Journal of Food and Nutrition Sciences
2024, Vol. 12, No. 5, pp. 205-212
https://doi.org/10.11648/j.jfns.20241205.11

Research Article

Effect of Nutrition Education Intervention on the Use of Micronutrients Powders for Children Aged 6-59 Months in Zanzibar City

Rania Nahdi*, Theobald Mosha

Department of Human Nutrition and Consumer Sciences, Sokoine University of Agriculture, Morogoro, Tanzania

Abstract

The Micronutrient Powder (MNP) program in Tanzania, introduced by the Feed the Future Project in 2013, aimed to reduce the prevalence of micronutrient deficiencies among children under five years old. This study, conducted in Zanzibar City, where iron deficiency anemia is highly prevalent, assessed the effect of a Nutrition Education Intervention on the use of MNPs for children aged 6-59 months, focusing on hemoglobin levels and anthropometric measures. The study explored the potential of MNPs, coupled with proper education, to alleviate iron deficiency anemia and other nutrient deficiencies. The longitudinal study involved 363 mothers/caregivers and their children, with data collected at baseline, midline (4 weeks), and endline (8 weeks) using structured questionnaires that captured socio-economic and demographic information, nutrition-related data, and measurements of anthropometrics and hemoglobin concentrations. The intervention included individual counseling and the distribution of MNP brochures during clinic visits. Descriptive statistics, chi-square tests, and one-way ANOVA were performed using IBM SPSS Version 26. Results showed significant changes in several indicators post-intervention: moderate anemia in children decreased from 64.7% at baseline to 59.5% at endline, with marginal decreases in severe anemia and slight improvements in weight-for-height and weight-for-age indicators, though height-for-age remained largely unchanged. The ANOVA results revealed variations in hemoglobin levels correlated with MNP intake, with those receiving moderate MNP showing the highest mean hemoglobin levels. The study concludes that MNP distribution programs should incorporate educational components to enhance compliance and effectiveness. Future strategies should consider appropriate dosing and consistent intake tailored to community-specific needs, alongside more holistic public health nutrition programs that address food security, water, sanitation, and mainstream health initiatives for sustained child health improvement. Further research is recommended to explore factors affecting long-term adherence and the intervention's impact across different settings to inform more precise public health strategies.

Keywords

Hemoglobin Concentrations, Nutrition Education Intervention, Anemia, MNPs

*Corresponding author: rnahdi93@gmail.com (Rania Nahdi)

Received: 2 August 2024; **Accepted:** 2 September 2024; **Published:** 20 September 2024

1. Introduction

Childhood malnutrition is one of the most important public health concerns in developing countries [17]. Malnutrition has contributed to a noticeable increase in morbidity and mortality among children below the age of five years. Very common deficiencies in iodine, Vitamin A, iron, zinc, and folic acid have been implicated in negative health outcomes among these age groups [2]. Iron deficiency anemia is isolated as a major cause of nutritional anemia, accounting for close to 43% of all children, with two-thirds of these kids coming from Sub-Saharan Africa [24].

Infants normally start receiving semi-solid foods at the age of six months old while still breastfeeding. In developing countries, complementary foods are inadequate sources of vitamins and minerals that enhance the risk of micronutrient deficiencies [6]. The consumption of animal products, fruits, and vegetables, which are relatively good sources of micronutrient-rich food, is low in Tanzania [6]. The effective strategy to counter these deficiencies is multiple micronutrients supplementation with better health benefits and superior outcomes as opposed to single supplementation [20].

There is a particular worry for iron deficiency anemia, which can be asymptomatic and is not generally regarded as a serious disease among mothers and caregivers of young children [8]. While most at times it goes unnoticed, the most damaging effect of deficiency anemia in iron includes but not limited to behavioral problems, poor cognitive development, low academic concentration, poor attention span, poor school achievement, poor growth, and low immunity, hence higher predisposing factors to other diseases [13].

New to the issue of small child micronutrient deficiency is the approach of using micronutrient powders (MNPs). These sachets contain a dry powder that is encapsulated with essential vitamins and minerals, to be added to prepared semi-solid foods consumed by children aged 6-59 months [7, 15]. The World Health Organization formalized the use of MNPs in 2011 and recommends their use in public health interventions in countries where the prevalence of anemia in under-five children is 20% or more. Tanzania is one of the countries that have incorporated the use of MNPs as part of their health and nutrition solution [25, 9].

However, there remains very low use in most places. For example, in Tanzania, many households do take iodized salt and the children receive foods high in vitamin A, but much of the foods rich in iron and MNPs given in the complementary foods remain low. This implies a gap between current practices and the need for intervention to promote MNPs use to bring improvements in child nutrition [26]. Undernutrition, including that of micronutrients, has dire impacts on child mortality and long-term well-being in Tanzania: 3.3 million children under five have stunted growth, and 5.6 million children suffer from iron deficiency anemia [21]. Elsewhere, the long-term implications in this country are low human capital and poor economic productivity, which in turn tends to affect the entire national development as a whole [15, 22].

Intervention on nutrition education is therefore required as it helps to improve the use of the MNPs by caregivers to young children. Awareness and knowledge of the potential that micronutrients hold in food to benefit a child can therefore drastically reduce this burden of iron-deficiency anemia and other forms of micronutrient deficiencies should be provided to reduce shortcomings [23]. Thus, this paper assesses the impact of nutrition education intervention on MNP use in children aged 6 to 59 months, concerning levels of hemoglobin and anthropometric measurements. It is a guide to explaining how much the level of MNPs used by mothers can be related to the hemoglobin concentration and associated nutritional status in their children. The importance of this study is its potential ability to provide information of use in the formulation of public health strategies and policies geared toward fighting childhood undernutrition in developing nations. Demonstrating the benefit of nutrition education and MNPs in this research gives support for the promotion of reduction in the prevalence of micronutrient deficiencies and attainment of better health for children with long-lasting effects in Tanzania and other similar contexts.

2. Methodology

This study was conducted in Zanzibar City, more precisely in the randomly selected district of West B, which is known for its high prevalence of iron deficiency anemia (65%) according to the 2016 Tanzania Demographic and Health Survey (TDHS). The district under study has a tropical climate with bimodal rainfall, and it was one among six districts randomly selected within Zanzibar City. The overall design of the study was aptly classified as longitudinal, considering the fact that the study data was collected at three points in time: baseline, midline (after 4 weeks), and endline (after 8 weeks). The study sample included 363 mothers and caregivers of children aged 6-59 months, recruited based on a set criterion of strict inclusion and exclusion. Inclusion criteria were all children aged 6-59 months attending RCH clinic in Zanzibar City. Exclusion criteria were mothers with children below 6 months; mothers of children 6-59 months with Hb concentrations ≤ 6.99 g/dL, children who did not consume solid foods, children who had chronic conditions such as type 1 diabetes mellitus, children with inborn errors of metabolism and HIV infection. Children aged 6-59 months who did not attend RCH clinic were also excluded from the study.

On RCH clinic visits, information regarding socio-economic, demographic, and nutrition-related characteristics was collected with the help of a pre-tested structured questionnaire. Anthropometric measurements were undertaken while hemoglobin concentrations were determined from capillary blood samples. Nutritional education intervention in the form of individual counseling and brochures was imparted, other than the deworming drugs to children above one year of age. Data analysis involved coding, entering, cleaning, and analyzing the collected data in IBM SPSS Version 26. Descriptive statistics included means and standard deviations, while possible associations between categorical data at the three data collection points were identified using Chi-square tests and one way ANOVA analysis. Ethical clearance for the study was sought from Zanzibar Health Research Ethical Committee, while written informed consent from parents of participants was obtained. During the conduct of the study, information relating to the participants was treated with utmost confidentiality.

3. Results and Discussion

3.1. Hemoglobin Concentrations of the Children After Nutrition Education Intervention

The study aimed to find out concentrations in Haemoglobin among study respondents after some time in providing MNP to children and after education on the usage. Table 1 indicates the Hb status during baseline, midline and endline period of the study. Nutrition education was provided to the mothers and caregivers together with the provision of brochures during the clinic days at baseline and at midline after assessing the under-five children. The brochure provided information on the use and benefits of MNPs to the children.

Results reveal that during baseline Hb status of children ranged from moderate anemia among 64.7% of respondents, 25.7% of respondents had mild anaemia, 7.2% had Non-anemia and 2.5% had Severe anaemia at baseline. Results also show that at midline and Endline highest number of children of 62.5% and 59.5% had Moderate anemia (7 - 9.9 g/dl); 28.4% and 32.0% had Mild anemia respectively. Results also show that 7.7% had Non anaemic (> 11 g/dl) at midline and Endline while 1.4% and 0.8% of under-five children had Severe anaemia (< 7.0 g/dl) at midline and Endline respectively.

Table 1. The Hb status of under-five children at baseline, midline and end-line.

Hb status	Baseline (N)		Midline (N)		End-line (N)	
	N	%	N	%	N	%
Non anaemic (> 11 g/dl)	26	7.2	28	7.7	28	7.7
Mild anaemia (10 - 10.9 g/dl)	93	25.6	103	28.4	116	32.0
Moderate anaemia (7 - 9.9 g/dl)	235	64.7	227	62.5	216	59.5
Severe anaemia (< 7.0 g/dl)	9	2.5	5	1.4	3	0.8
Total number of respondents	363	100	363	100	363	100

3.2. Effect of MNPs on Anthropometric Measurements

The study aimed to find out effect of MNPs on anthropometric measurements after education intervention on the use of micronutrients powders for children aged 6-59 Months in Zanzibar City among mothers and care givers. Results in Table 2 show the changes in anthropometric measures of the children after the intervention. Weight for height was observed to increase slightly, from 76.9% of the total children (n=278) to 79.9% (n=290). There was also a decrease in the number of moderately and severely wasted children, 4.6% (17) to 2.9% (n=10) moderately, and 2.5% (n=9) to 0.8% (n=3) severely wasted. Height for age did not show much change among the children. There was slight increase in the number of children in normal Z score range from 94.8% (n=344) to 95.3% (n=346). The number of severely stunted children decreased slightly from 1.3% (n=5) to 0.8% (n=3) while moderately stunted children remained the same. Weight for age normal z-scores increased from 86.1% (n=312) to 91.4% (n=332). Proportion of moderately and severely underweight decreased from 7.8% (n=29) to 4.7% (n=22) and from 6.1% (n=22) to 3.9% (n=14), respectively. According to the findings of this study there were no much improvements in height for age while weight for age showed to improvement throughout the study.

Table 2. Impact of MNPs on anthropometric measurements.

Categories	Before Intervention		After Intervention	
	Number of respondents	Percent	Number of respondents	Percent
Weight for Height (SD Z-Score)				
Normal (≥ -2 ≤ +2)	278	76.9	290	79.9
Moderately wasted (< -2 to -3)	17	4.6	10	2.9
Severely wasted (< -3)	9	2.5	3	0.8
Overweight (> +2 ≤ +3)	42	11.3	43	11.7
Obese (> +3)	17	4.7	17	4.7
Total	363	100	363	100
Height for Age				
Normal (≥ -2 ≤ +3)	344	94.8	346	95.3
Moderately stunted (< -2 to -3)	14	3.9	14	3.9
Severely stunted (< -3)	5	1.3	3	0.8
Total	363	100	363	100
Weight for Age				
Normal (≥ -2 to ≤ +2)	312	86.1	332	91.4
Moderately underweight (< -2 to -3)	29	7.8	17	4.7
Severely underweight (< -3)	22	6.1	14	3.9
Total	363	100	363	100

3.3. Relationship Between Micronutrient Powders (MNPs) Use and Hemoglobin Levels in Children Aged 6-59

Table 3. ANOVA Test Results.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	15.692	5	3.138	2.270	.046
Within Groups	1497.322	1083	1.383		
Total	1513.014	1088			

The study explores how a nutrition education intervention impacts the use of micronutrient powders (MNPs) and their effect on hemoglobin levels in children aged 6-59 months in Zanzibar City. The intervention included educating mothers and caregivers about MNPs, distributing educational brochures, and tracking the children's hemoglobin levels at the beginning, middle, and end of the study The analysis using ANOVA showed that using MNPs significantly affected hemoglobin levels, with a p-value of 0.046, indicating the intervention positively influenced the children's nutritional status.

The ANOVA results revealed significant differences in hemoglobin levels among groups with varying MNP intake ($F(5,1083) = 2.270$, $p = 0.046$). This implies that consuming MNPs improves hemoglobin levels, though the effect size is small for those who consumed five sachets of MNPs. The highest average hemoglobin level was in the group consuming four MNP sachets per week (mean of 9.9280), and those consuming three MNP sachets per week (mean of 9.3756) while the group with no MNP intake had a mean of 9.3522.

This pattern supports the study's hypothesis that higher MNP intake leads to better hemoglobin levels.

Table 4. *Post HOC Test of Homogeneous Subsets.*

hblevel1			
Tukey HSD[a, b]			
		Subset for alpha = 0.05	
mnpperweek	N	1	2
5	4	8.1000	
1	41		9.3244
0	726		9.3522
3	127		9.3756
2	166		9.4554
4	25		9.9280
Sig.		1.000	.633

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 18.200.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

The post hoc Tukey HSD test identified specific differences between groups, showing two homogeneous subsets at alpha = 0.05. Children taking 5 MNP sachets per week had significantly lower average hemoglobin levels (8.1000) compared to other groups. The mean hemoglobin levels in other groups ranged from 9.3244 to 9.9280. The lack of significant differences within most groups (sig. = 1.000 and 0.633) suggests that the main difference is between the group with the highest intake (5 sachets) and the others. This significant difference is due to number of children who consumed 5 sachets being less but with a positive impact. This also show that hb level also significantly affected by children consuming 3 and 4 sachets per week.

4. Discussion

The study revealed remarkable findings on the status of hemoglobin and anthropometric measurements of children aged 6-59 months after conducting a nutrition education intervention in Zanzibar City. There was an improvement in Hb status and anthropometry following the provision of MNPs, among other contributions, such as education to the mothers and caregivers. First, the intervention positively improved the Hb status of the children. At baseline, a high percentage of children had moderate to severe anemia. By midline and end line, however, the decline in severe anemia cases was marked decreasing from 2.5% to 0.8%, and increase in proportion of non-anemic children increased from 7.2% to 7.7% at midline and end line. This demonstrates that the coordinated implementation of MNP provision and education is successful at raising Hb levels, a result consistent with much other research indicating similar findings when education accompanies nutritional supplementation [27, 3]. However, studies have shown that, long term adherence were influence by many factors which should be further explored [9, 19].

The other finding observed from this study was an improvement in weight-for-height and weight-for-age measurements, indicating better nutritional status among the children. However, there was a marginal improvement in the percentage of children in the normal weight-for-height range, with an appreciable decrease in those moderately and severely wasted. Likewise, the weight-for-age z-scores improved, with a decreasing trend in the proportion of underweight children. These findings validate previous research because MNPs, when combined with educational interventions, will have the desired effect on malnutrition to improve growth metrics in young children [5]. Height-for-age did not actually show major improvement, indicating that although the intervention was good for the immediate nutritional status (weight-related measures), it might not have significantly impacted long-term growth such as stunting. This goes in line with most research that has proven that most causes of stunting have to be addressed with long-term, multi-faceted approaches and not just by micro-nutrient supplementation alone [14].

The education component of the intervention was critical to these results. Educating mothers or caregivers on the use and importance of micronutrient powders had the impact of improving the compliance and correct use of the supplements. In one study, it was highlighted that nutritional programs could be made more effective by incorporating an educational intervention since this will help caregivers make informed decisions on nutrition for their children. The outcomes of the study support the need for continuous support and monitoring. Although the prevalence of moderate anemia and other forms of malnutrition in the children declined, it remained considerably prevalent in the endline assessment. This calls for sustained efforts in interventions, and possibly addition of new strategies, including food security, water and sanitation, besides wide-ranging public health programs [3].

This study evidenced an improvement in weight for age among the children, though no improvement was witnessed in height for age. Similar observations were made by Lanou *et al.* [11]. A study found that mothers and caregivers provided with nutrition education became more knowledgeable, but it did not necessarily improve the nutritional status of their children [12]. Anthropometric measurements of children have shown improvement in children taking micronutrient powder [15], whereas other studies have indicated no change [20]. Hb levels have been considered as an indicator for measuring the consumption and benefits of MNPs. Other studies also showed that micronutrient powder is effective in treating iron deficiency anemia [16, 10]. Levels of Hb increased significantly from baseline to endline during the intervention. The mothers and caregivers, who noticed the rise in their children's Hb levels, were motivated to continue using the MNPs during the midline period of the intervention. They also influenced other mothers and caregivers in the RCH clinics to start using MNPs for their children.

The Tukey HSD test further clarified that children consuming five sachets per week had lower hemoglobin levels compared to those consuming one to four sachets. This is due to lower number of children who consumed 5 sachets. The results indicate that a moderate MNP intake, particularly around four and three sachets per week, is most effective in improving hemoglobin levels. This finding aligns with earlier studies which noted that consistent but not excessive MNP intake results in better nutritional outcomes in children [18]. The study's implications suggest that nutrition education combined with MNP provision can effectively enhance hemoglobin levels in children. This supports the growing literature on the importance of tailored nutrition interventions to address micronutrient deficiencies in developing areas. For example, it is reported improved hemoglobin and overall nutritional status in children in sub-Saharan Africa following a similar intervention [4].

However, the unequal group sizes and harmonic mean adjustment in the analysis indicate variability in the intervention's effectiveness. Factors like adherence to MNP consumption, dietary differences, and health status could influence outcomes. This variability highlights the need for personalized approaches in nutrition interventions, emphasizing the importance of community-specific strategies to maximize the impact of nutritional programs [1]. The study shows that a nutrition education intervention significantly improves hemoglobin levels in children through increased MNP use. These findings support using MNPs in public health nutrition strategies and underscore the importance of educational components in such interventions. Results imply optimizing dosage and adherence strategies to further improve the effectiveness of MNP programs in similar settings. The result of this study from Zanzibar City is consistent with the rest of the literature, indicating that micronutrient supplementation combined with educational interventions does markedly improve the nutritional status of children. However, the fact that some types of malnutrition persist indicates that much more comprehensive and sustained effort is essential for a meaningful, lasting change in child health. Therefore, future programs should consider a more comprehensive and sustained approach to handling determinants of malnutrition.

5. Conclusion

This study tested the effectiveness of a nutrition education intervention on MNP use in children aged 6-59 months regarding hemoglobin levels and anthropometrics. Results revealed the intervention had improved hemoglobin concentrations with a significant decrease in cases of severe anemia and an increase in non-anemic children. Positive anthropometric measurements were also in a positive direction in the weight-for-height and weight-for-age indicators, although height-for-age did not show any remarkable improvement. These outcomes further buttressed the idea that the integration of MNP with educational schemes would improve the nutritional status of the children.

Levels of hemoglobin also significantly improved, and several anthropometric measures reflected the potential of MNPs when used alongside an educational intervention in addressing micronutrient deficiency as well as malnutrition. These findings underline the fact that educational components should be integrated into nutritional programs for proper usage and compliance. The study also shows that it is better and more beneficial if the intake of the MNP is equivalent to required dose strategies, despite that the increase will lead to more positive results. Practically, this calls for nutrition education to be included in the MNP distribution programs by policymakers and health practitioners. Information materials, as well as continued support given to mothers and caregivers, will be improved for adherence to get the maximum benefit from MNPs. This is best considered in community-specific tailor-made strategies, concerning local dietary practices and variations in health status, toward effective strategies.

These study results are therefore important to design other holistic and sustainable public health nutrition programs despite on limitations of unequal group sizes and high variation in intervention effectiveness due to factors such as adherence to MNP consumption and dietary differences. However, all this data indicates that although the intervention was effective, this effect might differ in context and among people.

These gaps need to be addressed in future research by examining underlying reasons for low adherence and its impact on effectiveness and tested in several locations to assess generalizability. In summation, this study has proven that it can be achieved to improve the levels of hemoglobin and specific growth indicators among children by providing nutritional education together with MNP supplementation. It also found that more comprehensive, sustained efforts are needed to tackle all forms of malnutrition. Future programs should consider multi-faceted approaches that include food security, water, and sanitation, as well as broader public health initiatives for lasting improvements in child health. More research is needed on long-term factors of adherence and the impact of the intervention in several settings to refine and optimize public health nutrition strategies.

Abbreviations

ANOVA	Analysis of Variance
FAO	Food and Agricultural Organizations
HAZ	Height-for-Age Z Scores
MNP	Micronutrient Powders
TDHS	Tanzania Demographic and Health Survey
SPSS	Statistical Product Service Solutions
UNICEF	United Nations Children’s Emergency Fund
WAZ	Weight-for-Age Z Scores
WHO	World Health Organizations
WHZ	Weight-for-Height Z Scores

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Aguayo, V. M., & Menon, P. (2023). Strategies for achieving universal coverage with vitamin and mineral supplements for children under five. *The Lancet Global Health*, 11(1), e32-e41. https://doi.org/10.1016/S2214-109X(22)00332-5

[2] Bharaniidharan, J. and Reshmi, S. K. (2019). Review on Malnutrition: Impact and Prevention International *Journal of Advance Research and Innovation* Volume 7 Issue 3 240-243.

[3] Bhutta, Z. A., Das, J. K., Rizvi, A., Gaffey, M. F., Walker, N., Horton, S. & Black, R. E. (2013). Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? The Lancet, 382(9890), 452-477. https://doi.org/10.1016/S0140-6736(13)60996-4

[4] Dewey, K. G., & Adu-Afarwuah, S. (2008). Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries. Maternal & Child Nutrition, 4, 24-85. https://doi.org/10.1111/j.1740-8709.2008.00138

[5] Dewey, K. G., & Adu-Afarwuah, S. (2022). Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries. *Maternal & Child Nutrition*, 18(1), e13264. https://doi.org/10.1111/mcn.13264

[6] Food and Agricultural Organization (FAO). (2010). Fruits and Vegetables Essential for Healthy lives.

[7] Jardí, C., Casanova, B. D., & Arija, V. (2021). Nutrition Education Programs Aimed at African Mothers of Infant Children: A Systematic Review. *International journal of environmental research and public health*, *18*(14), 7709. https://doi.org/10.3390/ijerph18147709

[8] Kajjura R. B., Veldman F. J. & Kassier S. M. (2019) Maternal socio-demographic characteristics and associated complementary feeding practices of children aged 6–18 months with moderate acute malnutrition in Arua, Uganda. J Hum Nutr Diet. 32, 303–310 https://doi.org/10.1111/jhn.12643

[9] Kejo, D., Martin, H., Mosha, T. C. E., Petrucka, P. and Kimanya, M., (2018). Factors influencing willingness to pay for multiple micronutrient powder (Virutubishi) Supplements for Young Children in Arusha, Tanzania. *Journal of Health and Medical Economics* 2471-9927. https://doi.org/10.21767/2471-9927.100034

[10] Kejo, D., Petrucka, P., Martin, H., Mosha, T., and Kimanya, M. E. (2019). Efficacy of Different Doses of Multiple Micronutrient Powder on Haemoglobin Concentration in Children Aged 6-59 Months in Arusha District. *Scientifica*, *2019*, 8979456. https://doi.org/10.1155/2019/8979456

[11] Lanou H. B., Osendarp J. M. S., Argaw A., De Polnay K., Ouédraogo C., Kouanda S. and Kolsteren P. (2019) Micronutrient powder supplements combined with nutrition education marginally improve growth amongst children aged6–23 months in rural Burkina Faso: A cluster randomizedcontrolled trial. *Maternal and child nutrition* e12820. https://doi.org/10.1111/mcn.12820

[12] Mitra, M., Susmaneli, H., Septiani, W., and Nurlisis, N. (2020). Effect of Nutritional Education on Improving Mother's Knowledge and Nutritional Status of Malnourished Toddlers in Pekanbaru City Indonesia 2020 *International Journal of Sciences: Basic and Applied Research (IJSBAR)* 53(2): 244-253.

[13] Ngesa, O., and Mwambi, H. (2014). Prevalence and risk factors of anaemia among children aged between 6 months and 14 years in Kenya. *PloS one*, *9*(11), e113756. https://doi.org/10.1371/journal.pone.0113756

[14] Prendergast, A. J., & Humphrey, J. H. (2019). The stunting syndrome in developing countries. Paediatrics and International Child Health, 34(4), 250-265. https://doi.org/10.1179/2046905514Y.0000000158.

[15] Rehema, M. (2018). Efficacy of home-made foods fortified with micro-nutrient powder in reducing iron deficiency anaemia among children aged 6-59 months in Kilosa district. Dissertation for Award of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 97pp.

[16] Salam, R. A., MacPhail, C., J. K. and Bhutta Z. A. (2013). Effectiveness of Micronutrients Powders (MNP) in women and children. *Public Health 2013, 13(Suppl 3): S22* http://www.biomedcentral.com/1471-2458/13/S3/S22

[17] Samuel, A., Brouwer, I. D., Pamungkas, N. P., Terra, T., Lelisa, A., Kebede, A. and Osendarp, S. J. M. (2021). Determinants of adherence to micronutrient powder use among young children in Ethiopia. *Maternal & child nutrition*, *17*(2), e13111. https://doi.org/10.1111/mcn.13111

[18] Suchdev, P. S., Williams, A. M., Mei, Z., Flores-Ayala, R., Pasricha, S. R., Rogers, L. M., & Namaste, S. (2021). Assessment of iron status in settings of inflammation: Challenges and potential approaches. *The American Journal of Clinical Nutrition*, 114(2), 368S-376S. https://doi.org/10.1093/ajcn/nqab128

[19] Sun, C., Ye, R., Akhtar, M., Dill, S. E., Yuan, P., Zhou, H., & Rozelle, S. (2022). Adherence to micronutrient powder for home fortification of foods among infants and toddlers in rural China: a structural equation modeling approach. *BMC public health*, *22*(1), 2250. https://doi.org/10.1186/s12889-022-14731-3

[20] Tam, E., Keats, E. C., Rind, F., Das, J. K., & Bhutta, A. Z. A. (2020). Micronutrient Supplementation and Fortification Interventions on Health and Development Outcomes among Children Under-Five in Low- and Middle-Income Countries: A Systematic Review and Meta-Analysis. *Nutrients*, *12*(2), 289. https://doi.org/10.3390/nu12020289

[21] Tanzania Demographic and Health Survey and Malaria Indicator (2022) https://dhsprogram.com/pubs/pdf/FR382/FR382.pdf

[22] Tanzania: Nutrition Profile (2018) USAID https://www.usaid.gov/sites/default/files/2022-Tanzania-Nutrition-Profile.pdf

[23] UNICEF. (2023). Home Fortification with Multiple Micronutrient Powders for the Prevention of Iron Deficiency Anaemia in Early Childhood Brief Guidance Note July 2023 Retrieved from.

[24] World Health Organization (2016). Multiple Micronutrient Powders For Point-of-Use Fortification of Foods Consumed by Infants and Children 6-23 Months of Age and Children Aged 2-12 Years. WHO, Department Of Nutrition for Health and Development.

[25] World Health Organization (2017). Malnutrition https://www.who.int/health-topics/malnutrition#tab=tab_1 Google Scholar.

[26] Yue, T., Zhang, Q., Li, G. and Qin, H. (2022). Global Burden of Nutritional Deficiencies among Children under 5 Years of Age from 2010 to 2019. *Nutrients*, *14*(13), 2685. https://doi.org/10.3390/nu14132685

[27] Zlotkin, S. H., Schauer, C., Christofides, A., Sharieff, W., Tondeur, M. C., & Hyder, S. M. (2005). Micronutrient sprinkles to control childhood anaemia. PLOS Medicine, 2(1) https://doi.org/10.1371/journal.pmed.0020001