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MUAC as the sole discharge criterion from community-based management of severe acute malnutrition in Burkina Faso

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Abstract

The use of mid upper arm circumference (MUAC) measurement to screen and determine eligibility for admission to therapeutic feeding programs has been established, but evidence and programmatic experience to inform guidance on the use of MUAC as a discharge criterion is limited. We present results from a large-scale nutritional program using MUAC for admission and discharge and compare program outcomes and response to treatment when determining eligibility for discharge by proportional weight gain versus discharge by MUAC. The study population included all children admitted to the Ministry of Health therapeutic feeding program supported by Médecins Sans Frontières in northern Burkina Faso from September 2007 to December 2011 (n = 50,841). Recovery was high overall using both discharge criteria, with low risks of death, nonresponse, and transfer to inpatient care and high daily gains in weight, MUAC, weight-for-height Z score, and height. When discharge was made by MUAC only, recovery increased, while all adverse program outcomes and length of stay decreased, with increasing MUAC on admission. MUAC-based programming, where MUAC is integrated into program screening, admission, and discharge, is one of several new approaches that can be used to target resources to the most at-risk malnourished children and improve program efficiency and coherency. This analysis provides additional programmatic experience on the use of MUAC-based discharge criterion, but more work may be needed to inform optimal discharge thresholds across settings.

KEYWORDS

Burkina Faso, community-based management of acute malnutrition, discharge, mid upper arm circumference, proportional weight gain, severe acute malnutrition

1 | INTRODUCTION

Admission and discharge criteria for the community-based management of severe acute malnutrition (SAM) in children are currently based on two independent anthropometric criteria: weight-for-height Z score (WHZ) and mid upper arm circumference (MUAC; World Health Organization [WHO], 2015; WHO & UNICEF, 2009). However, debate continues on the need for two anthropometric criteria (Briend et al., 2016; CORTASAM, 2017; Grellety & Golden, 2016): The combination of WHZ and MUAC indices does not improve identification of children at highest risk of death (Briend, Maire, Fontaine, & Garenne, 2012) and may complicate field procedures due to discordances in eligibility (Berkley et al., 2005; Briend et al., 2012; Emergency Nutrition Network, Save the Children UK, Action Contre La Faim, & United Nations High Commissioner for Refugees, 2012; Grellety, Krause, Shams Eldin, Porten, & Isanaka, 2015; Isanaka et al., 2015; Ross, Taylor, Hayes, & McLean, 1990).

Recently, there has been increasing interest in the use of MUAC alone for admission and discharge in nutritional programming. The colour-coded, plastic bracelet used to measure MUAC is inexpensive, as well as easy to transport, use, and interpret at the community level. In field settings, minimally trained workers made fewer and smaller errors in screening children for SAM with MUAC than with WHZ (Velzeboer, Selwyn, Sargent 2nd, Pollitt, & Delgado, 1983), and mothers have also successfully screened their children using MUAC (Ale et al., 2016; Blackwell et al., 2015). MUAC selects younger and shorter children (Briend et al., 2016; Isanaka et al., 2015), but these children are often at a higher risk of death (Alam, Wojtyniak, & Rahaman, 1989; Briend et al., 1986; Briend, Garenne, Maire, Fontaine, & Dieng, 1989; Vella et al., 1993), and those selected for admission by MUAC have been shown to respond well to treatment (Goossens et al., 2012; Grellety & Golden, 2016; Roberfroid et al., 2013).

We previously reported on early experience from a Médecins Sans Frontières (MSF)-supported therapeutic feeding program from 2007 to 2009 in Burkina Faso where children were admitted using MUAC ≤ 118 mm and/or presence of oedema (Goossens et al., 2012). Children were discharged by proportional weight gain, the WHO recommendation for discharge at the time (WHO & UNICEF, 2009). That report highlighted the paradoxically negative outcomes associated with discharge by proportional weight gain, where children with lower (e.g., more severe) MUAC at admission were discharged with shorter lengths of stay. In April 2009, to improve program coherency, MSF revised the program discharge criteria to use MUAC as the sole anthropometric criterion for both admission and discharge.

WHO now recommends children be admitted and discharged from therapeutic feeding using the same anthropometric index (WHO, 2013, 2015); however, high quality evidence and experience to support decision making on specific criteria for discharge remains limited (P. J. Binns et al., 2016; Dale, Myatt, Prudhon, & Briend, 2013; Roberfroid et al., 2013). To add to the evidence base on the use of MUAC for discharge in nutrition programming, we extend the previous analysis of discharge by proportional weight gain with a comparison of program outcomes achieved with discharge using an MUAC-based criterion. This analysis presents the first results from a large-scale program using MUAC for admission and discharge.

Key messages

- The use of mid upper arm circumference (MUAC) measurement to screen and determine eligibility for admission to therapeutic feeding programs has been established, but evidence and programmatic experience to inform guidance on the use of MUAC as a discharge criterion is limited.
- Using a discharge criterion of MUAC ≥ 124 mm, we found that program outcomes were overall favourable, with high recovery and weight gain, and that program coherency was improved: Children who entered the program with the lowest MUAC had the longest lengths of stay.
- Further experience with MUAC-based programming, where MUAC is integrated into program admission, monitoring and discharge, should be shared with further consideration of optimal discharge thresholds, with consideration of the risk of relapse, nonresponse, and length of stay across settings.

2 | METHODS

2.1 | Study population

We conducted a retrospective analysis of routine program data of children admitted to the MSF and Ministry of Health supported community-based management of SAM program in Yako and Titao health districts in the Northern Region of Burkina Faso from 2007 to 2012 (Goossens et al., 2012). Through this approach, outpatient care with the provision of ready-to-use therapeutic food (RUTF) was made available for uncomplicated cases and inpatient care for the stabilization of children with clinical complications. The study population for this analysis included all children admitted to the MSF-supported therapeutic feeding program in Yako and Titao districts from September 2007 to December 2011.

2.2 | Program description

From September 2007, children were eligible for admission into the MSF-supported therapeutic feeding program if they were aged 6 to 59 months old and fulfilled at least one of the following criteria: MUAC ≤ 118 mm or presence of bipedal pitting oedema. MUAC was measured to the nearest 2 mm with a flexible tape at the midpoint between the acromion and olecranon processes. Bipedal oedema was detected by the production of a pit after placing moderate pressure with the thumb over the top of both feet and lower end of the tibias for 3 s. Admission using MUAC as the sole anthropometric criterion was adopted in 2007 with the aim of increasing program acceptability, coverage, and beneficiary understanding of program admission criteria compared with the standard combined definition of WHZ < −3 and/or MUAC < 115 mm. WHZ and MUAC are known to select different children (Berkley et al., 2005; Briend et al., 2012; Emergency Nutrition Network et al., 2012; Grellety et al., 2015; Isanaka et al., 2015; Ross et al., 1990); therefore, the threshold of MUAC ≤ 118 mm compared with <115 mm was chosen in order to maintain specificity and increase sensitivity of the MUAC-only criterion, compared with the standard WHZ < −3 and/or MUAC < 115 mm criteria (Fernandez, Delchevalerie, & Van Herp, 2010).

At admission, weight, MUAC, and height (after April 2008) were assessed using standard techniques. MUAC was measured using an MSF-designed MUAC bracelets demarcated in 2 mm, using even numbers. All children received routine preventive and therapeutic medical care, as well as nutritional treatment with RUTF, as per the national protocol. Weekly visits at the health facility were conducted until nutritional recovery or a maximum of 6 weeks; weight and MUAC were measured and a physical exam conducted at each visit. Children were referred to inpatient care for deterioration of clinical status, including poor appetite, increasing or new oedema, or weight loss or lack of weight gain for three consecutive visits.

From September 2007 to March 2009 (Period A), children were discharged as "recovered" if they had gained at least 15% of their weight at admission with a minimum length of stay of 4 weeks and no associated comorbidity (Table 1). From April 2009 to December 2011 (Period B), children were discharged as "recovered" if they had reached an MUAC ≥ 124 mm with a minimum length of stay of 4 weeks and no associated comorbidity. Discontinuation of the 15% weight gain criterion was motivated by the observation that it paradoxically resulted in shorter treatment for more severely malnourished children and longer treatment for less malnourished children (Goossens et al., 2012). Children with lower MUAC on admission met the proportional weight gain criterion for discharge more rapidly and thus spent less time benefitting from nutritional rehabilitation. The adoption of an MUAC-only based discharge criterion in 2009 was supported by the understanding that MUAC gain parallels weight gain during nutritional rehabilitation (P. Binns, Dale, Hoq, Banda, & Myatt, 2015; Burza et al., 2015; Connor, Manary, & Maleta, 2011) and the potential to simplify and increase transparency of procedures when using the same criterion for admission and discharge. In both Periods A and B, children were discharged as "default" when failing to appear for three consecutive weekly visits for outpatient care or three consecutive days in inpatient care. Nonresponse was defined as failure to recover after 6 weeks with no associated comorbidity or chronic disease.

All routine program information was registered on standard medical charts. Records of discharged children were double-entered into an electronic database on a weekly basis and included demographic information, anthropometric measurements and morbidities during follow-up, treatment received, and program outcome.

2.3 | Statistical analysis

To compare program outcomes using alternative discharge criteria, we compared patient characteristics and treatment outcomes between two groups: (a) children discharged as recovered from September 2007 to March 2009 with at least 15% weight gain (Period A) and (b) children discharged as recovered from April 2009 to December 2011 with MUAC ≥ 124 mm (Period B).

To compare baseline characteristics between groups, the chi-square test was used to compare proportions, including child sex and age group, and a Wilcoxon rank sum test was used to compare continuous variables, including nutritional status at admission. Log-binomial regression was used to compare the risk of program outcomes (e.g., recovery, transfer to inpatient care, default, and death) between groups. For children discharged as recovered, response to treatment, characterized by length of stay (days), proportional weight gain (%), weight gain (g kg^{-1} day^{-1}), MUAC gain (mm day^{-1}), height gain (mm day^{-1}), and WHZ gain (Z score day^{-1}), was calculated and compared between groups using linear regression. Anthropometric status at discharge among those recovered was also compared between groups using linear regression. All regression models were adjusted for sex, age (6–23 months; 24–59 months), inpatient versus outpatient admission, MUAC at admission (<100 mm; 100–110 mm; 112–114 mm; 116–118 mm), WHZ at admission (<−3; ≥−3), HAZ at admission (<−3; ≥−3 to <−2; ≥−2), and height at admission (<67 cm; ≥67 cm). Finally, we hypothesized that outcomes may differ by severity of malnutrition (defined by MUAC on admission, <100, 100–110, 112–114, and 116–118 mm) or age on admission (defined as <67 vs. ≥67 cm, where 67 cm height can be used as a proxy for age of 6 months in settings where age may not be reliably measured; Fabiansen et al., 2016). Analyses stratified by MUAC on admission and height are therefore presented for Period B. Likelihood ratio tests were used to test for statistical interactions between program outcomes and response to treatment by categories of MUAC and height at admission.

Stata 13 (StataCorp, College Station, Texas, USA) was used for statistical analysis. A P value <0.05 was considered statistically significant. Oral informed consent was obtained from the parent or caregiver at the time of admission to the therapeutic feeding program. This research fulfilled the exemption criteria set by the MSF Ethics Review Board for a posteriori analyses of routinely collected clinical data and thus did not require MSF ERB review. It was conducted with permission from Clair Mills, Medical Director, Operational Centre Paris, MSF. This study was registered retrospectively as an observational analysis of routine program data at ClinicalTrials.gov (NCT03303131).

3 | RESULTS

A total of 50,841 children were admitted with MUAC ≤ 118 mm to the MSF-supported therapeutic feeding program and were included in this analysis: 24,792 children in Period A (September 2007–March 2009) and 26,049 children in Period B (March 2009–December 2011). Overall, 89% of admissions were directly into outpatient care, and the majority (53%) entered with an MUAC 116–118 mm (Table 2). Nearly half (48%) of children were male, and 80% were <2 years of age. Compared with children admitted in Period A,

TABLE 1 Admission and discharge criteria

	Period A September 2007–March 2009	Period B April 2009–December 2011
Admission criteria	MUAC ≤ 118 mm and/or bipedal pitting oedema	
Discharge criteria	≥15% weight gain and no associated morbidity; minimum length of stay 4 weeks	MUAC ≥ 124 mm and no associated morbidity; minimum length of stay 4 weeks

TABLE 2 Baseline characteristics of children admitted to the nutritional program in Yako and Titao, Burkina Faso (September 2007 to December 2011)[a]

	Overall	Period A Sep 2007–Mar 2009	Period B Apr 2009–Dec 2011	*P* value[b]
N	50,841	24,792	26,049	---
Child sex				
Female	26,411 (51.9)	12,473 (50.3)	13,938 (53.5)	<0.001
Male	24,430 (48.1)	12,319 (49.7)	12,111 (46.5)	
Child age, months	15.2 ± 7.8	15.7 ± 7.9	14.7 ± 7.6	<0.001
6 to 23	40,869 (80.4)	19,503 (78.7)	21,366 (82.0)	<0.001
24 to 59	9,972 (19.6)	5,289 (21.3)	4,683 (18.0)	
Place of admission				
Outpatient	45,447 (89.4)	22,799 (92.0)	22,648 (87.0)	<0.001
Inpatient	5,383 (10.6)	1,993 (8.0)	3,390 (13.0)	
MUAC, mm	113.2 ± 6.1	112.5 ± 6.6	113.9 ± 5.4	<0.001
<100	1,949 (3.8)	1,306 (5.3)	643 (2.5)	<0.001
100 to 110	10,802 (21.2)	6,018 (24.3)	4,784 (18.4)	
112 to 114	11,220 (22.1)	5,378 (21.7)	5,842 (22.4)	
116 to 118	26,870 (52.9)	12,090 (48.8)	14,780 (56.7)	
WHZ	−3.3 ± 0.9	−3.4 ± 1.0	−3.2 ± 0.9	<0.001
<−3	27,952 (62.5)	12,345 (66.1)	15,607 (59.9)	<0.001
≥−3	16,750 (37.5)	6,319 (33.9)	10,431 (40.1)	
HAZ	−2.5 ± 1.4	−2.6 ± 1.5	−2.5 ± 1.4	<0.001
<−3	15,545 (34.8)	6,868 (36.8)	8,677 (33.3)	<0.001
≥−3 to <−2	13,001 (29.1)	5,083 (27.2)	7,918 (30.4)	
≥−2	16,184 (36.2)	6,734 (36.0)	9,450 (36.3)	
Height, cm				
<67 cm	12,655 (28.3)	4,581 (24.5)	8,074 (31.0)	<0.001
≥67 cm	32,075 (71.7)	14,104 (75.5)	17,971 (69.0)	

Note. MUAC: mid upper arm circumference; WHZ: weight-for-height z score; HAZ: height-for-age Z score.

[a]Values are *n* (%) or mean ± *SD*.

[b]*P* values are for Pearson's chi-square or Wilcoxon's rank sum tests.

children admitted in Period B were statistically significantly more likely to be female, younger, and of better anthropometric status (e.g., higher mean MUAC, WHZ, and HAZ). There was a greater proportion of children admitted directly to inpatient care in Period B than in Period A (13% vs. 8.0%).

Recovery was high overall in both periods, with low risks of death, nonresponse, and transfer to inpatient care (Table 3). Children in Period B (2009–2011, discharge at MUAC ≥ 124 mm), compared with children in Period A (2007–2009, discharge at 15% weight gain), were more likely to recover and less likely to default, but also statistically significantly more likely to be transferred to inpatient care. There was a low risk of death during treatment in both groups (260 deaths [1.1%] in Period A and 279 deaths [1.1%] in Period B; adjusted risk ratio = 0.93; *P* = 0.42). Among recovered children, average length of stay was shorter during Period B compared with Period A (37.1 days vs. 54.3 days). Daily anthropometric gains, including weight, MUAC, height, and WHZ gains, were high overall and statistically significantly greater in Period B than in Period A. However, at the time of discharge, children in Period B, compared with Period A, were discharged with a lower mean MUAC (127.6 mm vs. 130.7 mm) and lower WHZ (−1.7 vs. −1.5).

In Period B, we found that recovery increased and all adverse program outcomes (e.g., death, default, transfer, and nonresponse) decreased with increasing MUAC on admission (Table 4). Percent weight gain and weight gain (g kg^{-1} day^{-1}) were greater among children with MUAC < 100 mm on admission compared with those with higher MUAC on admission. However, these most malnourished children were less likely to recover and more likely to default, not respond, and be transferred to inpatient care. Children with MUAC < 100 mm on admission were discharged as recovered with a lower MUAC and a higher WHZ than those with higher MUAC on admission.

In Period B, 31% of children were admitted with a height < 67 cm (mean age 8.6 months). When using MUAC-based admission and discharge criteria (Period B), taller children were more likely to recover and less likely to die or not respond to treatment than shorter children (Table 5). Taller children experienced statistically significantly greater gains in weight, MUAC, and WHZ than shorter children.

4 | DISCUSSION

This analysis provides the first large-scale programmatic evidence describing the use of an MUAC-based criterion for the discharge of children from in the community-based management of SAM. Using a

TABLE 3 Program outcomes for admitted children and treatment response among recovered children at the nutritional program in Yako and Titao, Burkina Faso (September 2007 to December 2011)

	Overall[a]	Period A[a] Sep 2007–Mar 2009	Period B[a] Apr 2009–Dec 2011	Risk ratio or mean difference (95% CI)[b] Period B vs. A (ref)	*P* value[b]
Program outcomes					
Recovered	45,959 (90.5)	22,094 (89.4)	23,865 (91.6)	1.04 (1.03, 1.05)	<0.001
Death	539 (1.1)	260 (1.1)	279 (1.1)	0.93 (0.77, 1.11)	0.419
Default	3,209 (6.3)	1,961 (7.9)	1,248 (4.8)	0.73 (0.68, 0.79)	<0.001
Transfer	159 (0.3)	19 (0.1)	140 (0.5)	7.41 (4.26, 12.87)	<0.001
Nonresponse	899 (1.8)	384 (1.6)	515 (2.0)	1.07 (0.94, 1.23)	0.312
Treatment response among recovered children					
Length of stay, days	45.3 ± 25.7	54.3 ± 27.1	37.1 ± 21.2	−17.9 (−18.3, −17.4)	<0.001
Weight gain, g kg^{-1} day^{-1}	5.5 ± 3.1	5.4 ± 3.1	5.6 ± 3.1	0.5 (0.5, 0.6)	<0.001
MUAC gain, mm day^{-1}	0.43 ± 0.25	0.42 ± 0.26	0.43 ± 0.24	0.04 (0.04, 0.05)	<0.001
Height gain, mm day^{-1}	0.40 ± 0.40	0.37 ± 0.42	0.42 ± 0.38	0.03 (0.03, 0.04)	<0.001
WHZ gain, Z score day^{-1}	0.047 ± 0.032	0.045 ± 0.030	0.048 ± 0.033	0.006 (0.005, 0.006)	<0.001
Anthropometric status at discharge among recovered children					
Weight gain at discharge, %	20.7 ± 8.8	23.6 ± 7.6	17.9 ± 9.0	−4.5 (−4.7, −4.4)	<0.001
MUAC at discharge, mm	129.1 ± 6.3	130.7 ± 7.7	127.6 ± 4.2	−3.6 (−3.7, −3.5)	<0.001
WHZ at discharge, Z score	−1.58 ± 0.87	−1.47 ± 0.94	−1.68 ± 0.79	−0.24 (−0.26, −0.23)	<0.001

Note. CI: confidence interval; MUAC: mid upper arm circumference; *SD*: standard deviation; WHZ: weight-for-height Z score.

[a]Values are *n* (%) or mean ± *SD*.

[b]Log-binomial or linear regression models adjusted for sex, age (6–23 months; 24–59 months), in- versus out-patient admission, MUAC at admission (<100 mm; 100–110 mm; 112–114 mm; 116-118 mm), WHZ at admission (<−3; ≥−3), HAZ at admission (<−3; ≥−3 to <−2; ≥−2), and height at admission (<67 cm; ≥67 cm).

TABLE 4 Program outcomes for admitted children and treatment response among recovered children, stratified by MUAC at admission, at the nutritional program in Yako and Titao, Burkina Faso (April 2009 to December 2011)

	Overall[a]	MUAC <100 mm[a]	MUAC 100–110 mm[a]	MUAC 112–114 mm[a]	MUAC 116–118 mm[a]	*P* value[b]
Program outcomes						
Recovered	23,865 (91.6)	324 (50.4)	3,991 (83.4)	5,405 (92.5)	14,145 (95.7)	<0.001
Death	279 (1.1)	40 (6.2)	89 (1.9)	57 (1.0)	93 (0.6)	<0.001
Default	1,248 (4.8)	166 (25.8)	456 (9.5)	253 (4.3)	373 (2.5)	<0.001
Transfer	140 (0.5)	38 (5.9)	56 (1.2)	15 (0.3)	31 (0.2)	<0.001
Non-response	515 (2.0)	75 (11.7)	192 (4.0)	112 (1.9)	136 (0.9)	<0.001
Treatment response among recovered children						
Length of stay, days	37.1 ± 21.2	67.0 ± 33.5	48.0 ± 26.6	39.3 ± 22.1	32.5 ± 16.4	<0.001
Weight gain, g kg^{-1} day^{-1}	5.6 ± 3.1	7.5 ± 3.6	6.6 ± 3.4	5.9 ± 3.2	5.2 ± 2.9	<0.001
MUAC gain, mm day^{-1}	0.43 ± 0.24	0.57 ± 0.30	0.51 ± 0.26	0.45 ± 0.24	0.40 ± 0.23	<0.001
Height gain, mm day^{-1}	0.42 ± 0.38	0.51 ± 0.38	0.41 ± 0.35	0.41 ± 0.35	0.42 ± 0.41	<0.001
WHZ gain, z-score day^{-1}	0.048 ± 0.033	0.052 ± 0.033	0.055 ± 0.035	0.051 ± 0.034	0.045 ± 0.032	<0.001
Anthropometric status at discharge among recovered children						
Weight gain at discharge, %	17.9 ± 9.0	42.9 ± 14.3	26.0 ± 9.0	19.0 ± 7.2	14.7 ± 6.7	<0.001
MUAC at discharge, mm	127.6 ± 4.2	125.7 ± 3.2	126.3 ± 3.4	127.1 ± 3.8	128.2 ± 4.5	<0.001
WHZ at discharge, Z score	−1.68 ± 0.79	−1.29 ± 0.92	−1.61 ± 0.80	−1.68 ± 0.79	−1.70 ± 0.78	<0.001

Note. MUAC: mid upper arm circumference; *SD*: standard deviation; WHZ: weight-for-height z score.

[a]Values are *n* (%) or mean ± *SD*.

[b]Likelihood ratio test of significance across four MUAC categories for logistic and linear regression models adjusted for sex, age (6–23 months; 24–59 months), in- versus out-patient admission, WHZ at admission (<−3; ≥−3), HAZ at admission (<−3; ≥−3 to <−2; ≥−2), and height at admission (<67 cm; ≥67 cm).

discharge criterion of MUAC ≥ 124 mm, program outcomes were overall favourable, with high recovery and weight gain and low absolute risk of default, death, and transfer. Compared with discharge by proportional weight gain criterion, length of stay was shorter with the MUAC-based criterion and appropriately increased with severity of malnutrition.

TABLE 5 Program outcomes for admitted children and treatment response among recovered children, stratified by height at admission, at the nutritional program in Yako and Titao, Burkina Faso (April 2009 to December 2011)

	Overall[a]	Height < 67 cm[a]	Height ≥ 67 cm[a]	Risk ratio or mean difference (95% CI)[b] Height ≥ 67 vs. <67 (ref)	*P* value[b]
Program outcomes					
Recovered	23,865 (91.6)	7,039 (87.2)	16,826 (93.6)	1.04 (1.03, 1.05)	<0.001
Death	276 (1.1)	110 (1.4)	166 (0.9)	0.72 (0.54, 0.96)	0.025
Default	1,247 (4.8)	486 (6.0)	761 (4.2)	1.00 (0.88, 1.13)	0.945
Transfer	140 (0.5)	70 (0.9)	70 (0.4)	0.66 (0.44, 0.99)	0.046
Nonresponse	515 (2.0)	369 (4.6)	146 (0.8)	0.26 (0.21, 0.33)	<0.001
Treatment response among recovered children					
Length of stay, days	37.1 ± 21.2	44.0 ± 25.9	34.2 ± 18.1	−6.6 (−7.2, −6.0)	<0.001
Weight gain, g kg^{-1} day^{-1}	5.6 ± 3.1	5.4 ± 3.0	5.7 ± 3.2	0.2 (0.1, 0.3)	<0.001
MUAC gain, mm day^{-1}	0.43 ± 0.24	0.37 ± 0.21	0.46 ± 0.25	0.09 (0.08, 0.09)	<0.001
Height gain, mm day^{-1}	0.42 ± 0.38	0.48 ± 0.39	0.39 ± 0.38	−0.06 (−0.07, −0.05)	<0.001
WHZ gain, Z score day^{-1}	0.048 ± 0.033	0.039 ± 0.031	0.052 ± 0.033	0.009 (0.008, 0.010)	<0.001
Anthropometric status at discharge among recovered children					
Weight gain at discharge, %	17.9 ± 9.0	20.5 ± 10.8	16.8 ± 7.8	−2.4 (−2.6, −2.2)	<0.001
MUAC at discharge, mm	127.6 ± 4.2	126.3 ± 3.3	128.1 ± 4.5	1.2 (1.1, 1.3)	<0.001
WHZ at discharge, Z score	−1.68 ± 0.79	−1.57 ± 0.80	−1.72 ± 0.78	−0.04 (−0.06, −0.02)	<0.001

Note. CI: confidence interval; MUAC: mid upper arm circumference; *SD*: standard deviation; WHZ: weight-for-height Z score.

[a]Values are *n* (%) or mean ± *SD*.

[b]Log-binomial or linear regression models adjusted for sex, age (6–23 months; 24–59 months), in- versus out-patient admission, MUAC at admission (<100 mm; 100–110 mm; 112–114 mm; 116–118 mm), WHZ at admission (<−3; ≥−3), and HAZ at admission (<−3; ≥−3 to <−2; ≥−2).

Since the endorsement of the community-based management of acute malnutrition in 2007, implementing agencies have widely adopted the use of MUAC for screening and admission into therapeutic feeding programs (CORTASAM, 2017; Emergency Nutrition Network et al., 2012). Acceptability and programmatic experience with the use of MUAC for both screening and admission has thus been established in recent years. In contrast, there has been relatively less experience and evidence to inform guidance on the use of MUAC as a discharge criterion. In the absence of data, proportional weight gain as a discharge criterion for children was proposed in 2009 (WHO & UNICEF, 2009). Proportional weight gain was selected instead of a WHZ-based discharge criterion to alleviate the need for height measurements and to avoid the problem where children admitted by MUAC may qualify for discharge by WHZ-based criteria at or shortly after admission. The use of proportional weight gain for discharge, however, proved problematic. A smaller absolute weight gain was required to meet discharge criteria for children with the lowest initial weight (i.e., the most severely malnourished children). As previously reported, this led to a shorter duration of treatment for the most malnourished children (Goossens et al., 2012), as weight gain is higher in the most wasted children receiving appropriate treatment. The least malnourished children received the longest duration of treatment and had the greatest risk of nonresponse.

In 2013, WHO recommended using the same anthropometric measure for both admission and discharge to increase the coherency and transparency of programs. As weight gain and MUAC gains had been shown to respond to treatment in similar ways (P. Binns et al., 2015; Burza et al., 2015; Roberfroid et al., 2013), the use of MUAC for discharge was considered safe. The threshold of MUAC ≥ 125 mm for discharge was proposed given evidence for a lower mortality risk associated with this level (Myatt, Khara, & Collins, 2006) and coherency with the current cut-off between severe and moderate acute malnutrition. Recently, the use of MUAC ≥ 125 mm as a discharge criterion has been reported in a few small field studies. In Sudan, an MSF-supported program with 753 children admitted over 6 months and discharged with MUAC ≥1 25 mm for two consecutive visits reported outcomes within SPHERE standards (SPHERE Project, 2011), with 82% recovered, 15% default, and 1% death (Dale et al., 2013). The overall median length of stay of all children in the study was 60 days (interquartile range = 43, 81), and the overall percent weight gain was 21% (interquartile range = 14, 29). Children with lower MUAC at admission had longer durations of treatment and higher percent weight gain. A small study of children treated for SAM in the Gambia (*n* = 463) suggested that discharge based on MUAC ≥ 125 mm was associated with comparable MUAC gain and length of stay, as well as higher MUAC at discharge, compared with discharge based on WHZ ≥ −2(Burrell, Kerac, & Nabwera, 2017). In a study from Malawi (*n* = 253), Binns et al. reported program outcomes using the criterion of MUAC ≥ 125 mm for two consecutive weeks for discharge: only 63% recovered and 14% default, but a longer length of stay was also observed among the most severely malnourished children (P. J. Binns et al., 2016).

Our large program database supports these early reports showing that an MUAC-based discharge criterion eliminates the undesirable effect of shorter treatment among the most severely malnourished children, as was observed earlier with a proportional weight gain criterion (Goossens et al., 2012). Program coherency is improved with an MUAC-based discharge criterion: Children who entered the program at lowest MUAC had the longest lengths of stay, whereas those admitted close to the threshold still recovered near to 4 weeks. Poor outcomes among children admitted with MUAC < 100 mm observed in this program underscore the importance of early identification and prompt treatment of SAM. Programs may consider extending the maximum length of stay for children with MUAC < 100 mm on admission to allow for a full recovery.

An MUAC-based threshold for discharge from treatment is independent of age/height. Its adoption has therefore been complicated by concern for a possible "plateau effect," in which the youngest or smallest children would not satisfy the MUAC ≥ 125 mm threshold within a useful period of time but would have been considered as recovered according to a WHZ-based discharge criterion. In the analysis of program outcomes among 253 children in Malawi (P. J. Binns et al., 2016), Binns et al attributed the low recovery rate to a large proportion of children not satisfying the discharge criteria for recovery (MUAC ≥ 125 for two consecutive weeks) after 4 months of treatment. Lower MUAC thresholds, such as MUAC ≥ 120 mm at two consecutive weeks, have been proposed by various implementing agencies, although a higher MUAC at discharge may be associated with a lower risk of relapse (Somasse, Dramaix, Bahwere, & Donnen, 2016; Stobaugh et al., 2017). The program database used in the current analysis did not allow for consideration of alternative discharge criterion, but other thresholds should be explored and evaluated in the field for safety and feasibility.

A current practice in some settings is to restrict use of MUAC-based admission criterion to children ≥67 cm, such that short children (e.g., <67 cm) that are ≥6 months would be excluded from treatment (Fabiansen et al., 2016). This is not specifically recommended by the WHO but has been applied for two reasons when the age of a child is unknown. First, lengths of <65 or <67 cm are used as proxy for age <6 months. If a child is short and therefore thought to be <6 months, it has been argued that the child should be excluded, as children <6 months are not expected to be able to swallow RUTF and should be managed on an inpatient basis with therapeutic milk if severely malnourished. However, exclusion of short children for this reason can be avoided using an appetite test during which the child's ability to swallow is assessed at admission. Second, it has been suggested that short children ≥6 months are more likely to be stunted than wasted and less likely to demonstrate catch up growth. These stunted children would experience long lengths of stay and may not reach the MUAC discharge threshold, or may deposit fat rather than lean mass placing them at risk of noncommunicable diseases later in life.

Twenty-eight per cent of children in this study were admitted with height < 67 cm on admission and would have been excluded from outpatient therapeutic feeding because of short length. We showed that shorter children in our study had a weaker response to treatment and were more likely to die or not respond to treatment than taller children. Shorter children experienced longer length of treatment, but this was not surprising as shorter children also presented with a lower MUAC (results not shown). In Malawi, children with height < 65 cm at admission showed greater proportional weight gain and had longer lengths of stay than taller children, with no increased risk of negative outcomes 3 months after discharge (P. J. Binns et al., 2016). In Burkina Faso, there was no evidence of a difference in growth during recovery in children with MAM who were <67 cm and aged 6–23 months admitted for MAM treatment solely by MUAC (Fabiansen et al., 2016). Our findings should add to the evidence informing ongoing discussion regarding the response to treatment among short children and whether MUAC may be used for admission and discharge among children aged ≥6 months with a height < 67 cm. The increased risk of death observed in this group may support the inclusion of these children in therapeutic feeding programs.

There are several strengths and limitations to this study. We benefited from an exceptionally large program database, providing the most extensive experience with MUAC-based programming to date. The large sample size allowed for very precise estimates of program outcomes, and these results, taken in consideration of clinical significance, can be used to inform program planning and guidance. Causal interpretations, however, should not be assigned to differences observed due to the observational study design. The analysis also used routine program data. The quality of measurements is reflective of what one might find in any large program, and the limited scope of information routinely collected reduces our ability to understand why the risk of default and transfer may have differed over time. Finally, we did not have data on outcomes for children after treatment. Data on postdischarge mortality or relapse would be most informative to evaluate the safety of alternative discharge criteria. Recent evidence suggests that higher MUAC at discharge from supplementary feeding may be associated a lower risk of relapse in Malawi (Stobaugh et al., 2017) and Burkina Faso (Somasse et al., 2016).

5 | CONCLUSION

MUAC-based programming, where MUAC is integrated into program admission, monitoring, and discharge, is one of several new approaches that can be used to target resources to the most severely malnourished children and improve program efficiency and coherency. Using a discharge criterion of MUAC ≥ 124 mm, we found that program outcomes were overall favourable, with high recovery and weight gain. This analysis provides the first large-scale programmatic experience on the use of an MUAC-based discharge criterion, but more work is needed to explore optimal discharge thresholds, with balanced consideration of the risk of relapse, nonresponse, and length of stay across settings.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

CONTRIBUTIONS

SC contributed to the conception and design of the study. CTA and SF contributed to the statistical analysis. SI contributed to the design of the statistical analysis and interpretation of data and drafted the manuscript. RFG contributed to the conception of the study and interpretation of data. KEH contributed to interpretation of data. All authors critically reviewed the manuscript for important intellectual content and approved the final manuscript.

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