	−0·9 (1·0)	<0·0001	−1·8 (0·9)	−1·0 (1·1)	<0·0001	−2·0 (0·9)	−1·0 (1·0)	<0·0001	−2·1 (0·8)	−1·0 (1·0)	<0·0001
WAZ less than −2	182 (45·2%)	61 (15·2%)	<0·0001	297 (57·7%)	37 (13·3%)	<0·0001	320 (41·5%)	69 (18·2%)	<0·0001	815 (48·3%)	164 (15·5%)	<0·0001	480 (52·3%)	98 (14·4%)	<0·0001
WAZ less than −3	38 (9·4%)	12 (3·0%)	<0·0001	80 (15·5%)	1 (0·4%)	<0·0001	54 (7·0%)	14 (3·7%)	0·025	181 (10·7%)	25 (2·4%)	<0·0001	118 (12·9%)	13 (1·9%)	<0·0001
Infant and young child feeding															
Ever breastfed	377 (93·6%)	377 (93·8%)	0·89	496 (96·3%)	266 (95·7%)	0·66	718 (93·1%)	360 (94·7%)	0·29	1594 (94·4%)	1002 (94·5%)	0·79	873 (95·1%)	643 (94·6%)	0·63
Currently breastfed	302 (74·9%)	295 (73·4%)	0·61	311 (60·4%)	136 (48·9%)	0·0020	323 (41·9%)	153 (40·3%)	0·60	970 (57·4%)	601 (56·7%)	0·71	612 (66·7%)	430 (66·2%)	0·15
Caregiver reported symptoms of illness at enrolment															
Diarrhoea in previous 7 days	54 (13·4%)	27 (6·7%)	0·0020	105 (20·4%)	48 (17·3%)	0·29	347 (45·0%)	190 (50·0%)	0·11	467 (27·7%)	235 (22·2%)	0·0010	159 (17·3%)	75 (11·0%)	0·0005
Fever in previous 7 days	67 (16·6%)	52 (12·9%)	0·14	216 (41·9%)	86 (30·9%)	0·0020	252 (32·7%)	103 (27·1%)	0·054	534 (31·6%)	236 (22·3%)	<0·0001	284 (30·9%)	139 (20·4%)	<0·0001
Cough in previous 7 days	55 (13·7%)	44 (11·0%)	0·24	203 (39·4%)	90 (32·4%)	0·050	190 (24·6%)	93 (24·5%)	0·95	454 (26·9%)	224 (21·1%)	0·0008	259 (28·2%)	135 (19·9%)	<0·0001

(Table 1 continues on next page)

	Mali			South Sudan			Somalia			All country pooled			Mali and South Sudan pooled		
	Exposed (n=403)	Non-exposed (n=402)	p value	Exposed (n=515)	Non-exposed (n=278)	p value	Exposed (n=771)	Non-exposed (n=380)	p value	Exposed (n=1689)	Non-exposed (n=1060)	p value	Exposed (n=918)	Non-exposed (n=680)	p value
(Continued from previous page)															
Caregiver characteristics															
Mother has no formal education	253 (62·8%)	188 (46·8%)	<0·0001	356 (69·1%)	159 (57·2%)	0·0010	758 (98·3%)	375 (98·7%)	0·63	1322 (78·3%)	685 (64·6%)	<0·0001	609 (66·3%)	347 (51·0%)	<0·0001
Household characteristics															
Child is a twin	23 (5·7%)	10 (2·5%)	0·022	47 (9·1%)	6 (2·2%)	<0·0001	26 (3·4%)	7 (1·8%)	0·14	102 (6·0%)	23 (2·2%)	<0·0001	70 (7·6%)	16 (2·4%)	<0·0001
Number of siblings, median (IQR)	2 (1–4)	2 (1–4)	0·60	3 (2–5)	2 (1–4)	<0·0001	4 (3–6)	4 (2–5)	0·0010	3 (2–5)	3 (1–4)	<0·0001	3 (1–5)	2 (1–4)	<0·0001
Household Hunger Scale Category at enrolment*	..	..	0·15	..	..	<0·0001	..	..	0·91	..	..	<0·0001	..	..	<0·0001
Little to no hunger	386 (98·5%)	393 (99·8%)	..	205 (40·4%)	141 (52·2%)	..	537 (70·7%)	265 (70·3%)	..	1118 (67·4%)	805 (77·3%)	..	588 (65·4%)	532 (80·2%)	..
Moderate hunger	4 (1·0%)	1 (0·3%)	..	133 (26·2%)	95 (35·2%)	..	138 (18·2%)	71 (18·8%)	..	272 (16·4%)	165 (15·9%)	..	138 (15·4%)	97 (14·7%)	..
Severe hunger	2 (0·5%)	0	..	169 (33·3%)	34 (12·6%)	..	85 (11·2%)	41 (10·9%)	..	269 (16·2%)	71 (6·8%)	..	173 (19·2%)	35 (5·2%)	..
Wealth index quartiles	..	..	0·0045	..	..	<0·0001	..	..	0·32	..	..	<0·0001	..	..	<0·0001
Quartile 1	110 (27·3%)	89 (22·1%)	..	147 (28·5%)	44 (15·8%)	..	160 (20·8%)	74 (19·5%)	..	427 (25·3%)	207 (19·5%)	..	257 (28·0%)	133 (19·6%)	..
Quartile 2	110 (27·3%)	93 (23·1%)	..	140 (27·2%)	57 (20·5%)	..	175 (22·7%)	85 (22·4%)	..	431 (25·5%)	235 (22·2%)	..	250 (27·2%)	150 (22·1%)	..
Quartile 3	100 (24·8%)	101 (25·1%)	..	132 (25·6%)	64 (23·0%)	..	233 (30·2%)	144 (37·9%)	..	458 (27·1%)	298 (28·1%)	..	232 (25·3%)	165 (24·3%)	..
Quartile 4	83 (20·6%)	119 (29·6%)	..	96 (18·6%)	113 (40·7%)	..	203 (26·3%)	77 (20·3%)	..	372 (22·0%)	320 (30·2%)	..	179 (19·5%)	232 (34·1%)	..

Data are n (%) or mean (SD) unless otherwise specified. MUAC=mid-upper arm circumference. WHZ=weight-for-height z-score. HAZ=height-for-age z-score. WAZ=weight-for-age z-score. All pooled analyses were weighed by 1/(sample size) so that each country contributes proportionally to the regression despite differences in sample size. *The ns are reduced for this section on the basis of those who answered the question: for Mali the exposed group is 392 and the non-exposed is 394, for South Sudan the exposed group is 507 and the non-exposed is 270, for Somalia the exposed group is 760 and non-exposed is 377, for all country pooled the exposed group is 1659 and non-exposed is 1041, and for Mali and South Sudan pooled the exposed group is 899 and non-exposed is 664.

Table 1: **Study participant characteristics and comparison of study cohorts (exposed *vs* non-exposed)**

adjustments, the new sample size requirements were: 800 exposed and 400 non-exposed children in Somalia, 614 exposed and 306 non-exposed children in South Sudan, and 400 exposed and 400 non-exposed children in Mali.

We compared child characteristics at enrolment between the exposed and non-exposed cohorts using χ^2 test for binary variables, Student's *t* test for continuous variables, and the Wald χ^2 test for categorical variables. Normality was confirmed before conducting the *t* test. For skewed continuous outcomes, we used the Mann–Whitney and Kruskal–Wallis tests.

For cumulative incidence and RR of acute malnutrition, we used a Poisson regression model with robust standard errors.[20] The RR analysis included a crude model with exposure status only and an adjusted model incorporating the following covariates: age (in months, continuous); sex (female *vs* male); child WHZ at enrolment (continuous); mother's education (any *vs* none); number of siblings (continuous); whether the child was a twin or not; whether the child is currently breastfed or not; household food insecurity (Household Hunger Scale Categories: little or no hunger, moderate hunger, or severe hunger); household wealth quartile (lowest to highest wealth); caregiver reported diarrhoea, cough, or fever in the child at enrolment or not; day of enrolment; and a dummy variable for clinic. As an ad-hoc sensitivity analysis, we used a logit model with propensity score matching to estimate the average exposure effect on the cumulative incidence of having acute malnutrition by month 6 of follow up (ie, final follow-up) by matching children based on their exposure probabilities. Given the importance of WHZ at admission and the significant difference in this variable between the exposed and non-exposed group at enrolment, we created propensity scores by matching on WHZ at enrolment, age, and sex using Stata's teffects psmatch command.

To identify risk factors of relapse among the exposed group, we ran both crude and adjusted models using a Poisson model with cumulative incidence of acute malnutrition at month 6 as the outcome and the same covariates as for the cumulative incidence and RR of acute malnutrition, with the exception of day of enrolment. Due to multicollinearity between the anthropometric indicators, we used WHZ at discharge in the final regression models to identify risk factors of relapse. To assess the statistical fit of the models, we examined over-dispersion, the goodness of fit, and conducted a Wald test (appendix 1 p 19). A p value of less than 0·05 was considered significant. All analyses were conducted using Stata17.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of this report.

	0–1 months since discharge		0–2 months since discharge		0–3 months since discharge		0–4 months since discharge		0–5 months since discharge		0–6 months since discharge	
	Exposed	Non-exposed	Exposed	Non-exposed	Exposed	Non-exposed	Exposed	Non-exposed	Exposed	Non-exposed	Exposed	Non-exposed
Mali	n=379	n=392	n=379	n=392	n=379	n=392	n=379	n=392	n=379	n=392	n=379	n=392
Non-acute malnutrition	90 (87–93)*	98% (96–99)	84% (80–87)*	96% (94–98)	79% (74–83)*	95% (93–97)	75% (70–79)*	93% (90–96)	73% (68–77)*	92% (89–95)	70 (66–75)*	92% (88–94)
Acute malnutrition	10 (7–13)*	2% (1–4)	16% (13–20)*	4% (2–6)	21% (17–26)*	5% (3–7)	25% (21–30)*	7% (4–10)	27% (23–32)*	8% (5–11)	30 (25–34)*	8% (6–12)
Moderate acute malnutrition	8% (6–11)*	2% (1–4)	13% (10–17)*	4% (2–6)	17% (13–21)*	5% (3–7)	19% (15–23)*	7% (4–10)	20 (16–25)*	7% (5–10)	22% (18–27)*	8% (6–11)
Severe acute malnutrition	2% (1–3)*	0	3% (1–5)*	0	5% (3–7)*	0	7% (4–10)*	0	7% (5–10)†	<1% (0–1)	7% (5–11)†	<1% (0–1)
South Sudan	n=488	n=266	n=488	n=266	n=488	n=266	n=488	n=266	n=488	n=266	n=488	n=266
Non-acute malnutrition	75% (71–79)*	99% (96–99·6)	59% (55–64)*	97% (94–98)	50 (46–55)*	94% (91–97)	46% (42–51)*	93% (89–96)	40 (36–45)*	91% (87–94)	37% (33–41)*	90 (86–93)
Acute malnutrition	25% (21–29)*	2% (0·4–4)	41% (36–45)*	3% (2–6)	50 (45–54)*	6% (3–9)	54% (49–58)*	7% (4–11)	60 (55–64)*	9% (6–13)	63% (59–67)*	10 (7–14)
Moderate acute malnutrition	21% (18–25)*	2% (0·4–4)	33% (29–38)*	3% (2–6)	40 (35–44)*	5% (3–9)	42% (37–46)*	6% (4–10)	46% (41–50)*	8% (5–11)	46% (42–50)*	9% (6–13)
Severe acute malnutrition	3% (2–5)†	0	7% (5–10)*	0	10 (8–13)†	<1% (0–2)	12% (9–15)*	1% (0–3)	14% (11–18)*	2% (0·4)	17% (14–21)*	2% (0·4)

(Table 2 continues on next page)

	0–1 months since discharge		0–2 months since discharge		0–3 months since discharge		0–4 months since discharge		0–5 months since discharge		0–6 months since discharge	
	Exposed	Non-exposed	Exposed	Non-exposed	Exposed	Non-exposed	Exposed	Non-exposed	Exposed	Non-exposed	Exposed	Non-exposed
(Continued from previous page)												
Somalia	n=739	n=336	n=739	n=336	n=739	n=366	n=739	n=366	n=739	n=336	n=739	n=336
Non-acute malnutrition	94% (92–96)	96% (94–98)	88% (86–91)	91% (87–94)	85% (82–87)	88% (83–91)	83% (80–85)	85% (81–88)	80 (77–83)	83% (79–87)	78% (75–81)	82% (76–86)
Acute malnutrition	6% (5–8)	4% (2–6)	12% (10–14)	9% (6–13)	15% (13–18)	13% (9–17)	17% (15–20)	15% (12–19)	20 (17–23)	17% (13–21)	22% (19–25)	19% (14–23)
Moderate acute malnutrition	5% (4–7)	4% (2–6)	9% (7–11)	8% (5–11)	10 (8–12)	10 (7–14)	11% (8–13)	12% (9–16)	12% (10–15)	13% (9–17)	14% (11–17)	14% (10–18)
Severe acute malnutrition	1% (0·4–2)*	0	3% (2–5)	1% (0·3–3)	6% (4–8)‡	2% (0·8–4)	7% (5–9)‡	3% (2–6)	8% (6–10)‡	4% (2–7)	8% (6–10)‡	5% (3–7)
All country pooled§	n=1606	n=994	n=1606	n=994	n=1606	n=994	n=1606	n=994	n=1606	n=994	n=1606	n=994
Non-acute malnutrition	87% (85–88)*	98% (97–99)	77% (75–79)*	95% (34–96)	72% (69–74)*	92% (91–94)	68% (66–70)*	90 (89–92)	64% (62–67)*	89% (87–91)	62% (59–64)*	88% (86–90)
Acute malnutrition	13% (12–15)*	2% (2–4)	23% (21–25)*	5% (4–7)	29% (27–31)*	8% (6–10)	32% (30–35)*	10 (8–12)	36% (33–38)*	11% (9–13)	38% (36–41)*	12% (10–15)
Moderate acute malnutrition	11% (10–13)*	2% (2–4)	18% (16–20)*	5% (4–6)	23% (20–24)*	7% (5–9)	24% (22–26)*	8% (7–10)	26% (24–28)*	9% (8–11)	27% (25–30)*	10 (9–12)
Severe acute malnutrition	2% (1–3)*	0	5% (4–6)*	<1% (0–1)	7% (6–8)*	1% (0–2)	8% (7–10)*	1% (1–2)	10 (8–11)*	2% (1–3)	11% (9–13)*	2% (1–3)
Mali and South Sudan pooled§	n=867	n=658	n=867	n=658	n=867	n=658	n=867	n=658	n=867	n=658	n=867	n=658
Non-acute malnutrition	83% (80–85)*	98% (97–99)	72% (69–74)*	97% (95–98)	65% (61–68)*	95% (93–97)	61% (57–64)*	93% (91–95)	57% (53–60)*	92% (89–94)	54% (50–57)	91% (88–93)
Acute malnutrition	17% (15–20)*	2% (1–3)	28% (26–31)*	4% (2–5)	35% (32–39)*	5% (4–7)	40 (36–43)*	7% (5–9)	43% (40–47)‡	8% (6–11)	46% (43–50)*	9% (7–12)
Moderate acute malnutrition	15% (13–17)*	2% (1–3)	23% (21–26)*	4% (2–5)	28% (25–31)*	5% (4–7)	30 (27–33)*	6% (5–9)	33% (30–36)*	8% (6–10)	34% (31–37)*	8% (6–11)
Severe acute malnutrition	2% (2–4)*	0	5% (4–7)*	0	7% (6–9)*	<1% (0–1)	9% (8–11)*	<1% (0–2)	11% (9–13)*	1% (0–2)	12% (10–15)*	1% (0–2)

Data are % (95% CI). Cumulative incidence is defined as the number of new cases of malnutrition type at each month of follow-up with all children who died or were lost to follow-up at any point in months 0–6 removed from all calculations. *p <0·001. †p<0·01. ‡p<0·05. §All pooled analysis was weighed by 1/(sample size) so that each country contributes proportionally to the regression despite differences in sample size.

Table 2: **Cumulative incidence of acute malnutrition in the exposed *vs* non-exposed cohorts for Mali, South Sudan, Somalia, all country pooled, and Mali and South Sudan pooled using Poisson regression with robust standard errors (non-adjusted)**

Results

Between April 9, 2021, and June 2, 2022, 2749 participants were enrolled in the study and included in the analysis. 1689 (61·5%) of these children were exposed, and 1060 (38·6%) were non-exposed (figure 1). Loss to follow-up was low with data available for the full 6-month period for 2601 (95%) participants (appendix 1 p 19).

In all countries, children exposed to severe acute malnutrition had significantly lower anthropometric measurements at enrolment than non-exposed children (table 1). Severe stunting and severe underweight were over twice as prevalent in the exposed cohort. Caregivers reported higher illness rates among exposed children than non-exposed children, with Mali and South Sudan observing the greatest differences between the exposed and non-exposed cohorts. Other baseline characteristics were mostly similar between exposed and non-exposed cohorts in the countries.

6 months after discharge, the cumulative incidence of relapse to acute malnutrition in the exposed cohort was 112 of 379 children (29·6%, 95% CI 25–34) in Mali, 308 of 488 children (63·1%, 59–67) in South Sudan, and 162 of 739 children (21·9%, 19–25) in Somalia (table 2). Most relapse to acute malnutrition consisted of moderate rather than severe acute malnutrition. The cumulative incidence of acute malnutrition was significantly higher in the exposed cohort than the non-exposed cohort in Mali and South Sudan (Mali 30% *vs* 8%, 95% CI 6–12, p<0·0001; South Sudan 63% *vs* 10%, 7–14, p<0·0001; Poisson regression). Similarly, the cumulative incidence of severe acute malnutrition was higher in the exposed cohort compared with the non-exposed cohort in all three countries (Mali 7%, 5–11 *vs* <1%, 0–1, p=0·0010; South Sudan 17%, 14–21 *vs* 2%, 0–4, p<0·0001; Somalia 8%, 6–10 *vs* 5%, 3–7, p=0·033; Poisson regression; table 2). Mortality in the cohorts remained low in all countries with a rate of 1·13 deaths (95% CI 0·31–2·85) per 100 person-years in Mali, 1·37 deaths (0·38–3·48) per 100 person-years in South Sudan, and 2·17 deaths (1·09–3·84) per 100 person-years in Somalia (appendix 1 p 7).

The exposed cohort had a higher risk of acute malnutrition compared with the non-exposed cohort in all countries and pooled analyses, except Somalia (table 3). Exposed children were 3·5 (95% CI 2·4–5·0, p<0·0001, Poisson regression) times more likely to have acute malnutrition than non-exposed children in Mali and 6·2 (4·3–9·0, p<0·0001, Poisson regression) times more likely in South Sudan, and 3·3 (2·8–4·0, p<0·0001) times more likely in the pooled country analysis. The RR for acute malnutrition was elevated for exposed children in Somalia, although the difference was not statistically significant (1·2, 0·9–1·5, p=0·20, Poisson regression). Adjusting for covariates in the Poisson RR model did not alter the direction of the finding and resulted in a statistically significant RR in Somalia. However, the covariate adjustment did reduce the RR point estimate to 2·78 (1·91–4·06, p<0·0001) in Mali, 5·65 (3·64–8·77, p<0·0001) in South Sudan, 1·32 (1·02–1·69, p=0·032) in Somalia, and 3·95 (95% CI 2·95–5·28, p<0·0001) in the pooled country analysis (appendix 1 p 8).

Secondary analysis using the number of months that a child was acutely malnourished out of 6 months as the outcome in a Poisson model indicates a higher RR when compared with the cumulative incidence of acute malnutrition at month 6 of follow-up (ie, final follow-up), even when adjusting for covariates, with an RR of 3·12 (95% CI 2·47–3·93, p<0·0001) for the country pooled analysis (appendix 1 p 10). Propensity score matching sensitivity analysis (accounting for differences in sex, WHZ at enrolment, and age in months) resulted in similar findings: a higher risk of acute malnutrition for the relapse group; higher RR in South Sudan, followed by Mali and Somalia; and non-significance in Somalia only (appendix 1 pp 11, 19).

When accounting for incomplete follow-up, analyses show similar patterns of relapse risk. The 6-month acute malnutrition incidence rate among exposed children was 5·86 (95% CI 4·89–7·04, p<0·0001) per 1000 child-months in Mali, 16·73 (95% CI 14·99–18·67, p<0·0001) per 1000 child-months in South Sudan, and 4·17 (3·59–4·85, p=0·16) per 1000 child-months in Somalia (appendix 1 p 12). These rates were significantly higher than those in the non-exposed cohorts in Mali and South Sudan (p<0·0001), but not in Somalia. Kaplan–Meier curves comparing survival without acute malnutrition showed that exposed children more often had acute malnutrition than non-exposed children in Mali (p<0·0001) and South Sudan (p<0·0001), but not in Somalia (p<0·16; log-rank test; figure 2). The point prevalence of acute malnutrition was steady across all follow-up months in Mali and Somalia, with a slight peak at 3 months in South Sudan (appendix 1 p 7).

Among the exposed cohort, multiple factors were explored in pooled and country-specific analyses to

	Mali (n=771)	South Sudan (n=754)	Somalia (n=1075)	All country pooled* (n=2600)	Mali and South Sudan pooled* (n=1525)
Acute malnutrition	3·51 (2·44–5·04)†	6·22 (4·32–8·95)†	1·19 (0·91–1·54)	3·32 (2·77–3·98)†	5·32 (4·15–6·84)†
Moderate acute malnutrition	2·72 (1·85–3·98)†	5·31 (3·55–7·94)†	0·99 (0·72–1·36)	2·78 (2·26–3·41)†	4·26 (3·26–5·58)†
Severe acute malnutrition	28·96 (3·96–212·06)‡	11·45 (4·24–30·88)†	1·82 (1·05–3·16)§	6·36 (4·00–10·11)†	16·92 (6·94–41·22)†

Data are relative risk (95% CI). *All pooled analyses were weighed by 1/(sample size) so that each country contributes proportionally to the regression despite differences in sample size. †p<0·001. ‡p<0·01. §p<0·05.

Table 3: **Relative risk of acute malnutrition for the exposed *vs* non-exposed cohorts using Poisson regression with robust standard errors (non-adjusted)**

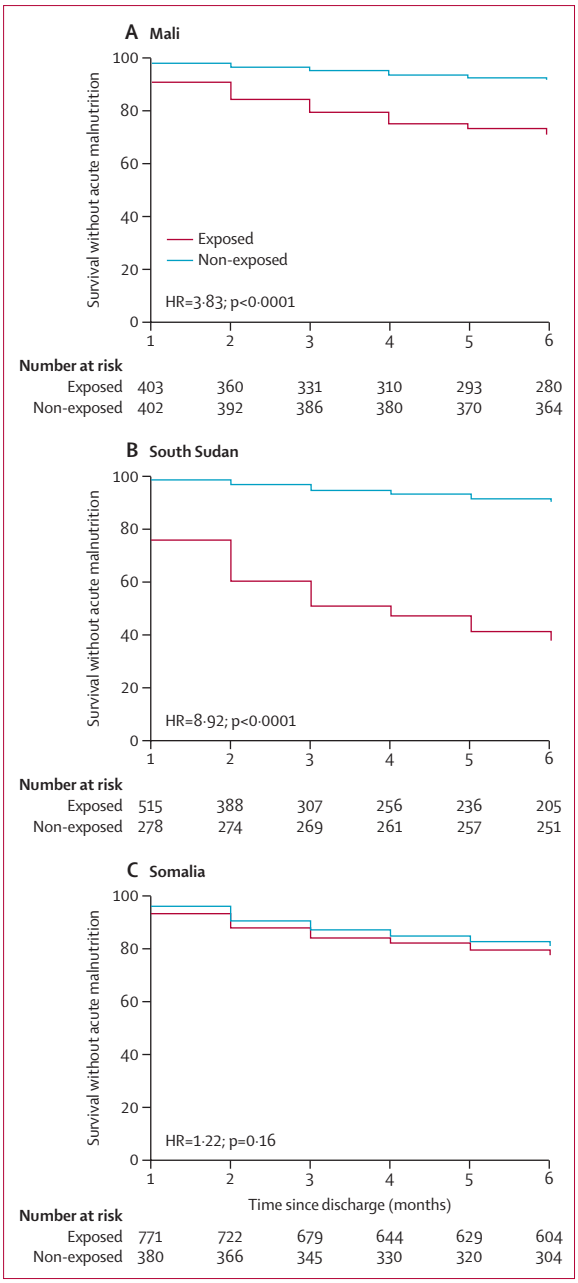


Figure 2: **Acute malnutrition-free survival using Kaplan–Meier curves for Mali, South Sudan, and Somalia by non-exposed versus exposed**
p values are from log-rank tests. HR=hazard ratio.

identify potential risk factors for relapse. Lower anthropometry at admission was associated with relapse in Mali and Somalia, while lower anthropometry at discharge was linked to relapse across all countries. After adjusting for covariates, discharge anthropometry showed a stronger and more consistent association with relapse (appendix 1 p 13). Among discharge anthropometrics, higher WHZ was most consistently associated with lower risk of relapse.

Beyond discharge WHZ, few other individual or household-level risk factors at the time of severe acute malnutrition recovery were associated with subsequent relapse (table 4). Being female was protective in both adjusted pooled analyses (all countries p=0·0092, Mali and South Sudan p=0·038, Poisson regression), although the association slightly declined when adjusting for covariates. Being in the highest wealth quartile compared with the lowest in South Sudan reduced the risk of relapse in the adjusted model (p=0·015, Poisson regression). Factors such as morbidity, age, feeding practices, maternal education, and number of siblings at the time of severe acute malnutrition recovery were not consistently associated with relapse (table 4). Food insecurity at severe acute malnutrition recovery was not predictive of future relapse (table 4), but severe food insecurity during the post-discharge period was associated with relapse in both pooled adjusted analyses (all countries p<0·0001 and Mali and South Sudan p<0·0001; appendix 1 p 14). Similar to the other models, controlling for covariates reduced the size of the risk.

During the post-discharge period, caregivers reported illness more frequently among relapsed children than non-relapsed children in Mali and South Sudan, although this pattern was not observed in Somalia (appendix 1 p 15). However, the association between morbidity and relapse was inconsistent. When controlling for other factors, diarrhoea within 7 days before a follow-up visit was associated with relapse only in Mali, the Mali and South Sudan pooled analysis, and the all country pooled analysis (Mali p=0·017, Mali and South Sudan p=0·0014, and all country pooled p=0·0033, mixed effects adjusted Poisson regression; appendix 1 p 14). Fever was associated with relapse in South Sudan and both pooled analyses (South Sudan p=0·028, Mali and South Sudan p=0·0001, and all country p<0·0001, mixed effects adjusted Poisson regression).

From enrolment to month 6, those who did not relapse showed significantly greater gains in WHZ and MUAC compared with those who relapsed (Mali p<0·0001, South Sudan p<0·0001, and Somalia p<0·0001, *t* test; appendix 1 p 16). Higher WHZ at discharge remained the most consistently significant variable associated with higher post-discharge WHZ gain (Mali p<0·0001, South Sudan p<0·0001, Somalia p<0·0001, Mali and South Sudan p<0·0001, all country pooled p<0·0001; Poisson regression; appendix 1 p 17). However, this relationship was not observed between MUAC at discharge and post-discharge MUAC gain (appendix 1 p 18).

Discussion

Our multi-country prospective cohort study shows that relapse among children previously exposed to severe acute malnutrition can be extremely high, ranging from 22% to 63% within 6 months after recovery. In pooled multi-country analyses, children exposed to severe acute malnutrition are 3·3 to 5·3 times more likely to develop

	Mali (n=338)		South Sudan (n=375)		Somalia (n=707)		All country pooled (n=1420)		Mali and South Sudan pooled (n=713)	
	Crude*	Adjusted	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted
Female (ref: male)	0·48 (0·34–0·68)†	0·69 (0·48–1·00)§	1·05 (0·90–1·23)	1·10 (0·94–1·29)	0·57 (0·43–0·75)†	0·79 (0·59–1·05)	0·71 (0·61–0·82)†	0·84 (0·74–0·96)‡	0·65 (0·65–0·99)‡	0·85 (0·74–0·99)§
Age (months)	1·02 (1·00–1·05)§	1·02 (0·99–1·05)	0·99 (0·98–1·00)	0·99 (0·97–1·00)§	1·04 (1·02–1·06)†	1·01 (0·99–1·04)	1·02 (1·02–1·03)†	1·00 (0·99–1·01)	1·01 (1·00–1·02)‡	1·00 (0·98–1·01)
WHZ at discharge (SD units)	0·25 (0·17–0·37)†	0·36 (0·23–0·59)†	0·87 (0·76–0·99)§	0·85 (0·74–0·97)§	0·45 (0·37–0·55)†	0·49 (0·39–0·61)†	0·51 (0·44–0·58)†	0·61 (0·53–0·70)†	0·63 (0·52–0·77)†	0·70 (0·60–0·82)†
Currently breastfed (ref: not currently breastfed)	0·83 (0·57–1·21)	1·10 (0·65–1·77)	1·13 (0·95–1·17)	0·98 (0·78–1·23)	0·74 (0·56–1·00)§	0·89 (0·66–1·20)	1·04 (0·89–1·21)	0·95 (0·80–1·13)	0·89 (0·75–1·07)	0·98 (0·80–1·21)
Mother has some education (ref: no education)	1·47 (1·06–2·04)§	1·24 (0·90–1·71)	1·01 (0·894 1·20)	1·09 (0·90–1·33)	0·82 (0·23–2·88)	1·35 (0·36–5·10)	1·38 (1·18–1·62)†	1·10 (0·93–1·29)	1·09 (0·92–1·29)	1·12 (0·94–1·33)
Twin (ref: not a twin)	1·51 (0·85–2·71)	1·12 (0·72–1·74)	1·18 (0·91–1·53)	1·14 (0·88–1·48)	1·27 (0·67–2·43)	1·32 (0·74–2·37)	1·43 (1·11–1·85)‡	1·29 (1·04–1·62)§	1·36 (1·04–1·79)§	1·27 (0·99–1·61)
Siblings (number)	0·93 (0·86–1·01)	0·97 (0·90–1·03)	1·02 (0·87–1·06)	1·02 (0·98–1·00)	0·99 (0·94–1·05)	1·01 (0·96–1·06)	0·97 (0·94–0·99)§	1·00 (0·97–1·03)	1·01 (0·98–1·05)	0·99 (0·96–1·03)
Food insecurity (Household Hunger Scale Category; ref: little to no hunger)										
Moderate hunger	3·40 (2·88–4·02)†	1·00 (0·62–1·64)	1·05 (0·89–1·25)	1·00 (0·81–1·20)	0·86 (0·59–1·26)	0·81 (0·56–1·17)	1·25 (1·06–1·49)‡	0·98 (0·83–1·16)	1·55 (1·30–1·90)†	1·04 (0·86–1·27)
Severe hunger	3·40 (2·88–4·02)†	1·16 (0·55–2·42)	1·01 (0·85–1·21)	0·93 (0·75–1·15)	0·92 (0·57–1·47)	0·94 (0·57–1·58)	1·43 (1·20–1·70)†	1·00 (0·83–1·20)	1·50 (1·26–1·81)†	1·02 (0·82–1·25)
Wealth index quartiles (ref quartile 1: lowest wealth)										
Wealth quartile 2	1·16 (0·82–1·66)	1·07 (0·67–1·69)	0·97 (0·81–1·17)	0·87 (0·70–1·07)	0·99 (0·71–1·37)	1·28 (0·83–1·96)	1·05 (0·89–1·23)	1·00 (0·83–1·20)	1·03 (0·86–1·24)	0·97 (0·79–1·19)
Wealth quartile 3	1·04 (0·71–1·52)	1·29 (0·74–2·25)	1·04 (0·87–1·24)	0·89 (0·72–1·10)	1·14 (0·86–1·53)	1·43 (0·95–2·15)	1·04 (0·88–1·21)	0·96 (0·81–1·15)	1·06 (0·88–1·28)	0·90 (0·73–1·10)
Wealth quartile 4	1·16 (0·79–1·72)	1·00 (0·55–1·78)	0·84 (0·66–1·08)	0·70 (0·52–0·93)§	0·90 (0·65–1·25)	0·92 (-0·58–1·47)	0·86 (0·71–1·04)	0·85 (0·68–1·06)	0·93 (0·74–1·16)	0·77 (0·59–1·00)
Diarrhoea in the past 7 days at enrolment (ref: no diarrhoea)	1·59 (1·09–2·32)§	1·07 (0·73–1·56)	0·98 (0·81–1·19)	0·98 (0·79–1·20)	1·08 (0·82–1·43)	1·10 (0·82–1·47)	0·97 (0·82–1·13)	1·03 (0·88–1·20)	1·26 (1·05–1·52)§	1·10 (0·91–1·32)
Fever in the past 7 days at enrolment (ref: no fever)	1·08 (0·71–1·65)†	0·72 (0·48–1·06)	1·02 (0·87–1·20)	0·89 (0·73–1·08)	1·26 (0·95–1·67)	1·40 (0·99–1·97)	1·23 (1·06–1·42)‡	0·94 (0·81–1·09)	1·27 (1·07–1·50)‡	0·84 (0·79–1·00)
Cough in the past 7 days at enrolment (ref: no cough)	0·82 (0·49–1·39)†	0·80 (0·47–1·36)	1·11 (0·95–1·31)	1·14 (0·94–1·37)	1·34 (1·00–1·80)	1·26 (0·94–1·68)	1·30 (1·11–1·51)†	1·10 (0·94–1·27)	1·28 (1·07–1·51)‡	1·06 (0·89–1·27)

Data are relative risk (95% CI). WHZ=weight-for-height z-score. All coefficients in the regression have been exponentiated to present relative risk. *All pooled analysis was weighed by 1/(sample size) so that each country contributes proportionally to the regression despite differences in sample size. †p<0·001. ‡p<0·01. §p<0·05.

Table 4: **Relative risk for individual and household level factors at the time of severe acute malnutrition recovery associated with subsequent relapse to acute malnutrition using Poisson regression for the exposed group only**

acute malnutrition and 6·4 to 16·9 times more likely to develop severe acute malnutrition compared with peers without a recent history of acute malnutrition. The risk of developing acute malnutrition including both moderate acute malnutrition and severe acute malnutrition for exposed children compared with non-exposed children was elevated in all countries and pooled analyses, irrespective of the model used. All elevated risks for the exposed children were statistically significant with the exception of Somalia, where significance differed according to model and outcome. This high risk of relapse among exposed children in all countries is consistent with two previous studies.[9,21] In a 2020 study in Nigeria,[9] exposed children were 52 times more likely to develop severe acute malnutrition compared with non-exposed children and a 2022 study in Ethiopia[21] found that exposed children were 14 times more likely to develop severe acute malnutrition than non-exposed children. The cumulative incidence for relapse to severe acute malnutrition (7–17%) in our study falls on the lower end of previously reported severe acute malnutrition relapse spanning 2% to 33%.[7,9,10,21–23] Among this wide range, studies observing higher severe acute malnutrition relapse rates occurred in contexts without treatment for moderate acute malnutrition.[9,22] In our study, relapsed children were treated for moderate acute malnutrition, which likely prevented some children from relapsing to severe acute malnutrition, causing an underestimation of the true burden of severe acute malnutrition relapse and death.

In all three contexts, the relapse rates and RR for acute malnutrition among exposed children were lowest in

Somalia. Upon assessment, there were multiple factors that could have resulted in this difference. First, WHZ upon enrolment among the exposed cohort was higher in Somalia than in Mali or South Sudan, suggesting that potential differences in nutritional status might have contributed to this variation (table 1). Second, the lower relapse rate in Somalia's densely populated urban internally displaced persons camps might be affected by high availability of humanitarian and other services. Conversely, cohorts in Mali and South Sudan resided in rural areas. Lower relapse rates in urban compared to rural areas is consistent with a previous Ethiopian study.[24] Third, previous research suggests that favourable community-based management of acute malnutrition indicators might mirror favourable post-discharge outcomes.[16,25] Although all CMAM programmes performed within globally accepted standards, Somalia had the highest recovery rate and lowest relapse rate, indicating a potentially higher quality of care compared with South Sudan and Mali. Conversely, South Sudan had the lowest recovery and highest relapse rate. Previous studies conducted in Mali and Haiti observed similar patterns, linking poor programme indicators to higher relapse rates.[16,25] Where post-discharge monitoring is not feasible, poorer treatment indicators might suggest higher relapse rates.

In Mali and Somalia, the point prevalence of relapse at each month of follow-up remained stable across the entire 6 months. In South Sudan, relapse peaked slightly around 3 months after discharge but remained high in all other months. Such consistent relapse over time following discharge aligns with other findings from another study in Mali[16] observing similar incidence of relapse across 0–3 months and the subsequent 4–6 months (5·3 per 100 child-months *vs* 4·4 per 100 child-months). Other studies document relapse occurring throughout 12 months after discharge.[21,26]

Regarding predictors of relapse, the most consistent risk factor in this study and others is having lower anthropometric measurements during severe acute malnutrition treatment, particularly at discharge.[7,9,16,22,27] A study in Malawi[27] showed that, regardless of the amount of time a child was fed supplementary food, lower anthropometrics at discharge drove relapse. Although children who are discharged as recovered reach the required anthropometric cutoffs, they might not be fully physiologically recovered, leaving their underlying health still compromised. Female sex as a protective factor against relapse is consistent with findings suggesting male individuals are more likely to be undernourished than female individuals.[28] However, the association between child sex and relapse is inconsistent across studies.[9,24] The exact causal pathway for the increased risk for male individuals is likely biological, although further investigation into the role of caregiving is warranted.[28] Other than in South Sudan, adjusted analysis showed no association between wealth and relapse, which is consistent with results from a meta-analysis on wealth and acute malnutrition.[29]

We found no association between illness at severe acute malnutrition recovery and subsequent relapse, which might be explained by undetected asymptomatic illness.[30] Also, one acute illness episode might not affect nutritional status several months later. Further research is needed to explore illness at severe acute malnutrition recovery and its effect on subsequent nutritional status. In contrast to illness at severe acute malnutrition recovery, diarrhoea and fever during the 6-month post-discharge period were associated with relapse in Mali and South Sudan, consistent with previous research documenting a high prevalence of post-discharge morbidity.[7,31,32] This association suggests that relapse might follow seasonal patterns of diarrhoeal diseases and malaria in rural contexts.

Our study indicates the association between food insecurity and relapse varies by context, as food insecurity during the 6-month post-discharge period was associated with relapse during the 6-month post-discharge period in South Sudan and in the pooled models, but not for Mali and Somalia. Compared with Mali and Somalia, South Sudan reported the highest Household Hunger Scale and the highest relapse rates. Participants in South Sudan also had the highest average age; previous research indicates older children might be more vulnerable in extreme food insecurity as they do not have the benefit of breastfeeding.[33] The inconsistent association between food insecurity and relapse aligns with existing evidence.[6,9,24] Studies conducted in Nigeria[9], India[34], and Ethiopia[24] have shown that severe household hunger predicts relapse, while a study in Malawi[35] following up children after moderate acute malnutrition did not.

This study has several limitations. HIV and malaria testing were unavailable, leaving more accurate measures of illness unaccounted for. The low prevalence of oedema limits the generalisability of results to populations with kwashiorkor. Longitudinal follow-up required exclusion of households that were unable to stay within the area for 6 months and children older than +s at enrolment. Given the child-level sampling design, we might have missed other social and ecological factors, particularly those functioning on a community level such as social dynamics. The study also used a matched design, although inclusion of an unexposed cohort with perfect matching on anthropometric indicators was not physiologically possible. Children without previous severe acute malnutrition differ fundamentally from those who have been exposed to severe acute malnutrition, particularly in anthropometry. This study shows that heightened risk starts immediately upon discharge, directly related to this difference. Differences in stunting between the exposed and non-exposed cohorts at baseline further highlight the need for additional analysis on how linear growth and particularly

catch-up growth might affect the relapse calculations when using WHZ as a criterion.

Ultimately, although exposed children are deemed to be recovered and clinically classified the same as non-exposed peers, they are far more vulnerable to subsequent acute malnutrition. Where possible, children discharged from community-based management of acute malnutrition programmes should be monitored for 6 months or longer, dependent on resources and funding. Adaptations to current severe acute malnutrition treatment could be considered to increase discharge anthropometry and address underlying health deficits. Still, our findings show only a small role for individual-level and household-level drivers of relapse, which could implicate more community and systemic-level drivers such as broader seasonal patterns, food systems, and historic environmental and economic stressors. Although the current CMAM model is highly effective at saving lives and treating acute malnutrition, children return to an unchanged environment facing the same conditions that likely contributed to their acute malnutrition in the first place. In protracted crises, higher discharge anthropometry alone might not be sufficient to significantly reduce high relapse rates without a continuum of care that links to prevention services following treatment. Given the substantial gaps in the evidence for effective relapse interventions, clinical trials are essential to identify strategies to reduce severe acute malnutrition relapse.[36]

Contributors

HS conceived and designed the study. EY supported provision of study resources. HS, SK, AM, LD'M-G, OC, and IT developed the study protocol and data collection processes. HS, SK, and LD'M-G developed tools and databases and oversaw implementation. SK, SMC, FAM, NGL, LD'M-G, MB, SD, MG, MSO, KA, SS, AHO, and AB coordinated and participated in data collection. AM led the statistical analysis. HS, SK, AM, and LD'M-G accessed and verified the data. HS, AM, SK, and LD'M-G 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.

Equitable partnership declaration

The authors of this paper have submitted an equitable partnership declaration (appendix 2). This statement allows researchers to describe how their work engages with researchers, communities, and environments in the countries of study. This statement is part of *The Lancet Global Health*'s broader goal to decolonise global health.

Declaration of interests

AM and SD report consulting contracts and compensation from Action Against Hunger, USA, in connection with this work. All other authors declare no competing interests.

Data sharing

The study's de-identified dataset is available from the corresponding author upon reasonable request.

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References

1 UNICEF, WHO, International Bank for Reconstruction and Development, World Bank. Levels and trends in child malnutrition: key findings of the 2023 edition of the joint child malnutrition estimates. World Health Organization, 2023.
2 WHO. WHO Guideline on the prevention and management of wasting and nutritional oedema (acute malnutrition) in infants and children under 5 years. World Health Organization, 2023.
3 Olofin I, McDonald CM, Ezzati M, et al. Associations of suboptimal growth with all-cause and cause-specific mortality in children under five years: a pooled analysis of ten prospective studies. *PLoS One* 2013; **8:** e64636.
4 WHO. Community-based management of severe acute malnutrition: a joint statement by the World Health Organization, the World Food Programme, the United Nations Standing Committee on Nutrition, and the United Nations Children's Fund. World Health Organization, 2007.
5 O'Sullivan NP, Lelijveld N, Rutishauser-Perera A, Kerac M, James P. Follow-up between 6 and 24 months after discharge from treatment for severe acute malnutrition in children aged 6–59 months: a systematic review. *PLoS One* 2018; **13:** e0202053.
6 Stobaugh HC, Mayberry A, McGrath M, et al. Relapse after severe acute malnutrition: a systematic literature review and secondary data analysis. *Matern Child Nutr* 2019; **15:** e12702.
7 Bliznashka L, Grantz KH, Botton J, et al. Burden and risk factors for relapse following successful treatment of uncomplicated severe acute malnutrition in young children: secondary analysis from a randomised trial in Niger. *Matern Child Nutr* 2022; **18:** e13400.
8 Cazes C, Phelan K, Hubert V, et al. Optimising the dosage of ready-to-use therapeutic food in children with uncomplicated severe acute malnutrition in the Democratic Republic of the Congo: a non-inferiority, randomised controlled trial. *EClinicalMedicine* 2023; **58:** 101878.
9 Adegoke O, Arif S, Bahwere P, et al. Incidence of severe acute malnutrition after treatment: a prospective matched cohort study in Sokoto, Nigeria. *Matern Child Nutr* 2021; **17:** e13070.
10 Abitew DB, Yalew AW. Bezabih AM, Bazzano AN. Predictors of relapse of acute malnutrition following exit from community-based management programme in Amhara region, Northwest Ethiopia: an unmatched case-control study. *PLoS One* 2020; **15:** e0231524.
11 Schoenbuchner SM, Dolan C, Mwangome M, Prentice AM, Moore SE, et al. The relationship between wasting and stunting: a retrospective cohort analysis of longitudinal data in Gambian children from 1976 to 2016. *Am J Clin Nutr* 2019; **110:** 498–507.
12 The Council of Research and Technical Advice on Acute Malnutrition. A research agenda for acute malnutrition (CORTASAM). No Wasted Lives, 2018.
13 King S, D'Mello-Guyett L, Yakowenko E, et al. A multi-country, prospective cohort study to measure rate and risk of relapse among children recovered from severe acute malnutrition in Mali, Somalia, and South Sudan: a study protocol. *BMC Nutr* 2022; **8:** 90.
14 von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Int J Surg* 2014; **12:** 1495–99.
15 Ballard T, Coates J, Swindale A, Deitchler M. Household Hunger Scale: indicator definition and measurement guide. Food and Nutrition Technical Assistance II Project, FHI 360, 2011.
16 Kangas ST, Coulibaly IN, Tausanovitch Z, et al. Post-recovery relapse of children treated with a simplified, combined nutrition treatment protocol in Mali: a prospective cohort study. *Nutrients* 2023; **15:** 2636.
17 WHO Multicentre Growth Reference Study Group. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development. World Health Organization. 2006.
18 Leroy J. ZSCORE06: Stata module to calculate anthropometric z-scores using the 2006 WHO child growth standards. Statistical Software Components S457279. Boston College Department of Economics, 2011.

See **Online** for appendix 2

19 Dimitris MC, Hutcheon JA, Platt RW, Himes KP, Bodnar LM, Kaufman JS. Comparison of methods for interpolating gestational weight gain between clinical visits in twin and singleton pregnancies. *Ann Epidemiol* 2021; **60:** 45–52.

20 Zou G. A modified Poisson regression approach to prospective studies with binary data. *Am J Epidemiol* 2004; **159:** 702–06.

21 Girma T, James PT, Abdissa A, et al. Nutrition status and morbidity of Ethiopian children after recovery from severe acute malnutrition: prospective matched cohort study. *PLoS One* 2022; **17:** e0264719.

22 Guesdon B, Katwal M, Poudyal AK, Bhandari TR, Counil E, Nepali S. Anthropometry at discharge and risk of relapse in children treated for severe acute malnutrition: a prospective cohort study in rural Nepal. *Nutr J* 2021; **20:** 32.

23 Daures M, Phelan K, Issoufou M, et al. Incidence of relapse following a new approach to simplifying and optimising acute malnutrition treatment in children aged 6–59 months: a prospective cohort in rural Northern Burkina Faso. *J Nutr Sci* 2021; **10:** e27.

24 Abitew DB, Worku A, Mulugeta A, Bazzano AN. Rural children remain more at risk of acute malnutrition following exit from community based management of acute malnutrition programme in South Gondar Zone, Amhara Region, Ethiopia: a comparative cross-sectional study. *PeerJ* 2020; **8:** e8419.

25 Cuneo CN, Dansereau E, Habib AR, Davies M, Ware S, Kornetsky K. Treating childhood malnutrition in rural Haiti: program outcomes and obstacles. *Ann Glob Health* 2017; **83:** 300–10.

26 Chang CY, Trehan I, Wang RJ, et al. Children successfully treated for moderate acute malnutrition remain at risk for malnutrition and death in the subsequent year after recovery. *J Nutr* 2013; **143:** 215–20.

27 Trehan I, Banerjee S, Murray E, et al. Extending supplementary feeding for children younger than 5 years with moderate acute malnutrition leads to lower relapse rates. *J Pediatr Gastroenterol Nutr* 2015; **60:** 544–49.

28 Thurstans S, Opondo C, Seal A, et al. Understanding sex differences in childhood undernutrition: a narrative review. *Nutrients* 2022; **14:** 948.

29 Brown C, Ravallion M, van de Walle D. Most of Africa's nutritionally deprived women and children are not found in poor households. *Rev Econ Stat* 2019; **101:** 631–44.

30 Cichon B, Fabiansen C, Yaméogo CW, et al. Children with moderate acute malnutrition have inflammation not explained by maternal reports of illness and clinical symptoms: a cross-sectional study in Burkina Faso. *BMC Nutr* 2016; **2:** 57.

31 Bahwere P, James P, Abdissa A, et al. Use of tuberculin skin test for assessment of immune recovery among previously malnourished children in Ethiopia. *BMC Res Notes* 2017; **10:** 570.

32 Ashraf H, Alam NH, Chisti MJ, et al. Follow-up experience of 6 months after treatment of children with severe acute malnutrition in Dhaka, Bangladesh. *J Trop Pediatr* 2012; **58:** 253–57.

33 Young H, Jaspers J. Nutrition matters: people, food and famine. Intermediate Technology Publications, 1995.

34 Burza S, Mahajan R, Marino E, et al. Seasonal effect and long-term nutritional status following exit from a community-based management of severe acute malnutrition program in Bihar, India. *Eur J Clin Nutr* 2016; **70:** 437–44.

35 Stobaugh HC, Bollinger LB, Adams SE, et al. Effect of a package of health and nutrition services on sustained recovery in children after moderate acute malnutrition and factors related to sustaining recovery: a cluster-randomized trial. *Am J Clin Nutr* 2017; **106:** 657–66.

36 Bliznashka L, Rattigan SM, Sudfeld CR, Isanaka S. Analysis of postdischarge interventions for children treated for moderate or severe wasting, growth faltering or failure, or edema: a systematic review. *JAMA Netw Open* 2023; **6:** e2315077.