Effect of Food–Based Intervention on the Linear Growth and Psycho-Cognitive Development of Malnourished Children Aged 6-59 Months in Kanam Communities of Plateau State

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Abstract

Malnutrition remains a significant public health concern globally, particularly among children in low-resource settings. This community based cross-sectional investigation aimed to assess the impact of food-based intervention on linear growth and psycho-cognitive development of malnourished children within selected communities in Kanam Local Government area (LGA), Plateau state. A mixed method approach that employed multi-stage cluster sampling technique to select participants, malnourished children aged 6 to 59 months residing in the targeted communities. Baseline survey was employed to determine the prevalence of malnutrition by application of anthropometric measurements, height/length, weight and mid-upper arm conference to assess nutritional status after screening. The trial had total enrolment of (n = 95) malnourished children selected from four clusters for intervention and a control group. A typical affordable daily dietary supplement formulated from millet, soybeans, sesame seeds at the ratios of 6:2:1, while Cray fish, orange flesh sweet potatoes, dried moringa leaves and baobab fruit pulp were supplemented at the ratio 2:1:1:1 using 15% proportions blends following standard procedures with increase macro and micronutrients content in addition to their normal diet, and counselling on optimal feeding practices. Baseline data and mid-term intervention outcome on anthropometric measurement and psycho-cognitive development questions were posed to mothers and caregivers, along with physical activities conducted with children to evaluate the developmental outcomes after three months. Statistical techniques including descriptive and inferential statistics were utilized to analyze quantitative and qualitative data. The findings revealed high baseline prevalence of malnutrition, 83.39% of the population is underweight and malnourished, while only 16.61% has healthy weight, indicating a critical need for targeted intervention. The variance analysis in the linear growth and t-test on psycho-cognitive development highlight a significant difference (<0.05) among the malnourished children exposed to food-based intervention as an effective strategy for addressing malnutrition. However, several challenges were identified including limited access to resources and community engagement. Through food-based interventions, remarkable improvements were observed in the physical growth and psycho-cognitive development of the malnourished children. The study recommends establishment of community food-based intervention programs and provision of adequate nutrition education to parents/caregivers to ensure access to nutrient-dense foods that tackle both the nutritional and psychological facets of children's development.

Introduction

Malnutrition remains a pressing global health concern, particularly affecting children in low- and middle-income countries. Malnutrition encompasses various forms of undernutrition, over nutrition, and micronutrient deficiencies, resulting from inadequate

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intake or absorption of nutrients essential for growth and development (UNICEF, 2020). Undernutrition includes stunting (low height-for-age), wasting (low weight-for-height), and underweight (low weight-for-age), reflecting chronic and acute deficiencies in macronutrients and micronutrients (WHO, 2024). Micronutrient deficiencies, such as iron, vitamin A, and iodine deficiencies, result from inadequate consumption or absorption of essential vitamins and minerals, impairing physiological functions (WHO, 2020). These forms of malnutrition can result from complex interactions of socioeconomic, environmental, and individual factors, which ultimately impact children's physical growth and cognitive functioning (Black et al., 2013).

Numerous factors contribute to the prevalence of malnutrition among children, spanning individual, household, and community levels. Many underprivileged communities face barriers to accessing nutritious foods due to economic constraints and limited availability of fresh produce in local market (Ruel et al., 2018). Black et al. (2013) highlighted socioeconomic disparities including poverty, limited access to nutritious foods, and inadequate healthcare services, play a central role in driving malnutrition rates, particularly in low- and middle-income countries. Lack of nutritional education and awareness further exacerbates the problem, leading to poor dietary choices and inadequate utilization of available resources (Nisbett et al.,2021). Inadequate maternal nutrition during pregnancy and lactation, coupled with suboptimal infant feeding practices, has been reported to exacerbate the risk of malnutrition in early childhood (Bhutta et al., 2013). Environmental factors, such as poor sanitation and unsafe drinking water, also increase susceptibility to infections and nutrient malabsorption, contributing to the burden of malnutrition (Black et al., 2013). Limited access to diverse, nutritious foods due to geographic isolation, seasonal variations, and high food prices exacerbates malnutrition in children (Ruel et al., 2013). Cultural beliefs, dietary taboos, and traditional practices may influence food choices and feeding behaviors, impacting nutritional status (Victora et al., 2010). Infectious diseases, such as diarrhea, pneumonia, and malaria, contribute to malnutrition by impairing nutrient absorption, increasing metabolic demands, and reducing appetite (Lukwa et al., 2021).

Nutritional interventions and support programs play a crucial role in addressing child malnutrition, aiming to improve nutritional status, promote healthy growth, and enhance cognitive development. These programs encompass a wide range of strategies, including supplementation, dietary counseling, community-based initiatives, and public health policies, designed to address the multifaceted determinants of malnutrition. Nutritional support is fundamental for ensuring proper growth and development, especially during critical periods such as infancy, childhood, and adolescence (Prentice, 2019). Adequate intake of essential nutrients like protein, vitamins, and minerals is necessary for optimal physical growth, organ function, and immune system maintenance. Studies have reported that linear growth, marked by increases in height and weight, is indicative of a child's physical health and nutritional status (Stein, 2010); and that proper nutrition and healthcare during this period are crucial for ensuring optimal growth trajectories, which in turn, influence overall health outcomes in adulthood (Black et al., 2013). During childhood, linear growth and psycho-cognitive development play pivotal roles in shaping an individual's physical and mental capabilities.

Psycho-cognitive development encompasses the processes of psychological and cognitive growth in individuals. This concept includes how people think, learn, and comprehend their environment as they progress in their development. Linear growth and psycho-cognitive development also contribute to a child's social and emotional well-being (Shonkoff et al., 2012). These developmental milestones lay the foundation for future learning abilities and academic achievement (Diamond, 2013). Nutrition deficiencies during early

childhood influence physical, cognitive and emotional development, ultimately affecting long-term potential and overall well-being (WHO,2024). Early interventions targeting cognitive stimulation can significantly enhance cognitive functioning and academic performance (Richter et al., 2017). Nutrient-rich diets support brain development and enhance cognitive abilities such as memory, attention, and problem-solving skills and exhibit better behavioral outcomes (Eilander et al., 2010).

A significant body of research has examined the impact of nutritional support interventions on malnourished children, aiming to understand the effectiveness of various strategies in improving nutritional outcomes, promoting growth, and enhancing developmental outcomes. These studies have employed diverse methodologies and focused on different contexts to explore the multifaceted nature of malnutrition and the potential pathways through which nutritional support can mitigate its adverse effects. Several studies have investigated the effectiveness of nutritional interventions, including therapeutic feeding programs, supplementary feeding, and micronutrient supplementation, in addressing malnutrition among children. For example, a randomized controlled trial conducted on the efficacy of ready-to-use therapeutic foods (RUTF) in treating severe acute malnutrition among children in Malawi showed significant improvements in weight gain, recovery rates, and survival compared to standard nutritional rehabilitation protocols (Manary et al., 2004). Similarly, a longitudinal study on the impact of a community-based nutrition education program on child growth and development outcomes in Ethiopia for caregivers combined with food supplementation for children, resulted in improved dietary diversity, linear growth, and cognitive development among participants (Leroy et al., 2015). The linear growth and the psycho-cognitive development of malnourished children improved significantly through an integrated mechanism of nutritional support, psychosocial stimulation and WASH interventions over those that received only one package (Jacob et al.,2024).

Statement of the Problem

The research problem stems from the persistent prevalence of malnutrition and food insecurity among marginalized populations, contributing to a range of health disparities and hindered socioeconomic development (Lukwa, 2020). Despite numerous interventions and programs, significant gaps remain ineffectively addressing root causes of nutritional deficiencies which have profound and lasting effects on physical growth, cognitive development, and overall health. Therefore, the effect of food-based intervention on the linear growth and psycho-cognitive development of malnourished children is a subject of significant research and public health interest. The provision of essential nutrients, including proteins, vitamins, minerals, and fatty acids, through complementary feeding programs have been linked to enhanced cognitive development, including improvements in attention, memory, and learning abilities (Aboud & Yousafzai, 2021). Through food-to-food supplementation of local staples, the synergies among these ingredients and sustainable health-promoting approach is desired to be examined.

Objective of the Study

The main objective is to examine the food-based intervention on the linear growth and psycho-cognitive development of malnourished children in selected communities in Kanam Local Government area, Plateau state. Specifically, the study:

1. determine the baseline prevalence of malnutrition among the children aged 6-59 months in selected communities of Kanam LGA.
2. examine the pattern of the linear growth of malnourished children due to food-based intervention within selected communities in Kanam LGA,
3. investigate the psycho-cognitive development of malnourished

children as a result of food-based interventions in specific communities within Kanam,

4. Establish the psycho-cognitive development pattern of malnourished children associated with linear growth as a result of food-based intervention within selected communities in Kanam LGA.

Methodology

Research Design: The research utilized a cross-sectional study design to investigate the impact of food-based intervention on the linear growth and psycho-cognitive development of malnourished children within selected communities in Kanam LGA. A cross-sectional study involves the collection of data from a single point in time to assess the prevalence of a condition or to examine association between variables in a specific population (Gordis, 2014). Data were collected simultaneously on both the exposure (food-based intervention) and the outcomes (linear growth and psycho-cognitive development) among malnourished children within the target communities.

Sample and Sampling technique: The study included a group of moderate and severely underweight children aged six to fifty-nine months whose mothers reside in rural areas, where most household are composed of peasant farmers. A multi-stage cluster sampling techniques was employed to obtain a representative sample of malnourished children within selected communities in Kanam LGA, facilitating the assessment of the impact of complementary nutritional support interventions on their growth and development. First stage involved selecting clusters or communities within Kanam LGA, four clusters and a control chosen based on geographical representation and accessibility. Each of the four clusters or communities Dengi, Gumshar, Jarmai, and Tuttung has one Primary Health Centre (PHC) and Gwamlar (PHC serve as control site. The second stage involved the selection of children within inclusion criteria age (6-59months), nutritional status (based on anthropometric measurement), and residence within communities. Caregivers within the inclusion criteria were mobilized by community leaders to bring their children to the Primary Health Centre in each cluster at a designated date for screening. A total of 511 children were screened using systematic random sampling by two trained research assistants (health workers) in each cluster and the control, following standard anthropometric measurement protocols. The research team, along with the research assistants, conducted interviews with caregivers and performed anthropometric measurements – including weight, height, and mid-upper arm circumference – for all the children participating in the study. Additionally, Quetelet index referred to body mass index (BMI) was calculated

$$\text{Body Mass Index} = \frac{Weight\ (Kg)}{Height(m2)}.$$

Children with a mid-upper arm circumference (MUAC) below 12.5cm, or a weight-for-height z score (WHZ) between -3 and -2, or a weight-for-age z score (WAZ) greater than 1.5 were identified. The purpose of the exercise was explained to the parents or guardians of those children that fulfilled the enrolment requirements and consent was obtained and was subsequently enrolled in the study. 25 malnourished children each were selected for each cluster and the control site.

Method of data collection: Baseline assessments on malnourished children before the intervention were taken and follow-up assessment at monthly intervals for five months including anthropometric measurements and psycho-cognitive development checklist. A typical strategy for meeting nutritional needs through food includes offering an affordable daily dietary supplement made from millet, soybeans, sesame seeds blended at the ratios of 6:2:1, while cray fish, orange flesh sweet potatoes, dried moringa leaves and baobab fruit pulp were supplemented at the ratio 2:1:1:1 using 15% proportions (Darbe et al,.2024). The supplement, consisting of a 100-gram sachet taken daily with daily regular meals for five months for all the four clusters, consumed as a hot cooked gruel. Series of psycho-

cognitive development questions were posed to mothers and caregivers, along with physical activities conducted with children to evaluate the developmental outcomes. Data on nutritional status, developmental outcomes, and exposure to food-based intervention were collected from each participant using standardized protocols (anthropometric measurements) and psycho-cognitive development checklist developed by the researchers.

Data analysis: Data analysis was conducted utilizing SPSS version 23, employing both descriptive and inferential statistical techniques. Specifically, measures such as mean, standard deviation, charts, as well as t-tests and analysis of variance (ANOVA), were utilized with a significance level set at $P<0.05$. Factorial analysis was conducted to compare linear growth and psycho-cognitive development in relation to nutritional support.

Ethical consideration: The research study was registered and approved by the Ethics Committee of the Federal College of Education, Pankshin. Permission to conduct the study at each site was granted by the Executive Chairman of the Kanam Local Government Area. Prior to participation, informed consent was acquired from the parents or guardians of the malnourished children.

Results

The data presented in Table 1 concerning the malnutrition status of children in Kanam communities indicates that 61.06% of children with Quetelet index below <16.9(kg/m^2) are classified as severely underweight. Additionally, 21.13% of children with a BMI between 17 -18.4(kg/m^2) are categorized as underweight. Those with a BMI falling between18.5 – 24.9 (kg/m^2) representing 16.63% of the sampled, are considered to have an ideal weight (healthy weight. Furthermore, only 0.98% of the children with a BMI ranging from 25 -29.5 (kg/m^2) identified as overweight.

Table 1: Area-wise prevalence of malnutrition by Quetelet index in different categories

Area	Quetelet index < 16.9(kg/m^2) Severely underweight	Quetelet index 17-18.4(kg/m^2) Underweight	Quetelet index 18.5-24.9(kg/m^2) Normal	Quetelet index 25-29.5 (kg/m^2) overweight	TOTAL
Dengi	68	14	10	2	94
Gumsher	50	30	22	3	105
Jarmai	74	25	21	-	120
Tuttung	64	23	17	-	104
Gwamlar	56	17	15	-	88
Total	312	109	85	5	511
%	61.06	21.13	16.63	0.98	

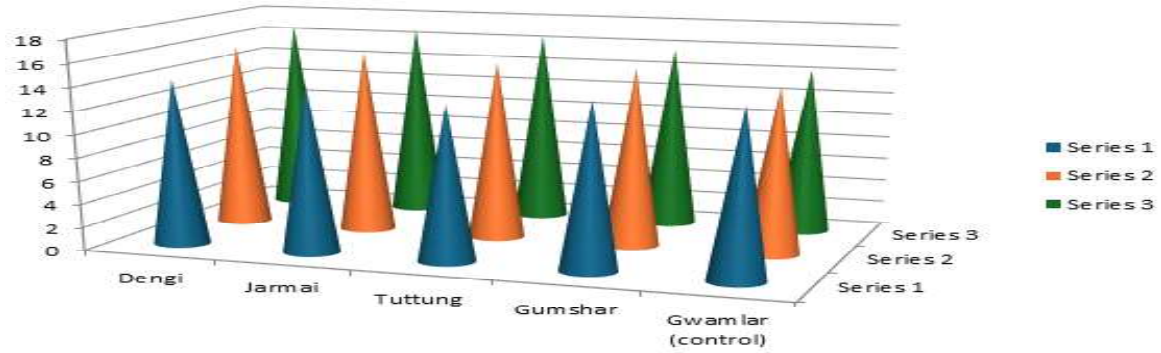

Fig1. Distribution of average Quetelet index for malnourished children after implementing food-based interventions in selected communities in Kanam LGA

Fig 1 illustrates the mean Quetelet Index of malnourished children observed from the baseline to five months within the four clusters and the control. The findings show a consistent rise in the Quetelet Index values across the four communities: Jaramai (from 14.3 to 17.4 kg/m^2), Tuttung (from 13.2 to 18.7 kg/m^2), Gumshar (from 14.6 to 15.4 kg/m^2) and Dengi (from 14.3 to 16.8 kg/m^2) except for Gwamlar (control) (14.2 to 14.4 kg/m^2). The overall improvement in Quetelet Index of malnourished children, observed from baseline to endline, indicates a positive linear growth trend among those who received food-based intervention.

Table 2 displays the results of the variance analysis, highlighting a significant difference (<0.05) in the linear growth of malnourished children exposed to food-based intervention, as measured by their body mass index.

Table 2: ANOVA Test Result indicating Significant Difference in the Linear Growth Quetelet Index of the Malnourished Children

Source	Type III Sum of Squares	Df	Mean Square	F	Sig(2-tailed)
Intercept	3035.166	1	3035.166	5543.621	0.000
Error	1.642	4	0.536		

Table 3 results display the psycho-cognitive development of malnourished children at both baseline and end-line (at six months) following exposure to food-based intervention in Kanam Local Government Area (LGA) of Plateau State.

Table 3: Average key milestones in psycho-cognitive development observed among malnourished children who received food-based interventions

s/n	Psycho-cognitive items statement	Baseline Average	Endline Average	Remark
1	The child participates in play activities around interestingly.	2.57	2.93	Positive
2	Activities that make up the child's everyday experiences are demonstrated.	2.22	2.90	Positive
3	There are specific child's daily functional behavior /activities as reported.	2.00	2.89	Positive
4	Ascertain the child behaviors that sustain child engagement			
	Strengths	2.08	2.92	Positive
	Interests	1.93	2.83	Positive
	Preferences	2.19	2.19	Positive
5	Identify materials (objects, toys, etc.) and interact with it in playing activities.	2.08	2.97	Positive
6	Activities/learning behavior that support and strengthen the child competencies			
	Throwing things	2.13	2.68	Positive
	Clapping hands	2.57	2.86	Positive
	Singing songs	2.22	2.83	Positive
7	Assess the child learning progress based on theattention given to play activities around.	2.00	2.97	Positive
8	The child is gaining in the learning opportunities available.	2.03	3.00	Positive
9	The child Looks closely at an interesting object or person	2.08	4.13	Positive
10	The child reaches or searches for an object or person that moves away from his/her sight.	1.93	3.08	Positive
11	The child points to something that attracts his/her attention.	2.19	3.05	Positive
	Overall Mean	**2.11**	**3.01**	Positive

Table 4 displays the results of t-test between the baseline and end line, highlighting a significant difference (<0.05) in the psycho-cognitive development of malnourished children exposed to food-based intervention.

Table 4: Paired samples t-test on the significant difference between baseline and end line psycho-cognitive development in malnourished children

	Mean	N	Std. Dev	t	df	Sig (2-tailed)
Baseline average	2.15	15	0.196	8.203	14	0.000
End line average	3.01	15	0.328			

Discussion

The finding suggest that a significant majority of the population totaling 82.39% representing both underweight and malnourished, whereas only a minority comprising 16.63% maintain a healthy weight. Although BMI is just one of the tools to assess nutritional status, and a comprehensive evaluation of an individual's health should consider other factors such as age, sex, growth patterns, and clinical assessment. This finding may be attributed to a combination of factors such as inadequate access to nutritious food, poor dietary practices, socioeconomic challenges, and limited healthcare resources in the rural areas. Contrast, only 16.63% of individuals maintain a healthy weight, highlighting the disparity in nutritional status. The results of this study coincide with Bhutta et al. (2013), who emphasize that malnutrition remains a substantial problem among children in low-income communities, emphasizing the urgent requirement for evidence-based interventions to address this challenge. Likewise, Leroy et al. (2014) emphasizes the crucial significance of nutritional interventions in low-income communities to address stunting, a visible consequence of malnutrition among children.

The results in Fig. 1 indicates a positive linear growth trend among those who received food-based intervention, highlighting a significant difference (<0.05) in the linear growth of malnourished children exposed to food-based intervention, as measured by their body mass index. The results is consistent with a systematic review conducted by Dewey and Adu-Afarwuah (2018), which illustrated that interventions focusing on food notably enhance the linear growth of children younger than two years old in developing nations. Likewise, Iannotti et al. (2014) carried out a randomized controlled trial in Haiti, revealing a significant rise in linear growth in young children who received a lipid-based nutrient supplement as a component of a food-based intervention. Bhutta et al. (2008) stresses the efficacy of diverse interventions aimed at maternal and child undernutrition, encompassing food-based strategies, to tackle the root causes of stunted linear growth and enhance child survival rates.

Factors including nutrition, significantly influence both linear and brain development, with nutritional deficiencies having a notable impact. The findings in Table 2 indicated significant improvement in the psycho-cognitive development of malnourished children exposed to food-based intervention. A study found that malnourished children exhibited underdeveloped cognitive skills-such as working memory, visual construction, learning, and memory-compared to their adequately nourished peers of the same age (Kar et al., 2008), which supports the current study's findings. Grantham-McGregor et al. (2013) also emphasized the vital connection between nutrition and cognitive development, underscoring the beneficial effects of food-based interventions on different facets of psycho-cognitive development in children. Likewise, Iannotti et al. (2014) demonstrated notable enhancements in psycho-cognitive development among malnourished children who participated in a food-based intervention. Additionally, a randomized controlled trial conducted by Robert et al. (2022) discovered that children who underwent supplementary food interventions exhibited significant advancements in psycho-cognitive abilities in comparison to those who did not receive such interventions. Interventions centered around food, particularly those focusing on nutrient-dense diets, have been linked to enhanced cognitive results in children (Prado

and Dewey, 2014). This suggests that food-based interventions hold promise for positively impacting psycho-cognitive development. Evidence derived from a meta-analysis conducted by Eilander et al. (2010) indicates that micronutrient supplementation incorporated into food-based interventions can result in noteworthy enhancements in psycho-cognitive function among susceptible populations.

The significant difference (<0.05) in the psycho-cognitive development between baseline and end line data on different facets of psycho-cognitive development in children exposed to food-based intervention are effectively improved. The finding corresponds with the study conducted

by Bhutta et al. (2013) who reported that food–based interventions that improve children's nutritional status are linked to enhanced cognitive outcomes, such as better memory, attention and problem-solving skills, while intervention that focus on providing balance diets have been shown to reduce anxiety and depression (Muscaritoli et al.,2021). The provision of nutrient-dense foods including vitamins, minerals, and proteins specifically designed to address the nutritional deficiencies positively improved the overall developmental outcomes and reduced the risk of cognitive impairment in malnourished children (Robert et al., 2022,). Various factors, including nutrition, significantly influence both linear and brain development, with nutritional deficiencies having a notable impact on these areas. Significant improvement in the linear growth and psycho-cognitive development was observed after implementing food-based intervention. A study found that malnourished children exhibited underdeveloped cognitive skills-such as working memory, visual construction, learning, and memory-compared to their adequately nourished peers of the same age (Kar et al., 2008), which supports the current study's findings. This finding highlight the significant role that food-based interventions can play important role in promoting linear growth and psycho-cognitive development of malnourished children in selected communities.

Various factors, including nutrition, in?uence the brain development. Nutritional de?ciencies

Conclusion and Recommendation

The findings of this study underscore the significant of food-based interventions on both linear growth and psycho-cognitive development of malnourished children in Kanam Local Government Area. Through food-based interventions, remarkable improvements were observed in the physical growth and cognitive abilities of the children. The increase in the Quetelet index and positive changes in psycho-cognitive indicators indicate the effectiveness of the intervention in addressing malnutrition and its associated developmental consequences in this population.

The recommends:

1. The establishment of community food-based intervention programs to ensure access to nutrient-dense foods and fortified blended local foods towards reducing nutritional status disparities among rural dwellers.
2. Provide nutrition education to parents/caregivers on adopting holistic approaches that tackle both the nutritional and psychological facets of children's development, fostering healthy feeding habits.

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