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Statistical Analysis of Malnutrition Status of Under-five's (0-59) Months Children in Bama, Dikwa and Ngala Local Government Areas of Borno State, Nigeria in 2018

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Abstract: *In this study, malnutrition in children aged 0-59 months was analyzed using estimated prevalence points and 95% confidence intervals for weight-for-height (WFH) and mid-upper-arm circumference (MUAC). These indicators overlapped with severe acute malnutrition (SAM) and global acute malnutrition (GAM) in Bama. SAM based on WFH was 3.0% (1.3-6.7; 95% CI), while SAM based on MUAC was 5.6% (2.3-13.2; 95% CI). GAM was 9.5% (5.4-16.2; 95% CI) based on WFH and 21.6% (15.8-28.6; 95% CI) by MUAC, indicating that acute malnutrition by MUAC was above the 15% alert threshold, whereas WFH was at the upper limit of the 3% alert threshold. SAM prevalence based on MUAC was about 50% higher than that based on WFH Z-scores, further supporting the weak correlation between SAM and GAM prevalence across MUAC and WFH criteria. MUAC captured more SAM cases than WFH because of its sensitivity for younger and shorter children, i.e., those below one year and less than 75 cm. The study revealed that the difference between the 95% confidence intervals for GAM and SAM prevalence was statistically insignificant, i.e., 0.8% and 0.5%, respectively.*

Keyword: *Weight-for-height, Mid-Upper-Arm Circumference, Severe Acute Malnutrition, Global Acute Malnutrition, Prevalence rate, Confidence intervals.*

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1.0 Introduction

Malnutrition remains one of the most significant global public health challenges, disproportionately affecting children under five years of age, particularly in low- and middle-income countries . Recent estimates by UNICEF, WHO and the World Bank indicate that millions of children under five continue to suffer from wasting and stunting, with the highest burden occurring in Sub-Saharan Africa and South Asia.Malnutrition during early childhood results in irreversible physical, cognitive and behavioural impairments, including reduced intellectual development, poor educational attainment, increased morbidity and mortality, and diminished economic productivity in adulthood According to the World Health Organization (WHO), malnutrition refers to deficiencies, excesses or imbalances in an individual's intake of energy and nutrients that adversely affect normal growth, development and physiological function (FEWS NET 2011). Malnutrition is one of the leading causes of morbidity and mortality in children less than 5 years of age in Sub-Saharan Africa (Ekpo & Umo, 2012). Globally, it is the most important risk factor for illness and death contributing to more than half of deaths of children worldwide. It could result from a variety of causes of which the most immediate is an individual or a population's insufficient intake of food (Ekpo & Udoumoh, 2013). With a prolonged exposure to insufficient food intake, there is growth failure or stunting manifested as low weight or height for age in the individuals affected, while a brief exposure to an acute food shortage is usually manifested by wasting or thinness, typically characterized by a low Weight-for-Height

(WFH) or Mid-Upper Arm Circumference (MUAC) in the individuals affected. The degree of acute malnutrition could be either moderate or severe. Global acute malnutrition (GAM) is the term used to include all children with moderate wasting, severe wasting or oedema or a combination of both (Anthony G. T. et al, 2001).

In Nigeria, particularly in conflict-affected north-eastern states, childhood malnutrition remains a major humanitarian and public health concern. For example , in East Borno was 10.4% (8.1-13.2) 95% CI with SAM and MAM as 1.8%, 8.6%, respectively. Nutrition is unarguably a socio-economic, health and basic human right issue. Poor nutrition undermines the achievement of all other Millennium Development Goals (MDGs) and the risk associated with malnutrition, it remains one of the lowest health priorities even in many areas with the highest burden (NFSS 2017). Weight-for-Height (WFH) Z-scores and Mid-Upper Arm Circumference (MUAC) are the two most widely used anthropometric indicators for assessing acute malnutrition; however, differences in their diagnostic performance have been reported in several emergency settings

Borno State, located in north-eastern Nigeria, has experienced prolonged armed conflict that has resulted in widespread displacement, food insecurity, disruption of healthcare services and increased vulnerability to childhood malnutrition. Bama, Dikwa and Ngala Local Government Areas are among the most severely affected communities and therefore remain priority locations for humanitarian nutrition interventions. (Nigeria Demographic and Health Survey, 2008).

Several multisectoral humanitarian interventions involving nutrition, health, food security, and water, sanitation and hygiene (WASH) have been implemented by governmental and international organizations to address the nutritional needs of internally displaced persons and host communities in Bama, Dikwa and Ngala Local Government Areas (Nutrition and Food Security Surveillance, 2017). Specifically, the interventions in communities were in three targeted Local Government Areas namely Bama (IDP Camp), Dikwa (Bulabulin, Fulatari, Masarmari camps) and Gamboru Host Community (Ward B and C) . Hausa and Fulfulde are the common languages of these inhabitants (Northeast, Nigeria 2018). These interventions in the forms of nutritional surveillance in specific locations provides real time monitoring and early warning of nutritional deteriorations in the state. The general objective of the study is to assess the nutritional status of children aged 6-59 months old and/or measuring from 65-110cm in height in the study population (Grellety G. et al., 2013). Previous studies conducted in north-eastern Nigeria have consistently reported elevated rates of acute malnutrition among children under five, particularly in areas affected by armed conflict and population displacement. However, most of these studies have focused primarily on estimating prevalence without statistically comparing anthropometric indicators or evaluating the precision of prevalence estimates using confidence intervals. From a statistical perspective, estimating prevalence together with 95% confidence intervals and comparing anthropometric indicators provides valuable evidence for assessing the reliability of nutritional surveillance data and improving programme decision-making

Despite ongoing nutritional surveillance in Borno State, limited studies have statistically compared prevalence estimates obtained using Weight-for-Height Z-scores and Mid-Upper Arm Circumference or examined whether differences in the prevalence of Severe Acute Malnutrition (SAM) and Global Acute Malnutrition (GAM) are statistically significant. Consequently, evidence on the comparative performance of these anthropometric indicators in conflict-affected populations remains limited. Therefore, this study aimed to statistically evaluate the nutritional status of children aged 0–59 months in Bama, Dikwa and Ngala Local Government Areas by estimating the prevalence and 95% confidence intervals of Severe Acute Malnutrition (SAM) and Global Acute Malnutrition (GAM) using Weight-for-Height Z-scores and Mid-Upper Arm Circumference, and by comparing the performance of these anthropometric indicators.

The findings of this study will provide evidence for humanitarian agencies, public health practitioners and policymakers to improve nutritional screening strategies, prioritize interventions and allocate resources more effectively in conflict-affected communities

2.0 Materials and Methods

2.1 Study Area and Study Population

The study was conducted in three Local Government Areas (LGAs), namely Bama, Dikwa and Ngala, located in Borno State, north-eastern Nigeria. The three LGAs cover land areas of approximately 5,158.87 km², 1,836.89 km² and 1,519.82 km², respectively. Borno State shares international boundaries with the Republic of Niger to the north, the Republic of Chad and Lake Chad to the northeast, and the Republic of Cameroon to the east. It also shares boundaries with Adamawa, Gombe and Yobe States within Nigeria. The selected LGAs have comparable socio-economic, geographical and cultural characteristics and have experienced similar humanitarian conditions arising from prolonged armed conflict, population displacement and food insecurity. Consequently, they were treated as a single survey domain in accordance with the Standardized Monitoring and Assessment of Relief and Transitions (SMART) survey methodology.

The study population comprised children aged 6–59 months who were permanent residents of the selected communities at the time of the survey. Eligible children measured between 65 and 110 cm in height and were available in their households during data collection. Children outside the specified age or height range were excluded from the anthropometric assessment. A household was defined as a group of individuals who lived together, shared meals from the same cooking pot and recognized one person as the household head. In polygamous households, one wife and her children were selected using simple random sampling to ensure equal probability of selection.

2.2 Study Design, Sample Size and Sampling Procedure

A community-based cross-sectional survey employing a multi-stage cluster sampling design based on the SMART and WHO Expanded Programme on Immunization (EPI) methodologies was conducted between 27 and 31 July 2018. Data collection was carried out simultaneously in Bama, Dikwa and Ngala by twelve trained survey teams under the supervision of experienced field coordinators. Three teams were assigned to Bama, three teams to Dikwa and six teams to Ngala, reflecting the relative population sizes of the survey locations. Each team consisted of one team leader and two anthropometric measurers. The sample size was determined using the SMART survey sample size formula based on an expected Global Acute Malnutrition (GAM) prevalence of 14.7%, a 95% confidence level, a desired precision of ±3.0%, a design effect of 1.5 and a 5% allowance for non-response. The calculation also considered that children under five years constituted approximately 17.5% of the total population and that the average household size was seven persons. The required minimum sample size was estimated at 874 eligible children, corresponding to approximately 822 households.

$$n = \left[\frac{t^2(p)(1-p)(DEFF)(1.05)}{d^2(pc)(hz)} \right] \quad (1)$$

where n = required sample size, expressed as number of households, for the KEY indicator, t = is a factor to achieve 95% confidence interval

p= is the estimated value of the indicator/expected prevalence 1.05=factor necessary to raise the sample size by 5 % for non-response

DEFF = design effect

d= relative desired precision

pc= proportion of children under five years, and

hz= average household size (that is, average number of persons per household).

Thirty clusters were selected across the three LGAs using probability proportional to population size (PPS). The allocated clusters were distributed proportionately across the three strata (Bama, Dikwa and Ngala) according to their population sizes. Within each cluster, approximately 76 households were visited until the required number of eligible children had been enrolled. Households that were absent during the initial visit were revisited once before being classified as non-respondents.

2.3 Cluster Selection

Cluster selection was performed using the ENA for SMART software following the probability proportional to size (PPS) sampling procedure. A complete list of settlements with their respective population sizes served as the sampling frame. The software automatically generated the required clusters based on cumulative population size. Within each selected cluster, the first household was selected using simple random sampling, after which subsequent households were selected following the standard SMART household selection procedure.

In households with more than one wife, a single wife together with her children was selected by simple random sampling. Mortality interviews were first administered to the selected household before anthropometric measurements were obtained for all eligible children. Where no eligible child was present, survey teams proceeded to the next household. Households with temporarily absent eligible children were revisited once later on the same day.

2.4 Training and Supervision

Forty-five experienced survey workers drawn from the study area participated in a three-day refresher training conducted between 24 and 26 July 2018. The training covered sampling procedures, household selection techniques, anthropometric measurements, identification of bilateral pitting oedema, interview techniques, data recording procedures, ethical conduct, and quality assurance measures. Practical sessions were conducted to standardize anthropometric measurements and minimize inter-observer and intra-observer variability.

At the conclusion of the training, participants completed written and practical standardization tests. Based on their performance, twelve survey teams were constituted. Each team comprised one team leader and two anthropometric measurers, including at least one female member to facilitate access to households where cultural norms restricted interactions with male surveyors.

Throughout the survey period, field supervisors closely monitored all teams to ensure strict adherence to the study protocol. Completed questionnaires were uploaded daily using Open Data Kit (ODK) and subjected to routine plausibility and consistency checks before data validation.

2.5 Data Collection

Data were collected using a standardized nutrition questionnaire programmed into the Open Data Kit (ODK) electronic data collection platform. Information collected included age, sex, weight, height (or length), Mid-Upper Arm Circumference (MUAC), and the presence of bilateral pitting oedema.

Age determination: Children's ages were obtained primarily from birth certificates or vaccination cards where available. In the absence of documentary evidence, mothers or caregivers were interviewed to estimate the child's age using recall of important local events.

Height/Length measurement: Height or recumbent length was measured using a standardized wooden measuring board to the nearest 0.1 cm. Children measuring 87 cm or taller were measured in the standing position, whereas children shorter than 87 cm were measured in the recumbent position in accordance with WHO recommendations.

Weight measurement: Body weight was measured using calibrated electronic weighing scales accurate to the nearest 0.1 kg. Children were weighed wearing light clothing and without shoes. Scale calibration was verified each morning before field activities commenced.

Mid-Upper Arm Circumference (MUAC): MUAC was measured at the midpoint of the left upper arm using a standard MUAC tape and recorded to the nearest 1 mm (0.1 cm).

Assessment of bilateral pitting oedema: Bilateral pitting oedema was assessed by applying gentle thumb pressure to the dorsum of both feet for approximately three seconds. Children presenting with bilateral oedema, MUAC <115 mm, or Weight-for-Height Z-score (WHZ) below −3 standard deviations according to the WHO Child Growth Standards were immediately referred to the nearest outpatient therapeutic programme for appropriate management.

2.6 Data Management and Statistical Analysis

Completed questionnaires were uploaded daily and reviewed for completeness and internal consistency. Anthropometric data were analysed using ENA for SMART software (Version 2015), with anthropometric indices calculated according to the WHO Child Growth Standards (WHO, 2006). Implausible anthropometric measurements were identified and excluded using the SMART plausibility flag criteria before statistical analysis.

Descriptive statistics were used to summarize the demographic characteristics of the study population. The prevalence of Severe Acute Malnutrition (SAM) and Global Acute Malnutrition (GAM) was estimated using both Weight-for-Height Z-scores (WHZ) and Mid-Upper Arm Circumference (MUAC), and corresponding 95% confidence intervals were computed. Estimates were adjusted for the cluster sampling design incorporated in the SMART software. Differences between prevalence estimates obtained using WHZ and MUAC were statistically evaluated based on overlapping confidence intervals, with statistical significance assessed at a 5% significance level.

2.7 Ethical Considerations

Ethical approval for the survey was obtained from the appropriate institutional and governmental authorities responsible for humanitarian health research in Borno State before commencement of the study. Permission to conduct the survey was also obtained from the relevant local government authorities and community leaders. Written or verbal informed consent was obtained from the parent or primary caregiver of every eligible child before participation. Participation was entirely voluntary, and all collected information was treated confidentially and used solely for research purposes. Children identified with severe acute malnutrition or bilateral pitting oedema during the survey were immediately referred to the nearest health facility for appropriate treatment in accordance with national and WHO guidelines.

3.0 Results and Discussion

3.1 Description of the Sample and Data Quality

A total of 1,390 children aged 6–59 months and/or measuring 65–110 cm in height participated in the nutrition survey conducted across the three study Local Government Areas (LGAs). Of these, 232 (16.7%) children were sampled from Bama, 281 (20.2%) from Dikwa, and 877 (63.1%) from Ngala. The relatively larger sample obtained from Ngala reflects its larger population size and the proportional allocation of clusters during the sampling process. The high response rate achieved across the three LGAs demonstrates good field coverage and provides a robust dataset for estimating the prevalence of acute malnutrition within the study population.

3.1.1 Age and Sex Distribution of the Study Population

The age and sex distribution of the children surveyed in Bama LGA is presented in Table 1. Overall, the sample consisted of 117 (50.4%) boys and 115 (49.6%) girls, yielding an overall boy-to-girl ratio of approximately 1:1, which indicates an almost equal representation of both sexes. The largest proportion of children (32.3%) belonged to the 18–29 months age group, followed by those aged 30–41 months (22.4%) and 6–17 months (22.0%), while children aged 54–59 months constituted the smallest proportion (9.5%). Although slight variations in the boy-to-girl ratio were observed across age groups, the overall distribution was relatively balanced, suggesting minimal risk of gender-related sampling bias.

The age and sex distribution of children surveyed in Dikwa LGA is presented in Table 2. A total of 281 children were examined, comprising 135 (48.0%) boys and 146 (52.0%) girls, resulting in a boy-to-girl ratio of 0.9. Children aged 6–17 months accounted for the largest proportion of the sample (33.1%), whereas those aged 54–59 months represented only 6.4%. Similar to Bama, no substantial gender imbalance was observed across the various age categories. The slight predominance of female children is unlikely to have influenced the prevalence estimates because both sexes were adequately represented.

As shown in Table 3, 877 children were assessed in Ngala LGA, including 433 (49.4%) boys and 444 (50.6%) girls, again demonstrating an almost equal sex distribution. Children aged 6–17 months constituted the largest age category (30.7%), followed by those aged 30–41 months (26.1%) and 18–29 months (20.6%), whereas only 4.6% of the participants were aged 54–59 months. The similarity in age and sex distribution across the three LGAs indicates that the sampling strategy successfully captured comparable demographic characteristics, thereby facilitating meaningful comparisons of nutritional status between the study locations.

The predominance of children younger than 30 months observed across the three LGAs is consistent with demographic patterns reported in previous nutrition surveys conducted in emergency settings, where younger children often constitute a larger proportion of the under-five population. This age group is particularly vulnerable to acute malnutrition because of rapid growth requirements, inappropriate complementary feeding practices, recurrent infections, and reduced immunity. Consequently, their adequate representation strengthens the reliability of the survey for estimating the burden of acute malnutrition.

Table 1: Age and Sex distribution of children in Bama LGA

	Boys		Girls		Total		Ratio
AGE (mo)	**no.**	**%**	**no.**	**%**	**no.**	**%**	**Boy: girl**
6-17	28	54.9	23	45.1	51	22.0	1.2
18-29	38	50.7	37	49.3	75	32.3	1.0
30-41	23	44.2	29	55.8	52	22.4	0.8
42-53	13	40.6	19	59.4	32	13.8	0.7
54-59	15	68.2	7	31.8	22	9.5	2.1
Total	117	50.4	115	49.6	232	100.0	1.0

Table 2: Age and Sex distribution of children in Dikwa LGA

	Boys		Girls		Total		Ratio
AGE (mo)	**no.**	**%**	**no.**	**%**	**no.**	**%**	**Boy: girl**
6-17	49	52.7	44	47.3	93	33.1	1.1
18-29	22	40.0	33	60.0	55	19.6	0.7
30-41	31	44.9	38	55.1	69	24.6	0.8
42-53	23	50.0	23	50.0	46	16.4	1.0
54-59	10	55.6	8	44.4	18	6.4	1.3
Total	135	48.0	146	52.0	281	100.0	0.9

Table 3: Age and Sex distribution of children in Ngala LGA

	Boys		Girls		Total		Ratio
AGE (mo)	**no.**	**%**	**no.**	**%**	**no.**	**%**	**Boy: girl**
6-17	146	54.3	123	45.7	269	30.7	1.2
18-29	83	45.9	98	54.1	181	20.6	0.8
30-41	107	46.7	122	53.3	229	26.1	0.9
42-53	73	46.2	85	53.8	158	18.0	0.9
54-59	24	60.0	16	40.0	40	4.6	1.5
Total	433	49.4	444	50.6	877	100.0	1.0

3.1.2 Data Quality Assessment Using Weight-for-Height Z-scores

The quality of the anthropometric measurements based on Weight-for-Height (WFH) Z-scores is summarized in Table 4. The mean WFH Z-score for children in Bama LGA was -0.83 ± 0.87, indicating that, on average, the nutritional status of the surveyed children was below the WHO reference median but remained within the acceptable range for emergency nutrition assessments. Only two observations lacked valid Z-scores, while no anthropometric measurements were classified as biologically implausible or outside the acceptable WHO limits. This finding demonstrates excellent measurement quality and suggests that field procedures were carefully implemented.

In Dikwa LGA, the mean WFH Z-score was -1.03 ± 1.17, representing the lowest mean value among the three study areas (Table 4). This lower mean suggests poorer overall nutritional status compared with Bama and Ngala. Although ten observations had unavailable Z-scores, no outlier measurements were recorded, indicating that data quality remained acceptable despite the relatively wider standard deviation. The larger variability observed in Dikwa may reflect greater heterogeneity in the nutritional status of children resulting from differences in household food security, disease burden, or access to humanitarian assistance.

Children surveyed in Ngala LGA recorded a mean WFH Z-score of -0.76 ± 0.85, the highest among the three LGAs (Table 4). Although still below the WHO growth reference median, this result indicates relatively better nutritional status than that observed in Bama and Dikwa. Similar to Dikwa, only ten records had unavailable Z-scores, while no biologically implausible values were identified. The absence of extreme anthropometric measurements across all three LGAs confirms that standardized measurement procedures and quality control measures were effectively implemented throughout the survey.

The design effects estimated for WFH-based acute malnutrition were 1.27, 1.81, and 2.22 for

Bama, Dikwa and Ngala, respectively (Table 4). A design effect close to one indicates limited clustering of malnutrition cases, whereas higher values suggest greater between-cluster variability. The relatively higher design effect observed in Ngala implies greater heterogeneity in the distribution of acute malnutrition across survey clusters, which may reflect differences in food availability, household vulnerability, access to nutrition services, or varying impacts of the humanitarian crisis within the LGA. Nevertheless, all design effects fall within acceptable limits for cluster-based nutrition surveys and indicate that the sampling strategy adequately captured spatial variability in nutritional status.

3.1.3 Data Quality Assessment Using Mid-Upper Arm Circumference (MUAC)

The distribution of MUAC measurements and corresponding data quality indicators are presented in Table 5. The mean MUAC values were 134.2 ± 12.0 mm in Bama, 143.3 ± 14.9 mm in Dikwa, and 142.0 ± 14.4 mm in Ngala. None of the surveyed children had missing or biologically implausible MUAC measurements, demonstrating excellent completeness and consistency of the anthropometric data collected during the survey.

The design effect for MUAC-based acute malnutrition was 1.00 in Bama, indicating an almost random distribution of cases across clusters. In contrast, design effects of 3.27 in Dikwa and 2.66 in Ngala suggest greater clustering of malnutrition cases within specific communities. Such clustering is expected in humanitarian emergencies where nutritional status is strongly influenced by localized factors, including population displacement, household food insecurity, disease outbreaks, sanitation conditions, and unequal access to humanitarian assistance.

Although Dikwa recorded the highest average MUAC measurement, this finding should not be interpreted as evidence of superior nutritional status in isolation because MUAC reflects arm circumference rather than body proportionality. Consequently, MUAC results should always be interpreted alongside Weight-for-Height Z-scores and clinical assessment to provide a comprehensive evaluation of acute malnutrition.

Table 4: Mean Z-scores and design effects in Bama, Dikwa and Ngala LGAs respectively

Indicator	n	Mean z-scores ± SD	Design Effect (z-score < -2)	z-scores not available*	z-scores out of range
Weight-for-Height	230	-0.83±0.87	1.27	2	0
Weight-for-Height	271	-1.03±1.17	1.81	10	0
Weight-for-Height	867	-0.76±0.85	2.22	10	0

Table 5: Mean Z-scores, design effects for MUAC in Bama, Dikwa and Ngala LGAs respectively

Indicator	n	Mean Z-scores ± SD	Design Effect (MUAC <125)	Z-scores not available*	Z-scores out of range
MUAC	232	134.2±12.0	1.00	0	0
MUAC	281	143.3±14.9	3.27	0	0
MUAC	877	142.0±14.4	2.66	0	0

3.1.4 Distribution of Mean MUAC Across Survey Clusters

The distribution of mean MUAC measurements across the survey clusters is illustrated in *Figs* 1–3. *Fig.* 1 shows that cluster mean MUAC values in Bama LGA were relatively homogeneous, with only modest variation between clusters. This pattern indicates consistent nutritional conditions across the surveyed communities and further supports the relatively low design effect observed for MUAC.

In Dikwa LGA, the cluster distribution shown in *Fig.* 2 exhibited greater variability, with some clusters recording substantially lower mean MUAC values than others. This observation is consistent with the higher MUAC design effect reported in Table 5 and suggests that acute malnutrition was concentrated in particular communities rather than being uniformly distributed throughout the LGA. Such spatial heterogeneity may reflect differences in livelihood opportunities, food availability, security conditions, and access to humanitarian interventions.

Similarly, *Fig.* 3 demonstrates moderate variability in cluster mean MUAC values across Ngala LGA, although the variation was less pronounced than in Dikwa. The distribution indicates that while the overall nutritional status of children in Ngala was relatively stable, pockets of elevated nutritional vulnerability remained within specific clusters. These findings emphasize the importance of cluster-level nutritional surveillance for identifying localized areas requiring targeted nutrition interventions.

The demographic characteristics and anthropometric quality indicators demonstrate that the survey achieved a representative sample of under-five children across the three LGAs. The nearly equal distribution of boys and girls minimizes the likelihood of sex-related sampling bias and allows meaningful comparisons of nutritional status between males and females. Likewise, the predominance of younger children is consistent with demographic patterns observed in previous nutrition surveys in conflict-affected settings and is particularly relevant because children below two years of age are biologically more susceptible to acute malnutrition.

The anthropometric data satisfied the quality standards recommended by the SMART methodology. The absence of biologically implausible Z-scores and the negligible proportion of missing anthropometric records indicate that field measurements were conducted with a high degree of precision. Similar levels of data quality have been reported in previous SMART nutrition surveys conducted in emergency settings, where rigorous training, standardization exercises, and routine plausibility checks contributed to reliable anthropometric measurements.

The observed differences in mean WFH Z-scores and MUAC values among the three LGAs suggest varying levels of nutritional vulnerability across the study area. In particular, the lower mean WFH Z-score recorded in Dikwa indicates comparatively poorer nutritional status, a finding that may be associated with greater disruption of livelihoods, prolonged displacement, and reduced access to food and healthcare services. Conversely, the relatively higher mean WFH Z-score observed in Ngala suggests comparatively better nutritional conditions, although the moderate design effect indicates that important geographical disparities persist within the LGA.

Overall, the high quality of the anthropometric data provides confidence in the validity of the subsequent estimates of Global Acute Malnutrition (GAM) and Severe Acute Malnutrition (SAM). The acceptable design effects and consistency of the anthropometric indicators indicate that the survey methodology was appropriate for estimating the prevalence of acute malnutrition and for comparing nutritional outcomes among the three conflict-affected LGAs.

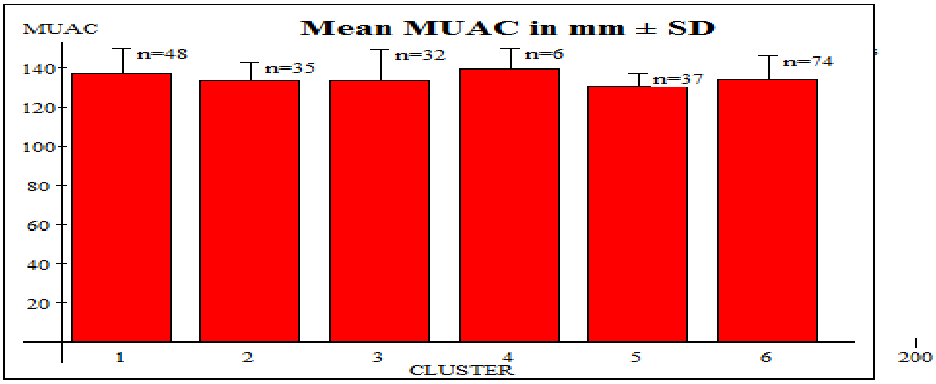

***Fig.* 1: Distribution of Mean MUAC in mm per Cluster for Bama LGA**

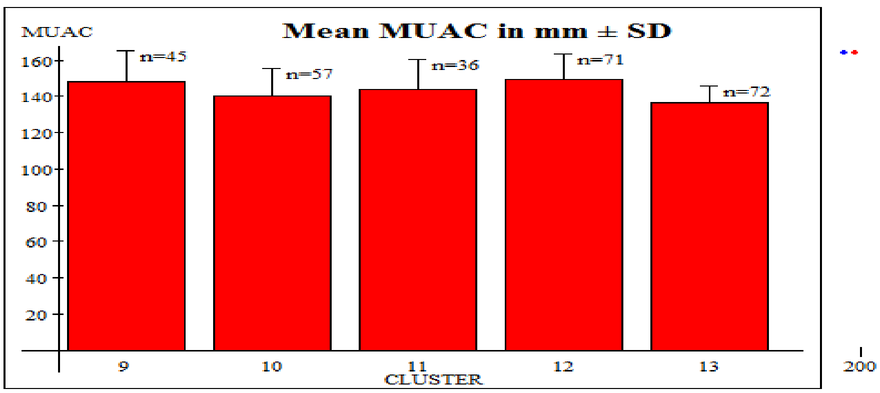

***Fig.* 2: Distribution of Mean MUAC in mm per Cluster for Dikwa LGA**

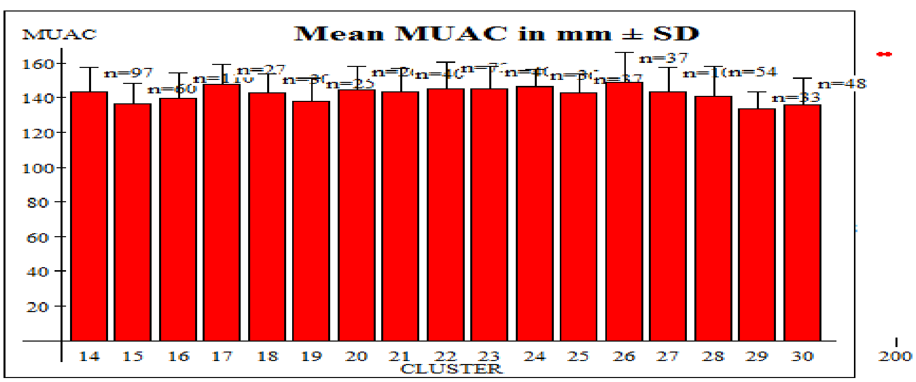

***Fig.* 3: Distribution of Mean MUAC in mm per Cluster for Ngala LGA**

3.2 Prevalence of Acute Malnutrition Based on Weight-for-Height (WHZ)

The prevalence of acute malnutrition among children aged 6–59 months was assessed using the World Health Organization (WHO) Weight-for-Height Z-score (WHZ) criteria and the presence of bilateral pitting oedema. The results are presented in Tables 6–14 and *Figs* 4–9. The findings revealed considerable variation in the prevalence of Global Acute Malnutrition (GAM) and Severe Acute Malnutrition (SAM) among the three Local Government Areas (LGAs), reflecting differences in nutritional vulnerability across the study locations.

Table 6: Prevalence of acute malnutrition based on Weight-for-Height Z-scores (and/or edema) and by sex in Bama LGA

Prevalence	All n = 232	Boys n = 117	Girls n = 115
Prevalence of global malnutrition (<-2 z-score and/or oedema)	(22) 9.5 % (5.4 - 16.2 95% C.I.)	(13) 11.1 % (5.3 - 21.8 95% C.I.)	(9) 7.8 % (2.6 - 21.2 95% C.I.)
Prevalence of moderate malnutrition (<-2 z-score and >=-3 z-score, no oedema)	(15) 6.5 % (3.4 - 12.0 95% C.I.)	(9) 7.7 % (4.1 - 14.0 95% C.I.)	(6) 5.2 % (1.7 - 15.2 95% C.I.)
Prevalence of severe malnutrition (<-3 z-score and/or oedema)	(7) 3.0 % (1.3 - 6.7 95% C.I.)	(4) 3.4 % (0.5 - 18.6 95% C.I.)	(3) 2.6 % (0.7 - 9.5 95% C.I.)

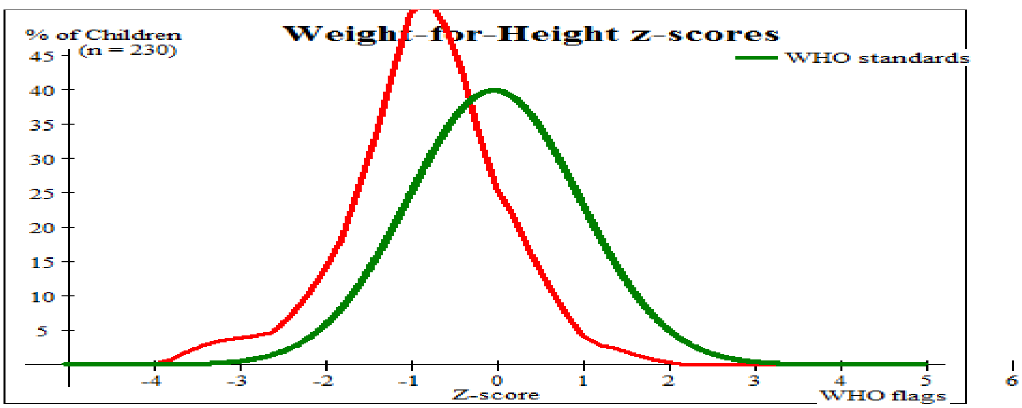

Fig. **4: Gaussian Curve for Weight- for- Height in Bama LGA**

Table 7: Prevalence of acute malnutrition based on Weight-for-Height Z-scores (and/or edema) and by sex in Dikwa LGA

Prevalence	All n = 281	Boys n = 135	Girls n = 146
Prevalence of global malnutrition (<-2 z-score and/or oedema)	(68) 24.2 % (16.2 - 34.6 95% C.I.)	(33) 24.4 % (13.1 - 41.1 95% C.I.)	(35) 24.0 % (16.9 - 32.8 95% C.I.)
Prevalence of moderate malnutrition (<-2 z-score and >=-3 z-score, no oedema)	(44) 15.7 % (8.2 - 27.9 95% C.I.)	(21) 15.6 % (6.7 - 32.3 95% C.I.)	(23) 15.8 % (9.3 - 25.4 95% C.I.)
Prevalence of severe malnutrition (<-3 z-score and/or oedema)	(24) 8.5 % (3.1 - 21.5 95% C.I.)	(12) 8.9 % (2.4 - 28.0 95% C.I.)	(12) 8.2 % (2.1 - 27.6 95% C.I.)

Fig. 5: Gaussian Curve for Weight- for- Height in Dikwa LGA

Table 8: Prevalence of acute malnutrition based on Weight-for-Height Z-scores (and/or edema) and by sex in Ngala LGA

Prevalence	All n = 877	Boys n = 433	Girls n = 444
Prevalence of global malnutrition (<-2 z-score and/or oedema)	(67) 7.6 % (5.1 - 11.3 95% C.I.)	(33) 7.6 % (5.0 - 11.5 95% C.I.)	(34) 7.7 % (4.4 - 13.1 95% C.I.)
Prevalence of moderate malnutrition (<-2 z-score and >=-3 z-score, no oedema)	(41) 4.7 % (3.5 - 6.2 95% C.I.)	(20) 4.6 % (3.0 - 7.0 95% C.I.)	(21) 4.7 % (3.0 - 7.3 95% C.I.)
Prevalence of severe malnutrition (<-3 z-score and/or oedema)	(26) 3.0 % (1.4 - 6.0 95% C.I.)	(13) 3.0 % (1.2 - 7.4 95% C.I.)	(13) 2.9 % (1.1 - 7.7 95% C.I.)

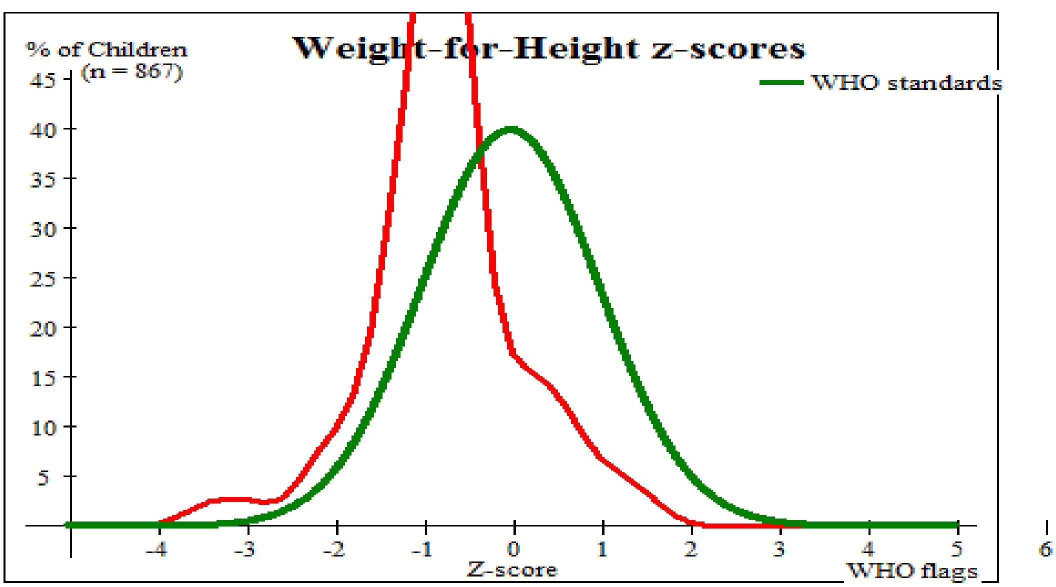

Fig. 6: Gaussian Curve for Weight- for- Height in Dikwa LGA

Table 9: Prevalence of acute malnutrition by age based on Weight-for-Height z-scores and/or oedema in Bama LGA

		Severe wasting (<-3 z-score)		**Moderate wasting (>= -3 and <-2 z-score)**		**Normal (> = -2 z score)**		**Oedema**	
Age (months)	Total no.	No.	%	No.	%	No.	%	No.	%
6-17	51	3	5.9	6	11.8	42	82.4	0	0.0
18-29	75	2	2.7	5	6.7	66	88.0	2	2.7
30-41	52	0	0.0	2	3.8	50	96.2	0	0.0
42-53	32	0	0.0	1	3.1	31	96.9	0	0.0
54-59	22	0	0.0	1	4.5	21	95.5	0	0.0
Total	232	5	2.2	15	6.5	210	90.5	2	0.9

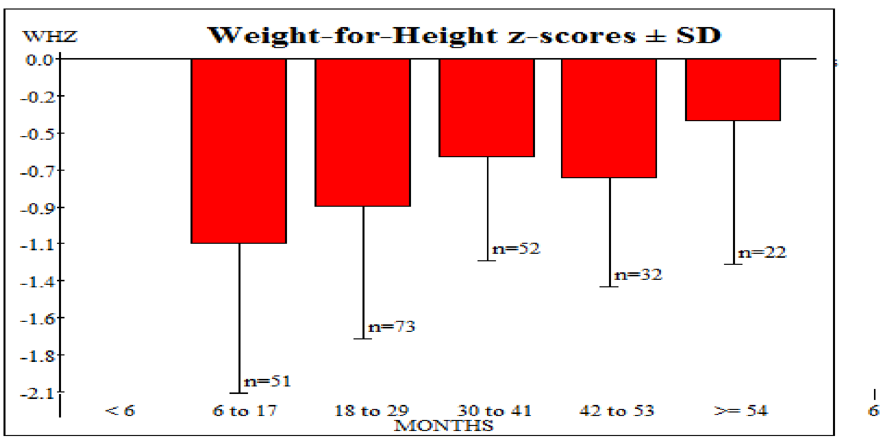

***Fig.* 7: Bar charts for age based Weight- for- Height in Bama LGA**

Table 10: Prevalence of acute malnutrition by age based on Weight-for-Height z-scores and/or oedema in Dikwa LGA

		Severe wasting (<-3 z-score)		**Moderate wasting (>= -3 and <-2 z-score)**		**Normal (> = -2 z score)**		**Oedema**	
Age (month)	Total no.	No.	%	No.	%	No.	%	No.	%
6-17	93	1	1.1	16	17.2	67	72.0	9	9.7
18-29	55	1	1.8	4	7.3	50	90.9	0	0.0
30-41	69	8	11.6	8	11.6	52	75.4	1	1.4
42-53	46	3	6.5	11	23.9	32	69.6	0	0.0
54-59	18	1	5.6	5	27.8	12	66.7	0	0.0
Total	281	14	5.0	44	15.7	213	75.8	10	3.6

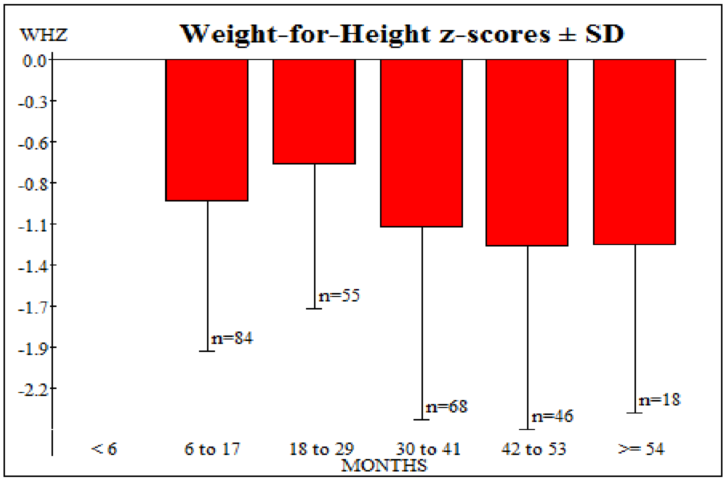

***Fig.* 8: Bar charts for age based Weight- for- Height in Dikwa LGA**

Table 11: Prevalence of acute malnutrition by age based on Weight-for-Height z-scores and/or oedema in Ngala LGA

		Severe wasting (<-3 z-score)		**Moderate wasting (>= -3 and <-2 z-score)**		**Normal (> = -2 z score)**		**Oedema**	
Age (month)	Total no.	No.	%	No.	%	No.	%	No.	%
6-17	269	3	1.1	17	6.3	243	90.3	6	2.2
18-29	181	1	0.6	7	3.9	171	94.5	2	1.1
30-41	229	7	3.1	7	3.1	213	93.0	2	0.9
42-53	158	3	1.9	9	5.7	146	92.4	0	0.0
54-59	40	2	5.0	1	2.5	37	92.5	0	0.0
Total	877	16	1.8	41	4.7	810	92.4	10	1.1

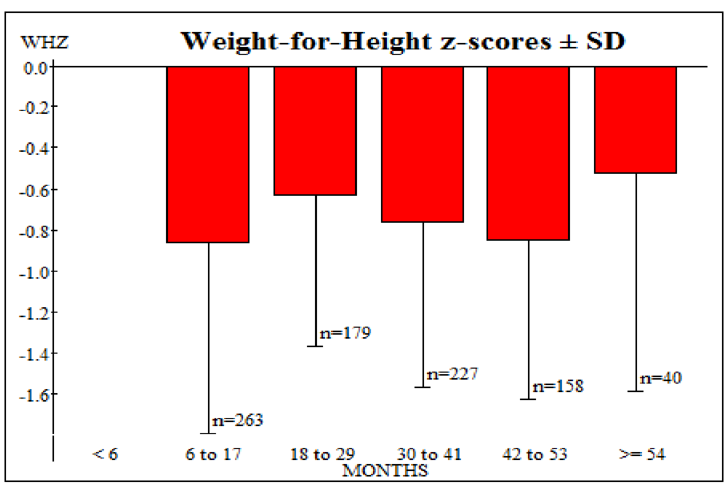

***Fig.* 9: Bar charts for age based Weight- for- Height in Ngala LGA**

Table 12: Distribution of acute malnutrition and oedema based on Weight-for-Height Z-scores in in Bama LGA

	<-3 z-score	**>=-3 z-score**
Oedema present	Marasmic kwashiorkor 0 (0.0 %)	Kwashiorkor 2 (0.9 %)
Oedema absent	Marasmic 5 (2.2 %)	Not severely malnourished 225 (97.0 %)

Table 13: Distribution of acute malnutrition and oedema based on Weight-for-Height Z-scores in Dikwa LGA

	<-3 z-score	**>=-3 z-score**
Oedema present	Marasmic kwashiorkor 1(0.4 %)	Kwashiorkor 9(3.2 %)
Oedema absent	Marasmic 14(5.0 %)	Not severely malnourished 257(91.5 %)

Table 14: Distribution of acute malnutrition and oedema based on Weight-for-Height Z-scores in in Ngala LGA

	<-3 z-score	**>=-3 z-score**
Oedema present	Marasmic kwashiorkor 0(0.0 %)	Kwashiorkor 10(1.1 %)
Oedema absent	Marasmic 16(1.8 %)	Not severely malnourished 851(97.0 %)

Table 15: Prevalence of acute malnutrition for children from 65 to 110 cm based on MUAC and/or presence of bilateral oedema in Bama LGA

Prevalence	**All** **n = 232**	**Boys** **n = 117**	**Girls** **n = 115**
Prevalence of global malnutrition **(< 125 mm and/or oedema)**	(50) 21.6 % (15.8 - 28.6 95% C.I.)	(29) 24.8 % (17.5 - 33.8 95% C.I.)	(21) 18.3 % (9.6 - 31.9 95% C.I.)
Prevalence of moderate malnutrition **(< 125 mm and >= 115 mm, no oedema)**	(37) 15.9 % (11.0 - 22.6 95% C.I.)	(24) 20.5 % (14.6 - 28.0 95% C.I.)	(13) 11.3 % (5.9 - 20.6 95% C.I.)
Prevalence of severe malnutrition **(< 115 mm and/or oedema)**	(13) 5.6 % (2.3 - 13.2 95% C.I.)	(5) 4.3 % (1.4 - 12.7 95% C.I.)	(8) 7.0 % (2.2 - 20.1 95% C.I.)

Note: Prevalence of oedema (n=0): 0.0%. Table 15 shows that GAM prevalence for boys is higher than girls. This difference can be to be statistically significant considering the fact that the numbers are not the same but the confidence interval overlap.

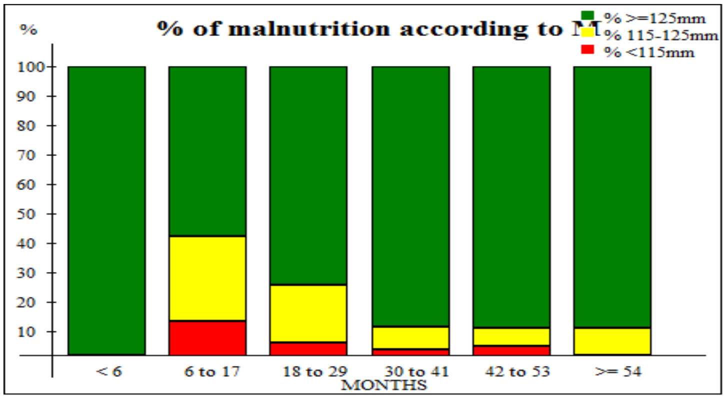

***Fig.* 10: Bar chart for age based prevalence indexed by MUAC in Bama LGA**

Table 16: Prevalence of acute malnutrition for children from 65 to 110 cm based on MUAC and/or presence of bilateral oedema in Dikwa LGA

Prevalence	**All n = 281**	**Boys n = 135**	**Girls n = 146**
Prevalence of global malnutrition (< 125 mm and/or oedema)	(34) 12.1 % (4.6 - 28.4 95% C.I.)	(18) 13.3 % (3.4 - 40.5 95% C.I.)	(16) 11.0 % (5.8 - 19.9 95% C.I.)
Prevalence of moderate malnutrition (< 125 mm and >= 115 mm, no oedema)	(21) 7.5 % (2.1 - 23.1 95% C.I.)	(10) 7.4 % (1.2 - 35.5 95% C.I.)	(11) 7.5 % (3.4 - 15.8 95% C.I.)
Prevalence of severe malnutrition (< 115 mm and/or oedema)	(13) 4.6 % (1.2 - 16.4 95% C.I.)	(8) 5.9 % (1.6 - 19.3 95% C.I.)	(5) 3.4 % (0.7 - 15.9 95% C.I.)

Prevalence of oedema (n=0): 0.0%. Table 16 shows that GAM prevalence for boys is higher than girls. This difference can be said to be statistically significant considering the fact that the numbers are not the same but the confidence interval overlap.

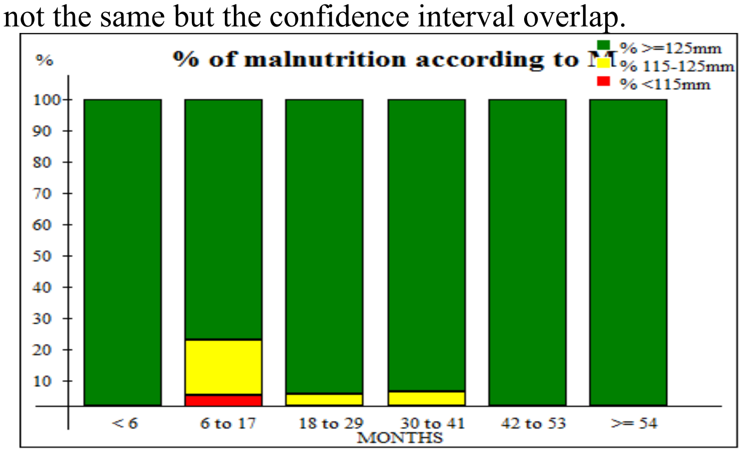

***Fig.* 11: Bar chart for age based prevalence indexed by MUAC in Dikwa LGA**

Table 17: Prevalence of acute malnutrition for children from 65 to 110 cm based on MUAC and/or presence of bilateral oedema in Ngala LGA

Prevalence	All n = 877	Boys n = 433	Girls n = 444
Prevalence of global malnutrition (< 125 mm and/or oedema)	(107) 12.2 % (9.1 - 16.1 95% C.I.)	(52) 12.0 % (8.5 - 16.7 95% C.I.)	(55) 12.4 % (8.9 - 17.0 95% C.I.)
Prevalence of moderate malnutrition (< 125 mm and >= 115 mm, no oedema)	(71) 8.1 % (5.6 - 11.6 95% C.I.)	(37) 8.5 % (5.1 - 13.9 95% C.I.)	(34) 7.7 % (5.4 - 10.7 95% C.I.)
Prevalence of severe malnutrition (< 115 mm and/or oedema)	(36) 4.1 % (2.6 - 6.4 95% C.I.)	(15) 3.5 % (2.0 - 5.9 95% C.I.)	(21) 4.7 % (2.8 - 7.8 95% C.I.)

Prevalence of oedema (n=0): 0.0%. Table 17 shows that GAM prevalence for girls is slightly higher than boys. This difference is not statistically significant considering the fact that the numbers even though not the same but the confidence interval did not overlap so much.

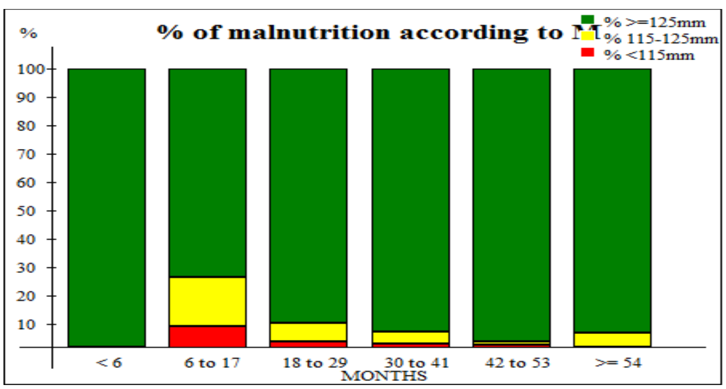

Fig. 12: Bar chart for age based prevalence indexed by MUAC in Ngala LGA

3.2.1 Prevalence of Acute Malnutrition in Bama LGA

The prevalence of acute malnutrition based on WHZ in Bama LGA is presented in Table 6. Overall, 9.5% (95% CI: 5.4–16.2%) of children were classified as having Global Acute Malnutrition (GAM), while 3.0% (95% CI: 1.3–6.7%) were affected by Severe Acute Malnutrition (SAM). Moderate Acute Malnutrition (MAM) accounted for 6.5% (95% CI: 3.4–12.0%) of the children surveyed.

Sex-disaggregated analysis showed that boys experienced a slightly higher prevalence of GAM (11.1%) than girls (7.8%). Similarly, SAM prevalence was marginally higher among boys (3.4%) than girls (2.6%). However, the substantial overlap between the 95% confidence intervals indicates that these differences were not statistically significant, suggesting that acute malnutrition affected male and female children similarly within the study population.

The WHZ distribution for Bama is illustrated in *Fig.* 4, which approximates a normal (Gaussian) distribution with a slight shift towards negative Z-scores. This leftward shift indicates that the nutritional status of children in Bama was generally below the WHO reference population, although the majority of children remained within the normal nutritional range. The relatively narrow spread of the curve also supports the good quality of the anthropometric measurements reported in Table 4.

According to the WHO classification of emergency nutrition situations, a GAM prevalence between 5% and 9.9% indicates a poor nutritional situation, whereas values between 10% and 14.9% are classified as serious. Consequently, the observed prevalence of 9.5% places Bama at the upper limit of the "poor" category and suggests that continued nutritional surveillance and targeted interventions are required to prevent further deterioration.

3.2.2 Prevalence of Acute Malnutrition in Dikwa LGA

The prevalence estimates for Dikwa LGA are presented in Table 7. Dikwa recorded the highest burden of acute malnutrition among the three LGAs. Overall, 24.2% (95% CI: 16.2–34.6%) of children were affected by GAM, while 8.5% (95% CI: 3.1–21.5%) suffered from SAM. Moderate acute malnutrition accounted for 15.7% (95% CI: 8.2–27.9%) of the surveyed children.

Unlike Bama, the prevalence of acute malnutrition among boys (24.4%) and girls (24.0%) was almost identical, indicating that sex had little influence on nutritional status in Dikwa. Similarly, SAM prevalence differed only marginally between boys (8.9%) and girls (8.2%), with overlapping confidence intervals confirming that the observed differences were not statistically significant.

The Gaussian distribution shown in *Fig.* 5 exhibits a more pronounced shift toward negative WHZ values compared with Bama, indicating a substantially poorer nutritional profile among children in Dikwa. The broader spread of the distribution is also consistent with the larger standard deviation and design effect reported in Table 4, suggesting greater variability in nutritional status among the surveyed children.

The observed GAM prevalence of 24.2% exceeds the WHO emergency threshold of 15%, indicating a critical public health emergency. Likewise, the SAM prevalence of 8.5% is considerably higher than the WHO alert threshold of 3%, reflecting severe nutritional stress among children in Dikwa. These findings are consistent with the prolonged humanitarian crisis experienced in the area, characterized by population displacement, disruption of agricultural activities, food insecurity, poor sanitation, and limited access to healthcare services.

3.2.3 Prevalence of Acute Malnutrition in Ngala LGA

The prevalence of acute malnutrition among children in Ngala LGA is summarized in Table 8. Overall, 7.6% (95% CI: 5.1–11.3%) of children were affected by GAM, while 3.0% (95% CI: 1.4–6.0%) were classified as having SAM. Moderate acute malnutrition was recorded in 4.7% (95% CI: 3.5–6.2%) of the study population.

The prevalence estimates were remarkably similar for boys and girls. GAM prevalence was 7.6% among boys and 7.7% among girls, while SAM prevalence was 3.0% and 2.9%, respectively. The overlapping confidence intervals again demonstrate that sex-related differences were not statistically significant.

The Gaussian distribution presented in *Fig.* 6 is centred closer to the WHO reference population than that observed in Dikwa, indicating comparatively better nutritional status among children in Ngala. Nevertheless, the slight leftward displacement of the curve confirms that acute malnutrition remains an important public health concern within the LGA.

Although Ngala recorded a lower GAM prevalence than Dikwa, the observed SAM prevalence of 3.0% still reaches the WHO emergency threshold, emphasizing the need for sustained nutritional interventions and continuous monitoring.

3.2.4 Comparison of Acute Malnutrition Across the Three LGAs

Comparison of Tables 6–8 reveals substantial geographical variation in the prevalence of acute malnutrition. Dikwa recorded the highest prevalence of both GAM (24.2%) and SAM (8.5%), followed by Bama (9.5% and 3.0%, respectively), while Ngala exhibited the lowest prevalence estimates (7.6% and 3.0%, respectively).

These differences correspond closely with the mean WHZ values presented earlier in Table 4, where Dikwa recorded the lowest mean Z-score (−1.03), indicating poorer overall nutritional status. The consistency between the prevalence estimates and the mean anthropometric indicators strengthens the validity of the survey findings.

The elevated prevalence observed in Dikwa may be attributed to greater food insecurity, disruption of livelihoods, prolonged displacement of households, inadequate dietary diversity, poor access to healthcare services, and repeated infectious disease outbreaks associated with the humanitarian crisis in north-eastern Nigeria. Similar findings have been reported in previous SMART surveys conducted in conflict-affected regions of Borno State, where persistent insecurity significantly compromised household food availability and child nutritional status.

3.2.5 Age-specific Distribution of Acute Malnutrition

The distribution of acute malnutrition according to age is presented in Tables 9–11, while the corresponding graphical summaries are shown in *Figs* 7–9.

In Bama LGA, Table 9 and *Fig.* 7 demonstrate that children aged 6–17 months experienced the highest prevalence of severe wasting (5.9%) and moderate wasting (11.8%). Nutritional status improved progressively with increasing age, with no cases of severe wasting recorded among children older than 30 months. This pattern is expected because infants and young children are particularly vulnerable during the transition from exclusive breastfeeding to complementary feeding.

A similar age-related pattern was observed in Ngala LGA (Table 11 and *Fig.* 9), although the prevalence of wasting remained generally lower across all age categories. Severe wasting ranged from 0.6% among children aged 18–29 months to 5.0% among those aged 54–59 months. Despite these variations, more than 90% of children in every age category were classified as nutritionally normal, indicating relatively favourable nutritional conditions compared with the other study areas.

The situation in Dikwa LGA differed considerably (Table 10 and *Fig.* 8). Moderate wasting exceeded 15% among children aged 42–53 months and reached 27.8% among children aged 54–59 months. Severe wasting was particularly high among children aged 30–41 months (11.6%), suggesting that nutritional vulnerability extended beyond infancy into later preschool years. Furthermore, the prevalence of oedema among children aged 6–17 months (9.7%) was considerably higher than that observed in Bama and Ngala, indicating severe nutritional deprivation among the youngest children.

The generally higher prevalence of wasting among younger children is consistent with previous studies demonstrating that inadequate complementary feeding, repeated episodes of diarrhoeal disease, respiratory infections, and poor household food security contribute substantially to acute malnutrition during the first two years of life. These findings underscore the importance of targeting infant and young child feeding programmes toward children under two years of age.

3.2.6 Distribution of Oedema and Severe Acute Malnutrition

The distribution of severe wasting and bilateral oedema is summarized in Tables 12–14. In Bama LGA (Table 12), no cases of marasmic kwashiorkor were identified, while 2 (0.9%) children presented with kwashiorkor and 5 (2.2%) were classified as marasmic. The overwhelming majority (97.0%) of children were free from severe acute malnutrition.

In Dikwa LGA (Table 13), 1 (0.4%) child presented with marasmic kwashiorkor, 9 (3.2%) had kwashiorkor and 14 (5.0%) were diagnosed with marasmus. Consequently, only 91.5% of children were free from severe acute malnutrition, representing the poorest nutritional profile among the three LGAs.

Similarly, Table 14 shows that Ngala LGA recorded no cases of marasmic kwashiorkor, 10 (1.1%) cases of kwashiorkor and 16 (1.8%) cases of marasmus, while 97.0% of children were not severely malnourished. The absence of marasmic kwashiorkor in both Bama and Ngala suggests that although acute malnutrition was present, the most severe combined forms of protein-energy malnutrition were relatively uncommon.

Overall, the oedema data confirm the findings obtained from the WHZ analysis, identifying Dikwa as the most nutritionally vulnerable LGA. The coexistence of wasting and nutritional oedema further highlights the severity of the humanitarian situation in this area and underscores the urgent need for strengthened community-based management of acute malnutrition (CMAM), supplementary feeding programmes, and continued nutritional surveillance.

3.3 Prevalence of Acute Malnutrition Based on Mid-Upper Arm Circumference (MUAC)

Mid-Upper Arm Circumference (MUAC) is widely recommended by the World Health Organization (WHO) and UNICEF as a rapid, reliable, and field-friendly anthropometric indicator for identifying acute malnutrition, particularly in emergency settings. Unlike Weight-for-Height Z-scores (WHZ), MUAC primarily reflects muscle mass and body fat reserves and has been shown to be a strong predictor of mortality among under-five children. The prevalence of acute malnutrition based on MUAC measurements and/or the presence of bilateral pitting oedema is presented in Tables 15–

17, while the age-specific distribution is illustrated in Figs, 10–12.

3.3.1 Prevalence of Acute Malnutrition in Bama LGA

The prevalence of acute malnutrition based on MUAC measurements in Bama LGA is presented in Table 15. Overall, 21.6% (95% CI: 15.8–28.6%) of children were classified as having Global Acute Malnutrition (GAM), while 5.6% (95% CI: 2.3–13.2%) met the criteria for Severe Acute Malnutrition (SAM). Moderate Acute Malnutrition (MAM) accounted for 15.9% (95% CI: 11.0–22.6%) of the surveyed children. Compared with the WHZ results presented earlier (Table 6), MUAC identified substantially more malnourished children. Specifically, the prevalence of GAM increased from 9.5% using WHZ to 21.6% using MUAC, while SAM increased from 3.0% to 5.6%. This finding demonstrates that MUAC detected a greater proportion of children at nutritional risk than WHZ within the same population.

Sex-specific analysis revealed that boys had a slightly higher prevalence of GAM (24.8%) than girls (18.3%). Similarly, MAM was more common among boys (20.5%) than girls (11.3%), whereas girls recorded a slightly higher prevalence of SAM (7.0%) than boys (4.3%). However, the overlap between the respective 95% confidence intervals indicates that these apparent differences were not statistically significant at the 5% significance level.

The age-specific distribution of MUAC-based malnutrition shown in *Fig.* 10 demonstrates that younger children contributed disproportionately to the burden of acute malnutrition. This pattern is consistent with the increased nutritional vulnerability of infants and toddlers during periods of rapid growth and transition to complementary feeding.

The observed GAM prevalence of 21.6% exceeds the WHO emergency threshold of 15%, indicating that acute malnutrition in Bama constituted a critical public health emergency when assessed using MUAC. This contrasts with the WHZ classification, which placed Bama below the emergency threshold, highlighting important differences in case detection between the two anthropometric indicators.

3.3.2 Prevalence of Acute Malnutrition in Dikwa LGA

The MUAC-based prevalence estimates for Dikwa LGA are presented in Table 16. Overall, 12.1% (95% CI: 4.6–28.4%) of children were affected by GAM, while 4.6% (95% CI: 1.2–16.4%) were classified as having SAM. Moderate acute malnutrition accounted for 7.5% (95% CI: 2.1–23.1%) of the study population.

Unlike the WHZ findings, MUAC produced lower prevalence estimates in Dikwa. WHZ identified 24.2% of children as having GAM (Table 7), whereas MUAC identified only 12.1%. Similarly, SAM decreased from 8.5% using WHZ to 4.6% using MUAC. This discrepancy suggests that WHZ detected a larger proportion of wasted children in Dikwa than MUAC.

Boys recorded a slightly higher prevalence of GAM (13.3%) than girls (11.0%), while SAM prevalence was 5.9% among boys compared with 3.4% among girls. Nevertheless, the extensive overlap between the confidence intervals demonstrates that these differences were not statistically significant.

The age-specific MUAC distribution presented in *Fig.* 11 indicates that acute malnutrition occurred across all age groups, although younger children remained the most affected. The relatively wide confidence intervals observed for several prevalence estimates reflect increased sampling variability resulting from cluster sampling and the relatively small number of severe malnutrition cases identified.

Although the MUAC-based prevalence of GAM in Dikwa falls below the WHO emergency threshold of 15%, the SAM prevalence remains above the WHO alert level of 3%, indicating that severe acute malnutrition continues to pose a significant public health concern within the LGA.

3.3.3 Prevalence of Acute Malnutrition in Ngala LGA

The prevalence of acute malnutrition based on MUAC measurements in Ngala LGA is summarized in Table 17. Overall, 12.2% (95% CI: 9.1–16.1%) of children were affected by GAM, while 4.1% (95% CI: 2.6–6.4%) had SAM. Moderate acute malnutrition accounted for 8.1% (95% CI: 5.6–11.6%) of the surveyed children.

Compared with the WHZ results (Table 8), MUAC again identified a larger proportion of malnourished children. GAM increased from 7.6% using WHZ to 12.2% using MUAC, while SAM increased from 3.0% to 4.1%. These findings suggest that MUAC was more sensitive than WHZ for detecting acute malnutrition in Ngala.

Unlike Bama and Dikwa, girls exhibited a marginally higher prevalence of GAM (12.4%) than boys (12.0%), while SAM prevalence was 4.7% among girls and 3.5% among boys. However, the confidence intervals overlapped considerably, indicating that the observed differences were not statistically significant.

The age-specific MUAC distribution shown in *Fig.* 12 indicates that younger children remained disproportionately affected by acute malnutrition, consistent with the pattern observed using WHZ. Although the overall nutritional situation in Ngala appeared better than in Dikwa, the persistence of SAM above the WHO alert threshold highlights the continued need for routine nutritional screening and community-based management of acute malnutrition.

3.3.4 Comparison of MUAC Findings Across the Three LGAs

Comparison of Tables 15–17 demonstrates important geographical variation in MUAC-based nutritional status. Bama recorded the highest prevalence of GAM (21.6%) and SAM (5.6%), followed by Ngala (12.2% and 4.1%) and Dikwa (12.1% and 4.6%), respectively.

These findings differ substantially from the WHZ-based results, which identified Dikwa as the LGA with the highest burden of acute malnutrition. The contrasting rankings indicate that MUAC and WHZ identify overlapping but not identical groups of malnourished children. Such differences have been widely reported in nutritional epidemiology because MUAC is influenced primarily by arm muscle and fat mass, whereas WHZ reflects body proportionality relative to height.

The higher MUAC-based prevalence observed in Bama suggests that a greater proportion of children experienced reduced muscle and fat reserves despite not meeting the WHZ criteria for wasting. Conversely, the higher WHZ prevalence recorded in Dikwa indicates that wasting was more readily detected using body proportionality than arm circumference.

3.3.5 Interpretation of Sex Differences

Across the three LGAs, boys generally exhibited slightly higher rates of GAM than girls, although girls recorded marginally higher SAM prevalence in some locations. Despite these apparent differences, none of the sex-specific comparisons demonstrated statistical significance because the corresponding 95% confidence intervals overlapped.

This finding suggests that both male and female children experienced comparable levels of nutritional vulnerability during the humanitarian crisis. Similar observations have been reported in previous nutrition surveys conducted in conflict-affected populations, where environmental and household food security factors exert a greater influence on child nutritional status than biological sex.

3.3.6 Comparison Between MUAC and Weight-for-Height

Comparison of the MUAC results (**Tables 15–17**) with the WHZ findings (Tables 6–8) reveals considerable differences in the estimated prevalence of acute malnutrition. In Bama and Ngala, MUAC identified substantially more children with both GAM and SAM than WHZ, whereas in Dikwa, WHZ detected considerably more cases than MUAC.

These differences arise because the two indicators measure different physiological characteristics. WHZ evaluates body weight relative to height and therefore reflects body proportionality, whereas MUAC measures upper arm circumference, providing an estimate of muscle mass and fat reserves. Consequently, children may satisfy one criterion but not the other.

Previous studies have demonstrated only moderate agreement between MUAC and WHZ, particularly among younger children. MUAC is generally more sensitive for identifying younger, shorter children and those at higher risk of mortality, whereas WHZ may identify children with acute weight loss who retain relatively larger arm circumferences. The discrepancies observed in the present study therefore agree with existing evidence and reinforce current WHO recommendations that both indicators should be used together during nutritional assessments.

The MUAC-based assessment confirms that acute malnutrition remains a major public health concern across the three conflict-affected LGAs. Although prevalence estimates differed from those obtained using WHZ, both anthropometric indicators consistently identified substantial nutritional deficits among under-five children.

The markedly higher MUAC prevalence observed in Bama suggests widespread depletion of body muscle and fat stores despite comparatively lower WHZ estimates. In contrast, the greater WHZ prevalence recorded in Dikwa indicates that body wasting was more pronounced than reductions in arm circumference. These findings emphasize that reliance on a single anthropometric indicator may underestimate the true burden of acute malnutrition. The absence of statistically significant sex differences further indicates that nutritional interventions should target all vulnerable children regardless of sex. Furthermore, the predominance of malnutrition among younger children highlights the importance of strengthening infant and young child feeding programmes, promoting exclusive breastfeeding, improving complementary feeding practices, and expanding community-based nutrition screening.

Overall, the MUAC findings complement the WHZ analysis and demonstrate that both anthropometric indicators provide valuable but distinct information regarding the nutritional status of children living in humanitarian settings. Their combined use offers a more comprehensive assessment of acute malnutrition and enhances the identification of children requiring immediate nutritional support.

3.4 Comparative Discussion of Weight-for-Height and MUAC Indicators

The present study employed two internationally recognized anthropometric indicators, Weight-for-Height Z-scores (WHZ) and Mid-Upper Arm Circumference (MUAC), to assess the nutritional status of children aged 6–59 months in Bama, Dikwa and Ngala LGAs of Borno State. Although both indicators are recommended by the World Health Organization (WHO) for identifying acute malnutrition, the findings demonstrate that they produced different prevalence estimates across the three study areas. This variation highlights the complementary nature of the two indicators and underscores the importance of using both measures during nutritional surveillance in humanitarian settings.

Comparison of the prevalence estimates obtained using WHZ (Tables 6–8) and MUAC (Tables 15–17) revealed important differences in the identification of children with acute malnutrition. In Bama LGA, the prevalence of Global Acute Malnutrition (GAM) increased from 9.5% based on WHZ to 21.6% using MUAC, while Severe Acute Malnutrition (SAM) increased from 3.0% to 5.6%. Similarly, in Ngala LGA, GAM increased from 7.6% to 12.2%, whereas SAM increased from 3.0% to 4.1% when MUAC was used instead of WHZ. In contrast, Dikwa LGA exhibited the opposite trend, with WHZ identifying substantially higher levels of acute malnutrition than MUAC. Specifically, GAM decreased from 24.2% based on WHZ to 12.1% based on MUAC, while SAM decreased from 8.5% to 4.6%. These findings indicate that neither anthropometric indicator consistently identifies the same children as acutely malnourished.

The observed discrepancies are consistent with previous studies demonstrating that WHZ and MUAC assess different physiological characteristics. Weight-for-Height evaluates body weight relative to height and primarily reflects body proportionality and recent weight loss. In contrast, MUAC measures the circumference of the upper arm and provides an estimate of muscle mass and subcutaneous fat reserves. Consequently, children with reduced muscle mass but relatively preserved body proportionality may be classified as malnourished by MUAC but not by WHZ. Conversely, children who have experienced rapid weight loss relative to height may satisfy the WHZ criterion without presenting a critically reduced arm circumference. These physiological differences explain the inconsistencies observed between the two methods in the present study.

The higher MUAC-based prevalence recorded in Bama and Ngala suggests that a substantial proportion of children experienced depletion of lean body mass despite maintaining WHZ values above the malnutrition threshold. Conversely, the higher WHZ prevalence observed in Dikwa indicates that acute wasting was more pronounced than reductions in arm circumference. The nutritional deterioration observed in Dikwa may reflect prolonged food insecurity, recurrent infectious diseases, displacement of households and disruption of livelihood activities arising from the humanitarian crisis. Such conditions often result in rapid weight loss that is more readily detected by WHZ than by MUAC.

Another important finding is the consistency of the sex-specific prevalence estimates across both anthropometric indicators. Although boys generally recorded slightly higher prevalence rates of Global Acute Malnutrition than girls in Bama and Dikwa, whereas girls showed marginally higher rates in Ngala, the corresponding 95% confidence intervals overlapped substantially. This indicates that the observed differences were not statistically significant and that the burden of acute malnutrition affected male and female children similarly. The absence of significant sex-related differences agrees with previous nutrition surveys conducted in emergency settings, where environmental and household factors exert greater influence on nutritional status than biological sex.

Age-specific analysis (Tables 9–11 and *Figs* 7–12) consistently demonstrated that younger children, particularly those aged 6–17 months, experienced a greater burden of acute malnutrition than older children. This finding is biologically plausible because the first two years of life represent a period of rapid physical growth accompanied by increased nutritional requirements. During this period, inappropriate complementary feeding practices, inadequate dietary diversity, recurrent diarrhoeal diseases, respiratory infections and poor access to healthcare substantially increase the risk of acute malnutrition. The relatively higher prevalence observed among younger children therefore emphasizes the importance of strengthening infant and young child feeding programmes in conflict-affected communities.

The assessment of bilateral pitting oedema (Tables 12–14) further supported the WHZ findings. Although the prevalence of oedema remained relatively low across the three LGAs, Dikwa recorded the highest proportion of children presenting with kwashiorkor and marasmic kwashiorkor. The occurrence of nutritional oedema is clinically significant because it indicates severe protein-energy malnutrition and is associated with a markedly increased risk of mortality if untreated. The identification of oedematous malnutrition therefore reinforces the need for continuous nutritional surveillance and timely referral of affected children to Community-based Management of Acute Malnutrition (CMAM) programmes.

Comparison of the prevalence estimates with WHO emergency thresholds provides additional insight into the severity of the nutritional situation. According to WHO classification, a GAM prevalence below 5% is considered acceptable, 5–9.9% indicates a poor nutritional situation, 10–14.9% represents a serious situation, and values of 15% or higher constitute a critical emergency requiring immediate intervention. Using WHZ, Dikwa exceeded the critical emergency threshold with a GAM prevalence of 24.2%, whereas Bama (9.5%) and Ngala (7.6%) remained within the poor category. However, MUAC classified Bama (21.6%) as exceeding the emergency threshold, while both Dikwa (12.1%) and Ngala (12.2%) fell within the serious category. These differences demonstrate that the choice of anthropometric indicator may influence the perceived severity of a nutritional emergency and, consequently, programme planning and resource allocation.

The findings of this study are consistent with reports from previous SMART surveys and humanitarian nutrition assessments conducted in north-eastern Nigeria, where armed conflict, population displacement, disruption of agricultural production, reduced household purchasing power and limited access to healthcare services have contributed significantly to child malnutrition. Similar studies conducted in conflict-affected regions of Ethiopia, South Sudan, Somalia and the Sahel have likewise reported considerable disagreement between WHZ and MUAC prevalence estimates, reinforcing the recommendation that both indicators should be used concurrently during nutritional assessments.

From a public health perspective, the results have important implications for nutritional programming in Borno State. The higher MUAC prevalence observed in Bama suggests that community-based screening programmes relying solely on WHZ may fail to identify a substantial number of nutritionally vulnerable children. Conversely, exclusive reliance on MUAC in Dikwa could underestimate the true burden of acute wasting identified by WHZ. Consequently, integrated nutritional screening incorporating both WHZ and MUAC would provide a more comprehensive assessment of child nutritional status and improve case detection.

The findings also emphasize the importance of strengthening preventive interventions alongside therapeutic programmes. Community nutrition education should focus on improving exclusive breastfeeding practices, timely introduction of appropriate complementary foods, dietary diversification and early health-seeking behaviour for childhood illnesses. Simultaneously, humanitarian agencies should continue to strengthen food assistance programmes, improve access to safe water and sanitation, expand routine growth monitoring and ensure uninterrupted supplies for outpatient therapeutic programmes and supplementary feeding centres.

A major strength of this study is the application of the standardized SMART survey methodology, which ensures internationally comparable estimates of acute malnutrition. The use of trained anthropometrists, standardized equipment, rigorous field supervision and daily plausibility checks contributed to the high quality of the anthropometric data. Furthermore, the inclusion of both WHZ and MUAC provides a more comprehensive evaluation of nutritional status than would have been achieved using either indicator alone.

Nevertheless, several limitations should be acknowledged. First, the cross-sectional design permits estimation of prevalence but does not establish causal relationships between nutritional status and associated risk factors. Second, the survey was conducted during a specific period in 2018; consequently, seasonal variations in food availability and disease occurrence were not evaluated. Third, the humanitarian context may have limited access to certain settlements, potentially affecting representativeness despite the use of probability-based sampling techniques. Finally, important determinants of child nutrition such as household dietary diversity, maternal education, household income, morbidity status and infant feeding practices were not analysed in the present study and therefore warrant further investigation.

Overall, the findings demonstrate that acute malnutrition remains a significant public health challenge among children aged 6–59 months in the conflict-affected LGAs of Borno State. Although the prevalence estimates varied according to the anthropometric indicator employed, both WHZ and MUAC consistently identified substantial levels of nutritional deprivation requiring sustained humanitarian intervention. The differences observed between the two methods highlight their complementary roles in nutritional assessment and support current WHO recommendations advocating the simultaneous use of WHZ, MUAC and clinical assessment for identifying children at risk of severe acute malnutrition. Continued nutritional surveillance, targeted supplementary feeding, improved infant and young child feeding practices, strengthened primary healthcare services and enhanced food security interventions are essential to reduce the burden of acute malnutrition and improve child survival in the study area.

4.0 Conclusion

The overall sex distribution showed that both boys and girls were well represented in the study, with an overall sex ratio p-value of P=0.896, P=0.512 and P=0.710 in Bama, Dikwa and Ngala, respectively. The point estimate and 95% confidence intervals of the prevalence indexed by WFH and MUAC overlapped for SAM and GAM, for instance in Bama, while SAM based on WFH was 3.0 % (1.3-6.7; 95% CI) for MUAC it was 5.6 % (2.3-13.2; 95% CI). In the case of GAM, it was 9.5% (5.4-16.2, 95% C.I.) based on WFH and 21.6% (15.8-28.6; 95% C.I.) by MUAC which indicates that, the prevalence of acute malnutrition indexed by MUAC were above the alert threshold of 15%, whereas that of WFH was exactly on upper limit of the alert thresholds of 3%. However, SAM prevalence based on MUAC was about 50% higher than that of WFH Z- scores. This result further supports the weak correlation between SAM and GAM prevalence based on MUAC and WFH criteria. Clearly, MUAC captures more SAM cases than WFH because of its sensitivity for younger and shorter children, i.e. those below one year and less than 75cm in height. The study also revealed that the difference between the 95% confidence intervals for GAM and SAM prevalence were statistically insignificant, i.e., 0.8% and 0.5% respectively. Prevalence of severe stunting, severe underweight and severe wasting among the study population in Bama was 22.0% (12.6-35.4, 95% CI), 6.5% (2.7-14.8 95% CI) and 5.9% respectively, for Dikwa it was 16.0% (6.2-35.6, 95% CI), 9.2% (6.8-12.3 95% CI) and 11.6% respectively while for Ngala it was 10.1% (6.8-14.9, 95% CI), 3.3% (1.9-5.9 95% CI) and 3.1%. This goes to show that about

22% of the children sampled were severely stunted, about 9.2% of the children sampled, were severely underweight and about 11.6% of the children sampled were severely wasted. According to the summary of the plausibility check, the quality of data used for this study were generally acceptable, for instance Bama overall score was 22%, which is acceptable, Dikwa had 17% overall score, which is also acceptable, and Ngala had an overall score of 19% which is also acceptable.

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