Additional Analysis of Two Field Studies Comparing Four Supplementary Foods for Treatment or Prevention of Malnutrition

A Report from the Food Aid Quality Review

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ACRONYMS

AIC	Akaike Information Criterion
ANOVA	Analysis of Variance
BHA	Bureau for Humanitarian Assistance
BIC	Bayesian Information Criterion
CHW	Community Health Worker
CSB+	Corn Soy Blend Plus
CSWB	Corn Soy Whey Blend
FAQR	Food Aid Quality Review
FBFs	Fortified Blended Flours
FFP	Office of Food for Peace
FGD	Focus Group Discussions
FVO	Fortified Vegetable Oil
IDI	In-depth Interview
IHO	In-home Observation
IYCF	Infant and Young Child Feeding
KII	Key Informant Interviews
LAZ	Length-for-age Z-score
LOESS	Locally Estimated Scatterplot Smoothing
MAM	Moderate Acute Malnutrition
MSG	Mother Support Group
MUAC	Mid-Upper Arm Circumference
PHU	Peripheral Health Unit
RRR	Relative Risk Ratio
RUSF	Ready-to-Use Supplementary Food
SAM	Severe Acute Malnutrition
SBCC	Social Behavior Change Communication
SC+	Super Cereal Plus
SC+A	Super Cereal Plus with Amylase
SFP	Supplementary Feeding Program
SLL	Sierra Leonean Leone
SNF	Supplementary Nutritious Food
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
WASH	Water, Sanitation, and Hygiene
WFP	World Food Programme
WHO	World Health Organization
WHZ	Weight-for-height Z-score

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EXECUTIVE SUMMARY

Recommendations for improving the composition of supplementary nutritious foods (SNFs) emerged from a 2011 report by the United States Agency for International Development's (USAID) Food Aid Quality Review (FAQR) entitled *Improving the Nutritional Quality of U.S. Food Aid: Recommendations for Changes to Products and Programs*. To test some of these recommendations, studies were carried out in Malawi (a feasibility study) as well as Burkina Faso and Sierra Leone (effectiveness studies). From evidence generated in the Malawi study, FAQR reported that interventions promoting the addition of fortified vegetable oil to fortified blended foods were both effective and cost-effective in increasing the amount of oil used to prepare the child's porridge. Results from the Sierra Leone and Burkina Faso study were designed to assess the relative effectiveness and cost effectiveness of four SNFs and found that none was more effective or cost-effective than corn soy blend plus (CSB+) with fortified vegetable oil in preventing wasting or stunting or in treating moderate wasting.

Though these results of the FAQR studies have been disseminated widely, there are data generated from these studies that may address complementary research questions not answered in the main studies, warranting further analysis. Throughout 2020, a team at Tufts University worked to address some of these additional research questions related to clinical, social, and environmental factors that may have influenced the previously disseminated FAQR studies' results regarding effectiveness and cost-effectiveness. These additional 10 research questions were addressed using quantitative and qualitative methods to explore factors influencing program quality and factors contributing to child feeding and care. The questions are listed in Table 1.

Table 1: Additional Research Questions for the Burkina Faso and Sierra Leone Effectiveness Trials
Factors Influencing Program Quality
1. What is the agreement of different cut points of WHZ and MUAC in diagnosing either severe or moderate acute malnutrition in children aged 6-24 months in Sierra Leone and Burkina Faso? 2. What is the predictive agreement between changes in MUAC changes in WHZ? 3. What factors are associated with worsening health among children 6-59 months participating in a supplementary feeding program? 4. What factors are associated with sustained recovery (at one month) in children 6-59 months who recovered from MAM? 5. Is growth faltering continuous or episodic in children 6-27 months in Burkina Faso?
Elements of Child Feeding and Care
1. What are the sanitary characteristics of beneficiary children's home environment? 2. What are the water, sanitation, and hygiene practices among caregivers of beneficiary children? 3. What are the food preparation practices among caregivers of beneficiary children? 4. Who are primary and secondary caregivers of beneficiary children? 5. What are the complementary feeding practices among caregivers of the beneficiary children?
WHZ: weight-for-height z-score using World Health Organization growth charts; MUAC: mid-upper arm circumference; IYCF: infant and young child feeding practices; SNF: supplementary nutritious food; SAM: severe acute malnutrition; MAM: moderate acute malnutrition

Implications for Program Design

Support the use of both MUAC and WHZ to identify acutely malnourished children.

The analysis found that mid-upper arm circumference (MUAC) and weight-for-height Z-score (WHZ) are consistent measures of wasting in that they change in the same direction and at the same time, but their agreement in identifying children with moderate acute malnutrition (MAM) or severe acute malnutrition (SAM) is weak, and even more so among males compared to females and among older children ≥25 months compared to younger children ≤24 months. The age and gender sensitivity of these measures has been well documented; our analysis does not diverge from, but rather confirms the conclusions of other studies that both MUAC and WHZ should be used as independent criteria for admission to either a supplementary (i.e. MAM) or therapeutic (i.e. SAM) feeding program.

Support the early identification of potential non-responders for additional intervention.

In Sierra Leone, among the children diagnosed with MAM and enrolled in a supplementary feeding program (SFP), those who deteriorated to SAM or failed to respond to MAM treatment program showed signs of poor response to treatment within the first four weeks. This was evident in stagnant weight gain or weight loss, MUAC loss, and stagnated changes in WHZ. This observation has important implications for treatment. Most studies focus on determinants of recovery from MAM, with those who do not recover grouped together as failures. Not only did our data show distinct trajectories for non-responders and those declining to SAM, but they also demonstrated that these children may be identified and, potentially, given more intensive intervention early in their treatment to improve their chances of recovery. There are currently no guidelines that assist program implementers with identification of children who respond poorly to MAM treatment, but there are considerable data available for such an analysis, apart from the studies reported here. For instance, routine collection of data during treatment includes indicators of growth (typically height, weight, MUAC), and often morbidity, as well as attendance (to monitor ration collection). Analyses of such data that are already regularly collected in MAM treatment programs implemented by USAID or the World Food Programme (WFP) can be combined with outcome data and used to inform the development of guidelines for early intervention.

Add an additional aim to MAM treatment effectiveness studies to understand factors associated with unresponsiveness to treatment and deteriorating nutritional status.

A greater proportion of children who deteriorated to SAM after admittance to the SFP in Sierra Leone reported an acute illness such as fever, cough, diarrhea, or vomit in the two weeks prior to exit than children who either graduated or simply failed to recover from MAM. In contrast, a greater proportion of children who graduated or failed to respond reported an acute illness in the two weeks prior to enrollment. Generally, children who deteriorated seemed to experience more clinical comorbidities at program entry, exit, or both, compared to children in the program who failed to respond. Little attention has been paid to the factors that influence poor response to treatment in effectiveness studies of MAM treatment. This could easily be rectified with the addition of an aim that treats deterioration or non-response as distinct outcomes and seeks to understand the factors that lead to them in ongoing or planned effectiveness studies.

Household Practices and Behaviors Worth Targeting

Build the evidence base for factors that influence sustained recovery from a MAM treatment program.

The analysis found no significant relationship between the factors recorded during in-depth interviews and sustained recovery one month after graduation. These included dietary diversity scores, access to safe drinking water, care practices, and use of the food ration during treatment. None of these factors that were reported nor other factors that were examined but unreported within this narrative were significantly related to sustained recovery. Whichever factors differentiate children who sustain recovery from children who relapse to MAM were either not measured as part of this study or are factors that change after the child exits treatment. There is a nascent but growing body of research into sustained recovery from MAM that demonstrates more needs to be explored to understand the reasons for relapse.

Evidence of continuous growth faltering warrants research into long term nutrition-sensitive/economic growth programming to prevent stunting.

In Burkina Faso, growth faltering was found to manifest largely through continuously slower growth rates (as opposed to a few acute episodes of growth failure) among those with the most extreme levels of growth faltering compared to those with less extreme growth faltering. Smoothness of the growth curve may also play a role in attained length, with children who attain greater length exhibiting smoother growth curves than those who end up shorter. In the context of the qualitative findings, which found considerable homogeneity in poor care and feeding practices, there is evidence that interventions meant to prevent growth faltering may need to focus on poverty alleviation over a long period of time as opposed to short-term nutrition-specific interventions focused on one target child.

Recommended Behaviors for Social Behavior Change Programming

The in-depth qualitative analysis using data from in-home observation notes identified nutrition-specific and nutrition-sensitive behaviors that could be targeted to support improved nutrition and health outcomes among children. Behaviors related to water, sanitation, and hygiene (WASH) that could potentially decrease incidence of enteric infection included: corralling animals to prevent their entering the cooking space and child environment, increasing frequency of caregivers' hand washing with soap at critical times, discouraging child mouthing of non-food objects, and placing children on mats instead of the ground. Other behaviors related to child feeding practices included: encouragement of continued feeding during illness, increased consumption of low-cost nutrient-dense foods, covering prepared food, and reheating leftover food before consumption.

Additional research questions originating from these analyses can be found in Appendix 2.

INTRODUCTION

In 2011, the United States Agency for International Development's (USAID) Food Aid Quality Review (FAQR) based at Tufts University released a report entitled *Improving the Nutritional Quality of U.S. Food Aid: Recommendations for Changes to Products and Programs* (1). Among the recommendations outlined were areas in need of further research to improve the programming of supplementary nutritious foods (SNFs). In subsequent phases of FAQR, three field studies were completed to fill some of these gaps, the results of which have been detailed in comprehensive reports and publications which can be found online. Details of the three studies are reported in the full study reports (2–4). Briefly, evidence generated in the Malawi study showed that interventions to promote the addition of fortified vegetable oil to fortified blended foods were both effective and cost-effective in increasing the amount of oil used to prepare the child's porridge. Results from the Sierra Leone and Burkina Faso studies were designed to assess the relative effectiveness and cost effectiveness of four SNFs and found that none was more effective or cost-effective than corn soy blend plus (CSB+) in preventing wasting or stunting or in treating moderate wasting.

To complement the main findings of the studies carried out in Burkina Faso and Sierra Leone, additional analyses were conducted to add greater detail about the programmatic, individual, or community-level factors that affected the effectiveness of SNFs in treating or preventing child malnutrition. Detailed in this report are the methods, results, and conclusions from these analyses. The studies in Burkina Faso and Sierra Leone focused on nutritional outcomes of children receiving one of four supplementary food rations. In Burkina Faso, the foods were Super Cereal Plus (SC+), Corn Soy Whey Blend with FVO (CSWB w/oil), ready-to-use supplementary food (RUSF), and Corn Soy Blend Plus with FVO (CSB+ w/oil); in Sierra Leone they were Super Cereal Plus w/amylase (SC+A), CSWB w/oil, RUSF, and CSB+ w/oil. The main analysis conducted for the Burkina Faso study explored the comparative effectiveness, cost-effectiveness, and factors that influenced the comparative effectiveness of the SNFs for the prevention of stunting and wasting in children 6-24 months of age. Enrollment was based on age, and not on any anthropometric criteria. Enrolled children received monthly food rations of one of the SNFs from enrollment at 6 months until exit at 24 months and were followed for three months thereafter. In this way, the study was able to examine longitudinal changes in anthropometric measures.

In contrast, the study in Sierra Leone explored similar research questions but for the treatment of moderate acute malnutrition (MAM) in children 6-59 months of age. Children were enrolled based on being diagnosed with MAM [11.5<MUAC <12.5cm]; they were provided a ration containing one of four SNFs every two weeks until an outcome was reached (graduated, failure, default, SAM, death) or for up to a maximum of 7 rations, with additional anthropometric and morbidity information gathered at 1, 3, and 6 months after exit in order to measure incidence of sustained recovery. These comparative effectiveness studies contrast with the feasibility study carried out in Malawi which examined whether the provision of additional fortified vegetable oil (FVO) with fortified blended flours (FBFs) alongside intensive social behavior change communication (SBCC) would improve FVO intake. Malawi was not an effectiveness study and gathered no anthropometric data, which excluded it from the planned additional analyses; therefore data from the Malawi study were not included in this report.

The two effectiveness studies used similar data collection methods and found similar results with respect to the comparative effectiveness of the four SNFs. In Burkina Faso, none of the SNFs performed significantly better than CSB+ w/oil at preventing either wasting or stunting, though CSWB w/oil did perform worse. In the cost-effectiveness analysis, CSB+ w/oil was the most cost-effective food. Sharing was shown to occur with all SNFs, but this was not found to influence effectiveness. These results were similar to those of the treatment study in Sierra Leone: none of the SNFs performed significantly better than CSB+ w/oil, and all foods were similarly cost-effective, though RUSF did perform worse at sustaining recovery at one month after recovery. Sharing was also observed via data collected from the in-home observations for all SNFs but was less common than in Burkina Faso and was also not shown to influence effectiveness.

This report is divided into three main sections: Section 1 contains the background and overarching methods used in the analyses; Section 2 contains the analysis-specific methods and results; and Section 3 contains the conclusions drawn from these analyses. The appendices contain the tables and figures, greater detail on the individual studies and SNFs used in the studies, and a list of additional research questions that emerged from these analyses.

SECTION 1: BACKGROUND AND DATA COLLECTION METHODS

Table 1: Additional Research Questions for the Burkina Faso and Sierra Leone Effectiveness Trials
Factors Influencing Program Quality
1. What is the agreement of different cut points of WHZ and MUAC in diagnosing either severe or moderate acute malnutrition in children aged 6-24 months in Sierra Leone and Burkina Faso? 2. What is the predictive agreement between changes in MUAC changes in WHZ? 3. What factors are associated with worsening health among children 6-59 months participating in a supplementary feeding program? 4. What factors are associated with sustained recovery (at one month) in children 6-59 months who recovered from MAM? 5. Is growth faltering continuous or episodic in children 6-27 months in Burkina Faso?
Elements of Child Feeding and Care
6. What are the sanitary characteristics of beneficiary children's home environment? 7. What are the water, sanitation, and hygiene practices among caregivers of beneficiary children? 8. What are the food preparation practices among caregivers of beneficiary children? 9. Who are primary and secondary caregivers of beneficiary children? 10. What are the complementary feeding practices among caregivers of the beneficiary children?
WHZ: weight-for-height z-score using World Health Organization growth charts; MUAC: mid-upper arm circumference; IYCF: infant and young child feeding practices; SNF: supplementary nutritious food; SAM: severe acute malnutrition; MAM: moderate acute malnutrition

The process of conducting these additional analyses began with identifying and prioritizing potential research questions that went beyond the original intent (primary questions asked) of the completed studies. Questions were divided into two main themes: Factors Influencing Program Quality and Factors Contributing to Child Feeding and Care. After teams at USAID and Tufts agreed on the final list of questions, the data from both Burkina Faso and Sierra Leone were explored to assess feasibility. After finalizing the research questions of interest, preliminary data exploration identified the questions which were feasible and thus retained for in-depth analysis. The final list of questions is detailed in Table 1.

The separate reports for the Burkina Faso prevention study and the Sierra Leone treatment study provide detail on the studies' designs and data collection methods (2,4). Each study used a variety of quantitative and qualitative methods to record information on beneficiary children's health and household and caregiver's behaviors and perceptions about both the SNF and malnutrition more generally. These methods are detailed in Table 2 in Appendix 1 (note all additional tables and figures can be found in Appendix 1). For the analyses detailed in this report, only the clinical data, in-home observations, and in-depth caregiver interviews were used.

SECTION 2: ANALYTICAL METHODS AND RESULTS

I. FACTORS INFLUENCING PROGRAM OUTCOMES

A. METHODS

Factors influencing sustained recovery from MAM

To explore factors influencing sustained recovery from MAM in the Sierra Leone treatment study (defined as maintaining a MUAC>12.5 cm at 1-month after graduation), we developed a conceptual framework that examined household level behaviors reported in the in-depth interview (IDI) and assessed their relationship to sustained recovery. The relationship between sustained recovery and household demographic characteristics such as socioeconomic status, household composition, or food insecurity were explored in the main report and excluded from this analysis. Specific characteristics of interest in this analysis on the sub-sample of IDIs included: child's dietary diversity, behaviors or characteristics related to positive water, sanitation, and hygiene (WASH) practices, and feeding practices of the study food. Bivariate logistic regression was used to evaluate the relationship between each individual characteristic and the growth outcome both on the entire subsample (pooled) and stratified by arm. We conducted both analyses because this analysis was not focused on differences among the foods; however, the foods could not be completely ignored, because the study design was randomized by food. Both sets of results are therefore reported; results from both approaches were consistent. We also accounted for the potential clustering effect by including peripheral health unit (PHU) as the random effect in the model.

Comparison between anthropometric measures for SAM or MAM diagnosis

To explore the relationship between MUAC and WHZ, Spearman's coefficient of correlation was calculated at each visit in both the Sierra Leone and Burkina Faso studies. Previous research has shown a monotonic (i.e. unidirectional) relationship between the two anthropometric measures, for which the Spearman coefficient is the appropriate method to describe the direction of the relationship as well as the strength of the association (5,6). The coefficient is equal to 1 if there is a perfect positive correlation, equal to 0 if there is no relationship, and equal to -1 if there is a perfect negative correlation.

We calculated Cohen's Kappa coefficient (k), stratified by gender and age group, to examine the agreement between MUAC and WHZ at predicting MAM or SAM status. Kappa coefficient assess agreement between two groups (e.g. MUAC and WHZ) at making a diagnosis (e.g. MAM or SAM) (7). To explore sex or age-specific variation in agreement between MUAC and WHZ, we also explored males compared to females and younger children compared to older (older than 24 months of age). This allowed for the examination of age and sex-sensitive trends in agreement between MUAC and WHZ. Agreement between two measures is considered poor if $k<0.20$, fair if $0.20 \le k \le 0.60$, substantial if $0.60<k\le 0.80$, and excellent if $0.8<k$ (8).

To conduct sensitivity and specificity analyses of MUAC and WHZ at diagnosing both MAM and SAM, we calculated the percent of agreement between the two measures at each visit. Sensitivity was defined as the percentage of "true positives" in diagnosing MAM and SAM (i.e. WHZ and MUAC both diagnose MAM or both diagnose SAM), and specificity was defined as the percentage of "false positive" in diagnosing MAM or SAM (i.e. WHZ diagnoses MAM or SAM but MUAC does not). As the enrollment criterion for Sierra Leone was MUAC, we set MUAC as the reference in both Sierra Leone and Burkina Faso for consistency.

Continuous or episodic growth faltering

To explore episodic growth faltering, we defined growth faltering as failure of a child to reach their potential trajectory for attained length and aimed to determine whether or not growth faltering in children happens episodically, with intermittent slowdowns of growth, or is a consequence of continuously slow growth.

Anthropometric data from the Burkina Faso prevention study were first cleaned to identify implausible values and assess the randomness of missing and implausible values. Biologically implausible values were identified by examining the jackknifed residuals from regression of each child's length or weight on their age. Jackknifed residuals above an absolute value of 5 were considered biologically implausible and set to missing (9). Missing data, including these values, were then assessed for randomness by regressing the indicators for missing values on socio-demographic variables and enumerator codes. Values were found to be missing at random, and data were imputed to complete the dataset, using predicted values from simple linear regressions of the anthropometric values on child age. The sample was restricted to those children who had at least 20 repeated measurements.

Children's individual growth curves were visualized to illustrate the timing and nature of growth faltering in children. The sample was divided into quintiles of attained length, defined by length at last measurement (mean age at last measurement was similar in all quintiles). Attained z-scores for length-for-age (LAZ) and WHZ were used in several visualizations, calculated using the 2006 WHO growth reference standard (10).

The method used to assess the timing and nature of growth faltering was regression of model parameters (R^2, regression coefficients) from individual regressions of length on age for each child, on attained length. The hypothesis is that if growth faltering is episodic, then a child's progress along their own growth curve will have more variance around that curve, and therefore a lower R^2. Higher values of R^2 from regressions of length on age indicate smoother growth, and lower values of R^2 could be associated with either major intermittent slowdowns or large growth spurts (11). Appropriate functional form for these models was determined using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) (12). We compared the AIC and BIC among simple linear regressions, linear regressions with polynomial terms for age, linear splines with 4-6 knots, and cubic splines. Linear splines with 6 knots had the best fit for the data. Using a second round of regressions, we tested for associations between smooth growth and attained length.

Deleterious outcomes in a MAM treatment program

To explore how changes in weight, WHZ, and/or MUAC may predict deleterious outcomes – specifically non-response or deterioration to SAM – in the Sierra Leone study, we assessed the magnitude and timing of change in MUAC, weight in kg, and WHZ at each visit compared with the previous visit. At each time point, the mean weight, MUAC, and WHZ were plotted with the 95% confidence intervals, stratified by outcome. When confidence intervals between any two outcomes did not overlap, a difference was considered observable. Note that at each visit, children were measured a minimum of twice (three times for MUAC); the measurement at each visit is the average of the individual child's separate measures.

To explore factors influencing deleterious outcomes, we adapted the original conceptual framework for the Sierra Leone study to examine two types of factors: clinical pathologies and household characteristics. The outcome variable was trichotomous: Graduated, failure to respond (Fail), and deterioration to SAM. We excluded children that did not achieve one of these outcomes. We calculated pooled descriptive statistics across the arms stratified by outcome to explore these relationships, because we were mainly concerned with differences across outcomes and not foods. Chi-squared statistic was reported for dependent categorical variables, and analysis of variance (ANOVA) model statistics reported for continuous dependent variables. Three multinomial logistic regressions were estimated: one semi-adjusted and two fully adjusted. The semi-adjusted model included the foods, with CSB+ w/oil as the reference, age in months at enrollment, SAM start (that is, child enrolled in MAM treatment after recovery from SAM), child's sex, and average MUAC at enrollment. Though the models were based on a conceptual framework, we tested all included factors for collinearity by calculating the variance inflation factors for each model; no factors needed to be excluded because of collinearity.

The first fully adjusted model included reported presence of diarrhea, vomiting, cough, or fever in the two weeks prior to enrollment and the same pathologies in the two weeks prior to reaching an outcome; the second fully adjusted model included caregiver's marital status, number of household members in the home, food insecurity, socioeconomic status, season of enrollment, season of exit, number of deceased and number of living siblings. Because of the small sample sizes in the outcomes of interest (deterioration to SAM and failure to respond), these models were used as guides for understanding relationships and considered for hypothesis generation rather than hypothesis testing. Finally, we looked at the different morbidity profiles of the children in each outcome by looking at the proportion of children experiencing each morbidity at enrollment and outcome and the pattern of comorbidity profiles reported as number of morbidities reported at each time point.

All analyses were performed using STATA 16.1 SE.

B. RESULTS

Factors influencing sustained recovery from MAM

Table 3 provides summary statistics of the entire sample of children who graduated and returned one month later for follow-up measures. Approximately 78% of the 1529 children who returned for a 1-month follow-up sustained recovery. There were no statistically significant differences between those children who sustained recovery and those who did not in either the child's characteristics (e.g. sex or age) or the home's characteristics (e.g. socioeconomic status or married caregiver).

Table 4 provides information from the subset of households selected for an IDI for whom we had 1-month follow-up information. Of the 640 children who graduated and were selected for an IDI, 590 returned at the 1-month follow-up visit. Approximately 443 (69.2%) of the 590 children who returned at 1-month had sustained recovery, and 147 had relapsed. There were no significant differences between those who sustained recovery and those who relapsed in characteristics related to caregiver engagement, study food use, or household-level factors.

Summary

There were no significant differences in factors observed in this study that differentiate children who relapsed to MAM from children who sustain recovery 1-month after graduation.

Relationship of MUAC and WHZ

To examine the relationship between MUAC and WHZ, we calculated Spearman's coefficient of correlation, Cohen's Kappa coefficients, and the sensitivity and specificity of WHZ compared to MUAC in diagnosing MAM and SAM children. We also evaluated MUAC and WHZ for sex-specific differences in their relationship.

Burkina Faso

In the Burkina Faso study, the total number of children in the analysis was 6,112, and 51% were males. Mean age at enrollment was 6.25±0.9 months, and 1% of children were aged 25 months or more. The mean MUAC and WHZ for females was 13.8 ± 1.01 and -0.77 ± 0.94 respectively, and the mean MUAC and WHZ for males was 14.01 ± 1.01 and -0.92 ± 1.03 respectively (data not shown)(2).

In Table 5, Spearman's coefficient of correlation between MUAC and WHZ is shown for each of the 22 visits, broken down by sex. The correlations ranged from 0.79 to 0.86 illustrating low variability in the correlations between the two measures as children aged. While we observed attrition in the follow-ups, there was no discernable pattern in the change in the correlation coefficient that is attributable to a change in the sample size or composition.

In Table 6, Kappa coefficients for sex and age group are shown. There was generally poorer agreement for male children (k = 0.16, p < 0.001) than for female (k = 0.29, p <0.001). Agreement was also poorer among older children (k =0.07, p < 0.001) than among younger (k = 0.2, p < 0.001). None of these measures, however, represents better than a "fair" degree of agreement. The impact of age and sex on the Kappa coefficient of the two anthropometric measures was less apparent in the sensitivity and specificity analysis shown in Table 7.

The sensitivity of diagnosing MAM by WHZ was slightly higher among males (40% - 68%) than among females (25% - 61%). This contrasts with a wider range for diagnosing SAM but similar sex-specific trend: sensitivity for male children was slightly higher (25% - 100%) than for female children (13% - 80%). *Specificity* of diagnosing MAM was similar for males (86% - 96%) and females (94% - 98%). This shows slight but observable differences between male children and female children, complementing the sex-specific differences in agreement between the two measures captured by the Kappa coefficient values.

Sierra Leone

The total number of children in the program was 2,650, of whom 57% were females. Mean age was 13.3 ±7.9 months, and 92% of children were aged 24 months or less. The mean MUAC and WHZ for female children at enrollment were 11.96 ± 0.27 and -1.61 ± 0.66 respectively, and for male children the mean MUAC and WHZ at enrollment were 11.98 ± 0.27 and -2.06 ± 0.73 respectively (data not shown) (4).

In Table 8, Spearman's coefficient of correlation between MUAC and WHZ is shown for each of the 13 visits, separated by sex. The pattern of correlations is different from that in Burkina Faso, showing very low values (.18 - .21) at the first visit and increasing steadily through the sixth visit, though consistently lower than those calculated in the Burkina Faso study. For the last two visits, no male children were followed up, and the follow up number for female children was low and insignificant at the last visit. The Kappa coefficients presented in Table 9 show slightly different sex and age-specific patterns than were observed in Burkina Faso. In Sierra Leone, the agreement between WHZ and MUAC were equal for both sexes (k=0.24, p<0.001); as in Burkina Faso, agreement was slightly poorer among older children (k=0.19, p<0.001) compared to younger (k=0.24, p<0.001). In all cases, though, the values are at the low end of 'fair' or are actually 'poor'; none would be considered to demonstrate "substantial" agreement.

Table 10 presents the sensitivity and specificity analysis, separated by sex at each visit. Because the enrollment criterion for children in Sierra Leone was MAM identified by MUAC, the comparison of WHZ to MUAC could not be calculated at the first visit due to a lack of comparison group (i.e. a group that may have been MAM by WHZ but not MUAC). The sensitivity of WHZ in identifying MAM (defined by MUAC) for male children was higher (33% - 66.7%) than among female children (15% - 33%). The specificity values were similar for male and female children, ranging from 75% - 100%.

In diagnosing SAM, the sensitivity of the measurement among male children was again higher (20% - 100%) than among female children (9% - 50%). As with identifying MAM, the *specificity* of the measurement for males and females was similar at diagnosing SAM, ranging from 94% - 100% for male children and 98% - 100% for female children. Altogether, we observe that sensitivity is consistently lower for female children for both MAM and SAM regardless of context.

Changes in anthropometry among children who fail to respond or who deteriorate to SAM during MAM treatment

In Sierra Leone, children who graduated from the program entered with a higher average weight, WLZ, and MUAC than children who failed to respond or deteriorated to SAM (Figures 1-3). Between enrollment and week four, the difference between the Fail and SAM groups' average weights and that of the Graduated had grown from an average difference of 0.5 kg to an average difference of 0.9 kg (Figure 1). In general, children who deteriorated to SAM lost an average of 4.5 g/kg/day by the 4th week of treatment compared to an average of 6.6 g/kg lost per day by the end of treatment (Figure 1). This contrasts with children who failed to respond, who gained 6.0 g/kg/day by the 4th week of treatment, and 5.6 g/kg/day over the course of treatment.

At enrollment, on average, both children that deteriorated to SAM and children that failed to respond to treatment weighed less than children who eventually graduated, without overlapping 95% confidence intervals, though there was no observable weight difference between children who failed to respond and children who deteriorated to SAM. A difference in the average weight between non-responders and SAM began to emerge at week 2, and by week 4 the differences between the groups widened and became observable. Figure 2 illustrates a similar pattern in average MUAC at each time point. Unsurprisingly, the pattern was similar for WHZ. At enrollment, average WHZ was similar among the three groups, but by week 2 the differences had expanded and continued to expand further throughout the duration of treatment (Figure 3).

Continuous or episodic growth faltering

The final dataset with imputations for missing and implausible values consisted of 5,039 children between 5-28 months, comprising 82% of the original sample. In total, there were 108,580 observations. In addition, a sensitivity analysis was conducted only using children with complete data (without imputations) to compare results. This consisted of 1,158 children (19% of the original sample) and 25,476 total observations; results from the two data sets were consistent.

Table 11 shows sample characteristics by quintile of attained length. In all quintiles, age at both first and last measurements is similar. At first measurement, there is a 5.3 cm difference in length between the highest and lowest quintiles, and at last measurement, the difference widens to 9.1 cm. The sensitivity analysis dataset used for longitudinal growth faltering analyses is similar to the primary dataset.

In Figure 4, we show population level shifts in linear growth among children by attained length quintiles, compared to the WHO growth reference population distribution. In all quintiles, as children age, the LAZ distribution shifts further to the left of the WHO reference. Even children in the highest quintile have a left-shifted distribution by the time they reach 24 months.

Individual growth trajectories of a sample of children from the sensitivity analysis dataset (excluding any with imputations) are shown in Figures 5a and 5b, broken out by selected centiles of attained length. Growth curves are flatter with less constant slopes among children in the lower centiles (Figure 5a), though growth velocity is highly heterogeneous over time among all children (Figure 5b). On average, growth velocities stay below the mean of 1.0 cm/month in the lower centiles of attained length, while they rise above the mean in the higher centiles, but the downward slopes of growth velocities over time are similar in each centile.

This finding is replicated in a larger sample using locally estimated scatterplot smoothing (LOESS) to visualize both average growth velocities and change in LAZ over time (Figure 6). While the slope of length velocity over time is similar among children in the top four quintiles, children in the lowest attained length quintile have slower rates of growth relative to their ages throughout the observed period. In the lowest quintile, length velocities remain the lowest throughout the study period, and the slope is more consistently negative than in the higher quintiles, with no periods of shallower slopes between 14-21 months as is seen in the higher quintiles. In summary, we observe that while on average slopes are similar among children in each of the quintiles of attained length, children in the lower quintiles start with lower length velocities from the outset, and thus maintain slower rates of growth throughout the study period. LAZ curves show similar results.

Regression parameters extracted from individual linear spline regressions of length on age are summarized by attained length quintile in Table 12. Those in higher attained length quintiles have higher initial lengths, higher R^2 (representing smoothness), and higher growth velocities overall. All values for R^2 are very high as they are derived from individual regressions of each child's length on their age, meaning that age is a very good predictor of length on its own. Because the values are so high, even small differences are significantly different, as tested by regression of the R^2 on quintile of attained length, thus the values in the table appear similar but are in fact, statistically significantly different in each quintile of attained length. In Figure 7, we observe that children with the lowest R^2 values (representing less smoothness of the growth curve), are also the shortest, and in Table 13, we confirm these results with linear regression of individual model parameters on attained length. Without the effect of growth velocities, an increase of 0.01 in R^2 is associated with a 3.1 cm increase in attained length (95% CI: 2.80, 3.41). The smoothness of the growth curve alone is significantly associated with increased length. As additional individual model parameters for each age category are added, the importance of R^2 decreases in relation to average growth velocities but remains statistically significant. The most influential age period for growth is between 9-11 months; during this period, for each cm increase in length gained, children achieve 6.71 additional cm of length at the end of the study period. In addition, an increase of 1 cm in initial length (at 6 months) is associated with 0.96 cm increase in attained length.

Summary

WHZ is sensitive to both age and sex in accurately measuring SAM or MAM status with MUAC used as the reference method, with some differences observed between the two study populations. MAM children who responded poorly to treatment entered the program with significantly lower weight and MUAC than children who graduated. By the second or fourth week in the program, children that were deteriorating to SAM were already exhibiting symptoms of deterioration including both weight stagnation and MUAC loss. Results suggest that growth faltering manifests early and through consistently slower growth, especially from 9-11 months of age, as well as greater levels of heterogeneity in growth velocities in children with severe growth faltering compared to those who experience less severe growth faltering, suggesting that growth faltering is continuous, but that smoother growth is beneficial to gaining height/length. Children who attain greater length have both smoother and faster growth.

<u>Deleterious outcomes in MAM treatment program</u>

In total, 2432 children were included in this analysis. Table 14 provides summary demographic characteristics of the beneficiary children and their caregivers at enrollment, broken down by their final outcome. Of the children included in this analysis, 1675 graduated, about 69% of the sample. Of the 618 children who transferred into the SFP after progressing from SAM to MAM, 218 (35%) deteriorated back to SAM, 80 (13%) failed to respond to MAM treatment, and 320 (52%) graduated from the SFP. Table 14 shows that children who transferred from SAM were 25% of the sample but were 44% of those who deteriorated to SAM during treatment, and were only 19% of those who recovered, suggesting transfer from SAM is a risk factor for unsuccessful treatment.

Table 15 presents the results of the multinomial logistic regressions examining factors associated with failure to respond or deteriorating to SAM compared to graduating from the SFP. In the partially adjusted model 1, average MUAC at enrollment had a significantly protective effect: that is, each additional cm added to the MUAC measurement at enrollment was associated with a decreased relative risk of deteriorating to SAM (RRR .02, p<.01) which was attenuated but still significant among non-responders (RRR 0.17, p<.01). Being transferred from SAM was associated with a 2.35 greater risk of deteriorating back to SAM (p<.01), and a 1.65 greater risk of being a non-responder (p<.01). Being older at enrollment was also protective, as was being male (for non-response compared with graduation) (p=.03).

In the fully adjusted model 2 shown in Table 15, which explored relationships between morbidities at enrollment and exit, the effects of sex, age, transfer from SAM program, and average MUAC at enrollment on the relative risk ratios of deteriorating to SAM or failing to respond were consistent in both direction and significance with the semi-adjusted model. Experiencing a morbidity at enrollment was protective against developing SAM or failing to respond, but this protective effect against deteriorating to SAM was only significant among those experiencing cough in the two weeks prior to enrollment (p=.01). Experiencing a morbidity at exit significantly (p<.01) increased the relative risk of deteriorating to SAM for fever (RRR 3.8), diarrhea (RRR 7.4), vomit (RRR 5.32) and cough (RRR 2.0). The effects were less pronounced in increasing the risk of non-response, but only for fever (RRR 1.68), diarrhea (RRR 2.24), and vomit (RRR 4.47). Cough at exit was not significantly associated with an increased risk of failing to respond.

Household and environmental characteristics are explored in model 3 shown in Table 16. Generally, household characteristics were not associated with risk of deteriorating to SAM nor of failing to respond. The one notable exception for both models was presence of an adolescent female sibling, which was associated with reduced risk of either deteriorating to SAM (RRR 0.87, p=.02) or failing to respond (RRR 0.86, p<.08). There were no other similar relationships apart from age, SAM start and MUAC at enrollment. The relative risk of deteriorating to SAM was higher by a factor of 1.92 (p=0.05) among those whose caregivers were separated from their partner compared to married couples, and lower at rainy season at exit compared to dry season (RRR: 0.57, p<.01). Having a male adolescent sibling increased the relative risk of non-response by 1.12 (p<.01) as was having a female adult older than 65 years (RRR 1.20, p=.04). Rainy season at exit was protective against deteriorating to SAM, while rainy season at entry reduced the risk of failing to respond compared to entering in the dry season (RRR: 0.71, p=.09).

Figure 8 shows the morbidity patterns separated by outcome. We find that across all morbidities, a greater proportion of children who deteriorated to SAM experienced a morbidity at either enrollment, exit, or both (59% compared to 42% among non-responders and 41% among graduates). The morbidity experienced by the most children independent of outcome was fever, followed by cough, diarrhea and vomiting. Figure 9 shows that a greater percentage of children who ultimately graduated were likely to be ill at enrollment (32%) and not at exit (6%) which contrasted with children who deteriorated to SAM (18% ill at enrollment compared to 32% at exit). About the same proportion of children had no comorbidity at either enrollment or exit in both the graduated and failure to respond categories. Finally, in Figure 10 we see that children who deteriorated to SAM experienced a greater variety of multiple comorbidities at exit whereas at enrollment this was true of children who ultimately graduated, but the contrast was less stark.

Summary

Children who deteriorated to SAM often exited the supplementary feeding program with a comorbidity but were more likely than children who graduated or failed to respond to not have experienced a comorbidity in the two weeks prior to enrollment. On average, children who deteriorate experience greater incidence of infection at exit than non-responders or children who graduate. In contrast, children who fail to respond to treatment seem to experience similar exposures and responses to those exposures as children who ultimately graduate.

II. ELEMENTS OF CHILD FEEDING AND CARE

A. METHODS

In home observations were conducted among a subset of 321 beneficiary households in Sierra Leone and 176 beneficiary households in Burkina Faso. The FAQR field team trained local enumerators in each study location on basic in-home observation (IHO) data collection methods, instructing enumerators to record observed household activities, with a focus on feeding and care of beneficiary children. IHOs were planned for four and five consecutive days respectively in Sierra Leone and Burkina Faso, but actual observation days ranged from three to five days. Paper forms were transcribed digitally by the FAQR field team. These data are unique, as the enumerators directly observed beneficiary family behaviors, such as child feeding and care, that are otherwise typically provided by self-report.

The FAQR Data Mining team used qualitative content analysis to analyze the detailed enumerator notes about behaviors they observed during their IHOs (31). The NVivo Qualitative Software (v12) package was used for data management. Data from Sierra Leone and Burkina Faso were analyzed in English and French, respectively. Research questions (Table 1) were determined based on available data. A random sample of IHO notes from households across the four study foods was selected to develop a preliminary codebook for both Sierra Leone and Burkina Faso, which was then applied to the remaining hundreds of notes transcripts, which resulted in some modifications to codes to better fit the data. The finalized codebooks were used to identify key categories and themes.

B. RESULTS

To examine the household environment and child feeding and care practices, analysis of the enumerator notes is presented by research question and study location with illustrative quotes. Similar trends emerged across both countries. Poor quality water, sanitation, and hygiene practices were common; children consumed poor quality diets, and the household environments were unsanitary overall. Beneficiary households in each country had similar water, sanitation and hygiene, and child feeding and care practices, but there were some observed differences in behaviors between the countries.

<u>What are the sanitary characteristics of beneficiary children's home environment?</u>

Sierra Leone

Households were inhabited by one family. Overall, domestic animals were not present in the home or home compound. Households were walking distance from neighbors and the family farm, where caregivers spent a significant portion of their day. Most compounds did not have their own water source, so caregivers or their elder children often had to walk to draw water from the stream or community pump daily. Similarly, households relied on wood for cooking, which caregivers or older children fetched. Overall, compounds were tidy and swept daily by the primary caregiver.

Beneficiary children were frequently placed on the dirt or patio cement floor to play either alone or with their siblings. As is common among toddler children, beneficiary children were frequently observed placing toys and other household items in their mouths. Their hands were not washed afterwards.

> *"Mummy Tejan (mother of the beneficiary child) woke up, swept the compound with a long broom and prepared [it] with a long broom and prepared the fire using charcoal, matches and plastic in a medium size coal pot."*

> *"She [mother] went into the kitchen, took a broom and she started sweeping the entire compound, together with Tenneh Kpaka (aunty) to the beneficiary child. They gathered dirt and threw it away. She went into the kitchen and built fire using wood, plastic and matches. She took a medium size locally made aluminum pot that was half filled with water she fetched from the river."*

> *"Theresa (mother) brought out Iye (beneficiary child) and put her out the floor to sit. And give her a bunch of keys, Iye (beneficiary child) rub the keys on the ground and put it into her mouth for 2 minutes and took it out by herself."*

Burkina Faso

In Burkina Faso, household compounds were generally multi-family, and caregivers were in polygamous marriages. The co-wives spent time together cooking and doing domestic chores. Other visitors to the family compounds were frequent. As in Sierra Leone, caregivers spent significant time on the family farm. Domestic animals, including dogs, goats, chickens, sheep, and pigs were commonly observed in the household compound. Domestic animals were frequently observed consuming food off the same plates used by the children. Caregivers or older children helped to fetch water from the community pump or stream, but access to sufficient water was a common challenge in Burkina Faso compared to Sierra Leone. Notably, the home compounds were less well-kept and dirtier than the compounds in Sierra Leone, and there was frequent mention of garbage, animal droppings, and plant debris around the compound.

Beneficiary children were frequently placed on the dirt floor to play either alone or with their siblings. As is common among toddler children, beneficiary children were frequently observed placing toys and other household items in their mouths. There were a few observations of the children playing with or ingesting animal feces. Their hands were not washed afterwards.

> *"Animals eat in the same instruments used by humans. The dish is soap free. The child's bath was done with the decoction of the roots and leaves of plants. Animal and vegetable debris is located in the courtyard, making some corners of the courtyard dirty and releasing unpleasant odors."*

> *"The courtyard is not clean, with dishes, pots, cups and clothes, deposited here and there."*

> *"Very mobile and well awakened child. Child plays a lot in dirty places, eats soil, drinks dirty water. Most of the drinking water comes from the dam. The courtyard is comparable to a bin where domestic animals and people live. Hygiene barely exists.[a]"*

> *"Very mobile child and remains dirty all day. Child plays with earth, ash, and drinks dirty water. He plunges dirty objects in the jar containing the drinking water."*

Summary

In Burkina Faso, domestic animals were commonly observed in the home compound and were frequently present during family mealtimes. Animals were also in close quarters with children throughout the day. There were several instances where animals were observed to eat off the same plates as children, and children were observed to play with or ingest animal feces. In both Sierra Leone and Burkina Faso, children were often left to play on the earthen floor of the compound

[a] Demonstrates the disgust observed by enumerators for behaviors practiced at the beneficiary family compound.

without supervision, and the children were frequently observed to place unhygienic toys, household items, and trash in their mouths.

<u>What are the water, sanitation, and hygiene practices among caregivers of beneficiary children?</u>

Sierra Leone
Handwashing practices among caregivers were poor and generally not practiced at critical times such as before eating or after toileting the child. If caregivers washed their hands, it was done during dish washing before cooking. There were a few observations of caregivers rinsing their hands and the hands of their children with water but not soap before eating. Yet overall, caregivers bathed children daily with soap, mostly using locally available 'black African soap,' 'sapo soap' or 'soda soap.' There was little reporting of disposal of child feces, but there were a few mentions of the child being rinsed with water after toileting.

> *"Hawa Massaquoi [grandmother] to the beneficiary child bathed the beneficiary child with hot water that she poured into the same medium green and black rubber bucket, and it was two calabash of the same hot water and two and half calabash of unheated water that was in the big blue and pink rubber bucket. And she poured in into the same hot/heated water, and she took it at the back of the same kitchen to bath the beneficiary child. She used soda soap, sapo, and water to bath her. Finished at around 18:00 and she took her inside the same veranda room to dress her."*

> *"Foday (beneficiary child) stool, his Aunty Mariama uses pump water to clean him up and washed him using water (pump) only. She than puts on him clean clothes."*

Burkina Faso
Water, sanitation and hygiene practices were poor among beneficiary households in Burkina Faso. Handwashing was almost never practiced at critical times nor when the caregivers returned from the family farm. Of the reported times when caregivers washed their hands or the hands of their children, soap was not used. Dishes were rinsed with water, but not washed with soap. Children were bathed with warm water by the caregivers almost daily, but soap was not used. There was little reporting of disposal of child feces, but there was some observation of the child being rinsed with water or just wiped without being rinsed after defecating.

> *"The dishes are cleaned without soap; the hands of the mother and the hands of the child have not been washed neither before the kitchen or after the kitchen."*

> *"The other twin had diarrhea all day often; even defecated on the beneficiary child. The mother cleanses with a dirty tea towel and without washing hands, continues to breastfeed."*

Summary
In both countries, there was limited observation of handwashing of adults and children in beneficiary households. Soap was rarely used when handwashing did occur. In Burkina Faso, soap was rarely used during any hygienic activities, including during dishwashing and handwashing after food preparation or toilet use. Further, while daily bathing of children was a common practice in both countries, caregivers regularly used soap (locally made African black soap or sapo soap) in Sierra Leone only.

<u>What are the food preparation practices among caregivers of beneficiary children?</u>

Sierra Leone
Prior to preparing meals, the caregivers wash the cooking pots and eating utensils with water or with local soap. The food preparers' hands may be washed during this time. After washing utensils,

foods are cooked over the fire. The mothers of the beneficiary children prepare most meals, but the children's grandmother or aunt cook occasionally. Beneficiary children may be in the kitchen while cooking is ongoing, sitting alone on the dirt floor or on a cloth mat.

Typically, a meal is prepared in the morning and in the evening. Leftovers of study food or other foods are sometimes covered and left in the kitchen for the child's consumption later. Leftovers are rarely reheated. The study food may be prepared during preparation of a family meal or separately. Typically, hands are not washed before eating.

> *"Mother went inside and brought out baby feeding utensils and put them near the kitchen. Mother (Messie) took a medium black rubber bucket and went to the stream which is less than a mile to fetch water. Mother came back with the water and used it to wash baby feeding utensils with soda soap and sapo."*

> *"Marie Sesay (grandmother/caregiver) washes the pot with clean water she brought from the tap and soap and sapo. She then brought the CSWB and FVO in a plastic bag from the room. She opens the CSWB and pours it in a baby feeding cup at the top line of the cup. She then measures two full baby feeding cup of cold water she brought from the tap and pours it to the pot and hang the pot on the fire. She measures one full baby feeding cup of water and adds to the CSWB flour (almost a full baby feeding cup) and stirs for two minutes, the water took four minutes on the fire, Marie Sesay (caregiver) adds the mixed CSWB flour with water to the hot water on the fire and stirs for one minutes, she then close the pot for two minutes."*

Burkina Faso

Observation notes indicate that dishes may be washed with water (not soap) prior to cooking, and dirty pans are sometimes used to prepare a meal. The food preparers hands may be washed during the washing of cooking utensils. Often, the household cooking space is dirty. Domestic animals and animal feces were present in the cooking space. The mother prepares most of the beneficiary child's meals over the hearth, but the other wives and the children's paternal grandmother occasionally prepare food for them.

Typically, two meals are prepared, one in the morning and in the evening. However, there were several reports of households only preparing one meal per day. The study food may be prepared during preparation of a family meal or separately. Leftovers of study food are sometimes left in the kitchen for the child's consumption at a later time but are not reheated prior to consumption. Hands are not washed before eating.

> *"Dishes are generally washed without soap. The kitchen instruments are laid out in the courtyard."*

> *"The kitchen is not clean, with different kinds of garbage. Remains of food are deposited on the wall, dishes without covers and on the floor of the home."*

> *"Hands are not washed before meals. Animals eat off of plates used by humans."*

Summary

Generally, children consumed more than one meal each day from utensils that had been washed, though not always with soap. Adult female caregivers were universally responsible for both preparation and feeding across contexts.

Who are primary and secondary caregivers of beneficiary children?

In both countries, the mother of the beneficiary child is the primary caregiver and cares for the child most of the time. Secondary caregivers include the beneficiary child's grandmother and, to a lesser extent, the father. In Sierra Leone, aunts and neighbors also help with childcare, while the other wives of the child's father aid in childcare in Burkina Faso. Other children (elder siblings of the beneficiary child) are not heavily involved in childcare. The elder sisters of the beneficiary child provide some care in both countries, such as occasionally feeding, bathing, care, and playing. In a few households, the elder sister watched the beneficiary child throughout the day while the caregiver was away from the home. Elder siblings frequently help the primary caregiver with household chores and play with the beneficiary children in the home compound.

Sierra Leone

> *"Mother/caregiver (Jilloh Musa) is preparing evening meals. Her younger siblings, Umaru Tarawally and Hawa Tawei are assisting her in the kitchen while processing the potato leaves, caregiver carry the beneficiary child, Musa Tarawally on her back."*
>
> *"Mother took beneficiary child from the ground, give her to her grandmother (Hawa Kamara) and she (mother) left the house to the stream to launder beneficiary child's clothes."*
>
> *"Neighbor called Kema feeds (beneficiary child) Foday with rice and soup. She feeds him with a tablespoon. Eating environment wash & swept. She gave him fish to eat; Foday drank water in un-wash cup."*

Burkina Faso

> *"After lunch, the caregiver returned to work in the field, leaving the beneficiary child with her sister. She worked there until the evening before coming home. The child stayed with the children in his court then with his grandmother until his mother has arrived."*
>
> *"The other wife served the couscous of CSB14 to the beneficiary child, and the other pregnant woman (wife) served her a yellow pea preparation with the couscous of CSB14."*
>
> *"Today the mother and her child were up very early. The child got up at the same time as his mother and begin to play with his elder siblings. The mother left them and went to sweep the courtyard. Then she did the dishes and lit a fire to heat the water. Then she went to fetch some water from the tub and came back to continue cooking. She bathed her children and went to serve the meal."*

Summary

Children were primarily fed and cared for by their mothers, but grandmothers and other adult women in the family (e.g. aunts, other wives in Burkina Faso) also played an important role. If mothers had to run errands or work on their farms, they often brought their children with them. Overall, there was little mention by enumerators about whether the mothers brought snacks for or breastfed their children when they left the house to work or run errands. However, in Sierra Leone, enumerators observed that some mothers brought snacks and breastfed their children while running errands. The children's fathers did not play a primary role in child feeding and care, but they did regularly play with the children or watch them while the mother did household chores. In addition to childcare, mothers in both countries were observed to manage and clean the household, in addition to work on the family farms. In both study settings, elder siblings were not the primary caregivers of their younger siblings, despite concerns of this practice within the international nutrition community. However, elder sisters were more frequently observed to feed and care for their younger siblings than elder brothers.

<u>What are the complementary feeding practices among caregivers of the beneficiary children?</u>

Sierra Leone

In Sierra Leone, beneficiary children consumed a grain-based diet, which was supplemented with small amounts of animal-sourced proteins and vegetables. Sweet cakes, fruits, and packaged junk foods are commonly provided to children as snacks. Apart from the study food, children consume foods out of the family pot. Children were observed to eat grain-based foods multiple times per day, while other foods were consumed less frequently. Typically, children would consume two meals per day plus breastfeeding and snacks. Commonly consumed foods (foods mentioned in the notes over 110 times), include rice, cassava, sweet cakes, groundnuts, soup, fufu, palm oil, porridge, cassava, and potato leaves sauces. Less commonly consumed foods (mentioned in the notes fewer than 100 times) include coconut, potatoes, eggs, fish, corn, sweet biscuits, beans, banana, pineapple, mango, stew, palm fruit, orange, bread, paw-paw, mix pap (i.e. porridge), and kola nut. Children were regularly offered water after meals, which was often from the local community pump or stream.

Children are often breastfed when they first wake up in the morning, as well as periodically throughout the day. Mothers feed from both breasts and will offer to nurse the child when they cry, wake up from a nap, or after a meal. Several instances were observed where children refused to nurse because they were ill.

Overall, children consume the portion of the study food offered by caregivers. The children often ate on the ground or on a cloth mat. If they were old enough, they would feed themselves; otherwise they were fed primarily by their caregivers. There were some instances of the study food being refused by the child, but this was often due to illness. If there were any leftovers of the study food, they would be shared to the siblings of the beneficiary child. Occasionally, the mother would prepare a portion of the study foods and feed it to the child throughout the day. Overall, breastfeeding and consumption of other foods was poor during illness.

> "*She [beneficiary child] is eating the pineapple all by herself whiles she is still sitting on the floor (mud) in the veranda at the household. whiles the beneficiary child was eating the pineapple she was as well play on the hearth."*
>
> *"Whiles the beneficiary child is playing, a kid (Aunty Tenneh's child) came to the market hut with some cooked beans in a small green rubber plate. She then feeds the beans (cooked with oil) to the beneficiary child. The beneficiary child and the kid older than ten years consumes all the beans (cooked black eye beans) about less than half of the small green rubber bowl."*
>
> *"The beneficiary child eats half of the pap in the cup (baby feeding) but did consume all the pap offered; was more than half of a blue baby feeding cup. The leftover was placed in a long covered rubber cup."*
>
> *"Haja Nessie (mother) gave the beneficiary child rice and okra sauce in a small blue rubber bowl half quarter, heating of the food was not observed. The food was believed to be leftover. The beneficiary child fed herself using her right bare hands. Hand washing was not observed. Sitting on the ground in their kitchen, and there was no leftover from the meal."*
>
> *"The beneficiary child is eating the CSWB pap. Marie Sesay (caregiver) feeds the child the leftover pap from the previous serving (morning); she was feeding the child with a teaspoon. The child (Matailor) ate some of the pap, and there was left over from this serving. Marie Sesay (caregiver) gave some water she brought from the room to the child and the child was drinking directly from the cup in the veranda at the household."*

Burkina Faso

In Burkina Faso, beneficiary children also consumed a grain-based diet, which is supplemented with small amounts of animal-sourced proteins and vegetables. From the notes, the diets appear more varied than the diets of children in Sierra Leone. Apart from the study food, children consume foods out of the family pot. Children were observed to eat grain-based foods multiple times per day, while other foods were consumed less frequently. Typically, children would consume two or more meals per day plus breastfeeding and snacks. Commonly consumed include 'fat rice' (oily rice with vegetables or meat), couscous, beans mixed with rice, white bread, sweet cakes, soup, gumbo, cooked peanuts, dried fish, stewed beans, various local sauces (e.g. baobab, jute, kapok), sorghum or corn porridge, unfermented *dolo* (local, homemade beer), cow milk or cow milk porridge, pasta, chicken, and local sweet drinks. Less commonly consumed foods include watermelon, chicken, fish, sweet biscuits, shea fruit, mango, corn, coffee or tea, grape, wild fruits, wild eggplant, beef meat, organ meat. Fried sweet cakes (e.g. beignets), fruits, candies, and local, sweet juices are commonly provided to children as snacks. There were some observations of the children consuming dirt or mud. Children were regularly offered water after meals, which was often from the local community pump or stream.

Children are often breastfed when they first wake up in the morning and throughout the day. Mothers breastfeed on both breasts and will offer to nurse the child when they cry, wake up from a nap, or after a meal. Several instances observed where children refused to nurse because they were ill.

Overall, children consume the portion of the study food offered by caregivers. There were more instances of the study food being refused by the child than in Sierra Leone, which was often due to illness. If there were any leftovers of the study food, they would be shared to the siblings of the beneficiary child, the caregiver and the other wives. The children often ate on the ground or on a cloth mat. If they were old enough, they would feed themselves; otherwise they were fed primarily by their caregivers.

There were over three dozen observations recorded of the study foods not being consumed by the beneficiary children. The study food was not consumed because the child was ill or because the caregiver did not prepare it. The CSWB study food had the highest number of observations of non-consumption. Overall, breastfeeding and consumption of other foods was poor during illness.

> *"The child eats alone, the dish mixed with sand. Drinking water is dirty and muddy. The mother also ate child's CSB+, with the other children. The child preferred to eat the family meals than eat the CSB+ couscous the mother has prepared."*
>
> *"She (caregiver) washed neither her hands nor hands of the child. The mother served [the CSB+] to her child and the child's cousin at the same time. The two children eat together and don't finish all the porridge. The mother delivered the rest to the elders of the child who finished eating all and went to set the empty plate. The child breastfed a lot and eat a lot of family meals."*
>
> *"She (caregiver) breastfeeds her child and then the child eat the family meals. Animals often eat from plates and pots used by men."*
>
> *"The child vomited three times successive after the mother's administering paracetamol. He was a lot sleeping and finally woke in the afternoon. He recovered his joy of living (temperament) with the drop of fever. However, he didn't consume CSWB all day."*

Summary

Observation of the consumption of fresh fruits, vegetables and animal-sourced proteins was limited, but the types of foods consumed appeared to be more varied in Burkina Faso. In both countries, breastfeeding was commonly practiced throughout the day, and children were fed about two meals daily. Often, the mother would prepare the study food once in the morning and serve it to the child throughout the day. Overall, children consumed the servings provided, but their leftovers were frequently shared to their siblings. Foods prepared for the children were often left uncovered and not reheated when served. There were several observations of children eating food that had been left out overnight.

SECTION 3: CONCLUSIONS AND KEY TAKEAWAYS

I. LIMITATIONS

There are several limitations worth noting in these analyses. In the analysis of sustained recovery and factors associated with deleterious outcomes in the MAM treatment program, the small sample sizes in the outcomes of interest may limit our ability to detect a significant effect or association between the comparison groups. These studies were also not designed to answer the research questions contained in this report and, therefore, may be missing important confounding factors that would affect conclusions.

In comparing MUAC and WHZ, a limitation specific to the Sierra Leone study was the enrollment criterion: MAM was diagnosed by MUAC. This enrollment criterion means that we are missing children who would have otherwise been diagnosed as MAM by WHZ. This characteristic of the study limited comparability between WHZ and MUAC in diagnosing SAM and MAM among these children and may explain differences in the degree of agreement of the two measures between the two studies.

In the episodic growth faltering analysis, limitations include the lack of data on birth size and measurements up to 6 months of age, as well as lack of data on maternal height, which has been shown to be a predictor of LAZ and can influence child growth by affecting fetal growth and birth size. However, our use of longitudinal data from a large sample of children adds important nuance to the discussions of the timing of growth faltering that can have implications for the optimal timing and nature of interventions to limit growth faltering in children (see recommendations section).

Note that while enumerators were trained to record observed behaviors objectively, some notes reflect the subjective opinions of the enumerators. This was most notable in Burkina Faso, where the enumerators expressed general disgust for the beneficiary households' water, sanitation, and hygiene practices. Finally, the qualitative analysis on complementary foods did not include quantitative data on child diet quality or specific amounts of food consumed, limiting findings on child diet and generalizability to the study's entire sample of children.

II. RECOMMENDATIONS

Implications for Program Guidelines

Support the use of both MUAC and WHZ to identify acutely malnourished children.

Our analysis adds credence to current SPHERE guidelines that both MUAC and WHZ should be used as criteria for identifying acutely malnourished children (13). Had WHZ been used as the sole criterion for diagnosing acute malnutrition, only about one-fifth to one-third of girls and approximately half of males would have been correctly diagnosed (where correct is defined as diagnosis by MUAC). In addition, the agreement between WHZ and MUAC in diagnosing SAM and MAM contrasted between Burkina Faso and Sierra Leone but were comparable among children within each country.[b] Specifically, the agreement between WHZ and MUAC among the children enrolled in the Sierra Leone study were on average poor in contrast to children enrolled in the Burkina Faso study which averaged fair, though at the low end of 'fair'. This within population consistency has been replicated in previous studies (6,14–18).

When disaggregated by age and sex, our results were consistent with previous studies identifying differences between these groups. As with other studies, males tended to exhibit 'better' agreement compared to females as did younger children compared to older (16,18–21). In general, MUAC and WHZ seem to agree on children who are not MAM or SAM rather than children who are MAM or SAM. Consequently, using only one diagnostic criterion would exclude SAM or MAM children from a treatment program who would otherwise be eligible by the other (13). As noted in the CMAM guidelines, the best practice to ensure proper diagnosis of all children who are acutely malnourished is to use both MUAC and WHZ criteria so that children would be enrolled if they met either criterion. Previous literature that also looks at comparing MUAC and WHZ espouse this recommendation (6,16,19).

Support the early identification of potential non-responders for additional intervention.

Analysis of changes in weight and MUAC during the first two and four weeks of treatment for MAM revealed that children who are likely to graduate respond to treatment quickly, within the first four weeks. Similarly, children who fail to respond or deteriorate to SAM show clear signs of poor response by the fourth week either by showing no change/decline in weight and/or no change/decline in MUAC. This suggests an opportunity for identifying children in need of an early intervention to ensure that children diagnosed as MAM do indeed recover. Currently, there are no guidelines to assist implementers or health professionals in identifying children who may not be responding well to treatment and are at risk of worsening health (13,22). Given the amount of information available to implementers and policy makers, it may be possible to begin formulating such guidelines with data already obtainable.

Add an additional aim to MAM treatment effectiveness studies to understand factors associated with unresponsiveness to treatment and deteriorating nutritional status.

Examination of potential environmental and clinical factors associated with poor response to treatment of children diagnosed with MAM showed differences in presence of other illnesses but little difference in exposure to environmental factors. Children whose nutritional status deteriorated during the treatment tended not to have experienced a comorbidity (diarrhea, fever, vomit, or cough) in the two weeks prior to enrollment. However, these same children tended to experience greater presence of a comorbidity in the two weeks prior to exit. Household composition seemed to be associated with response to treatment. Presence of a female over the age of 65 was associated with increased risk of failing to respond to treatment, while presence of an older adolescent female (e.g. sister) was associated with greater likelihood of recovery. This finding is consistent with what was previously reported in the effectiveness analysis of the Sierra Leone treatment study (4).

Other effectiveness studies of MAM treatment have reported deleterious outcomes, but none seems to have examined factors influencing these (see, for example 7–9). Most such studies explore the comparative effectiveness of different foods or different nutrition interventions, but none explores what distinguishes children who fail to respond or who worsen from children who recover (26,27). In our analysis, we found the factors that cause deterioration to SAM may not be identical to those that drive failure to respond. One key determinant of the likelihood of deteriorating to SAM was having been referred to MAM treatment from a SAM program. Understanding these factors may

[b] Reference the limitations section for detail on how this may be explained by study design.

improve the ability to intervene early and thus the effectiveness of programs during treatment and in the post-treatment period.

Household Practices and Behaviors Worth Targeting

Build the evidence base for factors that influence sustained recovery from a MAM treatment program.
This analysis revealed that factors associated with sustained recovery from a MAM treatment program are not easy to identify. These factors may be related to household behaviors and/or to environmental factors that were not measured during treatment. Alternatively, this analysis may reveal that the factors that affect sustained recovery from MAM are influencing health *after treatment is ended* and are therefore not measured by the data we have available, which were collected only during treatment. As has been reported, sustained recovery is currently an area in need of further research to understand both incidence and influencing factors (4).

Evidence of continuous growth faltering warrants research into long term nutrition-sensitive/economic growth programming to prevent stunting.
Our results reveal that most children in the Burkina Faso study experience some level of growth faltering even as they were receiving supplemental nutritious foods. Children who experience the most extreme levels of growth faltering have both slower growth throughout their early childhood and more variability in their growth velocities over time. The presence of growth faltering in all the children points to the utility of addressing the wider environmental conditions in which children live that constrain their growth. In addition, the household observations indicated that children in both Burkina Faso and Sierra Leone remained in suboptimal environments, an observation replicated in existing literature.

The updated UNICEF Frameworks for Undernutrition is useful to interpret these analyses and the several factors at the household and community levels that contributed to a poor enabling environment for child nutrition (28). For example, the Global Nutrition report estimated high stunting rates of children under-five in both Burkina Faso (21%) and Sierra Leone (38%) (29,30). Burkina Faso and Sierra Leone also have high poverty rates, with 43 and 35 percent of their respective populations living below the international poverty line of $1.90 per person per day (31,32). Importantly, diets of children in these studies lacked nutrient-dense foods, while nutritious diets remain unaffordable for 89% of Burkinabés and 85% of Sierra Leoneans (33). Analysis of the in-home observation notes revealed poor water, sanitation, and hygiene practices observed among caregivers of beneficiary children in both Burkina Faso and Sierra Leone. These factors, in addition to limited national security in Burkina Faso and weak government health, education and economic systems in both Burkina Faso and Sierra Leone, contribute to environments that challenge child nutrition. It is possible that with community-level, systemic factors addressed, rather than simply household factors, programs may be more successful at preventing growth faltering in children.

Recommended Behaviors for Social Behavior Change Programming
From the findings of the qualitative analysis, the following evidence-based behaviors have been identified for inclusion in social behavior change (SBC) activities to support improved child health and nutrition in the communities studied. These findings may be relevant to similar contexts, but evidence suggests that SBC activities should be tailored to the context and audience for best results (34).

Corral animals and keep them away from the household cooking space
Corralling the animals in a space away from the home would keep them away from young children, concentrate the animal waste in one location, and reduce the likelihood that the animals soil the home, cooking space, or household items.

Encourage handwashing with soap at critical times
Encouraging caregiver handwashing with soap at critical times, including before and during food preparation, before eating and feeding the child, after using the toilet or changing the child's diaper, and after working in the field or doing household chores, is an important practice to improve hygiene and reduce risk for infection among caregivers and their children.

Increase child consumption of low-cost nutrient-dense foods
Child diets were largely made up of starchy staples (grains and tubers) and lacked nutrient-rich animal sourced foods, fruits, and vegetables. Consumption of sweetened juices and packaged snacks was commonly observed. Child diet quality may be improved by encouraging increased consumption of locally available, culturally appropriate, and affordable nutrient-dense foods, possibly in substitution for sweets and snacks. SBC may be targeted to build demand for and increase consumption of locally available, affordable nutrient-dense foods and limit consumption of calorie-dense, nutrient-poor snack foods.

Cover prepared food & reheat before consumption
Often, caregivers prepared food for the child in the morning and refed the child the leftovers later without reheating. Occasionally, food was left out overnight and refed to the child in the morning without proper storage or reheating. Appropriate storage of prepared food and reheating leftovers before consumption are important practices to reduce the risk of foodborne illness.

Place child on clean mat to play under adult supervision
Children were regularly placed on the dirt floor to play alone or with siblings, which contributed to frequent mouthing of unsanitary objects including dirty household tools, trash, and toys. Placing a child on a clean, thick mat to play may improve the cleanliness of the child's environment and reduce the risk of children ingesting harmful enteropathogens.

Discourage child mouthing of non-food objects
Toddler children explore the world by placing objects in their mouths. However, in these study contexts, children regularly placed dirty household items, trash, toys and food that fell in the dirt into their mouths. There were a few observations where children played with or put animal feces into their mouth. Mouthing of these items may increase risk of enteropathogenic infection among children. Mechanisms for preventing this behavior appropriate to each context should be explored.

Encourage continued child feeding during illness
Beneficiary children in the study contexts often refused to eat, drink, and breastfeed when they were ill. This is a well-recognized problem that should be addressed through context-specific SBC, because continued child feeding during illness can prevent worse outcomes and contribute to better recovery during child illness.

III. CONCLUSION

The field studies carried out in Sierra Leone and Burkina Faso as part of FAQR were focused on either the treatment or prevention of acute or chronic undernutrition among young children. The primary results of these studies have been documented in reports and academic papers elsewhere, and the analyses contained in this report explored questions focused on factors that may explain poor nutritional outcomes despite the provision of food aid. Our analyses highlight that household and community environment have an important role in child nutrition, growth, and development outcomes.

The UNICEF Framework of the Determinants of Child Undernutrition illustrates that while child diets and health status are critically important, underlying factors like household food security, child feeding and care practices, and health services also contribute to optimizing child nutrition and health (35). The Framework also describes how basic environmental factors such as household resources, financial capital, and the sociopolitical environment may influence child nutrition and health outcomes (35). In 2020, Black, Lutter, and Trude released an update to this Framework, focused on children's survival and ability to thrive in their environments (28). The updated Framework places equal focus on proximal determinants for child nutrition including access to and consumption of safe and nutritious food, responsive childcare, quality health care, learning opportunities, and safety for children to grow well and thrive in their communities (28). Our findings suggest avenues for more investigation into how different components of nutrition interventions may address household and environmental factors that impact a child's nutrition, growth and development.

In our qualitative analysis, for example, we found considerable homogeneity in household and environmental factors between both Sierra Leone and Burkina Faso. Despite their different contexts, these communities both experience poverty at both a household and a community level and experience weak government health, economic, and education systems. That poverty contributes to poor livelihoods opportunities, limited access to clean water, poor health care, low-quality diets, and unsanitary environments. When coupled with evidence of growth faltering that is continuous rather than episodic, our results indicate that interventions may consider approaches to improve the overall socioeconomic wellbeing of the community, in addition to focusing on the short term nutrient needs of the child, which may prevent insults that stymie growth and development, as indicated by Black, et. al (28). We were unable to identify factors that influence failure to sustain recovery from MAM, which warrants further attention to community-level factors that may prevent a child from fully recovering from diverse forms of undernutrition.

These analyses also add credence to existing recommendations and highlighted areas for improvement of nutrition programs. Our results on the sensitivity and specificity of MUAC and WHZ to one another reinforces the current SPHERE guidelines for using both these measures to identify acutely malnourished children (13). Once acutely malnourished children are identified, however, tracking changes in anthropometry in the first four weeks of entry to a program may identify children in danger of failing to recover. Designing guidelines to assist field-level identification of at-risk children and appropriate early interventions to prevent deleterious outcomes may serve to improve the effectiveness of MAM and SAM treatment programs.

Our findings encourage careful review of how future interventions aim to address child undernutrition and influence the wider household and community conditions that contribute to an enabling environment for the child's nutrition, growth and development. Acknowledging that there are a host of complex factors and systems that influence child nutrition, growth, and development, nutrition researchers have advocated for interventions that address multiple causes of children undernutrition (33). Our analyses highlight only a few of these potential interventions. We have also included a complete list of questions for future research that have emerged from these analyses in Appendix 2.

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APPENDIX 1: TABLES AND FIGURES

Table 2: Summary of Data Collection Methods Used in Both the Burkina Faso and Sierra Leone Effectiveness Studies

Data Collection Tool	Burkina Faso Prevention	Sierra Leone Treatment
Clinic/Distribution Cards	Collected monthly on all children from enrollment at 6 months until exit at 24 months. (18 measures). Contains anthropometry, household characteristics, and morbidity information.	Collected bi-weekly from MAM diagnosis until outcome and at 1, 3, and 6 months after graduation. (maximum 10 measures). Contains anthropometry, household characteristics, and morbidity information.
In-Depth Interviews (IDI)	Quantitative paper survey on a sub-set of caregivers that explored preparation and feeding practices and some sanitation and hygiene practices.	Quantitative electronic survey on a sub-set of caregivers that explored preparation and feeding practices and some sanitation and hygiene practices.
In-home Observations (IHO)	Four-day consecutive in-home observation conducted by trained enumerator using a paper grid data collection form in addition to summarized notes of preparation and feeding practices and some sanitation and hygiene practices.	Five-day consecutive in-home observation conducted by trained enumerator using electronic tablet in addition to detailed daily notes of preparation and feeding practices and some sanitation and hygiene practices.
Focus Group Discussions (FGDs)	Focus group of a subset of caregivers exploring perceptions of the SNFs and the program.	Focus group of a subset of caregivers exploring perceptions of the SNFs and the program.
CHW/Lead Mother In-depth Interviews	Quantitative survey carried out using a paper survey on a sub-set of community health workers or lead mothers in communities. The survey explored knowledge of feeding practices and counseling practices.	Quantitative survey carried out using a paper survey on a sub-set of community health workers or lead mothers in communities. The survey explored knowledge of feeding practices and counseling practices.
Key Informant Interviews (KII)	Semi-structured interviews with key stakeholders at the local, regional, and national levels that explored perceptions of and experiences with program implementation.	Semi-structured interviews with key stakeholders at the local, regional, and national levels that explored perceptions of and experiences with program implementation.

CHW: community health worker; MAM: moderate acute malnutrition; SNF: supplementary nutritious food

Table 3: Selected Characteristics of Children Enrolled in a Supplemental Feeding Program Who Either Sustained Recovery or Relapsed to MAM, Pujehun District, Sierra Leone, 2016-2018

	Sustained Recovery	Relapsed	Total
		n (%)[1] or mean ± SD	
Beneficiary Child Characteristics			
Child is Male	538 (45%)	142 (42%)	680 (45%)
Age of child at enrollment	14.1 ± 8.3	11.9 ± 7.5	13.7 ± 8.2
Child transferred from SAM Feeding program	229 (19%)	65 (19%)	294 (19%)
Anthropometric Measures			
Average weight at Exit	7.5 ± 1	7.1 ± 1	7.4 ± 1
Average length at Exit	70.2 ± 6	68.2 ± 5.6	69.8 ± 6
Average MUAC at Exit	12.8 ± 0.2	12.7 ± 0.2	12.8 ± 0.2
Average WHZ at Exit	-1.2 ± 0.7	-1.2 ± 0.7	-1.2 ± 0.7
Average number of weeks in program	4.9 ± 3.1	5.6 ± 3.3	5 ± 3.2
Average number of missed visits	0.1 ± 0.4	0.1 ± 0.4	0.1 ± 0.4
Household Characteristics			
Caregiver is married	1017 (86%)	291 (87%)	1308 (86%)
Caregiver has no formal education	661 (56%)	193 (57%)	854 (56%)
Household has private or in-home latrine	448 (38%)	123 (36%)	571 (37%)
Household water source is borehole or tube well	760 (64%)	234 (69%)	994 (65%)
Socioeconomic status quintiles			
Lowest	230 (20%)	62 (19%)	292 (19%)
Mid-Low	231 (20%)	80 (24%)	311 (21%)
Medium	246 (21%)	65 (19%)	311 (21%)
Mid-High	246 (21%)	61 (18%)	307 (20%)
Highest	214 (18%)	67 (20%)	281 (19%)

SAM: Severe Acute Malnutrition; MUAC: mid-upper arm circumference; WHZ: weight-for-height z-score; SD: standard deviation[1]Percent represents percent of children within the outcome, not % of the study population, and is rounded to nearest whole number; this is because of the very different samples within each outcome. p-value *** < .01 ** <.05

Table 4: Households Participating in In-Depth Interview: Characteristics of Children Who Either Sustained Recovery or Relapsed to MAM

	Sustained Recovery	Relapsed
Characteristics	**n (%)[1] or mean ± SD**	
N	443 (69.2%)	147 (23%)+
Caregiver Engagement		
Who told the caregiver to go to clinic with the child?		
The female caregiver made the decision on her own	88 (19.9%)	35 (23.8%)
Community Health Volunteer/Health Promoter	96 (21.7%)	32 (21.8%)
Lead Mother/MSG (mother-to-mother support group)	2 (0.5%)	1 (0.7%)
Nurse, SFP or health center staff	130 (29.3%)	35 (23.8%)
Village or community leader	10 (2.3%)	5 (3.4%)
Traditional birth attendant	9 (2%)	1 (0.7%)
Friend or neighbor	103 (23.3%)	35 (23.8%)
Radio	19 (4.3%)	2 (1.4%)
Collection practices		
The mother went to collect the ration	406 (91.6%)	139 (94.6%)
The caregiver walked to collect the ration	353 (79.7%)	121 (82.3%)
The caregiver paid for transportation to travel to clinic	80 (18.1%)	25 (17%)
Price of transportation (SLL)	7362.5 ± 5406.3	7440 ± 5986.7
The caregiver walked home after ration collection	362 (81.7%)	121 (82.3%)
Mother last fed the ration to the beneficiary child	406 (91.6%)	137 (93.2%)
Study Food Use		
The child ran out of food ration before the next clinic visit	249 (56.3%)	75 (51%)
Since receiving the ration, who in the HH has eaten the ration?		
Other children in the household <five years of age	40 (9%)	9 (6.1%)
Other children in the household >five years of age	10 (2.3%)	3 (2%)
The caregiver/mother of the beneficiary child	13 (2.9%)	2 (1.4%)
Other adults in the household	7 (1.6%)	1 (0.7%)
Household factors		
Dietary Diversity Score for beneficiary child (24-hour recall)	2.7 ± 1.8	2.3 ± 1.7
The HH treats the drinking water	300 (67.7%)	102 (69.4%)
The HH normally uses latrine	317 (71.6%)	116 (78.9%)
The HH has electricity in the home	2 (0.5%)	2 (1.4%)

HH: household; SFP: supplementary feeding program; MSG: mother support group; SD: standard deviation. SLL: Sierra Leonean Leone

[1]Percent represents percent of children within the outcome, not % of the study population; this is because of the very different samples within each outcome. + these % are of the percent of children from the 690 children who graduated and are in sub-sample. There were no significant differences ($p<.1$) in any of the characteristics.

Table 5: Spearman's Coefficient of Correlation Between MUAC and WHZ by Each Visit and Sex, Sanmatenga Province, Burkina Faso, 2014-2016

Visit	Male (n)	Female (n)
1	0.82 (3104) ***	0.80 (2999) ***
2	0.84 (2950) ***	0.82 (2783) ***
3	0.85 (2875) ***	0.82 (2787) ***
4	0.85 (2879) ***	0.83 (2744) ***
5	0.85 (2848) ***	0.83 (2723) ***
6	0.85 (2819) ***	0.84 (2716) ***
7	0.85 (2788) ***	0.84 (2669) ***
8	0.86 (2723) ***	0.84 (2649) ***
9	0.85 (2708) ***	0.84 (2613) ***
10	0.85 (2711) ***	0.84 (2584) ***
11	0.84 (2678) ***	0.82 (2568) ***
12	0.83 (2670) ***	0.83 (2559) ***
13	0.84 (2645) ***	0.83 (2515) ***
14	0.83 (2620) ***	0.82 (2528) ***
15	0.83 (2653) ***	0.82 (2573) ***
16	0.83 (2662) ***	0.82 (2533) ***
17	0.82 (2645) ***	0.81 (2556) ***
18	0.81 (2654) ***	0.81 (2538) ***
19	0.80 (2654) ***	0.81 (2536) ***
20	0.79 (2479) ***	0.80 (2367) ***
21	0.80 (2250) ***	0.79 (2143) ***
22	0.81 (1829) ***	0.79 (1681) ***

Note. $p<0.001$ ***, $p<0.01$ **, $p<0.05$ *

Table 6: Cohen's Kappa Coefficient (k) for MUAC and WHZ in Diagnosing SAM and MAM by Sex and Age, Sanmatenga Province, Burkina Faso, 2014-2016

		WHZ MAM	WHZ SAM	TOTAL
All Children			*k = 0.20*	
MUAC MAM		3796	1137	4933
MUAC SAM		167	286	453
	TOTAL	3963	1423	5386
Male			*k = 0.16*	
MUAC MAM		1691	799	2490
MUAC SAM		37	140	177
	TOTAL	1728	939	2667
Female			*k = 0.29*	
MUAC MAM		2105	338	2443
MUAC SAM		130	146	276
	TOTAL	2235	484	2719
Age ≤ 24 months			*k = 0.21*	
MUAC MAM		3516	1042	4558
MUAC SAM		157	274	431
	TOTAL	3673	1316	4989
Age ≥ 25 months			*k = 0.07*	
MUAC MAM		198	79	277
MUAC SAM		8	8	16
	TOTAL	206	87	293

SAM: Severe Acute Malnutrition; MUAC: mid-upper arm circumference; WHZ: weight-for-height z-score; MAM = moderate acute malnutrition.

Table 7: Sensitivity and Specificity of MAM and SAM Diagnosis by WHZ Versus MUAC for Female and Male Children Using MUAC as Reference, Sanmatenga Province, Burkina Faso, 2014-2016

		MAM		SAM	
		Sensitivity*	Specificity+	Sensitivity*	Specificity+
By visit and sex (n)		% (95% Confidence Interval)			
1	Male (3104)	47 (41.1, 53)	95.8 (95,96.5)	25 (3.2, 65.1)	98.7 (98.2, 99.1)
	Female (2999)	25.2 (21.5, 29.2)	98.2 (97.5, 98.6)	12.5 (0.3, 52.7)	99.7 (99.5, 99.9)
2	Male (2950)	50.4 (44.3, 56.4)	92.2 (91.1, 93.2)	65 (40.8, 84.6)	98.3 (97.7, 98.7)
	Female (2783)	34 (29.5, 38.8)	97 (96.3, 97.7)	20 (9.1, 35.6)	99.3 (99, 99.6)
3	Male (2875)	52.3 (46.1, 58.5)	90.1 (88.9, 91.2)	78.3 (56.3, 92.5)	97.8 (97.1, 98.3)
	Female (2787)	36.9 (32, 42.1)	96.1 (95.3, 96.8)	42 (28.2, 56.8)	99.3 (98.9, 99.6)
4	Male (2879)	57.6 (51.3, 63.7)	90 (88.8, 91.1)	83.3 (58.6, 96.4)	97.4 (96.8, 98)
	Female (2744)	47.1 (41.8, 52.5)	96.6 (95.8, 97.3)	50 (28.2, 71.8)	99 (98.5, 99.3)
5	Male (2848)	52.3 (45.3, 59.1)	89.5 (88.3, 90.7)	81 (58.1, 94.6)	96.9 (96.2, 97.5)
	Female (2723)	52.2 (46.7, 57.6)	96.8 (96, 97.5)	64.3 (35.1, 87.2)	99.1 (98.6, 99.4)
6	Male (2819)	62.6 (55.5, 69.4)	87.8 (86.5, 89.1)	86.7 (59.5, 98.3)	97.3 (96.7, 97.9)
	Female (2716)	52.9 (47, 58.8)	94.9 (93.9, 95.7)	42.3 (23.4, 63.1)	99 (98.6, 99.4)
7	Male (2788)	57.9 (50.8, 64.8)	87.2 (85.9, 88.5)	100 (71.5, 100)	96.9 (96.1, 97.5)
	Female (2669)	54.8 (48.8, 60.7)	94.1 (93.1, 95)	66.7 (41, 86.7)	99.1 (98.6, 99.4)
8	Male (2723)	55.9 (48.3, 63.3)	85.5 (84.1, 86.9)	90.9 (58.7, 99.8)	96.6 (95.9, 97.3)
	Female (2649)	49.8 (43.4, 56.2)	93.5 (92.4, 94.5)	53.3 (26.6, 78.7)	98.9 (98.4, 99.2)
9	Male (2708)	49.7 (41.4, 57.9)	87 (85.6, 88.3)	85.7 (57.2, 98.2)	96.8 (96.1, 97.4)
	Female (2613)	53.6 (47, 60.1)	94.6 (93.6, 95.5)	60 (32.3, 83.7)	99.1 (98.7, 99.4)
10	Male (2711)	50.3 (42, 58.7)	88.5 (87.2, 89.7)	100 (29.2, 100)	96.9 (96.1, 97.5)
	Female (2584)	50 (42.8, 57.2)	95.4 (94.5, 96.2)	57.1 (18.4, 90.1)	98.8 (98.3, 99.2)
11	Male (2678)	59.3 (49.4, 68.6)	88.6 (87.3, 89.8)	85.7 (42.1, 99.6)	97.9 (97.3, 98.4)
	Female (2568)	52.1 (44.2, 60)	95.6 (94.6, 96.3)	77.8 (40, 97.2)	99.3 (98.9, 99.6)
12	Male (2671)	55.5 (45.7, 64.9)	89.4 (88.1, 90.5)	100 (15.8, 100)	97.9 (97.3, 98.4)
	Female (2559)	46 (38.2, 54)	95.4 (94.4, 96.2)	63.6 (30.8, 89.1)	99.2 (98.8, 99.5)
13	Male (2645)	57.3 (46.4, 67.7)	89 (87.8, 90.2)	50 (1.3, 98.7)	98.1 (97.6, 98.6)
	Female (2515)	54.1 (45.7, 62.4)	94.8 (93.8, 95.7)	70 (34.8, 93.3)	99.4 (99.1, 99.7)
14	Male (2620)	52 (41.7, 62.2)	89.9 (88.6, 91)	85.7 (42.1, 99.6)	98.1 (97.5, 98.6)
	Female (2528)	52.2 (43.5, 60.8)	95.4 (94.5, 96.2)	70 (34.8, 93.3)	99.2 (98.8, 99.5)

*SAM = severe acute malnutrition. MAM = moderate acute malnutrition. * percent (%) correctly diagnosed as MAM; + percent (%) correctly diagnosed as normal*

		MAM		SAM	
		Sensitivity*	Specificity+	Sensitivity*	Specificity+
By visit and sex (n)		% (95% Confidence Interval)			
15	Male (2653)	57.3 (47.2, 67)	89.9 (88.5, 90.9)	50 (1.3, 98.7)	98.1 (97.5, 98.6)
	Female (2573)	54.5 (46, 62.9)	95.4 (94.5, 96.2)	62.5 (24.5, 91.5)	99.3 (98.9, 99.6)
16	Male (2662)	56.6 (44.7, 67.9)	91.1 (89.9, 92.1)	50 (6.8, 93.2)	98.7 (98.2, 99.1)
	Female (2533)	52.6 (43.1, 61.9)	95.9 (95, 96.7)	80 (28.4, 99.5)	99.4 (99, 99.6)
17	Male (2645)	59.7 (47.5, 71.1)	91.5 (90.3, 92.5)	50 (6.8, 93.2)	98.7 (98.2, 99.1)
	Female (2556)	47.4 (37.2, 57.8)	96.2 (95.3, 96.9)	50 (15.7, 84.3)	99.6 (99.2, 99.8)
18	Male (2654)	58.5 (44.1, 71.9)	91.2 (90, 92.3)	50 (11.8, 88.2)	99.1 (98.6, 99.4)
	Female (2538)	40.7 (30.5, 51.5)	95.8 (95, 96.6)	28.6 (3.7, 71)	99.3 (98.9, 99.6)
19	Male (2654)	67.2 (54, 78.7)	91.8 (90.7, 92.8)	100 (2.5, 100)	99.2 (98.8, 99.5)
	Female (2536)	61.4 (50.1, 71.9)	94.9 (94, 95.7)	66.7 (22.3, 95.7)	99.7 (99.4, 99.9)
20	Male (2479)	67.9 (54, 79.7)	92 (90.8, 93)	100 (2.5, 100)	99.2 (98.7, 99.5)
	Female (2367)	50 (38.6, 61.4)	94.9 (93.9, 95.8)	66.7 (9.4, 99.2)	99.4 (99, 99.6)
21	Male (2250)	58.9 (45, 71.9)	90.8 (89.6, 92)	.	.
	Female (2143)	54 (43, 64.8)	94.5 (93.4, 95.4)	66.7 (9.4, 99.2)	99.2 (98.7, 99.5)
22	Male (1829)	40 (23.9, 57.9)	92.3 (90.9, 93.4)	.	.
	Female (1681)	50 (36.8, 63.2)	93.6 (92.3, 94.8)	25 (0.6, 80.6)	99.3 (98.8, 99.7)

*SAM = severe acute malnutrition. MAM = moderate acute malnutrition. * percent (%) correctly diagnosed as MAM; + percent (%) correctly diagnosed as normal*

Table 8: Spearman's Coefficient of Correlation Between MUAC and WHZ by Each Visit and Sex, Pujehun District, Sierra Leone, 2016-2018

Visit	Male (n)	Female (n)
1	0.21 (1123)***	0.18 (1522)***
2	0.46 (1027)***	0.45 (1406)***
3	0.58 (990)***	0.55 (1370)***
4	0.66 (953)***	0.65 (1301)***
5	0.73 (871)***	0.69 (1170)***
6	0.72 (347)***	0.70 (829)***
7	0.68 (225)***	0.70 (583)***
8	0.73 (150)***	0.66 (392)***
9	0.70 (84)***	0.65 (271)***
10	0.78 (18)***	0.78 (176)***
11	- 0.50 (3)	0.59 (50)***
12	.	0.61 (18)**
13	.	0.30 (5)

Note. p<0.001 ***, p<0.01 **, p <0.05 *

Table 9: Cohen's Kappa Coefficient (k) for MUAC and WHZ in Diagnosing SAM and MAM by Sex and Age, Pujehun District, Sierra Leone, 2016-2018

		WHZ MAM	WHZ SAM	TOTAL
All Children			*k = 0.23*	
MUAC MAM		2741	372	3113
MUAC SAM		407	212	619
	TOTAL	3148	584	3732
Male			*k = 0.24*	
MUAC MAM		1498	298	1796
MUAC SAM		144	123	267
	TOTAL	1642	421	2063
Female			*k = 0.24*	
MUAC MAM		1243	74	1317
MUAC SAM		263	89	352
	TOTAL	1506	163	1669
Age ≤ 24 months			*k = 0.24*	
MUAC MAM		2422	286	2708
MUAC SAM		379	185	564
	TOTAL	2801	471	3272
Age ≥ 25 months			*k = 0.19*	
MUAC MAM		263	74	337
MUAC SAM		25	24	49
	TOTAL	288	98	386

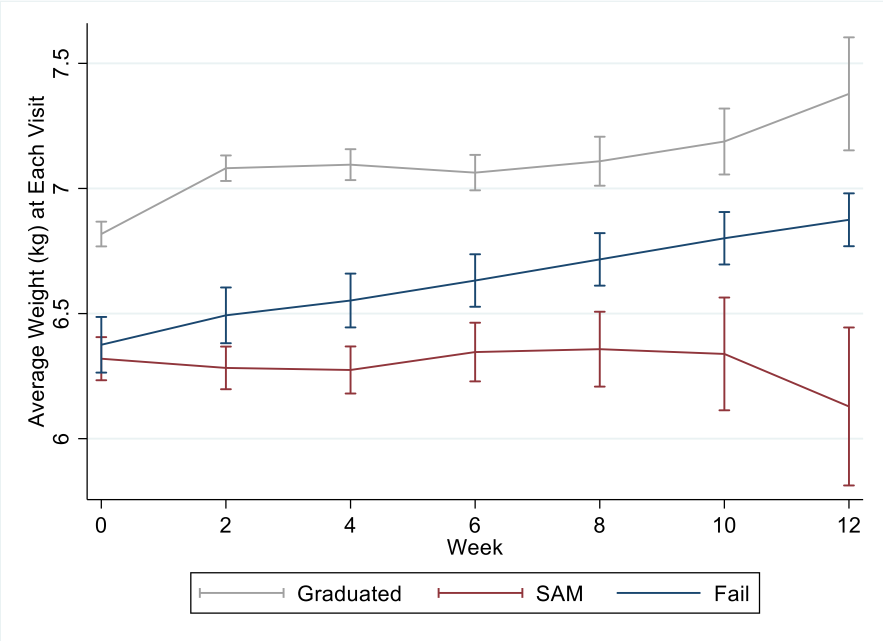
SAM: Severe Acute Malnutrition; MUAC: mid-upper arm circumference; WHZ: weight-for-height z-score; MAM = moderate acute malnutrition.

Table 10: Sensitivity and Specificity of MAM and SAM Diagnosis by WHZ versus MUAC for Female and Male Children Using MUAC as Reference, Pujehun District, Sierra Leone, 2016-2018

By visit and sex (n)		MAM Sensitivity*	MAM Specificity+	SAM Sensitivity*	SAM Specificity+
		% (95% Confidence Interval)			
1	Male (1123)	.	.	.	.
	Female (1522)	.	.	.	.
2	Male (1027)	39.8 (36.1, 43.7)	75.4 (70.6, 79.8)	40.7 (29.9, 52.2)	93.6 (91.8, 95)
	Female (1406)	19.9 (17.4, 22.5)	81.8 (77.8, 85.4)	9.2 (4.7, 15.8)	99 (98.3, 99.5)
3	Male (990)	38.1 (33.9, 42.5)	84.5 (80.9, 87.6)	35.2 (22.7, 49.4)	95 (93.4, 96.3)
	Female (1370)	21.1 (18.3, 24.1)	87.3 (84.3, 89.9)	14.6 (8.4, 22.9)	99.4 (98.8, 99.7)
4	Male (953)	40.2 (35.2, 45.3)	83.2 (79.9, 86.2)	36.2 (24.0, 49.9)	96.4 (95, 97.5)
	Female (1301)	23.3 (20.0, 26.9)	91.1 (88.8, 93.2)	15.2 (8.6, 24.2)	99.5 (98.9, 99.8)
5	Male (871)	45.6 (39.9, 51.3)	85 (81.8, 87.8)	45.7 (30.9, 61)	97.5 (96.1, 98.4)
	Female (1170)	23.8 (20.2, 27.8)	92.5 (90.3, 94.4)	20.5 (12, 31.6)	99.4 (98.7, 99.7)
6	Male (534)	47.6 (40.6, 54.6)	85.1 (80.7, 88.7)	48.6 (31.9, 65.6)	96.8 (94.8, 98.1)
	Female (829)	23.6 (19.5, 28.1)	92.5 (89.6, 94.8)	30.6 (18.3, 45.4)	99.1 (98.2, 99.6)
7	Male (347)	48.6 (40.1, 57.1)	82.4 (76.5, 87.4)	20 (4.3, 48.1)	94 (90.8, 96.3)
	Female (583)	23.3 (18.3, 29.0)	88.8 (84.9, 92.0)	15.8 (6.0, 31.3)	98.9 (97.6, 99.6)
8	Male (225)	41 (30, 52.7)	83.7 (76.7, 89.3)	40 (12.2, 73.8)	95.8 (92.2, 98.1)
	Female (392)	23.1 (16.7, 30.5)	93.2 (89.2, 96.1)	45.5 (16.7, 76.6)	99.7 (98.5, 100)
9	Male (150)	58.6 (44.9, 71.4)	77.2 (67.2, 85.3)	28.6 (3.7, 71)	96.5 (92, 98.9)
	Female (271)	22.2 (14.1, 32.2)	91.2 (86.0, 94.9)	41.7 (15.2, 72.3)	100 (98.6, 100)
10	Male (84)	66.7 (49, 81.4)	79.2 (65, 89.5)	33.3 (0.8, 90.6)	98.8 (93.3, 100)
	Female (176)	32.7 (20.7, 46.7)	89.3 (82.3, 94.2)	20 (2.5, 55.6)	98.8 (95.7, 99.9)
11	Male (18)	33.3 (4.3, 77.7)	100 (73.5, 100)	100 (2.5, 100)	100 (80.5, 100)
	Female (50)	15.0 (3.2, 37.9)	96.7 (82.8, 99.9)	50 (1.3, 98.7)	97.9 (88.9, 99.9)
12	Male (3)	.	.	.	.
	Female (18)	16.7 (0.4, 64.1)	100 (73.5, 100)	.	.
13	Male (0)	.	.	.	.
	Female (5)	0 (0, 97.5)	75 (19.4, 99.4)	.	.

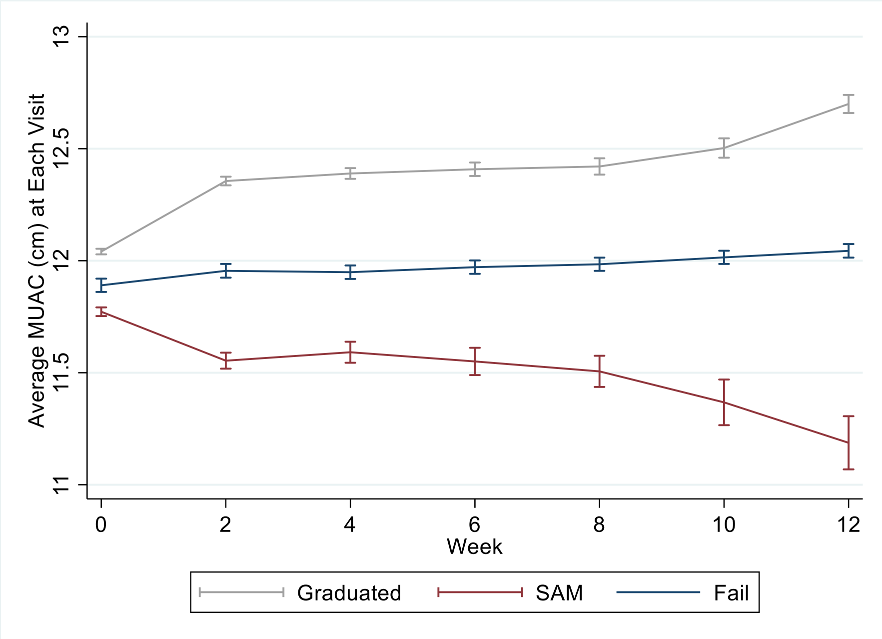
*SAM = severe acute malnutrition. MAM = moderate acute malnutrition. * percent (%) correctly diagnosed as MAM; + percent (%) correctly diagnosed as normal*

Figure 1: Average Weight (kg) of Children Enrolled in a Supplementary Feeding Program at Each Ration Collection Visit, by Outcome, Pujehun District, Sierra Leone, 2016-2018



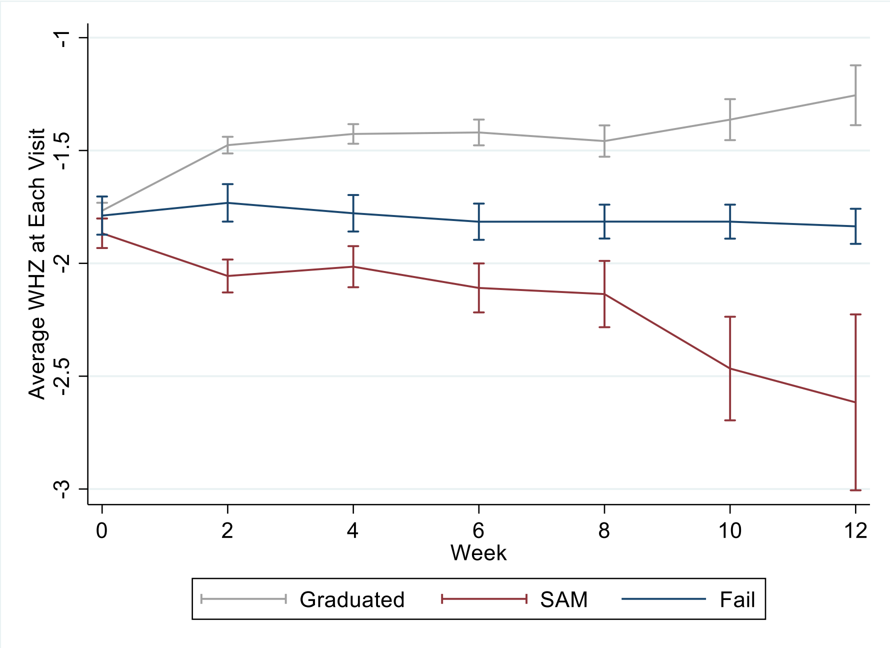
SAM: Severe Acute Malnutrition – children who deteriorated to SAM after being admitted as MAM; FAIL: children who did not respond to treatment after 12 weeks enrolled in the program. Bars represent 95% confidence intervals around mean at each time point.

Figure 2: Average MUAC (cm) of Children Enrolled in a Supplementary Feeding Program at Each Ration Collection Visit, by Outcome, Pujehun District, Sierra Leone, 2016-2018



SAM: Severe Acute Malnutrition – children who deteriorated to SAM after being admitted as MAM; FAIL: children who did not respond to treatment after 12 weeks enrolled in the program. MUAC: mid-upper arm circumference. Bars represent 95% confidence intervals around mean at each time point.

Figure 3: Average WHZ of Children Enrolled in a Supplementary Feeding Program at Each Ration Collection Visit, by Outcome, Pujehun District, Sierra Leone, 2016-2018



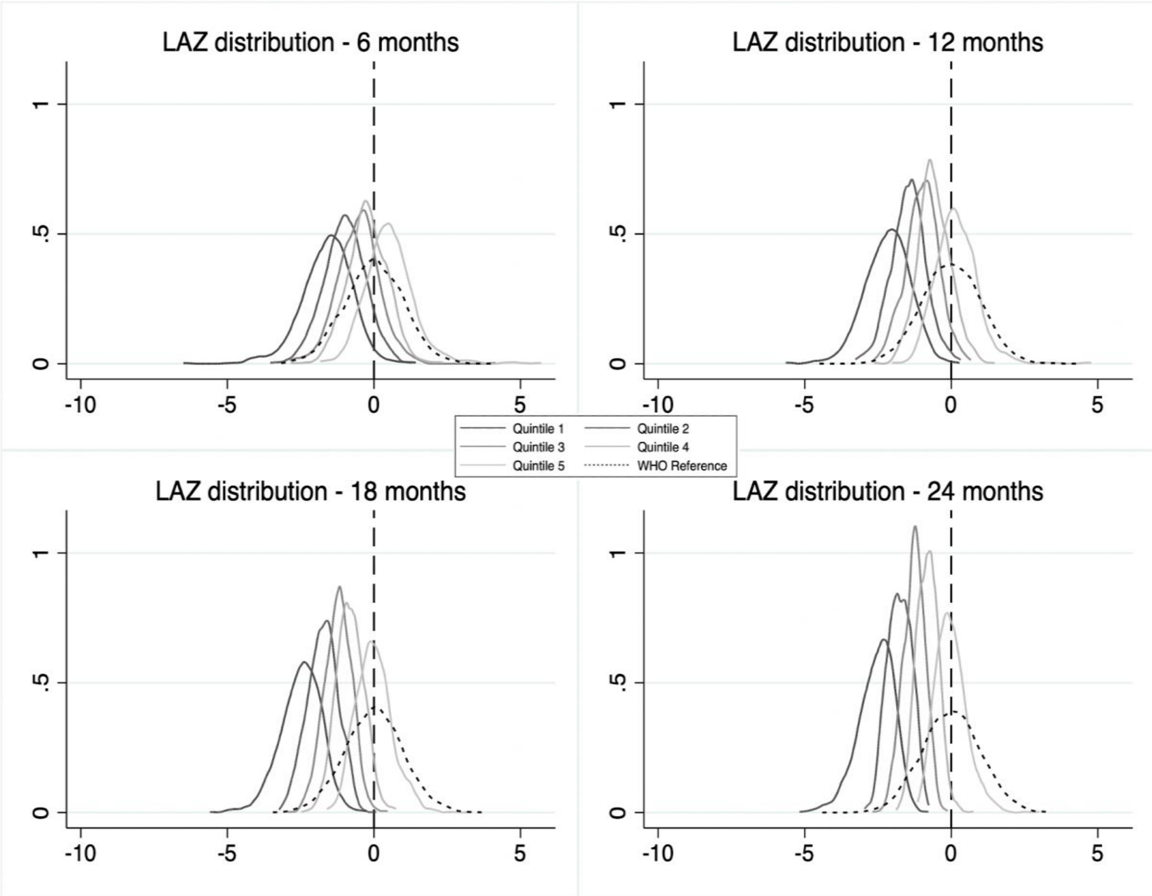
SAM: Severe Acute Malnutrition – children who deteriorated to SAM after being admitted as MAM; FAIL: children who did not respond to treatment after 12 weeks enrolled in the program. WHZ: weight-for-height z-score. Bars represent 95% confidence intervals around mean at each time point.

Table 11. Sample Characteristics by Quintile of Attained Length (cm at Last Measurement), Sanmatenga Province, Burkina Faso, 2014-2016

	Main Dataset					
	Overall (N=5,039)	Quintile 1 (n=1,028)	Quintile 2 (n=999)	Quintile 3 (n=1,010)	Quintile 4 (n=1,009)	Quintile 5 (n=993)
Total # Observations	108,580	21,996	21,489	21,784	21,825	21,486
Female Sex	2,484 (49.3)	610 (59.3)	522 (52.3)	505 (50.0)	465 (46.1)	382 (38.5)
Observations per Child	21.55 ± 0.68	21.40 ± 0.76	21.51 ± 0.69	21.57 ± 0.65	21.63 ± 0.64	21.64 ± 0.63
Linear Growth Velocity (cm/month)	0.94 ± 0.59	0.85 ± 0.59	0.91 ± 0.58	0.94 ± 0.58	0.98 ± 0.58	1.02 ± 0.58
Age at First Measurement	6.16 ± 0.58	6.10 ± 0.59	6.13 ± 0.58	6.13 ± 0.57	6.19 ± 0.58	6.23 ± 0.59
Age at Last Measurement	26.68 ± 0.75	26.48 ± 0.86	26.61 ± 0.76	26.67 ± 0.74	26.80 ± 0.66	26.86 ± 0.65
Length (cm) at First Measurement	65.62 ± 2.58	63.06 ± 1.98	64.59 ± 1.71	65.64 ± 1.78	66.55 ± 1.72	68.36 ± 2.06
Length (cm) at Last Measurement	84.96 ± 3.25	80.43 ± 1.66	83.32 ± 0.52	85.01 ± 0.49	86.71 ± 0.51	89.49 ± 1.57
	Sensitivity Analysis Dataset					
	Overall (N=1,158)	Quintile 1 (n=236)	Quintile 2 (n=228)	Quintile 3 (n=231)	Quintile 4 (n=232)	Quintile 5 (n=231)
Total # Observations	25,476	5,192	5,016	5,082	5,104	5,082
Female Sex	532 (45.9)	138 (58.5)	115 (50.4)	106 (45.9)	96 (41.4)	77 (33.3)
Observations per Child	22.0 ± 0.00	22.0 ± 0.00	22.0 ± 0.00	22.0 ± 0.00	22.0 ± 0.00	22.0 ± 0.00
Linear Growth Velocity (cm/month)	0.94 ± 0.56	0.84 ± 0.56	0.91 ± 0.55	0.94 ± 0.56	0.97 ± 0.55	1.02 ± 0.57
Age at First Measurement	6.00 ± 0.38	5.94 ± 0.38	5.96 ± 0.36	5.99 ± 0.42	6.05 ± 0.36	6.07 ± 0.35
Age at Last Measurement	27.00 ± 0.40	26.90 ± 0.41	26.94 ± 0.43	26.95 ± 0.43	27.02 ± 0.36	27.04 ± 0.37
Length (cm) at First Measurement	65.52 ± 2.50	62.98 ± 2.06	64.38 ± 1.68	65.49 ± 1.54	66.58 ± 1.67	68.18 ± 1.78
Length (cm) at Last Measurement	85.23 ± 3.26	80.68 ± 1.62	83.47 ± 0.54	85.36 ± 0.55	86.98 ± 0.49	89.71 ± 1.51

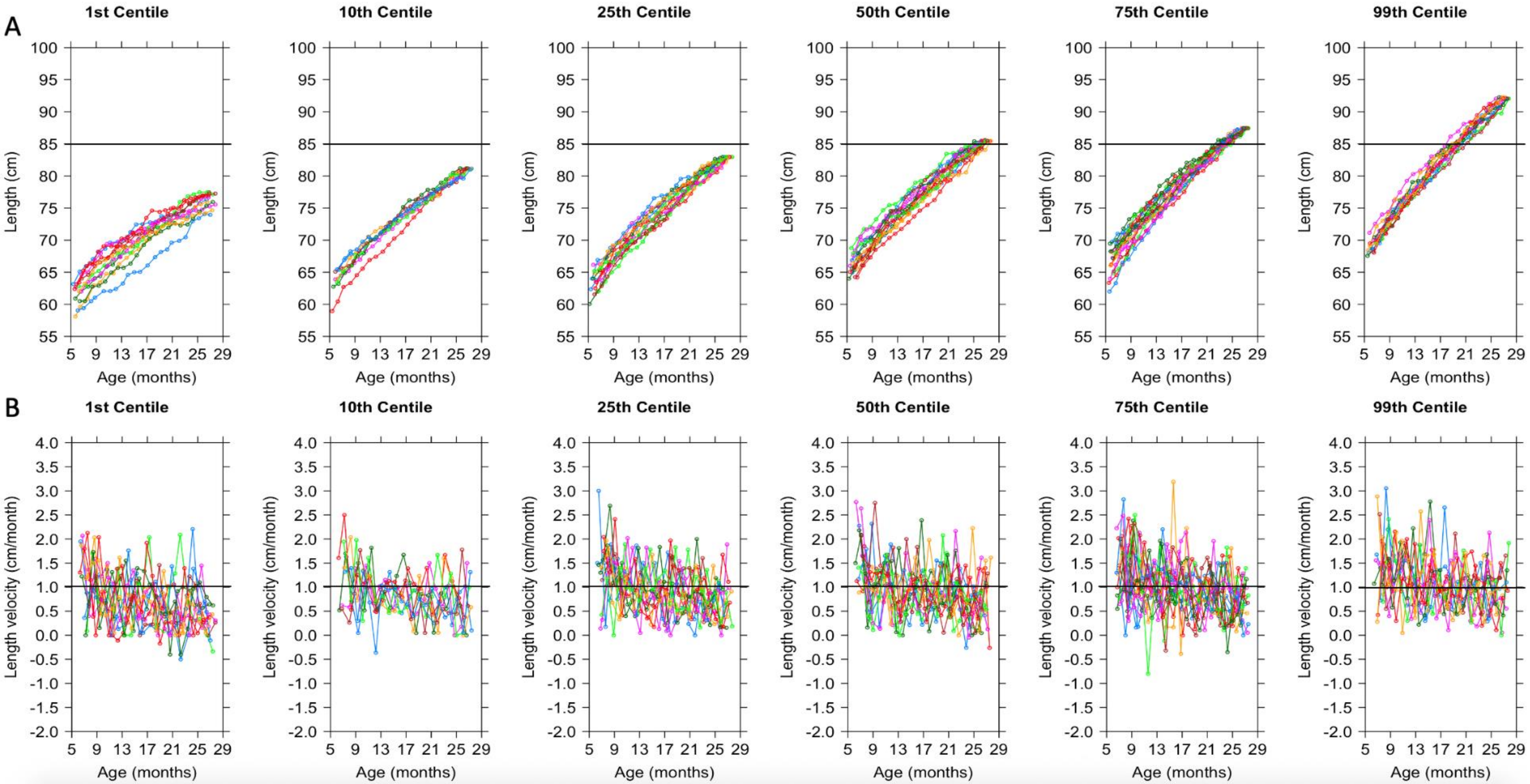
Notes: Values are mean ± SD or n (%)

Figure 4: Kernel-Density Plots of Length-for-Age Z-Scores (LAZ) Among Children in Sanmatenga Province, Burkina Faso, 2014-2016, in Each Quintile of Attained Length (cm) at Selected Ages, Compared to WHO Growth Curve Distribution.



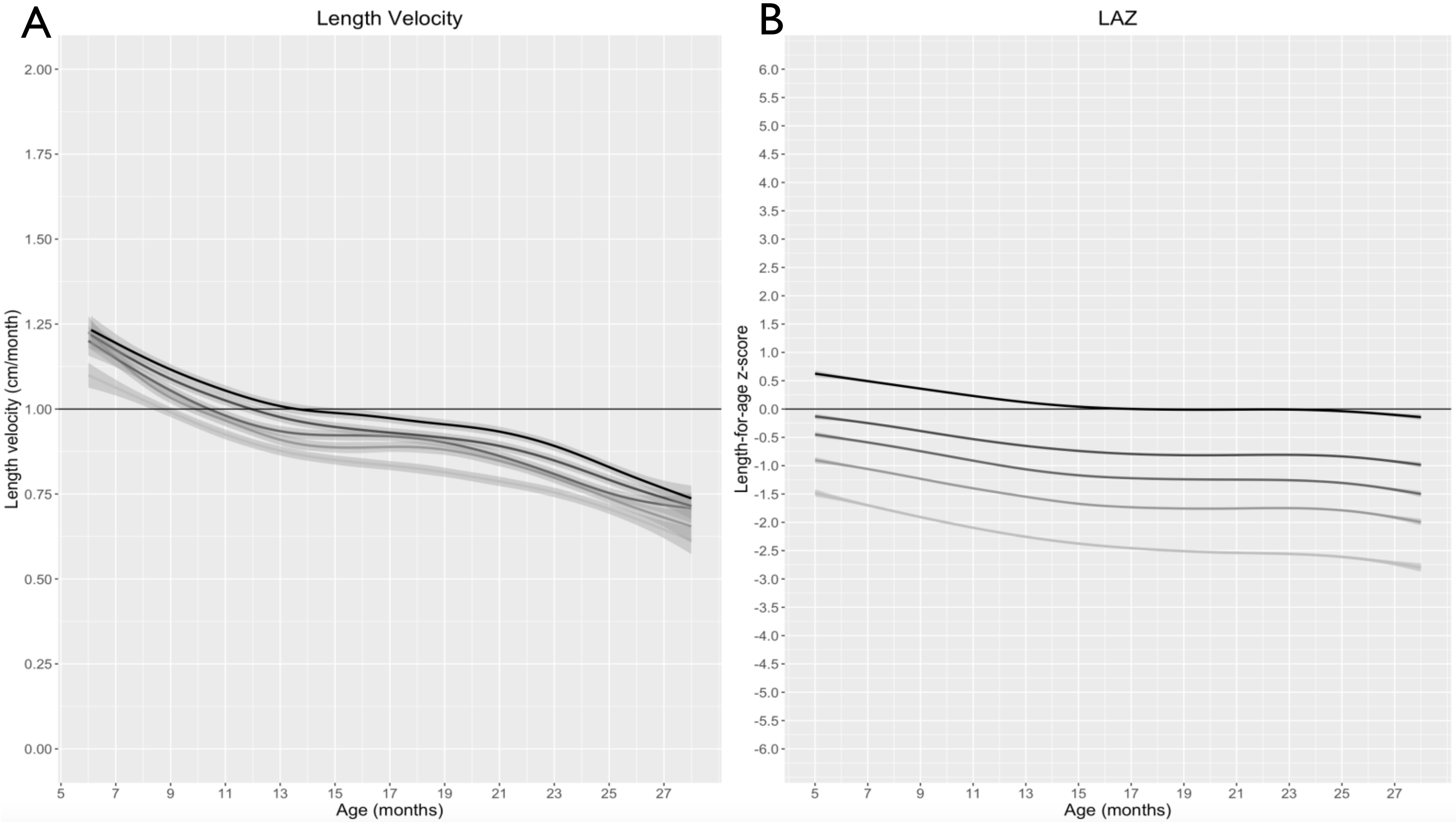
Note:World Health Organization normal distribution simulated using a hypothetical z-score distribution with a mean of zero and standard deviation of one.

Figure 5: (A) Length (cm) and (B) Length Velocity (cm/month) by Age Among Children from Selected Centiles of Overall Attained Length, Sanmatenga Province, Burkina Faso, 2014-2016.



Note: Each colored line represents the growth curve over time of one individual child. Horizontal bars indicate average attained length overall (A) and average length velocity (B).

Figure 6: Locally Estimated Scatterplot Smoothing (LOESS) Curves of (A) Length Velocity (cm/month) and (B) Length-for-Age Z-Scores (LAZ) by Age Among Children in Sanmatenga Province, Burkina Faso, 2014-2016, from Quintiles of Overall Attained Length



Note: Quintiles presented in order from bottom to top: Quintile 1 (lowest), Quintile 2, Quintile 3, Quintile 4, Quintile 5 (highest).

Table 12: Descriptive Statistics of Regression Diagnostics From Individual Linear Spline Regressions of Length on Age Among Children in Sanmatenga Province, Burkina Faso, 2014-2016

	Overall	**Quintile 1**	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**
	N=5,039	n=1,028	n=999	n=1,010	n=1,009	n=993
Intercept	57.88 ± 3.84	56.07 ± 3.46	57.12 ± 3.17	57.70 ± 3.64	58.52 ± 3.95	60.03 ± 3.71
R^2	1.00 ± 0.00	0.99 ± 0.00	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00
Beta, 6-8 months	1.27 ± 0.40	1.16 ± 0.37	1.24 ± 0.36	1.30 ± 0.39	1.31 ± 0.44	1.35 ± 0.40
Beta, 9-11 months	1.02 ± 0.30	0.95 ± 0.30	1.00 ± 0.29	1.01 ± 0.29	1.06 ± 0.27	1.11 ± 0.30
Beta, 12-14 months	0.94 ± 0.28	0.86 ± 0.27	0.89 ± 0.27	0.94 ± 0.27	0.99 ± 0.26	1.04 ± 0.27
Beta, 15-17 months	0.92 ± 0.27	0.82 ± 0.28	0.89 ± 0.26	0.93 ± 0.27	0.94 ± 0.25	1.01 ± 0.26
Beta, 18-20 months	0.88 ± 0.26	0.77 ± 0.28	0.87 ± 0.25	0.89 ± 0.25	0.92 ± 0.25	0.97 ± 0.24
Beta, 21-23 months	0.82 ± 0.26	0.74 ± 0.28	0.81 ± 0.25	0.81 ± 0.25	0.86 ± 0.24	0.91 ± 0.25
Beta, 24-28 months	0.70 ± 0.51	0.62 ± 0.69	0.65 ± 0.49	0.71 ± 0.44	0.73 ± 0.28	0.79 ± 0.54
F-statistic	895.18 ± 539.27	742.23 ± 462.74	841.24 ± 518.16	865.44 ± 510.16	984.45 ± 576.42	1047.33 ± 568.72

Note: Values are mean ± standard deviation

Figure 7: Scatterplot of R2 from Linear Spline Regressions of Length on Age Among Children on Sanmatenga Province, Burkina Faso, 2014-2016

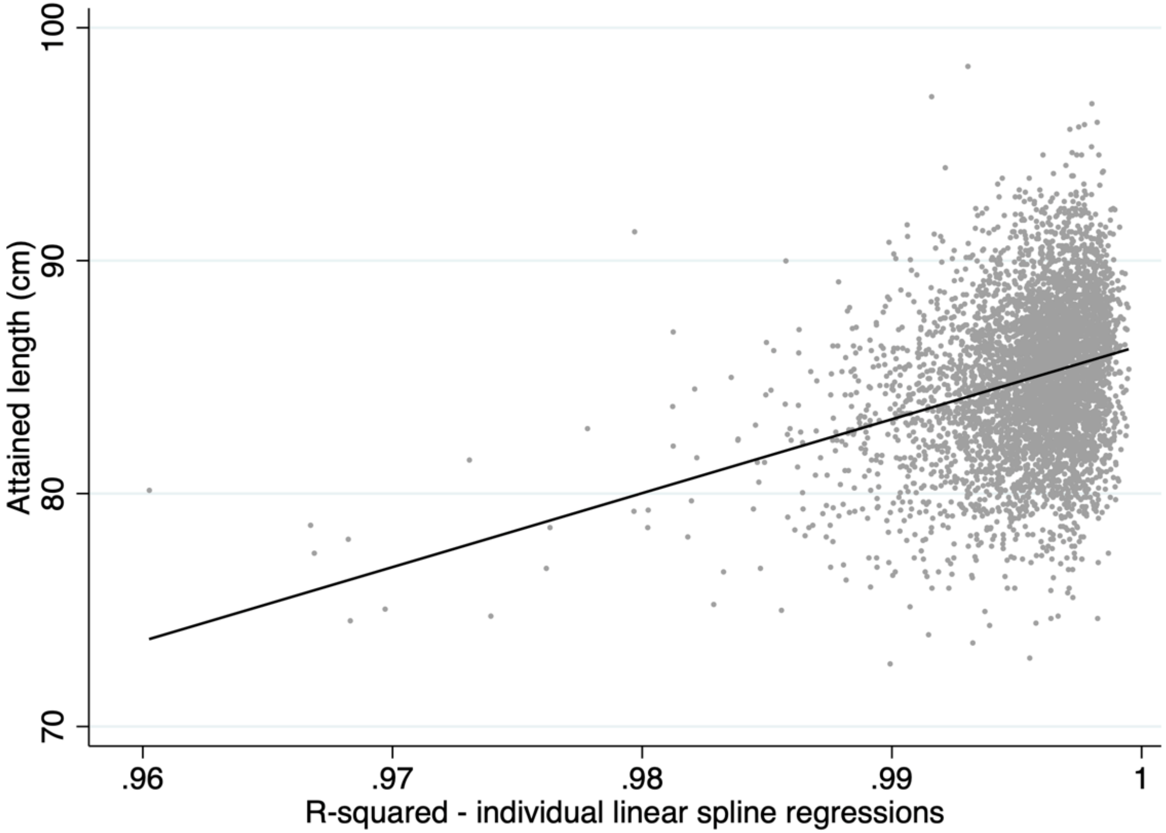


Table 13: Beta Coefficients and (95% Confidence Intervals) from Linear Regression Models of Attained Length on Model Parameters from Individual Growth Models for Children in Sanmatenga Province, Burkina Faso, 2014-2016

	Beta Coefficients (95% Confidence Intervals)								
R^2 (Smoothness)	3.10	3.37	3.3	2.66	2.09	1.73	1.17	0.57	0.41
	(2.80, 3.41)	*(3.11, 3.63)*	*(3.06, 3.54)*	*(2.47, 2.84)*	*(1.94, 2.25)*	*(1.58, 1.89)*	*(1.03, 1.31)*	*(0.44, 0.69)*	*(0.30, 0.53)*
Initial length		0.61	0.67	0.95	0.98	0.96	0.94	0.96	0.96
		(0.58, 0.64)	*(0.64, 0.70)*	*(0.93, 0.97)*	*(0.96, 1.00)*	*(0.94, 0.97)*	*(0.93, 0.96)*	*(0.94, 0.97)*	*(0.95, 0.97)*
Average velocity 6-8 months			2.26 *(2.09, 2.44)*	3.71 *(3.57, 3.85)*	3.68 *(3.56, 3.79)*	3.59 *(3.48, 3.70)*	3.47 *(3.37, 3.58)*	3.44 *(3.35, 3.53)*	3.43 *(3.35, 3.51)*
Average velocity 9-11 months				6.3 *(6.10, 6.49)*	7.18 *(7.01, 7.35)*	7.01 *(6.85, 7.18)*	6.84 *(6.69, 6.99)*	6.75 *(6.63, 6.88)*	6.71 *(6.59, 6.83)*
Average velocity 12-14 months					3.86 *(3.70, 4.02)*	4.15 *(4.00, 4.31)*	4.06 *(3.92, 4.20)*	3.94 *(3.82, 4.06)*	3.91 *(3.79, 4.02)*
Average velocity 15-17 months						1.76 *(1.60, 1.92)*	2.26 *(2.11, 2.41)*	2.21 *(2.08, 2.34)*	2.20 *(2.08, 2.32)*
Average velocity 18-20 months							2.38 *(2.23, 2.53)*	2.91 *(2.78, 3.04)*	2.90 *(2.78, 3.02)*
Average velocity 21-23 months								2.79 *(2.66, 2.91)*	3.06 *(2.94, 3.18)*
Average velocity 24-28 months									0.85 *(0.79, 0.91)*

Note: All coefficients are significant at the 1% level ($p<0.01$). Sensitivity analyses using alternative functional forms for the individual regression models (linear polynomial model with cubic term for age, restricted cubic splines, linear splines with four knots) give a range of 2.44-2.83 for R^2, when attained length is regressed on R^2, with 95% confidence intervals spanning 2.39-3.09.

Table 14: Selected Characteristics of Children Enrolled in a Supplemental Feeding Program Who Deteriorated to SAM, Failed to Respond, or Graduated, Pujehun District, Sierra Leone, 2016-2018

	SAM	FAIL	Recovered	Total[2]
Characteristics	**n (%)[1] or mean ± SD**			
n	498 (21%)[3]	259 (11%)	1675 (69%)	2432 (100%)
Child is male	194 (39%)	90 (35%)	738 (44%)	1127 (43%)
Age (in months) at enrollment ***	12.4 ± 6.9	11.5 ± 8.2	13.7 ± 8	13.2 ± 0
Breastfeeding at enrollment ***	403 (81%)	230 (89%)	1292 (77%)	1925 (79%)
Average weight (kg) at enrollment ***	6.3 ± 0.9	6.4 ± 1	6.8 ± 1	6.7 ± 0
Average length (cm) at enrollment ***	66.4 ± 5.6	66.5 ± 6.3	68.7 ± 6.2	68 ± 0
Average MUAC (cm) at enrollment ***	11.8 ± 0.2	11.9 ± 0.3	12 ± 0.3	12 ± 0
Weight-for-age z-score at enrollment ***	-3.1 ± 0.7	-2.9 ± 0.8	-2.8 ± 0.8	-2.9 ± 0
Length-for-age z-score at enrollment ***	-3 ± 1.1	-2.7 ± 1.3	-2.7 ± 1.3	-2.8 ± 0
Caregiver age	27.8 ± 7.4	28 ± 8.3	27.9 ± 8.1	27.9 ± 0
Marital status:				
Married	431 (86%)	228 (88%)	1419 (85%)	2078 (85%)
Separated **	14 (2.8%)	6 (2.3%)	24 (1.4%)	44 (2%)
Single	54 (11%)	24 (9%)	224 (13%)	302 (12%)
Caregiver received no formal education	249 (50%)	154 (60%)	919 (55%)	1322 (54%)
Number of deceased siblings**	0.9 ± 1.3	0.9 ± 1.3	0.7 ± 1.3	0.8 ± 0
Number of living siblings	2 ± 1.7	2.2 ± 1.8	2 ± 1.7	2 ± 1.7
Socioeconomic quantiles				
Lowest	115 (23%)	52 (20%)	320 (19%)	487 (20%)
Medium	88 (18%)	57 (22%)	330 (20%)	475 (20%)
Highest	90 (18%)	49 (19%)	321 (19%)	460 (19%)
Transferred from SAM ***	218 (44%)	80 (31%)	320 (19%)	618 (25%)
Rainy season at enrollment	268 (54%)	144 (56%)	1075 (64%)	1487 (61%)
Rainy season at exit	270 (54%)	157 (61%)	1156 (69%)	1583 (65%)

*SAM: Severe Acute Malnutrition – children who deteriorated to SAM after being admitted as MAM; FAIL: children who did not respond to treatment after 12 weeks enrolled in the program; SD: standard deviation[1] Percent represents percent of children within the outcome, not % of the study population; this is because of the very different samples within each outcome. [2]This is the total number of children included in this analysis, not the entire study population (please see appendices for additional information). [3]This is the only percent that is of the study sample and not specific to the outcome. Chi-square (for categorical variables) or F-statistic (for continuous variables: p-value *** < .01 ** <.05*

Table 15: Multinomial Logistic Regression Comparing Children Who Deteriorated to SAM And Children Who Graduated, or Children Who Failed to Respond and Children Who Graduated, Pujehun District, Sierra Leone, 2016-2018

	Model 1: Semi-adjusted				Model 2: Fully Adjusted for Morbidities			
	SAM v. Graduated		Fail v. Graduated		SAM v. Graduated		Fail v. Graduated	
	RRR (95% CI)	P	RRR (95% CI)	P	RRR (95% CI)	P	RRR (95% CI)	P
CSB+ w/oil (ref.)	*Ref.*		*Ref.*		*Ref.*		*Ref.*	
CSWB w/oil	1.01 (0.78, 1.3)	0.96	1.10 (0.79, 1.54)	0.58	1.06 (0.82, 1.38)	0.65	1.12 (0.79, 1.6)	0.52
SC+A	0.94 (0.7, 1.28)	0.71	0.91 (0.67, 1.25)	0.56	1.08 (0.83, 1.39)	0.58	0.93 (0.68, 1.28)	0.66
RUSF	1.1 (0.87, 1.4)	0.43	0.75 (0.51, 1.11)	0.15	1.4 (1.06, 1.86)	0.02	0.78 (0.51, 1.18)	0.24
Sex (male)	0.86 (0.7, 1.06)	0.15	0.71 (0.52, 0.97)	0.03	0.87 (0.69, 1.1)	0.25	0.73 (0.54, 0.98)	0.04
Age at enrollment (months)	0.99 (0.98, 1)	0.09	0.97 (0.95, 0.99)	0.00	0.98 (0.96, 0.99)	0.01	0.97 (0.94, 0.99)	0.00
Transfer from SAM	2.35 (1.82, 3.02)	0.00	1.65 (1.23, 2.21)	0.00	2.39 (1.72, 3.33)	0.00	1.64 (1.2, 2.24)	0.00
Average MUAC (cm) at enrollment	0.02 (0.01, 0.03)	0.00	0.14 (0.08, 0.25)	0.00	0.02 (0.01, 0.03)	0.00	0.14 (0.08, 0.27)	0.00
Morbidity at Enrollment								
Fever at Enrollment					1.1 (0.71, 1.71)	0.67	1.11 (0.78, 1.59)	0.55
Diarrhea at Enrollment					0.51 (0.23, 1.15)	0.11	0.69 (0.43, 1.09)	0.11
Vomit at Enrollment					0.60 (0.25, 1.41)	0.24	0.60 (0.27, 1.35)	0.22
Cough at Enrollment					0.57 (0.37, 0.87)	0.01	0.88 (0.59, 1.31)	0.52
Morbidity at Exit								
Fever at Exit					3.80 (2.79, 5.18)	0.00	1.68 (1.12, 2.51)	0.01
Diarrhea at Exit					7.41 (4.16, 13.21)	0.00	2.24 (0.98, 5.08)	0.05
Vomit at Exit					5.32 (2.1, 13.49)	0.00	4.47 (1.81, 11.06)	0.00
Cough at Exit					2.00 (1.26, 3.16)	0.00	1.13 (0.7, 1.82)	0.63

CSB+ w/oil: Corn Soy Blend Plus w/ fortified vegetable oil; CSWB: Corn Soy Whey Blend; SC+A: Super Cereal Plus with Amylase RUSF: Ready to use supplementary food; MUAC: Mid-upper Arm Circumference; RRR: Relative Risk Ratio; SAM: Severe Acute Malnutrition. P: p-value

Table 16: Multinomial Logistic Regression Comparing Children Who Deteriorated to SAM and Children Who Graduated, or Children Who Failed to Respond and Children Who Graduated

	Model 3: Fully Adjusted for HH Characteristics			
	SAM v. Graduated		Fail v. Graduated	
	RRR (95% CI)	P	RRR (95% CI)	P
CSB+ w/oil (ref.)	*Ref.*		*Ref.*	
CSWB w/oil	1.03 (0.77, 1.38)	0.83	1.03 (0.7, 1.53)	0.87
SC+A	0.99 (0.71, 1.38)	0.96	0.94 (0.69, 1.29)	0.72
RUSF	1.07 (0.81, 1.4)	0.64	0.74 (0.51, 1.08)	0.12
Sex (male)	0.97 (0.76, 1.23)	0.81	0.63 (0.42, 0.95)	0.03
Age at enrollment (months)	0.99 (0.98, 1)	0.12	0.97 (0.95, 0.99)	0.01
Transfer from SAM	2.42 (1.85, 3.16)	0.00	1.70 (1.28, 2.25)	0.00
Average MUAC (cm) at enrollment	0.02 (0.01, 0.03)	0.00	0.14 (0.07, 0.25)	0.00
Marital Status				
Married	*Ref.*		*Ref.*	
Separated	1.92(0.99, 3.73)	0.05	1.83 (0.72, 4.63)	0.20
Single	0.92(0.61, 1.38)	0.69	0.82 (0.55, 1.21)	0.31
Household Composition				
Males <5 in household	0.89 (0.77, 1.03)	0.13	1.10 (0.92, 1.32)	0.28
Females <5 in household	1.06 (0.96, 1.18)	0.26	0.99 (0.85, 1.15)	0.91
Males 6-15 y.o in household	1.07 (0.97, 1.17)	0.16	1.12 (1.05, 1.19)	0.00
Females 6-15 y.o. in household	0.87 (0.78, 0.97)	0.02	0.86 (0.73, 1.02)	0.08
Males 16-65 y.o. in household	0.99 (0.86, 1.13)	0.85	0.90 (0.77, 1.05)	0.17
Females 16-65 y.o. in household	1.00 (0.92, 1.09)	0.98	1.03 (0.91, 1.17)	0.62
Males >65 y.o. in household	1.09 (0.66, 1.79)	0.75	1.04 (0.68, 1.58)	0.86
Females >65 y.o. in household	0.85 (0.59, 1.22)	0.37	1.20 (1.01, 1.44)	0.04
Food Insecurity Score	1.00 (0.98, 1.01)	0.81	1.00 (0.98, 1.02)	0.90
Number of deceased siblings	1.05 (0.97, 1.14)	0.26	1.06 (0.96, 1.17)	0.27
Number of living siblings	0.97 (0.9, 1.05)	0.48	1.04 (0.96, 1.12)	0.39
SES				
Lowest	*Ref.*		*Ref.*	
Mid-low	0.89 (0.62, 1.27)	0.52	0.83 (0.54, 1.28)	0.40
Medium	0.76 (0.53, 1.11)	0.16	1.13 (0.71, 1.79)	0.61
Mid-High	0.82 (0.57, 1.2)	0.31	1.08 (0.66, 1.77)	0.75
Highest	0.84 (0.52, 1.36)	0.49	1.11 (0.76, 1.62)	0.58
Season of Entry	0.78 (0.54, 1.12)	0.18	0.71 (0.47, 1.06)	0.09
Season of Exit	0.57 (0.44, 0.73)	0.00	0.82 (0.51, 1.3)	0.40

CSB+ w/oil: Corn Soy Blend Plus w/ fortified vegetable oil; CSWB: Corn Soy Whey Blend; SC+A: Super Cereal Plus with Amylase RUSF: Ready to use supplementary food; MUAC: Mid-upper Arm Circumference; RRR: Relative Risk Ratio; SAM: Severe Acute Malnutrition. P: p-value

Figure 8: Summary of Percent of Children Ever Experiencing a Morbidity at Enrollment or Exit from Treatment, Pujehun District, Sierra Leone, 2016-2018

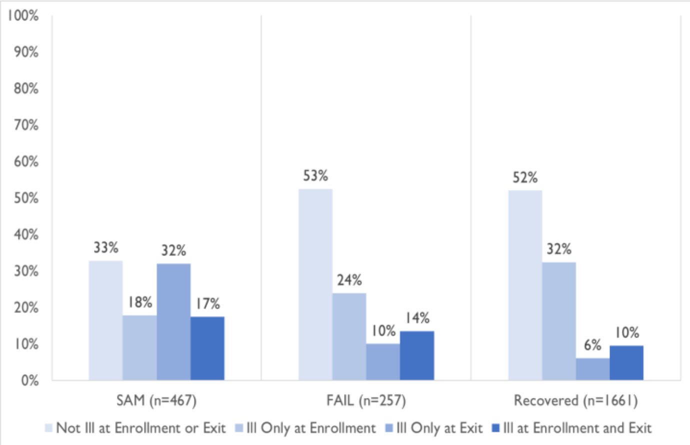


Figure 9: Summary of Percent of Children Experiencing Comorbidities at Enrollment by Outcome, Pujehun District, Sierra Leone, 2016-2018

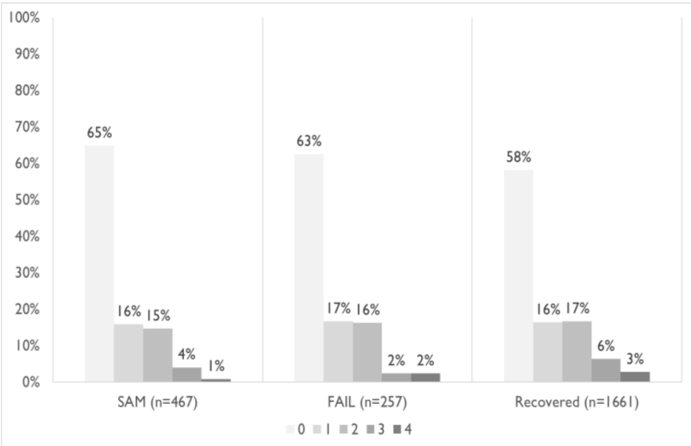
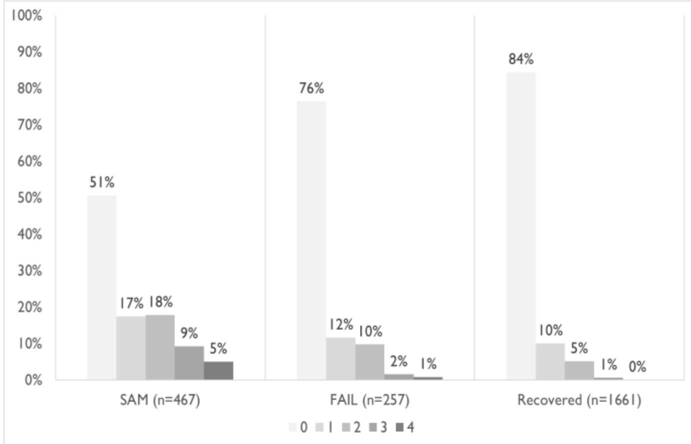


Figure 10: Summary of Percent of Children Experiencing Comorbidities at Exit by Outcome, Pujehun District, Sierra Leone, 2016-2018



APPENDIX 2: QUESTIONS FOR FURTHER RESEARCH

1. Is four weeks an appropriate window for identifying children who may be responding to MAM treatment poorly, and should this trigger specific therapeutic intervention?

2. What may be an appropriate early intervention to assist MAM children who are responding poorly to treatment so that they ultimately recover?

3. What specific feeding behaviors after exit influence sustained recovery from MAM?

4. What household or community-level factors may influence sustained recovery from MAM?

5. What role does illness play in modifying the effect of treatment for MAM? Should incidence of illness affect MAM treatment?

6. What roles do different household members have in the care and support of children diagnosed with MAM both during and after treatment?

7. Is the effect of continuous slow growth versus episodic growth failure on achieved length/height consistent in different contexts?

8. Do safety net or nutrition sensitive programs aimed at improving economic well-being improve the effectiveness of nutrition specific programs, or to what extent do they achieve these goals as stand-alone programs?

9. What is the role of specific household-level care and feeding behaviors in the growth and development in children who are at risk of stunting/stunted and/or acutely malnourished?

10. How does the presence of elder maternal grandmothers in the daily care and support of children under-2 influence their nutritional status?

11. What is the role of elder siblings, especially adolescent girls, in overall child feeding and care, and how does that care influence nutrition outcomes of children under-2?