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AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 26 No. 1
January 2026
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2026; 26(1): 28354-28374 https://doi.org/10.18697/ajfand.148.26205

Date	Submitted	Accepted	Published
	29th July 2025	3rd December 2025	29th January 2026

BODY COMPOSITION OUTCOMES OF MODERATE ACUTE MALNUTRITION TREATMENT IN 2-3 YEAR-OLD CHILDREN: A STUDY USING DEUTERIUM DILUTION TECHNIQUE IN WESTERN KENYA

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SCHOLARLY, PEER REVIEWED
Volume 26 No. 1
January 2026
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ABSTRACT

Moderate Acute Malnutrition (MAM) treatment utilizing ready-to-use therapeutic food (RUTF) has been shown to enhance survival rates and facilitate weight gain. Nonetheless, the impact of RUTF on body composition in children remains inadequately investigated in different contexts. The presence of excess adiposity is associated with an increased risk of chronic diseases in later life, including cardiovascular diseases and diabetes mellitus. This study evaluated the effects of MAM treatment on body composition among children aged 2–3 years who had previously received MAM treatment versus those untreated, using the Deuterium Dilution Technique. In a cross-sectional study, 206 children (67 MAM treated and 139 untreated) were enrolled through simple random sampling at the Maternal and Child Health (MCH) clinic of Siaya County Referral Hospital in western Kenya. Child weight, height, and Mid-Upper Arm Circumference (MUAC) were measured using a Seca weighing scale, a wooden length/ height board and MUAC tape, respectively. Body composition indicators, including Fat Mass (FM) and Fat-Free Mass (FFM), were assessed and the Fat Mass Index (FMI) and Fat-Free Mass Index (FFMI) computed. MAM treatment involved a standard regimen of Corn Soy Blend Plus (CSB+) for 6 to 12 weeks or until recovery. Generally, children born with shorter childbirth intervals, specifically those closely following immediate older siblings, were more likely to be malnourished and MAM-treated ($p=0.001$), as were those with lower birth weights ($p<0.001$). Children who received MAM treatment had lower FFM (9.82 ± 2.55 kg) compared to untreated children (10.95 ± 1.34 kg) and the difference was statistically significant ($p=0.01$). Between the two groups, there were no variations in FMI and FFMI. Multiple linear regression analysis, however, showed that MAM treatment status was associated with FFMI ($p=0.00$), % FFM ($p=0.029$), and % FM ($p=0.029$). These findings indicate that previously MAM-treated children demonstrate a notable reduction in FFM compared to the untreated group. This suggests possible metabolic discrepancies in lean tissue recovery post-treatment, highlighting the need for improved prevention and follow-up strategies for childhood wasting.

Key words: Body composition, MAM, Deuterium Dilution Technique, Fat Mass, RUTF

Citation: **Tarkwen P, Konyole SO and S Oiye** Body Composition Outcomes of Moderate Acute Malnutrition Treatment in 2-3 Year-Old Children: A Study Using Deuterium Dilution Technique in Western Kenya. *Afr. J. Food Agric. Nutr. Dev.* 2026; **26(1):** 28354-28374.
https://doi.org/10.18697/ajfand.148.26205

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ISSN 1684 5374

INTRODUCTION

Moderate Acute Malnutrition (MAM) among children remains a significant public health challenge in low- and middle-income countries worldwide. Wasting, the key indicator of acute malnutrition central to MAM, affects 45 million (6.8%) of under-five children globally. In Kenya, Siaya County reports a wasting prevalence of 2%, higher than neighbouring Kakamega County (1.5%). Stunting in Siaya remains high at 19%, but the primary concern for this study is the burden of wasting among children aged 2–3 years. It is significantly affected by poverty, food insecurity, and inadequate healthcare systems [1]. Moderate acute malnutrition in children is characterized by insufficient nutrition intake and absorption, leading to deficits in energy, protein, and essential nutrients. The prevalence of MAM varies across countries and regions, typically with rural areas exhibiting higher rates than urban areas. In the sub-Saharan African countries, malnutrition continues to be a major concern with adverse effects on child morbidity, mortality, and long-term health outcomes. Food and Agricultural Organization (FAO), estimated that in 2022, about 45 million (6.8%) of underfive children were wasted while 149 million (22.3%) experienced stunted growth [2]. In Kenya, Siaya County is among the counties that grapple with high levels of MAM among children aged 2-3 years. The County reports high pravelence of wasting (2%) compared to neighboring Kakamega County (1.5%). In addition, it has high prevalence of stunting (19%) compared to neighbouring Counties like Kisumu (9%), Busia (15%) and Kakamega (12%) and also national statistics (18%) [3].

Effective treatment and management of MAM are critical to mitigate the adverse effects on child health and development [4]. The children eligible for MAM treatment are those with a Mid-Upper Arm Circumference (MUAC) measurement of between 11.5 cm and 12.5 cm and a Weight-for-Height Z-score (WHZ) of between -3 and -2 standard deviations from the median. This is based on Kenya's National Guidelines for the Integrated Management of Acute Malnutrition (IMAM). The treatment of MAM involves the provision of Ready-to-Use Therapeutic Foods (RUTF) and nutritional counselling through Outpatient Therapeutic Programs (OTPs) or community-based interventions [5]. The standard treatment period for MAM using Corn Soy Blend Plus (CSB+) typically ranges from 6 to 12 weeks depending on the child's response to the intervention [6]. However, the efficacy of these interventions in addressing the underlying nutritional deficits and promoting healthy growth and development among children aged 2-3 years for 36 weeks remains inadequately understood, yet they are crucial [7]. There is a critical gap in understanding how interventions for MAM affect body composition indicators, which is vital for designing effective nutritional programs and policies. The conventional metrics routinely used to monitor nutritional recovery among MAM children, such as weight gain and anthropometric measurements, may not fully capture changes in body composition, including fat mass, and total body water [8]. Excessive fat deposition increases the risk of chronic diseases and metabolic dysfunction while lean mass is essential for strength, metabolic health and overall physical resilience [9,10].

The Deuterium Dilution Technique (DDT) represents a gold standard method [8] for assessing body composition by estimating fat-free mass, fat mass and measuring total body water. Several studies have utilized this technique for measuring body composition indicators, and it has been proven to be effective [8–10]. The deuterium dilution technique offers a non-invasive and accurate means of quantifying changes in body composition over time, thus, providing insights into the efficacy of nutritional interventions and the dynamics of nutrient utilization and metabolism [9]. This study addressed the knowledge gap in body composition assessment by investigating the effect of MAM treatment on body composition among children aged 2-3 years, utilizing DDT as a precise measurement tool. The study examined the changes in fat mass, fat-free mass and total body water among children treated for MAM and made comparisons with those who had not been treated for MAM. Understanding the relationship between MAM treatment and body composition in this age group is vital for informing targeted interventions and improving childrennutritional status and overall health outcomes in Siaya County, Kenya.

MATERIALS AND METHODS

Study area

The study was conducted at the Siaya County Referral Hospital (SCRH) in Siaya County in Western part of Kenya. The hospital has a MCH clinic that has an active nutrition wing where children are screened for malnutrition and those with MAM are managed from there. The study area was chosen because in Siaya County, malnutrition remains a serious problem with a high rate of stunting, wasting and underweight at 19%, 2% and 7%, respectively[3]. Wasting as an indicator of acute malnutrition was 2% higher than Kakamega County (1.5%) while stunting, marker of chronic malnitrition in Siaya County is higher than neighbouring Counties of Kisumu (9%), Busia (15%), Kakamega (12%) and Vihiga (17%) and also the national statistics that is at 18% [3]. The facility serves as both rural and urban population with majority being rural population of the resource constrained Siaya County.

Study population

The study targeted children aged 2-3 years who had been previously treated for MAM and those who did not have any history of MAM treatment. The records on MAM treatment kept by the hospital nutrition unit were reviewed to identify and trace eligibe participants in the study. Based on the information, children were categorized into two groups that included MAM treated and MAM untreated.

https://doi.org/10.18697/ajfand.148.26205

Study design

The study adopted a cross-sectional analytical study design to compare the body composition indicators between MAM treated and those who were not identified with MAM and, therefore, untreated children between the ages of 2-3 years at one point in time in Siaya County, Kenya.

Sample size determination

The sample size was determined using the Fisher et al. formula [11] ($n = Z^2pq \div e^2$). In this calculation, Z represented the standard normal deviation at the required confidence level of 1.96. The proportion of stunting, used as an indicator of chronic malnutrition in Siaya County, was set at 19% [3], denoted as p. The margin of error (e), was set at 0.05 for a 95% confidence level, while q was calculated as 1−p. Substituting the values into the formula ($n = 1.96^2 \times 0.196(1 - 0.196) \div 0.05^2$ =237), plus 10% attrition led to as a sample size of 261. Four (4) samples were damaged during storage and transport. In addition, due to challenges in recruitment of children with history of MAM treatment, 51 participants were not reached. Therefore, only 206 participants were included in the study. This gave a response rate of 79.0%, which was sufficient to meet the objective of the study[12].

Sampling design

Siaya County was purposively chosen due to the previously reported high prevalence of malnutrition related to high levels of poverty and food insecurity [3]. Siaya County reports an HIV prevalence rate of 13.2% while the national overall HIV prevalence stands at 3.7%, as per the National Syndemic Disease Control Council [NSDCC] [13]. The Siaya County Referral Hospital is the largest hospital in the County, serving both the urban and rural community within Siaya. The study children were selected from the hospital register using simple random sampling. A pre-generated table of random numbers was employed to randomly enroll children as they attended their routine clinical visits, ensuring an unbiased representation of the population for the study. Each child was assigned sequential numbers beginning with one during hospital visits and computed in the table of random numbers. First child to arrive for clinic was assigned number one (child 1), second to arrive as child two (child 2) and third as child three (child 3) and so on. The first child was picked randomly based on the first number appearing in the table of random numbers, which was 3. The second child was child number 5, corresponding to the second random number in the table, which was 5 and the rest as they attended clinic until saturation.

Exclusion and inclusion criteria

Children aged 2–3 years previously treated for MAM, defined by weight-for-height Z-score between –3 and –2 SD and/or MUAC between 11.5 cm and 12.5 cm, were eligible.Exclusion criteria involved children with Severe Acute Malnutrition (SAM) defined as weight-for-height < –3 SD), children younger than 2 years or older than 3 years and children with other infections like malaria. Finally, children whose parents or guardians did not give an informed consent to participate in the study were excluded. These criteria ensured a focused and ethically sound study population.

Data collection methods and procedures

Height for all participating children was measured using a wooden length/height board following WHO procedures.. Anthropometric data were collected as per the World Health Organization (WHO) 2009 standards [14]. Correct age and birth weight of the children were confirmed from mother and child health (MCH) handbook or by the response from the mother. Height and weight of the children were taken and recorded in the semi-structured questionnaire. For children about 2 years and unable to stand properly , the height was taken using a wooden length board in a recumbent position. For those able to stand, a Wooden height Board meter was used to take the height in a standing position, both to the nearest 0.1 cms. Weight -for-Height and Weight for Age Z score were later computed as per the WHO guidelines[14]. The birth interval and birth order were confirmed from the mother of the child.

Body composition was assessed by the deuterium dilution (DDT) as per the Standard Operating Procedures (SOPs) by the IAEA, [15]. Deuterium is a stable isotope that has previously been used in the form of deuterium oxide (D_2O) to assess body composition of individuals and the technique is based on a 2-component model of body [16]. The individual D_2O doses were prepared in a clean food grade area. The doses were weighed accurately to the nearest 0.01g. Batch numbers were recorded and the exact mass of D_2O for each participant. Sterile cryovial tube and sterile cotton swabs were prepared for saliva collection. Sample collection begun after a 2 hour fasting.

A 2ml pre-dose (T0) saliva sample was collected using sterile cotton wool then extracted into a firmly topped cryovial tube using a syring. It was labelled with participant ID, date/time and designated as predose. Then the children were dosed with 15ml of D_2O solution orally using a syringe. The syringe was measured before and after dosing to determine exactly how much was ingested. The exact time of ingestion was recorded and any spillage/vomiting reported. Post dose samples were collected at 3 hours (T2) and 4 hours(T3) and all the samples collected stored in a freezer at 20 ^{o}C while awaiting transportation.

The samples were airlifted in a dry ice bundle to the Centre for Public Health Research (CPHR) in Lusaka, Zambia, for analysis using the Fourier Transform Infrared (FTIR) spectrophotometer (Shimadzu, Vienna, Austria) following the guidelines set by the International Atomic Energy Agency (IAEA) [15]. Total Body Water (TBW) was calculated using the information of the initial dose and enrichment

https://doi.org/10.18697/ajfand.148.26205

of D2O at equilibrium. Once TBW was calculated, Fat Free Mass (FFM) (lean mass) was determined as TBW divided by 0.79 (TBW/0.79) for both genders. The FFM hydration factors recommended in the IAEA protocol [15] were used, which vary by age and sex. Fat Mass (FM) was obtained by subtracting the FFM from the subject's weight. Free Fat Mass Index (FFMI) and the Fat Mass Index (FMI) were obtained by isolating individual children's FFM and the FM by the square of their separate height. Free Fat Mass Index (FFMI) and the Fat Mass Index (FMI) were computed by dividing an individual child's FFM and the FM by the squares of their respective heights.

Data analysis and presentation

Data from the questionnaire were cleaned, coded and entered into the Statistical Package for Social Sciences (SPSS) version 26. The data on body composition was also checked for consistency and included into the SPSS data set. Descriptive statistics of frequencies, means and standard deviations were used to analyses child's demographics. T-test was also used to determine the difference in body composition indicators (FM, FFM, FMI, and FFMI) between MAM-treated and MAM untreated children. Multiple Linear regression determined the strength of association between MAM treatment status and body composition. The multiple linear regression analysis was adjusted for key covariates that could influence body composition including the mother's age, birth weight, birth interval and number of household members. Association/difference was statistically significant at P-value less than 0.05.

Ethical considerations

Ethical approval sought from Masinde Muliro University of Science and Technology Ethics Review Committee (MMUST-IERC) REF No: MMUST/IERC/119/20 and a research licence was obtained from the Kenyan National Commission for Science and Technology and Innovations (NACOSTI) Ref. No: NACOSTI/P/20/5470. The Siaya County Ministry of Health (MOH) and the hospital administration approved the study. A voluntary informed consent was obtained from the caregivers before data collection by explaining benefits and risks associated with study participation. The researchers ensured privacy and confidentiality whereby interviews were done in a secluded place where no one would hear the conversations and only authorised personnel accessed the data obtained. The participants' names were replaced with unique identification numbers on the questionnaire. The participants were free to withdraw from the study at any point they feel uncomfortable and had a chance to explain their worries to ensure voluntarism and autonomy.

RESULTS AND DISCUSSION

Maternal and Child Socio-Demographic Characteristics

The findings in Table 1 show that more than half of the mothers, 51.4% (n=106), were aged between 25 to 35 years, while a significant proportion (42.7%, n=88) of the mothers were below 25 years. Regarding their marital status, a vast majority of the mothers were married, comprising 80.1% (n=165) of the total respondents, while single mothers constituted 16% (n=33). In terms of their religion, nearly all the mothers (99.5%, n=205) identified as Christians, and this reflects a predominantly Christian population in the study area. The education levels among the mothers varied, with slightly over half of them having attained primary education (50.5%, n=104), while those with secondary education formed 44.7% (n=92) of the study population. Only a small proportion had reached tertiary education (4.9%, n=10). This indicates that while a significant number of mothers had basic education, very few had advanced educational qualifications, and this could possibly influence their knowledge and practices related to child health and nutrition [17].

The employment status of the mothers showed a diverse distribution. Casual labourers constituted 23.8% (n=49), followed by unemployed mothers at 21.8% (n=45). Self-employed mothers accounted for 16% (n=33) while salaried employees represented a smaller proportion at 5.3% (n=11). This suggests that a significant number of mothers in the study population were engaged in informal or unstructured economic activities with limited representation in formal employment. This poses significant financial challenges that may affect access to adequate nutrition and healthcare for their children [18,19]. Based on the household characteristics, most households comprised four to six members (57.5%, n=119), smaller households with one to three members were 19.4% (n=40) while larger households with seven to nine members made up 18.6% (n=38). These findings indicate that most households had a moderate number of members which may have implications on household food security [20]. The majority of households (91.7%, n=189) had one or two children under five years, while only 8.3% (n=17) of the households had 3 or 4 children under five years.

The demographic characteristics of the children showed that there was a slightly higher number of male (55.3%, n=114) than female (44.7%, n=92) children recruited for the study. The mean birth interval for the children was 2.6 ±2.1 years, indicating moderate spacing between births, and the mean birth order is 2.3±1.6, suggesting that most children were second or third-born. The birth interval is in line with the recommendations of the World Health Organization (WHO) and other international organizations that mothers should observe a birth spacing of between two to three years [21]. Children born with a birth spacing of less than 2 years are at increased risk of infant mortality before they reach the age of five years and/or have an

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Volume 26 No. 1
January 2026
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

increased risk of developing other complications [22]. The mean of the birth weights of the children that were obtained from the MCH booklet was 3.2 ± 0.6 kg which is within the recommended average birth weight of between 2.5-4.0 kg [23]. Maternal nutrition during pregnancy plays a key role in determining the child birth weight and mothers with good dietary practices deliver children with normal birth weight [24]. Despite having a normal mean birth weight, 32.5% (n=67) of children were classified as treated for MAM, while only 67.5% (n=139) had not been treated for MAM. This suggests that a significant proportion of children in Siaya County attending the MCH clinic at the hospital had experienced MAM after birth as evidenced by the number who have undergone treatment. Comparing with the 2022 KDHS, it is also evident since Siaya County is among the top ten counties reporting high prevalence of malnutrition and reports the highest prevalence among the Western Kenya counties [3].

The study did not include a true control group. Instead, it compared children who had previously received MAM treatment with those who had no recorded history of MAM treatment. The untreated group does not necessarily represent children who never experienced MAM, only those never enrolled in treatment according to hospital records. Therefore, the observed group differences represent "treated" versus "untreated" children, not necessarily "MAM" versus "never-MAM," since some untreated children may have previously experienced MAM without being enrolled in treatment.

Association between Maternal-Child characteristics and MAM treatment status

Table 2 shows that mother's age and number of household members were significantly associated with MAM treatment status ($p<0.05$). This is consistent with other studies that have shown that an increase in family size is closely associated with high risk of household food insecurity, more so in households with high unemployment rates and low-income, and this significantly contributes to child malnutrition [20, 25]. There were more male children (18.4%) treated for MAM than females (14.1%). This finding indicating a higher likelihood of undernourishment among boys compared to girls is corroborated by several other research studies [26–28]. This may be attributed more frequent occurrence of childhood conditions such as lower respiratory infections, diarrheal diseases, malaria, and preterm birth among boys than girls [29]. There was a statistically significant difference in birth interval and MAM treatment status ($p<0.05$). This indicates that MAM treatment status is associated with shorter birth intervals. Similar studies have children who are closely spaced to have higher chances of developing under nutrition compared to those with longer birth intervals [30–32]. Evidence from Demographic Health Survey in Ghana recommended mother's birth spacing as a tool for reducing child malnutrition [33]. There was a statistically significant difference in birth weight and MAM treatment status ($p<0.05$). This may be interpreted that the children born with a low birth weight (LBW) have increased chances of developing MAM as opposed to those born with a normal birth weight. This phenomenon may be attributed to the fact that the LBW children have reduced nutrient reserves due to intrauterine growth restriction which makes them more vulnerable to malnutrition as they struggle to catch up with the nutritional requirements essential for growth and development [34].

Body composition of MAM-treated Vs MAM-untreated

Table 3 depicts a statistically significant difference in Fat-Free Mass (FFM), the lean mass, with higher values among children not treated of MAM compared to those who were treated ($p = 0.01$). All the other indicators of body composition in the Table 3 did not show a significant difference with MAM treatment status ($p>0.05$). In the Malian children study those treated for MAM in a short time reported improvements in FFM following recovery [35]. The present studysuggests that children who received treatment for MAM did not have higher levels of Fat-Free Mass (non-fat body components such as muscle mass, bone tissue, body water, and internal organs) compared to their untreated counterparts. Moderate acute malnutrition is attributed to the loss of non-fat components and thus upon treatment and recovery from MAM regain is expected [7, 35]. Children who did not experience MAM (and therefore untreated) did not experience these loses and thus had much more stable non-fat components. It is apparent that in the present study context, the post-treatment recovery may be life-saving but introduces the risks associated with lower lean mass compared to the untreated. It is also important to note that in the present study the measurements were not done immediately after the treatment and the time lapse could depict the long term metabolic changes due to the treatement. Together with the Malian study, we postulate that immediately after treatment, the FFM can be favourable for the treated due to the rapid recovery but with time the metabolic changes (due to acute treatement) may lead to comparatively lower FFM.

A further regression analysis shown in Table 4 revealed a statistically significant association between MAM treatment and the various body composition indicators and indices. Specifically, the results indicated significant associations with Fat Free Mass Index(FFMI) ($p=0.00$), percent Fat Free Mass (FFM%) ($p=0.029$), and percent Fat Mass (FM%) ($p=0.029$). This confirmed the apparent link between treatement and sub-optimal recovery of the FFM for children undergoing MAM treatment. The role of prevention of acute malnutrition may not only be to minimise the childhood life-threthening risks but also foster and assuring long-term health status. Studies show body composition is associated with higher risk of NCD-related outcomes in later life [38].

Limitations

The use of a descriptive cross-sectional study design, which involved data collection at a single point in time, made it impossible to observe longitudinal trends in the effects of MAM treatment on body composition.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

The findings from the study reveal significant differences in body composition between MAM-treated and untreated subjects, particularly in terms of fat-free mass (FFM). It is evident that, within this context, MAM treatment may facilitate weight restoration; however, it may not completely recover the lost lean body mass. This incomplete recovery has the potential to impact the child's overall physiological development and health, even into later stages of life. These findings underscore the critical need to scale up initiatives aimed at preventing childhood wasting.

ACKNOWLEDGEMENTS

We sincerely appreciate the Siaya County Referral Hospital Management for accepting us to conduct the study in the hospital. We extend our sincere gratitude to all the mothers and children who participated in the study. We appreciate the Kenya Medical Research Institute (KEMRI)-Center of Public Health Research for the technical support. We also acknowledge the Center of Public Health Research (CPHR) in Lusaka, Zambia, for analyzing the saliva samples. We thank the Research Assistants who helped in collection of data and samples from the children.

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Authors' contributions

TP, KSO and SO conceptualized and designed the study; TP collected the data and drafted the manuscript. All the authors analysed and interpreted data. KSO and SO supervised the data collection and all authors revised the manuscript in its present form. All authors read and approved the final manuscript.

Conflicts of interest

The authors declare no conflicts of interest at any time in the course of the study

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Funding

The authors received materials and equipment support from the International Atomic Energy Agency (IAEA),Vienna Austria for this work.

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SCHOLARLY, PEER REVIEWED
Volume 26 No. 1
January 2026
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1: Maternal and Child Socio-Demographic Characteristics

Characteristic	Categories	Frequency (%) /Mean ± SD	
Maternal characteristics			
Mother's age in years	< 25 years	88	(42.7)
	25-35 years	106	(51.4)
	Above 35 years	12	(5.8)
Marital status	Single	33	(16)
	Married	165	(80.1)
	Separated/Divorced/ Widowed	8	(3.9)
Mothers religion	Christian	205	(99.5)
	Muslim	1	(0.5)
Maternal level of education	Primary	104	(50.5)
	Secondary	92	(44.7)
	Tertiary	10	(4.9)
Occupation	Salaried employee	11	(5.3)
	Self-employed	131	(63.6)
	Casual laborer	49	(23.8)
	Unemployed	15	(7.3)
Number of household members	1-3 members	40	(19.4)
	4-6 members	119	(57.8)
	7-9 members	38	(18.6)
	>9 members	9	(4.4)
Number of children <5 year	1-2 children	189	(91.7)
	3-4 children	17	(8.3)
Child characteristics			
Gender	Male	114	(55.3)
	Female	92	(44.7)
MAM treatment status	MAM treated	67	(32.5)
	MAM untreated	140	(67.5)
Birth interval	Mean ±SD	2.6 ± 2.1	
Birth order	Mean ±SD	2.3 ± 1.6	
Birth Weight	Mean ±SD	3.2 ± 0.66 Kgs	

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Table 2: Maternal and Child Socio-Demographics by MAM Treatment Status

Indicators	Categories	Frequencies (%) /Mean (SD)		OR	p-value[1]
		MAM Treated (n=67)	MAM Untreated (n=139)		
Maternal characteristics					
Mothers Age (years)	≤ 25	42 (20.4)	66 (32)	1.858	0.041
	>25	25 (12.1)	73 (35.4)		
Marital status	Married	50 (24.3)	114 (55.3)	0.645	0.218
	Not Married	17 (8.3	25 (12.1)		
Mothers religion	Christian	67 (32.5	138 (67)	0.673	0.486
	Muslim	0 (0)	1 (0.5)		
Education level	Primary	38 (18.4)	66 (32)	1.449	0.214
	Post-primary	29 (14.1)	73 (35.4)		
Employment status	Employed	18 (8.7)	42 (20.4)	0.848	0.620
	Unemployed	49 (23.8)	97 (47.1)		
No. of Household members	≤ 5 members	32 (15.5)	92 (44.7)	0.467	0.011
	> 5 members	35 (17)	47 (22.8)		
No. of children under 5 years	1-2 children	62 (30.1)	127 (61.7)	1.172	0.775
	3-4 children	5 (2.4)	12 (5.8)		
Child characteristics					
Gender	Male	38 (18.4)	76 (36.9)	1.594	0.085
	Female	29 (14.1)	63 (30.6)		
Birth interval	Mean ±SD	2.68 ±2.18	3.78 ± 2.001	N/A	0.001
Birth order	Mean ±SD	2.25 ± 0.215	2.37 ± 1.509	N/A	0.652
Birth Weight	Mean ±SD	2.91 ± 0.728	3.3 ± 0.539	N/A	0.000

[1]P-value significant at $p<0.05$, Chi-square for categorical variables, T-test for continuous variables, OR-Odds Ratio, SD –Standard deviation

Table 3: Body composition and MAM treatment status

Indicator	Mean (SD) or %		P-Value[1]
	MAM Treated (n=67)	MAM Untreated (n=139)	
FM(Kg)	9.84 ± 2.71	10.38 ± 1.67	0.14
% FM	3.05 ± 2.39	2.55 ± 1.46	0.11
FFM(Kg)	9.82 ± 2.55	10.95 ± 1.34	0.01
%FFM	3.02 ± 2.21	2.71 ± 1.59	0.31
FMI(Kg/m^2)	77.01 ± 16.39	81 ± 9.23	0.67
FFMI(Kg/m^2)	22.99 ± 16.39	19 ± 9.23	0.67

[1]P- value determined using students t-test comparing MAM treatment and MAM untreated children, p-significant at $p<0.05$. FFM= Fat-Free Mass, FM= Fat Mass, FFMI=Fat free mass index, FMI=fat mass Index

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SCHOLARLY, PEER REVIEWED
Volume 26 No. 1
January 2026
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 4: Association between MAM treatment and body composition indicators

Body composition indicators	Unstandardized Coefficients		Standardized Coefficients	t	P	95.0% Confidence Interval for B	
	B	SE	Beta			Lower	Upper
FFM	0.534	0.308	0.121	1.736	0.084	-0.072	1.141
FM	-0.496	0.27	-0.127	-1.835	0.068	-1.028	0.037
FFMI	1.116	0.271	0.277	4.123	0.000	0.582	1.65
FMI	-0.299	0.27	-0.077	-1.108	0.269	-0.831	0.233
%FFM	3.942	1.792	0.153	2.2	0.029	0.408	7.476
%FM	-3.942	1.792	-0.153	-2.2	0.029	-7.476	-0.408
FM:FFM Ratio	-0.534	0.255	-0.145	-2.097	0.037	-1.037	-0.032
TBW	0.418	0.242	0.121	1.73	0.085	-0.058	0.894
Mothers age*	0.003	.0007	0.042	0.497	0.620	-0.010	0.017
Birth Interval*	.039	.019	.173	2.044	0.043	.001	.077
Birth weight*	.013	.012	.086	1.129	0.261	-.010	.036
Household size*	-.033	.018	-.141	-1.828	0.069	-.068	.003

P-value determined using multiple linear regression, Independent variable: MAM treatment, p-significant at p<0.05. FFM= Fat-Free Mass, FM= Fat Mass, FFMI=Fat free mass index, FMI=fat mass Index. *The regression analysis was adjusted for maternal age, birth interval, Birth weight and household size

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