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Risk Factors for Acute Malnutrition among Children 6-36 months old receiving a Lipid-based Nutrient Supplement

South Darfur, Sudan

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Risk Factors for Acute Malnutrition among Children 6-36 Months Old Receiving a Preventative Supplement

South Darfur, Sudan

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An abstract submitted to the faculty of the
Rollins School of Public Health of Emory University
In partial fulfillment of the requirements for the degree of
Master of Public Health in Global Health
2015

Abstract

Introduction: Despite dietary supplementation, refugees and internally displaced persons in Africa's Sahel are faced with a seasonal doubling of acute malnutrition. This study aims to determine risk factors for acute malnutrition during the hunger gap among 6-36 month old internally displaced persons receiving a dietary supplement for prevention of this outcome in South Darfur, Sudan.

Methods: A 6-month cohort study was conducted from March to October 2011 among 220 6-36 month olds in Gereida Internally Displaced Persons camp, South Darfur, Sudan. Anthropometric indicators of weight, height, and mid-upper arm circumference were collected along with information on illnesses and product adherence, and feeding of the child. This information was analyzed to determine risk factors associated with development of acute malnutrition.

Results: Among our study's participants, 24.8% developed acute malnutrition while receiving Plumpy'doz over the 6-month follow-up. Among children 6-12 months of age, 11/28 (39%) developed acute malnutrition. Those with diarrhea at baseline had 2.7 times the risk of becoming acutely malnourished when adjusting for age and gender (95% Confidence Interval 1.2, 6.4).

Discussion: Nearly 25% of this population developed acute malnutrition while receiving Plumpy'doz to prevent this outcome. Since our study found that risk of developing acute malnutrition was heightened among children who had diarrhea and were less than 1 year of age, it is important for humanitarian actors to consider these factors when implementing blanket supplementary feeding programs to prevent acute malnutrition during the hunger gap.

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Manuscript

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Introduction

Acute malnutrition, defined as a weight-for-height z score (WHZ) of < -2 (WHO growth standards), MUAC < 125 millimeters, and/or presence of bilateral pitting edema, is an important risk to health and life for children under five years of age. Annually, over 52 million children under 5 years old suffer from this condition, with 875,000 dying as a result of acute malnutrition [1] . In humanitarian contexts, the situation is often exacerbated by food shortages, increased risk of infectious diseases, and the impact of conflict and resulting insecurity, which leads to reduced access to services.

In agricultural societies within the African Sahel, there are seasonal variations in acute malnutrition, where the prevalence has been recorded to double or even triple in the

months immediately preceding the harvest [2]. This period, deemed the hunger gap, coincides with the rainy season, and is possibly exacerbated by it, as there is also an increase in the incidence of diarrhea and respiratory infection during the rainy period [3]. Thus, the effect of infection in conjunction with food shortage is associated with the increase in acute malnutrition during the hunger gap [3, 4]. In South Darfur, Sudan, July and August represent the peak of the hunger gap when the prevalence of malnutrition often exceeds the nutritional threshold for an emergency [2].

Blanket supplementary feeding programs (BSFP) are implemented to prevent acute malnutrition during the hunger gap. This intervention provides a dietary supplement to all members of an at-risk group, typically with no individual assessment or follow-up outside of the initial registration and screening. Several authors have assessed ready to use supplementary foods (RUSF) for use in prevention of acute malnutrition [5-16]. RUSFs contain essential fatty acids and micronutrients to promote growth in young children. These supplements have low moisture content, and require no preparation, so the risk of bacterial contamination is reduced.

Plumpy'Doz (PD) is an RUSF that meets the micronutrient needs of children aged 6-36 months. The caregivers of children in our study were advised to ensure their child consumed the amount specified for prevention of acute malnutrition: a daily dose of 46.3 grams, or 3 teaspoons per day [17]. The results of studies determining PD's capabilities to prevent acute malnutrition have been overall positive, but inconclusive [5, 6, 9, 10, 16]. A cluster-randomized controlled trial of 1,038 children 6 to 36 month olds in Chad found no difference in incidence of acute malnutrition or mean WHZ between a group receiving PD and a control group. The author offered explanation for the absence of effect to be insufficient power to detect differences [6]. A study by International Committee of the Red Cross (ICRC) determined that PD improved growth indicators of children receiving the intervention [2]. However, this study was judged as insufficient due to lack of measurement during the hunger gap, lack of control group, and low sample size. A quasi-experimental study evaluating PD against the standard BSFP intervention of improved dry rations amongst 1,551 children 6-36 months old in South Darfur, Sudan found a reduction of .27 wasting events per child-year among those receiving PD [5]. This study also found that mean WHZ was significantly higher in the PD group by 0.23 z-scores [5]. The author emphasized that the WHZ of both groups was maintained, and the programmatic significance of reduced burden of disease among PD users might not be noticeable. However, the author also commented that PD is safer and more convenient compared to improved dry rations, as it requires no preparation.

Previous research has highlighted younger age, infant and young child feeding practices, and diarrhea as acting to explain acute malnutrition among 6-59 month olds [18-20]. (See

Appendix A for literature review of the causes of malnutrition). However, these studies have not explored associations with acute malnutrition among children receiving a nutritional supplement. Since the seasonal increase in acute malnutrition among IDPs and refugees, despite dietary supplementation, is such a common problem faced in these settings, the purpose of this study is to understand the risk factors for acute malnutrition during the hunger gap amongst 6-36 month year old IDPs receiving supplemental PD.

Methods

Study Design

The longitudinal cohort study consisted of 220 children 6 to 36 months old measuring between 65 and 90 cm in height (the height proxy for children aged 6 to 36 months) participating in a BSFP of PD enacted by ICRC. Data was collected with the use of structured questionnaires to caregivers and anthropometric measurements to children. Initial assessment was in April 2011, on the site of the first BSFP distribution. Follow-up measurements and interviews were conducted along with BSFP distributions in May, June, July, and August 2011, with a final follow-up measurement in October 2011.

Children with missing baseline anthropometric measures were excluded from the study, as were children who were determined to have implausible anthropometric measurements of WHZ and HAZ with the use of Emergency Nutrition Assessment software [21]. Children with acute malnutrition at baseline were also excluded from our study. Lastly, subjects whose caregiver reported entry into a therapeutic feeding program during the study period were excluded, as their nutrition status represents a program other than the PD intervention.

The nutrition monitors were required to directly count and register all children 6-36 months in Gereida camp in order to prepare and conduct the blanket distribution of PD. Approximately 8,500 children were registered to receive PD in 2011. The children to include in this follow up study were randomly selected from the registration list. The children were consecutively numbered (ie: 1-8,500), with the 39^{th} child selected first using a random number generator, and a sampling rate of 39 applied to achieve a final sample of 220 children. This sample size was determined based on an evaluative study conducted by ICRC among this population in 2010 [See Figure 1].

Measurements

Our primary study outcome measures were anthropometric. Nutrition monitors appointed by ICRC measured children's length/height, weight, mid-upper arm circumference (MUAC), and presence of bilateral pitting edema six times throughout the study period. These monitors were trained in anthropometric measurement methods with the use of standardized measurements and calibrated equipment. Child length/height was measured

to the nearest millimeter using a wooden measurement board meeting UNICEF specifications. Weight was measured to the nearest 0.1 kg using a hanging Salter scale. MUAC was measured to the nearest millimeter with non-stretchable tape designed for this purpose.

Additional Variables

At the time of anthropometric measurement, nutrition monitors also administered questionnaires to the child's caregiver. The variables collected in the questionnaires are divided into several categories:

- General information: identification and registration.
- Anthropometric information: weight, height, age, sex.
- Information related to nutrition and health: prevalence of diarrhoea, cough, vomiting and fever in the two week period prior to measurement, breastfeeding, age of introduction of first foods, exclusive breastfeeding, and the general food ration.
- Information related to wealth status of households.
- Information related to compliance and use of the product (PD): proper distribution of the product, knowledge and attitudes.

The nutrition monitors also determined if the child was admitted to a therapeutic nutrition program at each measurement. If so, the interview was still completed but these children were removed from our study. See Appendix C for the instruments used to collect this information from study participants and their caregivers.

Data Analysis

Weight and height were processed into WHZ for each subject based on the World Health Organization reference population using Emergency Nutrition Software [21]. SAS 9.3 was utilized for the purpose of data analysis, which consisted of data cleaning, deriving estimates for cumulative incidence (risk) of acute malnutrition, deriving risk ratios (RR) of binary exposure groups, as well as employing PROC GENMOD to derive adjusted risk ratios for acute malnutrition to assess for confounding and interaction (SAS/STAT software; SAS institute, Cary, NC). See Appendix E for the SAS procedures used in this analysis.

Cumulative incidence of acute malnutrition was calculated as the percentage of subjects who developed acute malnutrition at any time during the study period. Once acute malnutrition had been observed, further assessments of that child were censored from analysis. Age was categorized into five groups: 6-12 months, 13-18 months, 19-24 months, 25-30 months, and 31-36 months. Stunting as an explanatory variable was

defined as height-for-age z-score < -2. The number of days living in Gereida was dichotomized based on the mean time living in the camp, which was 73 days. Ever reporting diarrhea, cough, fever, or vomiting during the study period were calculated.

Variables possibly associated with acute malnutrition were identified independently through calculation of the risk ratio (RR), and significance was determined using the X^2 p-value. These variables were subsequently entered into models adjusting for age, gender and other risk factors. We eliminated variables from our model using backward selection based on p-value to arrive at the final model.

To determine significance of risk factors affecting a small proportion of the population, the fisher's exact p-value was presented. Confidence intervals (CI) around the RR were estimated using the Taylor Series approach. A p value ≤ 0.05 was considered statistically significant. No adjustments were made for multiple comparisons. Mean WHZ and illness throughout the study period were also analysed [See Appendix D].

Ethical Considerations

Consent of camp leaders (Sheiks) to conduct this study was obtained by ICRC. An oral explanation of the procedures (the product that the child will receive and the measurements and interviews planned) was followed by oral obtainment of consent from the child's caregiver. The head of household was also informed that withdrawal from the evaluation would not exclude the child from receiving the intervention planned for all children in the camp. Only ICRC staff members directly involved in the study have access to the paper copies of questionnaires. The names of any persons and any other identifying information were removed from the dataset used for this analysis. ICRC is committed to use the results of the study to improve the nutrition programs in all its missions, and in particular in Gereida camp. The Institutional Review Board of Emory University granted exemption for the Emory investigator to conduct the data analyses with the previously collected data.

Results

The number of children with height and weight measurements in April, May, June, July, August, and October was 215, 209, 206, 187, 169, and 173, respectively. After exclusion criteria were assessed, 157 children were included for analysis [See Figure 1]. At baseline in May 2011, the children included in our study were an average age of 22 months old. Within two weeks prior to baseline, 21 (14%) children had a fever, 20 (13%) had a cough, 13 (8%) had experienced diarrhea, and 8 (5%) had vomited [See Table 1].

During our 6-month follow-up, 39 (24.8%) study participants became acutely malnourished. Among those that became malnourished, 2 (5%) of these children qualified as malnourished due to MUAC measurement alone, 3 (8%) qualified due to

WHZ criteria, and 34 (87%) qualified as malnourished under both criteria. There were no observed cases of bilateral pitting edema. See Appendix D for complete data of reported illnesses including acute malnutrition during the study period.

In crude risk factor analyses, children with diarrhea at baseline had 2.4 times the risk of becoming acutely malnourished (95% CI 1.3, 4.4). Children who were breastfeeding at baseline had 1.9 times the risk of acute malnutrition (95% CI 1.08, 3.28). Children whose caregiver ever reported vomiting had 1.8 times the risk of acute malnutrition (95% CI 1.1, 6.5). Gender, baseline stunting, vomiting, cough, fever, time in the camp, PD use, ever vomiting, ever having a fever, ever having diarrhea, or ever having cough were not independently associated with acute malnutrition.

When all risk factors were entered into a model adjusting for age and gender and backwards selection was performed until only significant risk factors remained, diarrhea at baseline was associated with 2.7 times the risk of becoming acutely malnourished (95% CI 1.2, 6.4). Children who had been in the camp for 73 days or more had 2 times the risk of becoming malnourished (95% CI 0.99, 3.9). Baseline fever, vomiting, cough, gender, stunting, breastfeeding, PD use, ever having fever, ever having diarrhea, ever vomiting or ever having a cough were not associated with acute malnutrition in adjusted models. When the risk of acute malnutrition depending on age group was examined, we found that children aged 6-12 months had the highest risk of acute malnutrition, with 11 (39%) children in this age group becoming acutely malnourished [See Table 2].

Throughout the study period, adherence to the intervention was high, with 146 (93%) guardians reporting feeding PD to their children three times daily, and only two guardians reporting sharing of PD. Throughout the study period, there were no occasions of reported child refusal of PD. As explanatory variables regarding PD use were mostly uniform throughout the cohort, these were not included in risk factor analyses.

Discussion

Although these children were receiving PD to prevent acute malnutrition, nearly 25% developed this outcome during our 6-month study period. In an attempt to determine why acute malnutrition could not be prevented for these children, we determined that children who initially had diarrhea had 2.7 times the risk of becoming acutely malnourished when adjusting for other factors. This result supports assertion of diarrhea as a cause of acute malnutrition among children being supplemented with PD. Unsuccessful prevention affected a high proportion of the youngest children in our study, with 11 (39%) 6-12 month olds becoming acutely malnourished. This evidence should be used to further target additional or alternative interventions for prevention of acute malnutrition.

Although children that were breastfeeding at baseline had 1.9 times the risk of acute malnutrition in crude analyses, this effect was not significant in models adjusting for age and gender. This is perhaps due to the confounding effect of age on breastfeeding.

There are several limitations to our study. The small sample size for analysis after exclusion of subjects to meet study design criteria may have limited the statistical power to detect differences between nourished and malnourished children. This study also was not able to collect complete response data on all children for all data collection points, with 5 unmeasured children at baseline, 11 unmeasured at 1st follow-up, 14 at 2nd follow-up, 33 at 3rd follow-up, 51 unmeasured at 4th follow-up, and 47 unmeasured at final follow-up. These exclusions introduced the potential for selection bias to our study. Potential measurement error of child's age at recruitment and other anthropometric variables such as length may have resulted in misclassification of subjects or systematic bias. The collection of information from caregivers was self-reported, hence subject to reporting bias. This could have resulted in distorted estimates of risk factors included in our analyses.

In conclusion, this study emphasizes that PD cannot single-handedly prevent the seasonal spike in acute malnutrition. Prevention of acute malnutrition depends on other factors aside from a child's diet, such as age and diarrhea. Further targeting of interventions towards the age group with the highest risk, children 6-12 months old, will help to reduce the burden of malnutrition during the hunger gap. The risk of acute malnutrition in Gereida also depends on the ability of families to return to their homes, as children staying there the longest had 2 times the risk of acute malnutrition. Programs distributing implementing BSFP to prevent acute malnutrition should consider these factors to achieve improved outcomes of participants.

Appendices

Appendix A: Figures and Tables

Figure 1: Study flow chart illustrating exclusion of subjects for analysis

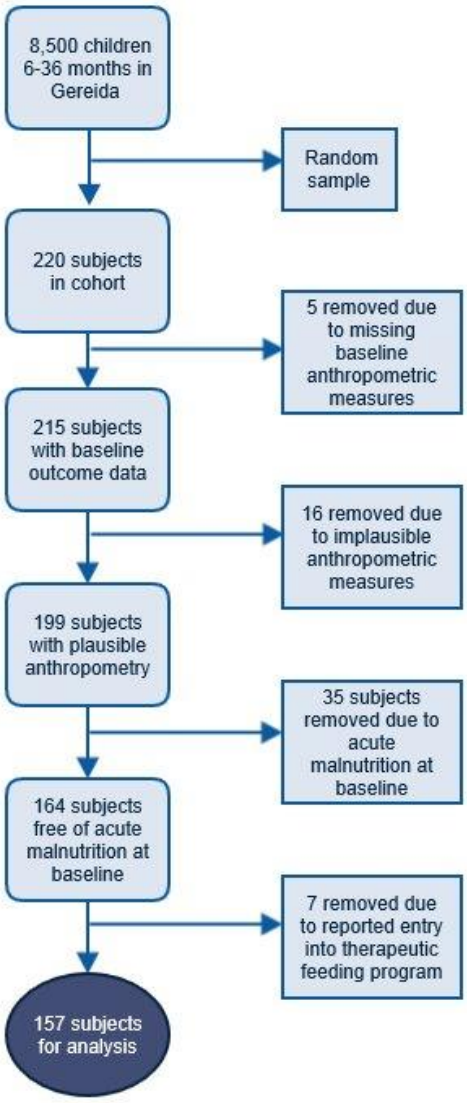


Table 1: Description of children 6-36 months old at baseline, Gereida, South Darfur, Sudan (n=157)

Characteristic	n (%)
Age Group	
6-12 mo	28 (17.8)
13-18 mo	28 (17.8)
19-24 mo	55 (35.0)
25-30 mo	23 (14.7)
31-36 mo	23 (14.7)
Gender	
Male	82 (52.2)
Female	75 (47.8)
Duration in camp	
<73 days	73 (46.5)
≥73 days	84 (53.5)
Chronic malnutrition	
Yes	64 (40.8)
No	93 (59.2)
Diarrhea	
Yes	13 (8.3)
No	144(91.7)
Fever**	
Yes	21 (13.5)
No	135 (86.5)
Vomiting**	
Yes	8 (5.1)
No	148 (94.9)
Cough**	
Yes	20 (12.8)
No	136 (87.2)
Chronic Malnutrition	
Yes	64 (40.8)
No	93 (59.2)

*n=199 **n=156

Table 2: Risk Factors for acute malnutrition in independent analyses and a model adjusting for age, gender and other risk factors, Gereida, South Darfur, Sudan (n=157)

	Unadjusted			Adjusted		
Covariate	RR	95% CI	P	RR	95% CI	P
Baseline diarrhea	2.4	(1.30, 4.43)	0.02*	2.7	(1.20, 6.36)	0.02
Baseline fever	1.7	(0.89, 3.10)	0.14	1.1	(0.41, 2.84)	0.88
Baseline vomiting	1.5	(0.60, 3.94)	0.40	1.4	(0.42, 4.74)	0.57
Baseline cough	1.2	(0.59, 2.57)	0.58	1.3	(0.39, 3.97)	0.71
Baseline breastfeeding	1.9	(1.08, 3.28)	0.02	1.5	(0.58, 3.67)	0.41
Female	0.96	(0.56, 1.66)	0.89	1.1	(0.58, 2.08)	0.79
Ever diarrhea	1.5	(0.89, 2.63)	0.12	1.1	(0.55, 2.29)	0.76
Ever Fever	1.7	(0.96, 2.85)	0.07	1.6	(0.81, 2.97)	0.18
Ever Vomiting	1.8	(1.03, 3.19)	0.05	1.0	(0.6, 2.7)	0.13
Ever Cough	0.9	0.51, 1.67)	0.79	0.8	0.41, 1.63)	0.57
≥73 Days in Camp	1.7	(0.97, 3.13)	0.06	2.0	(0.99, 3.90)	0.05
Stunting	1.3	(0.65, 2.78)	0.43	1.1	(0.82, 1.36)	0.68
Age		n (%)				0.58
6-12 mo		11/28 (39)				
13-18 mo		7/28 (25)				
19-24 mo		15/55 (27)				
25-30 mo		1/23 (4)				
31-36 mo		5/23 (22)				

*Fisher's

Appendix B: Literature Review

Introduction

This literature review aims to provide a synopsis of current and existing research exploring risk factors for acute malnutrition globally, as well as existing research on causes of acute malnutrition. There is currently limited amount of research exploring global acute malnutrition, which is one of the outcome indicators in the current study. For this reason, most studies included in this review assess risk factors for malnutrition and SAM.

This literature review is divided into four sub-sections:

A) Causes of Malnutrition

This section includes studies and reviews assessing the causes of acute or chronic malnutrition. The indicators used to measure malnutrition in articles featured in this section are weight-for-height z-score (WHZ) < -2, height-for-age z-score (HAZ) < -2, mid-upper arm circumference (MUAC) < 125 mm, or bilateral pitting edema.

B) Causes of Severe Acute Malnutrition (SAM)

This section includes studies assessing the causes of SAM, as indicated by a WHZ < -2 or bilateral pitting edema. Children participating in these studies were participating in inpatient treatment for severe acute malnutrition.

C) Causes of Global Acute Malnutrition (GAM)

This section includes studies assessing the causes of GAM, as indicated by WHZ < -2, MUAC < 125 mm, or bilateral pitting edema.

D) Gaps in the Literature

A) Causes of Malnutrition

In an attempt to harmonize the policies and activities in nutrition of the United Nations system, the nutrition policy paper titled "Malnutrition and Infection" was published in 1989. This paper gave a picture of malnutrition's relationship with infection, describing this relationship as a cycle beginning with inadequate dietary intake. This has the potential to weaken the immune system, resulting in greater incidence, severity, and duration of disease [22] [See Figure 2].

The discussion paper also asserts that diarrhea and respiratory infection are particularly important causes of poor growth. The impact of these infections on nutritional status

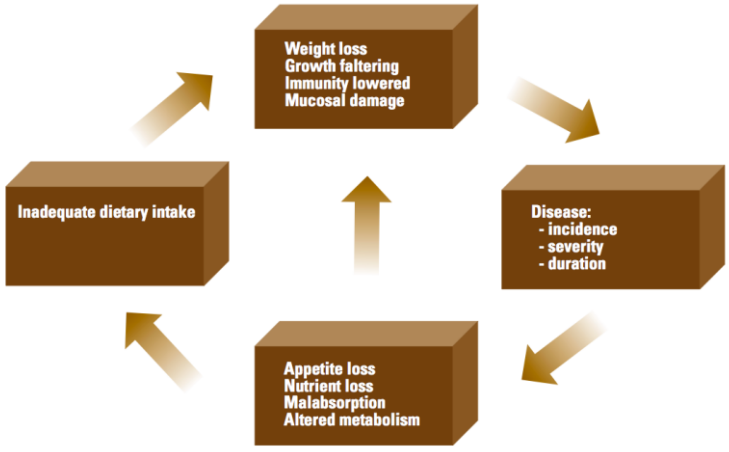
could depend on previous nutritional status of the child, the availability of food, cultural beliefs and access to health facilities. Hence, these infections are causes of malnutrition in the presence of tertiary risk factors [22].

Nieburg's paper reviewed the relationship between malnutrition and mortality. This article asserted that greater severity and frequency of infections explains the relationship between mortality and malnutrition. Although other factors of overcrowding, inadequate water and sanitation, and lack of vaccine play a part in increased frequency of infections, increased disease severity was linked to malnutrition [23].

De Onis used the WHO Global Database on Child Growth to investigate the prevalence of malnutrition among under 5 year olds in developing countries. In the introduction of this study, the author emphasized the relation between nutrition and health. She re-asserted the claim of the previous study that nutrition problems could be the result of severe and repeated infections [24]. This report claims that this fact establishes anthropometric measurements as indicators of population health status. However, there are no justifications or previously cited work to support these claims.

UNICEF's 1998 report, "The State of the World's Children" gave an in-depth explanation of causes of malnutrition. The two direct causes listed in this report were inadequate dietary intake and disease. The underlying causes of malnutrition leading to the immediate causes are inadequate maternal and child-care practices, poor water/sanitation and inadequate health services [4]. This report also recommends resources to mitigate the effects of these risk factors for malnutrition [See Figure 3].

Figure 2: The relationship between malnutrition and infection



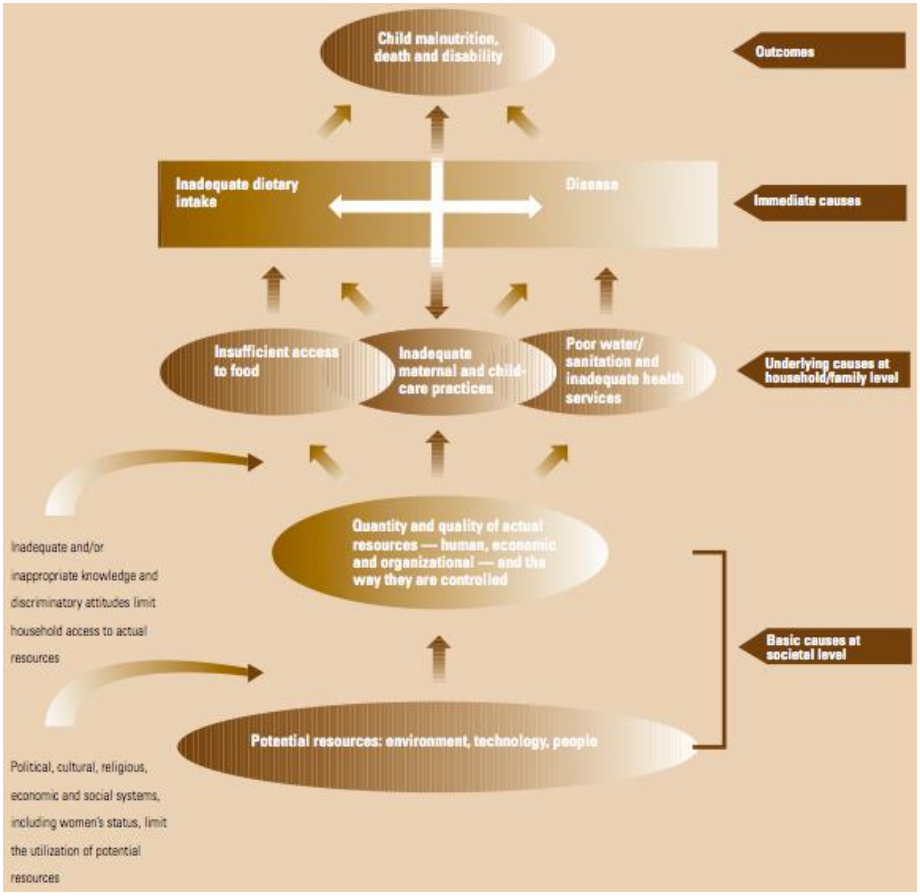
Source: UNICEF's The State of the World's Children

Mamoun aimed to inform guidelines for interventions dealing with malnutrition in displacement camps by assessing the prevalence of malnutrition along with risk factors

for the disease among 327 children under 5 in Mayoo camp in Khartoum, Sudan. This study used a studentized t-test to detect differences in mean weight, height, age and MUAC between nourished and malnourished children. The investigators also built a regression model containing expected risk factors to predict the outcome of malnutrition. This analysis found no association between malnutrition and the expected risk factors of last month diarrhea, last month fever, formula feeding, or absence of parents [25].

Although this study appears to imply that we cannot predict which children will become malnourished, there is some confusion in the methodology leading to this conclusion. The outcome variable indicating malnutrition was scantily described, with no classification criteria listed. Significance of differences in weight and height were assessed using the student's t-test. However, these are not the standard indicators used to assess nutritional status. A ratio of these values compared to a reference population is a more appropriate indicator of the condition under investigation. Hence, the conclusion of this study that none of the risk factors measured are associated with malnutrition cannot be followed.

Figure 3: The causes of malnutrition



Source: UNICEF's The State of the World's Children

Olwedo estimated the prevalence of and investigated risk factors for malnutrition among 678 children 3-59 months old living in IDP camps in Omoro county, Gulu district,

Uganda. They used a cross-sectional study design to collect information on known causes of malnutrition, nutrition and health services offered, as well as anthropometric indicators of study participants. The methods for collection of risk factors were focus groups to caregivers and key informant interviews to village leaders. Among children 3-59 months old, children 3-24 months were found to have higher odds of acute malnutrition, with adjusted odds ratio of 2.78. De-worming was found to be protective against acute malnutrition, with de-wormed children having .44 the odds of developing it when compared to children that were not de-wormed [26]. This study concluded that activities focused on integrated management of childhood illnesses should be strengthened.

Overall, these studies contribute to evidence that feeding practices, illness, and socioeconomic factors are associated with malnutrition. Infection was reported as a cause of malnutrition, but the relationship was not linear and exposure did not precede disease. This evidence is applicable to conditions of chronic malnutrition, underweight, and acute malnutrition. Therefore, these results are not directly applicable to the current study measuring risk factors for acute malnutrition.

B) Causes of SAM

Brown investigated risk factors for SAM among 100 Bangladeshi children admitted to the hospital for treatment of the condition. The author conducted his investigation by examining the children to determine presence of infection. It was found that 90% of study participants had some form of infection. Of these, 75% were pneumonia, bacteremia, diarrhea, or one or more of these three. Also, 49% of children with infections presented with pneumonia. Lastly, Brown discovered that the prevalence of intestinal parasites increased with age among children with SAM [27]. This study concluded that the treatment of infection must be considered as a component of rehabilitation of severely malnourished children.

Amsalu's study of 204 children under 5 admitted to Gondar University Hospital in Ethiopia aimed to determine risk factors for SAM among children under 5. The investigators accomplished this by conducting an age-matched case-control study. Cases were children admitted to the hospital with SAM, and controls were identified as the first age-matched admission with good nutritional status following admission of the case.

This study found that maternal illiteracy left children with 3.83 times the odds of developing SAM, and paternal illiteracy left children with 2.04 times the odds of developing SAM. Monthly income less than 50 USD gave children 3.44 times the odds of developing SAM, and children in families with more than 3 children had 1.96 times the odds of developing SAM [28]. Because these indicators are commonly used to measure

socioeconomic status, these results imply that this contributes to a child becoming severely malnourished.

The investigators also found that infant and young child feeding practices were different between cases and controls. In a logistic model controlling for the effects of other significant risk factors, lack of exclusive breastfeeding in the first six months left children in this study with 3.22 times the odds of developing SAM. Also, initiation of complementary diet later than 6 months of age left children with 3.39 times the odds of the condition [28]. This study concludes that in order to reduce childhood malnutrition, improved knowledge and practice of parents on appropriate infant and young child feeding practices should be emphasized.

Talbert's study aimed to identify risk factors for death among 1,206 children 6 months to 12 years old admitted to Kilifi District Hospital in Kenya with SAM. In order to identify what made children more vulnerable to mortality, investigators conducted clinical assessments and lab tests upon admission. Baseline characteristics of children with an outcome of mortality were compared to those who did not suffer this outcome using the chi squared test of proportions. The current study has also applied the chi-squared test to assess proportional differences of malnourished children between exposure groups. They found that 49% of study participants presented with diarrhea at some point during their hospital stay. Mortality was also significantly associated with diarrhea, with 19% of children with diarrhea dying, and 9% of those without diarrhea dying [29]. This study concludes that diarrhea is a common and deadly complication of SAM.

Trehan aimed to determine whether routine administration of antibiotics as part of outpatient management for SAM was associated with improved outcomes. In order to accomplish this, he used a double blind placebo control clinical trial design to assess differences in anthropometric outcomes of 2,767 children 6-59 months old in 18 feeding clinics in rural Malawi. The investigators found that the relative risk of treatment failure between the placebo group and the group receiving the antibiotic cefdinir was 1.64 [30]. They also found that those in the placebo group had 1.8 times the risk of death when compared to those receiving the antibiotic cefdinir. This study concluded that antibiotics used for treatment of SAM improve recovery and mortality rates. Although this study did not assess risk factors for acute malnutrition, reduced mortality and improved recovery among those receiving antibiotics implies that infection prevents recovery and promotes mortality among children suffering from SAM.

In Southern Ethiopia, Dereje aimed to identify determinants for SAM among 216 children under 5. In order to accomplish this, the investigators employed an age matched

community-based case control design. The study ascertained this information using structured interview to the caregiver and anthropometric measurements of the children. Adjusted odds ratios were estimated using logistic regression. The investigators discovered that children with diarrhea 2 weeks prior to survey had 4.13 times the odds of having SAM [31]. This indicator was collected as part of the current study. Because this study found that diarrhea 2 weeks prior to measurement was significantly associated with SAM, we will analyze this as risk factor for global acute malnutrition in our study.

Jamro assessed risk factors for SAM using a prospective observational design among 270 children from 6 to 59 months old admitted to Mahar Hospital in Sukkur, Pakistan for SAM. Risk factors were collected using a structured questionnaire. It was found that 66.7% of cases had a large family size, delayed weaning in 55.6% of cases, and inappropriate feeding practices in 74% of cases [32]. Although this study identifies risk factors through determining if a majority of cases share the indicator, there is the lack of a control group to compare the proportions. Hence, these risk factors could be a result of population prevalence. For this reason, we cannot implicate these factors as being associated with SAM.

Nguka attempted to determine risk factors for SAM among 204 children 6-59 months admitted with SAM to Juba University Hospital in South Sudan. This study used a case-control design to collect risk factors with a structured questionnaire for logistic regression analysis against a SAM outcome. Like our study, this study also used proportions to determine differences between cases and controls. This study also found that children with large family size had 1.7 times the odds of SAM. It also found that non-exclusive breastfeeding in the first 6 months of life gave children 3 times the odds of SAM [33]. This study concludes with emphasis on the association of inappropriate feeding practices with SAM.

Most recently, Mishra utilized a case-control design to assess risk factors for SAM among 191 children between 6 and 59 months in Kalawati Saran hospital in New Delhi, India. A logistic model was built to determine that socio-demographic factors and lack of exclusive breastfeeding for the first 6 months were risk factors for acute malnutrition [34]. This study concludes that community-based studies should be conducted regarding risk factors of SAM.

The results above implicate infection as a cause of SAM. There is also a significant amount of recent evidence to assert that infant and young child feeding practices contribute to the burden of SAM, especially lack of exclusive breastfeeding for the first 6 months. Recent studies also point to socioeconomic factors and large family size as

contributors to SAM cases. Most of the studies in this section are hospital-based, and employ a case-control design. Since our current study is community-based with a cohort design, these results are not directly applicable. These results are also assessing risk factors for SAM when children are under treatment. As our current study is assessing children under preventative treatment, the risk factors identified in these studies do not directly apply to the current study.

C) Causes of GAM

Maleta's study followed 767 children in rural Malawi from birth to 36 months to understand age of greatest vulnerability for development of GAM, as well as predictors of this condition based on background characteristics. The children were visited monthly from birth to 18 months then at 3-month intervals. Child anthropometric measurements were taken with standardized instruments, and maternal interview indicated infant feeding practices and infant morbidity and mortality. Incidence of acute malnutrition was calculated from the first time a child had an anthropometric index value below the cutoff point of WHZ< -2. The calculation of incident GAM is directly comparable to the current study, as this study used risk ratios to determine risk factors. Variables included in adjusted models were identified using exploratory bivariate analysis with binary risk factors. This method was adapted to our current study.

This study found that the incidence of wasting was highest from 6 to 18 months [19]. This informed our current study's methods when determining age category cutoff points. The youngest age category in our study consisted of children 6 to 18 months. Also, frequent episodes of illness in infancy (birth to 6 months) doubled the risk of becoming wasted. This study concludes that strategies combatting infant morbidity are likely to reduce the burden of wasting.

Odunayo determined the current nutritional status, as well as influences of feeding practices and family characteristics on the nutritional status of 420 children under 5 in the rural village of Ifewara, Nigeria. The investigators accomplished this using a community-based cross sectional survey. They assessed the significance of individual risk factors on malnutrition using a chi-squared test of proportions. The same statistical test was employed for the current study. This study found that 33% of children given formula after they became 6 months old developed GAM, compared to 6.7% of those given formula when they were less than 6 months [20]. Overcrowding and formula feeding of children over 6 months of age were associated with a higher proportion of GAM. Based on these results, this study concluded that improved living standards for families, empowerment of mothers, and parental education on appropriate feeding practices would reduce incidence of acute malnutrition among children under 5. This study did not

consistently report the same figures for all risk factors. For some risk factors, the authors gave a proportion of cases compared to controls, and for others, the chi-square figure and p-value were reported. For this reason, the quality of the study is lowered.

Egata employed an unmatched community-based nested case-control study to identify predictors of GAM among 2,199 children 6-36 months old in Eastern Ethiopia. The age group assessed in this study is directly comparable to the current study. These investigators used an outcome indicator of WHZ < -2, also resembling the current study. Like the previous study, this study also employed a bivariate analysis to determine which variables were independently associated with GAM. This appears to be an acceptable way to identify risk factors, and will be utilized confidently for the current study. The Ethiopia case-control study found that those with low socioeconomic position had 1.49 increased odds of wasting, and middle-income children had 1.52 increased odds of wasting. Also, children with non-exclusive breastfeeding had 1.65 times the odds of GAM [18]. The investigators concluded the study with a recommendation to improve infant and young child feeding. The risk factor of non-exclusive breastfeeding was not well defined. This leaves us to question the credibility of the study results. However, the high sample size gives confidence that the results are generalizable to the population.

The technical review, "Associations between wasting and stunting, policy, programming and research implications" aimed to identify factors common to both wasting and stunting. As part of this process, the paper outlined known causes of both conditions. There were several immediate causal factors of wasting identified in this paper that are common indicators to the current study. The causes identified by the briefing paper were infectious disease, diarrhea, and inappropriate complementary feeding.

The risk factors identified by these studies are the most applicable to the current study, as the outcome is shared. Many of the studies above use a case-control design, whereas the current study employs the cohort design. Studies with GAM as an outcome overwhelmingly blamed infant and young child feeding practices for development of the condition.

Gaps in the Literature

Studies assessing risk factors for acute malnutrition are focused on the severe form of the disease in a hospital setting, with a prominence of case-control design. As this condition is not rare, this design is not the most appropriate. Many of the studies also called for community-based assessments of risk for this condition. As the current study is a community-based cohort examining all forms of acute malnutrition, it will contribute

results that will be generalizable to the community as opposed to severely malnourished inpatients.

The prior studies, aside from Maleta's cohort, have the limitation of the case-control design, in which the odds ratio is used as an approximation of the risk ratio. While the odds ratio can be an approximation of the risk ratio for rare diseases, it is not appropriate for GAM, which affects more than 5% of a population. While Maleta's study employed the risk ratio to estimate effects of exposures, the study population he assessed was not under a preventative supplement. This is the first study to use cumulative incidence to determine risk factors for GAM among BSFP recipients. Since the risk ratio takes into account temporality, it will give us a clear picture of what is happening to children who become malnourished during the hunger gap.

Although there are several studies using GAM as the outcome measure, they do not emphasize illness as a driving factor. As illness was frequently listed in studies exploring causes of malnutrition and severe acute malnutrition, it is important to conclude if this variable is also associated with GAM. Although Maleta's study links GAM with illnesses in children less than 6 months of age, this study population is not relevant to programs preventing GAM, hence, not applicable to the current study. Our study aims to address this gap.

Overall, scientific literature regarding the causes of malnutrition has failed to take into account those that become malnourished during the hunger gap. No studies were found that addressed the seasonal fluctuations in malnutrition which practitioners are commonly faced with. Given the unfavorable research conditions present in many locations where this effect is observed, this continues to be an under-researched population that would otherwise benefit from academic and scientific research to address the needs of these populations. Despite the need for specific services and interventions targeting those becoming malnourished during the hunger gap while participating in BSFP, there continues to be a dearth of current and relevant research surrounding the malnutrition risk amongst children in Sudan and elsewhere around the world.

Appendix C: Data Collection Instruments

Plumpy'Doz SURVEY IN GEREIDA IDP CAMP, DARFUR-SUDAN

FIRST QUESTIONNAIRE (for all children)

A. General Information

1. Date of data collection	/ /	
2. Sector (& monitor number)		
3. SatelliteSite No (1 - 3)		
4. Team number		
5. Child number (ie. follow-up 1-220)		
6. Name of the child		
7. Child Plumpy'doz registration number		
8. Sex of the child	Female …….	1
	Male …….	2
9. Estimated age		
10. Relationship of the respondent with the child	Mother…….	1
	Father……	2
	Sister/Brother……	3

	Aunt/Uncle……		4
	Other…….		5
11. Total people HH			
12. Total children 6 - 36 months in HH			
13a. Are both parents of the child in Gereida (now)?	Yes	……	1
	No	……	2
13b. I**f no,** who is **not** in Gereida?	Mother……..		1
	Father……..		2
	Both…….		3

B. Anthropometric information about the child

1. Weight in kg:	
2. Height / length in cm:	
3. WfH z score:	
4. MUAC in cm:	

C. Information related to nutrition and health

1. Presence of nutritional oedema	Yes	……	1
	No	……	2

2. In the past two weeks, has the child suffered from:					
i	2.a Diarrhoea	Yes	……	1	
		No	……	2	
ii	2.b Cough / Cold	Yes	……	1	
		No	……	2	
iii	2.c Fever	Yes	……	1	
		No	……	2	
v i	2.d Vomit	Yes	……	1	
		No	……	2	
3a.	Is the child currently breastfed ?	Yes	……	1	
		No	……	2	**(go to Q4)**
3b.	**If yes,** to Q3a are you giving the child any foods **in addition** to breast milk.	Yes	……	1	
		No	……	2	
3c.	**If yes,** what is the type of food (s)?	meat……1 milk……..2 cereal……...3 vegetable….4 other…… .6	5		

4 **If not currently breastfeeding**, at what age did breastfeeding stop?

	mths

5. **If not currently breastfeeding,** at what age did you give the child it's first food?

	mths

D. Other information

1. What is the duration of stay in this camp?		mths	
2. Does the household receive food aid?	Yes	……	1
	No	……	2
3. How much land did you cultivate last season (last 12 mths)?		Mkh	

4. How many sheep and goats do you own ?	sheep		goat	
5. How many donkeys and horses do you own?	donkey		horse	

PLUMPY'DOZ SURVEY IN GEREIDA IDP CAMP, DARFUR-SUDAN

FOLLOW-UP QUESTIONNAIRE 1,2,3,4,5 MONTHS

A. General Information

1. Date of data collection	/ /		
2. Sector (monitor number)			
3. SatelliteSite No (1 - 3)			
4. Team number			
5. Name of the child			
6. Child registration number			
7. Sex of the child	Female	.....	1
	Male	.....	2
8. Estimated age			
9. Relationship of the respondent with the child	Mother		1
	Father		2
	Sister/Brother		3
	Aunt/Uncle		4
	Other		5
10. Total people HH			
11. Total children 6 - 36 months in HH			
12a. Are both parents of the child in Gereida (now)?	Yes	.....	1
	No	.....	2
12.b **If no,** who is **not** in Gereida?	Mother		1
	Father		2
	Both		3

B. Anthropometric information about the child

1.	Weight in kg:			
2.	Height / length in cm:			
3.	WfH Z score			
4.	MUAC in cm:			

C. <u>Information related to nutrition and health</u>

1.	Presence of nutritional oedema	Yes	……	1
		No	……	2
2.	In the past two weeks, has the child suffered from:			
i	2.a Diarrhoea	Yes	……	1
		No	……	2
ii	2.b Cough / Cold	Yes	……	1
		No	……	2
iii	2.c Fever	Yes	……	1
		No	……	2
iv	2.d Vomit	Yes	……	1
3.	Is the child currently breastfed?	Yes	……	1
		No	……	2
4a	**If yes**, are you giving the child any foods?	Yes	……	1

.

in addition to breast milk. No ……. 2

4b. **If yes,** what is the type of food (s)? Please circle

meat milk cereal veg other			

5a. **If not currently** breastfeeding the child, at what age was breastfeeding stopped?

mths

5b. **If not currently breastfeeding** at what age did you give the child it's first food?

mths

Admission to Feeding Centre

1a. Since the last follow-up visit has the child been admitted to a feeding programme

HBC/ …… 1
OTP ….
Stab. …… 2
Center ….
…… 3
SFC ….

1b. **If yes,** is the child still in the Program mentioned above?

Yes…… 1
…
No…… 2
…..

D. Information related to Plumpy'doz

1a. Did you receive information on the use of Plumpy'doz? Yes …….. 1
No …….. 2

1b. **If the information was received,** was it enough ? Yes …….. 1

	No ……..	2
2. How do you give your child Plumpy'doz?	Spoon ……..	1
	Fingers ……..	2
	Cup ……..	3
3. Did your child accept to take Plumpy'doz?	Yes ……..	1
	No ……..	2
4a. How many times each day does your child eat Plumpy'doz?		
	Once …….	1
	Twice …….	2
	Three times …….	3
	More times …….	4
4b. If **less than three times** per day please give reasons?		
5a. Do you see any benefit of the Plumpy'doz?	Yes ……..	1
	No ……..	2
5b. If yes to Q5a. What benefits do you think your child gets?		
	More healthy ……	1
	Better appetite ……	2
	More active …..	3
	Gain weight …	4

	Other …….	5
6a. Do you see any negative effects of the Plumpy'doz?	Yes ……..	1
	No ……..	2
6b. If yes, what are these?		

7. Did the child ever eat Plumpydoz from another household?

Yes……1

No……..

2

Appendix D: Supplemental Analyses

Mean WHZ

Methods

Mean change in WHZ over the study period was determined. Factors affecting WHZ trajectory were also determined. Factors to be included in adjusted models explaining WHZ trajectory were identified with initial exploratory bivariate analysis of factors explaining acute malnutrition. The PROC MIXED procedure was used to fit models explaining WHZ trajectory over the study period. A t-test with backward selection, along with goodness of fit tests were used to determine significance of variables in the models [35].

Results

Mean WHZ of the study population did not change significantly from baseline to follow-up [See Table 5]. However, mean WHZ trajectory was not linear, with the largest decline being 0.25 z-scores between June and July ($p<0.001$) [See Figure 4]. Those who experienced 3 or more illnesses over the study period had a lower initial WHZ by 0.05 ($p<0.01$) z-scores, as well as a decrease in WHZ of 0.04 z-scores more than those who had experienced less than 3 illnesses ($p<0.01$). WHZ trajectory also differed significantly by age. From June to July, 6-17 month olds experienced a significantly larger drop than 24-36 month olds by a WHZ of 0.5 z-scores [See Figure 5].

Discussion

Although mean WHZ was maintained from first measurement to follow-up, there was a significant decline during the height of the hunger gap. Our study found that change in mean WHZ during the hunger gap was dependent on age. Twenty four to 36 month olds were less affected by the hunger gap than 6-17 month olds. We notice that subjects experiencing several illnesses had a significant decline in WHZ, but started our study with a lower WHZ than those that had experienced fewer illnesses [See Table 3].

Table 3: Mixed effects model examining association of WHZ with explanatory variables amongst children 6-36 months in Gereida, Sudan (n=157) 2011

		Unconditional Means Model Estimate (Standard Error)	Unconditional Growth Model E (SE)	Final Model E (SE)
Fixed Effects				
Composite Model	Intercept (initial status)	-0.9 (0.05) ^	-1.10 (0.03) ^	-0.67(0.07)^
	MONTH		0.008 (0.02)	-0.06(0.03).04
	MORB			-0.05 (0.11)***
	MORB BY TIME			-0.04 (0.02).03
	AGE BY TIME			0.03 (0.01)
				0.01
	WHZ1 BY TIME			-0.02 (0.01).04
Variance Components				
Level 1	Within-person	0.17	0.15	<0.01
Level 2	In intercept	0.41	0.44	0.37
	In rate of change		0.01	0.004
Goodness of Fit	Goodness of Fit			
	Deviance	1327.1	1308.7	1259.2
	AIC	1331.1	1316.7	1277.2
	BIC	1337.2	1328.9	1304.7

^p<0.0001 *** p<0.01 **p=0.05 * p=0.10

Figure 4: Change in mean WHZ during the hunger gap among 6-36 month year olds, Gereida, Sudan (n=157)

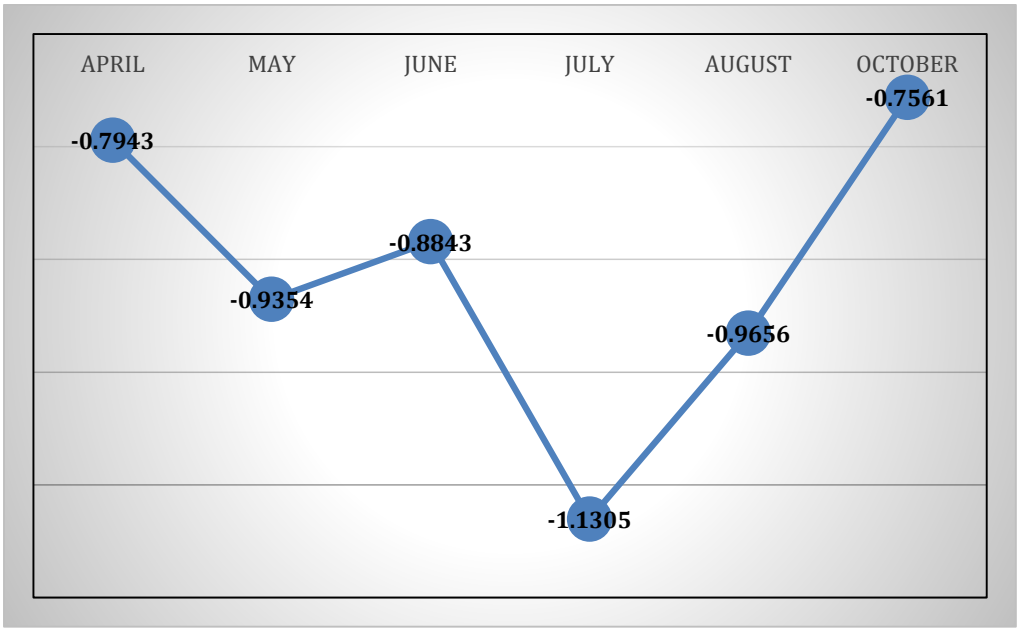
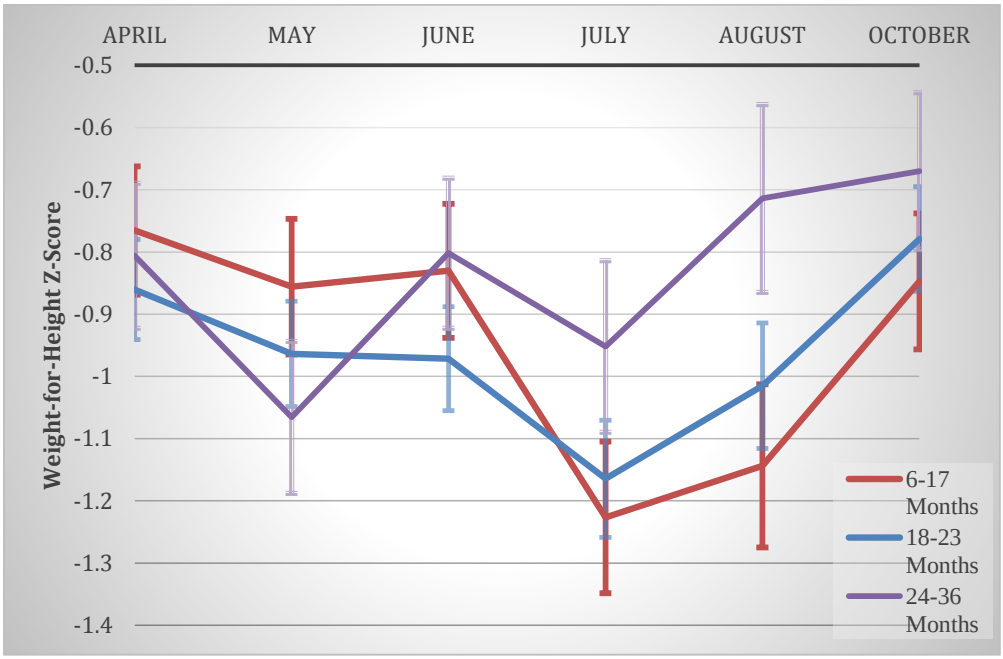


Figure 5: Change in mean WHZ depending on age among 6-36 month year olds, Gereida, Sudan (n=157)



Illness in Gereida Camp

Over the course of the 6-month study period, the percentage of children with fever spiked in May, with 27 (17.2%) caregivers reporting that their children had a fever within two weeks before measurement. April and May were the peak time for caregivers reporting that their child experienced cough, with 20 (12.7%) children in our study population experiencing a cough. Report of diarrhea peaked in July, with 25 (17.6%) children falling ill due to diarrhea [See Table 4].

Table 4: Percentage of children experiencing illnesses in Gereida, Sudan 2011

Illness	April	May	June	July	August	October
Diarrhea	13 (8.3%)	20 (12.7%)	24 (16.3%)	25 (17.6%)	10 (7.7%)	4 (3.3%)
Fever	21 (13.4%)	27 (17.2%)	18 (12.2%)	15(10.6%)	8 (6.2%)	2 (1.7%)
Cough	20 (12.7%)	20 (12.7%)	16 (10.9%)	7 (4.9%)	5 (3.9%)	2 (1.7%)
Vomiting	8 (5.1%)	6 (3.8%)	10 (6.8%)	13 (9.1%)	5 (3.9%)	1 (0.8%)
Wasting	35(16.2%)*	10 (6.6%)	6 (4.1%)	13 (8.8%)	10 (7.8%)	0 (0%)

**Removed from cohort at baseline*

Appendix E: SAS Code

```
**********************
Natalie Johnson
Thesis Analysis
Fall 2014/Spring 2015
**********************;
/*creating library for all data files*/
libname darfur 'h:/thesis';
/*creating case variable*/
data darfur.darfur2;
set darfur.darfurjan3;
 if whz_who1=. then case1=.;
        else if muac1<125 then case1=1;
  else if whz_who1 < -2 THEN case1=1;
  else case1=0;

 if whz_who2=. then case2=.;
        else if muac2<125 then case1=1;
```

```
  else if whz_who2<-2  THEN case2=1;
  else case2=0;

  if whz_who3=. then case3=.;
  else if muac3<125 then case1=1;
  else if whz_who3<-2  THEN case3=1;
  else case3=0;

          if whz_who4=. then case4=.;
          else if muac4<125 then case1=1;
  else if whz_who4<-2 THEN case4=1;
  else case4=0;

       if whz_who5=. then case5=.;
                  else if muac5<125 then case1=1;
  else if whz_who5<-2 THEN case5=1;
  else case5=0;

       if whz_who6=. then case6=.;
                  else if muac6<125 then case1=1;
  else if whz_who6<-2 THEN case6=1;
  else case6=0;

run;
data darfur.darfurwork;
        set darfur.darfur2;
        /* Remove records with data quality flag or malnutrition at baseline enrollment
visit. */
        if ChildID=16 or ChildID=148 or ChildID=5 or ChildID=12 or ChildID=14 or
ChildID=16 or ChildID=49 or ChildID=56 or
                ChildID=106 or ChildID=125 or ChildID=126 or ChildID=138 or
ChildID=181 or ChildID=183 or ChildID=188 or
                ChildID=191 or ChildID=192 or ChildID=207 or ChildID=211 or
ChildID=212 or ChildID=214 or basemal=1
        then dataflag=1;
        else dataflag=0;
        /* Defines a case according to admission to a feeding program. Children may
have been admitted to a feeding program between study visits with anthropometry
        below threshold measured between study visits. */
```

```
        if (admission1=1 or admission2=1 or admission3=1 or admission4=1 or
admission5=1 or admission6=1) and casewhz=0 and casemuac=0
        then caseprogram=1;
        else caseprogram=0;

                /* For cases, defines dmonthbefore to be 1 if there was diarrhea reported
in the month prior to becoming a case. */
        dmonthbefore=0;
        if casefinal=1 then monthbefore=startcase-1;
                else monthbefore=.;
        array dmonth(6) diarrhea1 - diarrhea6;
        if casefinal=1 then do;
                Do i=1 to 6;
                        if i=monthbefore then do;
                        if dmonth(i)=1 then dmonthbefore=1;
                        end;
                end;
        end;
        evercough=0;
        array coughall(6) cough1 - cough6;
        if casefinal=0 then do; /*casefinal is the case designation variable. Zero is a
control */
                Do i=1 to 6;
                        if evercough=0 then do;
                        if coughall(i)=1 then evercough=1;
                        end;
                end;
        end;
        if casefinal=1 then do;
                Do i=1 to startcase; /*startcase is a numeric variable = timepoint at which
a case became a case */
                        if evercough=0 then do;
                        if coughall(i)=1 then evercough=1;
                        end;
                end;
        end;
        everfever=0;
        array feverall(6) fever1 - fever6;
```

```
        if casefinal=0 then do; /*casefinal is the case designation variable. Zero is a
control */
                Do i=1 to 6;
                        if everfever=0 then do;
                        if feverall(i)=1 then everfever=1;
                        end;
                end;
        end;
        if casefinal=1 then do;
                Do i=1 to startcase; /*startcase is a numeric variable = timepoint at which
a case became a case */
                        if everfever=0 then do;
                        if feverall(i)=1 then everfever=1;
                        end;
                end;
        end;

        evervomit=0;
        array vomitall(6) vomit1 - vomit6;
        if casefinal=0 then do; /*casefinal is the case designation variable.  */
                Do i=1 to 6;
                        if evervomit=0 then do;
                        if vomitall(i)=1 then evervomit=1;
                        end;
                end;
        end;
        if casefinal=1 then do;
                Do i=1 to startcase; /*startcase is a numeric variable = timepoint at which
a case became a case */
                        if evervomit=0 then do;
                        if vomitall(i)=1 then evervomit=1;
                        end;
                end;
        end;
/*creating boolean for illness variables for modeling purposes*/
        if diarrhea1=1  then diarrhea1rc=1;
                else diarrhea1rc=0;
                if diarrhea2=1  then diarrhea2rc=1;
                else diarrhea2rc=0;
```

```
        if diarrhea3=1  then diarrhea3rc=1;
        else diarrhea3rc=0;
        if diarrhea4=1 then diarrhea4rc=1;
        else diarrhea4rc=0;
        if diarrhea5=1 then diarrhea5rc=1;
        else diarrhea5rc=0;
        if diarrhea6=1 then diarrhea6rc=1;
        else diarrhea6rc=0;

if fever1=1  then fever1rc=1;
        else fever1rc=0;
        if fever2=1  then fever2rc=1;
        else fever2rc=0;
        if fever3=1  then fever3rc=1;
        else fever3rc=0;
        if fever4=1 then fever4rc=1;
        else fever4rc=0;
        if fever5=1 then fever5rc=1;
        else fever5rc=0;
        if fever6=1 then fever6rc=1;
        else fever6rc=0;

if vomit1=1  then vomit1rc=1;
        else vomit1rc=0;
        if vomit2=1  then vomit2rc=1;
        else vomit2rc=0;
        if vomit3=1  then vomit3rc=1;
        else vomit3rc=0;
        if vomit4=1 then vomit4rc=1;
        else vomit4rc=0;
        if vomit5=1 then vomit5rc=1;
        else vomit5rc=0;
        if vomit6=1 then vomit6rc=1;
        else vomit6rc=0;
if cough1=1  then cough1rc=1;
        else cough1rc=0;
        if cough2=1  then cough2rc=1;
        else cough2rc=0;
        if cough3=1  then cough3rc=1;
```

```
                else cough3rc=0;
                if cough4=1 then cough4rc=1;
                else cough4rc=0;
                if cough5=1 then cough5rc=1;
                else cough5rc=0;
                if cough6=1 then cough6rc=1;
                else cough6rc=0;
        /*create boolean for gender*/
        if sex="f" then male=0;
                else if sex="m" then male=1;
        /*censoring future data for cases of acute malnutrition and illness to be only
included among healthy children*/
  data darfur.darfurcohort;
  set darfur.darfurwork;
  if dataflag=1 then do;
                case2=.;
                case3=.;
                case4=.;
                case5=.;
                case6=.;
                diarrhea2rc=0;
                diarrhea3rc=0;
                diarrhea4rc=0;
                diarrhea5rc=0;
                diarrhea6rc=0;
                cough2rc=0;
                cough3rc=0;
                cough4rc=0;
                cough5rc=0;
                cough6rc=0;
                vomit2rc=0;
                vomit3rc=0;
                vomit4rc=0;
                vomit5rc=0;
                vomit6rc=0;
                fever2rc=0;
                fever3rc=0;
                fever4rc=0;
                fever5rc=0;
```

```
        fever6rc=0;
end;
else if case2=1 then do;
        case3=0;
        case4=0;
        case5=0;
        case6=0;
        diarrhea3rc=0;
        diarrhea4rc=0;
        diarrhea5rc=0;
        diarrhea6rc=0;
        cough3rc=0;
        cough4rc=0;
        cough5rc=0;
        cough6rc=0;
        vomit3rc=0;
        vomit4rc=0;
        vomit5rc=0;
        vomit6rc=0;
        fever3rc=0;
        fever4rc=0;
        fever5rc=0;
        fever6rc=0;
end;
else if case3=1 then do;
        case4=.;
        case5=.;
        case6=.;
        diarrhea4rc=0;
        diarrhea5rc=0;
        diarrhea6rc=0;
        cough4rc=0;
        cough5rc=0;
        cough6rc=0;
        vomit4rc=0;
        vomit5rc=0;
        vomit6rc=0;
        fever4rc=0;
        fever5rc=0;
```

```
            fever6rc=0;

        end;
        else if case4=1 then do;
            case5=0;
            case6=0;
            diarrhea5rc=0;
            diarrhea6rc=0;
            cough5rc=0;
            cough6rc=0;
            vomit5rc=0;
            vomit6rc=0;
            fever5rc=0;
            fever6rc=0;

        end;
        else if case5=1 then do;
            case6=.;
            diarrhea6rc=0;
            cough6rc=0;
            vomit6rc=0;
            fever6rc=0;
        end;

        /*proc freq to check if all cases of acute malnutrition and illness are only counted
among healthy children*/
        proc freq;
                    table
dataflag*case2*case3*case4*case5*case6*diarrhea2rc*cough2rc*vomit2rc*vomit3rc*co
ugh3rc*cough4rc*vomit4rc*cough5rc*vomit5rc/list missprint;
  run;
/*making 5 age categories for proportion analysis. Dichotomizing duration in the camp at
the mean*/
data darfur.darfur2;
        set darfur.darfurcohort ;
        where dataflag=0;
        if age1<=12 then age=1;
        else if age1>=13 and age1<=18 then age=2;
        else if age1>=19 and age1<=24 then age=3;
```

```
        else if age1>=25 and age1<=30 then age=4;
        else age=3;
        if duration1>73 then durationb=1;
        else durationb=2;
run;

/*Descriptive characteristics of the population at baseline*/
proc means data=darfur.darfur2 std mean ;
        WHERE DATAFLAG=0;
        class casefinal;
        var age1 whz_who1 haz_who1 hhtotal1 hhchild1 duration1;
run;
proc freq data=darfur.darfur2;
        tables age male diarrhea1rc cough1rc fever1rc vomit1rc;
run;
/*checking how many measurements for each occasion*/
proc means data=darfur.darfur2 n ;
        var whz_who1 whz_who2 whz_who3 whz_who4 whz_who5 whz_who6;
run;
/*Conducting Chi-squared test of proportions on baseline characteristics and ever
reporting illness during the study period */
proc freq data=darfur.darfur2;
        tables durationb*casefinal age*casefinal sex*casefinal bf1*casefinal
diarrhea1*casefinal cough1*casefinal vomit1*casefinal
        fever1*casefinal evervomit*casefinal1 everdiarrhea*casefinal1
evercough*casefinal1 everfever*casefinal1/all;
run;
/*Creating booleans for modeling */
data darfur.darfur3;
        set darfur.darfur2;
        where dataflag=0;
        if evervomit=2 then evervomit=0;
        if diarrhea1=2 then diarrhea1=0;
        if bf1=2 then bf1=0;
        if durationb=2 then durationb=0;
        if casefinal=2 then casefinal=0;
        if evervomit=2 then evervomit=0;
run;
```

```
/*Modeling wasting with significant variables from chi-squared while adjusting for age
and gender*/

proc genmod data=darfur.darfur3 ;
        model casefinal= evervomit durationb diarrhea1 bf1 age male/link=log d=p;
        estimate 'breastfeeding' bf1 1 /exp;
        estimate 'vomit ever' evervomit 1 /exp;run;quit;
                                                        run;
/*Ever vomit has the highest p. Remove*/
proc genmod data=darfur.darfur3 ;
        model casefinal=durationb diarrhea1 bf1 male age /link=log d=p;
                                                        run;
/*Breastfeeding has the highest p. Remove*/
proc genmod data=darfur.darfur3 ;
        model casefinal=durationb diarrhea1 male age /link=log d=p;
                                                        run;
/*Both remaining risk factors are significant. Find the adjusted risk ratio*/
proc genmod data=darfur.darfur3 ;
        model casefinal=durationb diarrhea1 male age /link=log d=p;

        estimate 'Greater than 73 days' durationb 1 /exp;
        estimate 'Diarrhea at baseline' diarrhea1 1 /exp;
run;quit;

  /*Prevalence calculations*/
Proc freq DATA=darfur.darfur3;
        where dataflag=0;
        tables casefinal case1 case2 case3 case4 case5 case6 diarrhea1rc diarrhea2rc
diarrhea3rc diarrhea4rc diarrhea5rc diarrhea6rc vomit1rc vomit2rc vomit3rc
        vomit4rc vomit5rc vomit6rc cough1rc cough2rc cough3rc cough4rc cough5rc
cough6rc fever1rc fever2rc fever3rc fever4rc fever5rc fever6rc;;
run;
/*creating a long dataset for looking at WHZ over time*/

data darfur.darfurlong;set darfur.darfur3;
        month=0; whz=whz_who1;haz=haz_who1; diarrhea=diarrhea1rc;
cough=cough1rc; fever=fever1rc; vomit=vomit1rc; output;
        month=1; whz=whz_who2;haz=haz_who2; diarrhea=diarrhea2rc;
cough=cough2rc; fever=fever2rc; vomit=vomit2rc;output;
```

```
        month=2; whz=whz_who3;haz=haz_who3; diarrhea=diarrhea3rc;
cough=cough3rc; fever=fever3rc; vomit=vomit3rc; output;
        month=3; whz=whz_who4;haz=haz_who4; diarrhea=diarrhea4rc;
cough=cough4rc; fever=fever4rc; vomit=vomit4rc; output;
        month=4; whz=whz_who5;haz=haz_who5; diarrhea=diarrhea5rc;
cough=cough5rc; fever=fever5rc; vomit=vomit5rc; output;
        month=6; whz=whz_who6;haz=haz_who6; diarrhea=diarrhea6rc;
cough=cough6rc; fever=fever6rc; vomit=vomit6rc; output;
        drop relation1-relation6; drop hhtotal1-hhtotal6;drop hhchild1-hhchild6;drop
parpresent1-parpresent6;
run;

/*Looking at WHZ over the study period*/
proc mixed data=darfur.darfurlong;
        model whz=month/ solution;
        random month /subject=childid type=un;
run;
/*looking at least squared means of WHZ over the study period*/
proc mixed data=darfur.darfurlong;
        class month;
        model whz=month/ solution;
        repeated month/subject=childid type=un;
        lsmeans month/pdiff;
run;
/*Creating a wave variable for looking at WHZ over time stratified by age*/
data temp;
        set darfur.darfurlong;
        wave=month;
run;
/*Looking at WHZ over time stratified by age*/
proc mixed data=temp method=ml;
class childid age wave;
model whz=wave age morb age*wave/ solution;
repeated wave /subject=childid type=un;
lsmeans wave*age / pdiff;
run;
**********************************************
Finished
```

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