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Review article

Ready-to-use therapeutic food as a promising therapy for the prevention and cure of undernutrition in pre-school children: A review

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Abstract: The nutritional status of preschool children is a reflection of the health of children around the world and forms the basis for the development of success-oriented intervention programs. This study indicates the prevalence of undernutrition in children under the age of five in Nigeria. It also showed the prevalence of undernutrition in the six geopolitical regions of Nigeria, with the northern areas reported to have the highest burden of undernutrition compared to the other regions due to several factors such as inadequate breastfeeding, lack of access to healthcare, lack of clean water, armed conflict, inadequate dietary intake, inappropriate feeding, fetal growth restriction, inadequate sanitation, lack of parental education, large family size, incomplete vaccination, poverty and low socioeconomic status, and the desire to have more children. Several nutritional interventions have been put in place to prevent and cure undernutrition in preschool children, including promotion of exclusive breastfeeding, micronutrient supplementation, food fortification, nutrition education, complementary feeding, cash transfer programs, ready-to-use therapeutic foods (RUTF), nutrition rehabilitation centers, parenteral nutrition, and nutrition counseling and education. However, RUTF has been reported to be an effective intervention for the prevention and treatment of severe acute malnutrition (SAM) in preschool children. It is an energy-dense, shelf-stable and ready-to-eat food consisting of peanut butter, sugar, full-fat milk and mineral-vitamin premix. Other plant-based ingredients such as chickpeas, soybeans, sesame, maize, oats, sorghum and sunflower oil have also been used in the production of RUTF and have reported to be effective for the complete recovery of SAM children.

Keywords: Preschool children, Prevalence, Ready-to-use therapeutic, Severe acute malnutrition, Under-nutrition

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Introduction

Undernutrition refers to not consuming enough nutrients or insufficient intake of nutrients and energy to meet the needs of the body for maintaining good health [1]. While malnutrition technically refers to both undernutrition and overnutrition, it is a condition that develops from an inadequate supply of the proper amount of protein, energy, vitamins and other nutrients to the body to maintain healthy tissues and organ function [1]. The terms undernutrition and malnutrition are often used interchangeably. Various descriptive terms, including kwashiorkor, marasmus, and micronutrient deficiencies, have been referred to as malnutrition. However, the term "undernutrition" was suggested because it covers both protein-energy undernutrition and micronutrient deficiencies since protein-energy malnutrition does not occur in isolation from particular micronutrient deficiencies. One of the primary causes of morbidity and mortality in preschool children worldwide is malnutrition [2]. Malnutrition in children is recognized to have both immediate and long-term effects that are detrimental to the growth and development of preschool children. Malnourished children tend to have an increased risk of morbidity and mortality and often suffer from delayed mental development, poor school performance and reduced intellectual achievement [2].

Globally, undernutrition is a significant public health concern, particularly in low- and middle-income countries. According to a report by the World Health Organization (WHO) in 2019 [3], an estimated 149 million children under the age of five were affected by stunting (low height for age), while 45 million children under five years old were affected by wasting (low weight for height) and 115 million were underweight. In developing countries, an estimated 230 million children under the age of five were reported to be chronically undernourished [4]. It was also estimated that about 54 % of deaths among children in this age group in developing countries are believed to be associated with malnutrition [5]. In Africa, undernutrition is a major health issue, and the prevalence varies across the continent. According to the WHO [3], the prevalence of stunting among children under the age of five in Africa was estimated at 29 %, while the prevalence of wasting was 7 %. In Sub-Saharan Africa, 41 % of children under the age of five are malnourished and the number of deaths in the region is increasing daily [5]. In 2013, Nigeria was reported as one of the countries with the highest prevalence of under-nutrition within Sub-Saharan Africa [6]. In Nigeria, undernutrition is also a significant public health concern. According to the United Nations Children's Fund [7], the prevalence of stunting among children under five years old in Nigeria was 37 %, while the prevalence of wasting was reported to be 7 %. There are over 2.6 million children severely malnourished and over 13 million stunted, making Nigeria the third country with the highest number of stunted and wasted children globally [8]. In Nigeria, the regional prevalence of undernutrition varies, with the highest rates found in the northern part of the country. According to a survey by the National Bureau of Statistics [9], the prevalence of stunting among children under the age of five in the north central region was 43.6 %, while higher prevalence (49.9 %) was reported in the north-east. According to the Nigeria Demographic and Health Survey (NDHS) report [10], the prevalence rate of stunting, wasting and underweight in the six geopolitical regions of Nigeria in North-Central was 37.4 %, 12.9 % and 28.0 %, respectively. In the north-east, the prevalence of stunting was 51.9 %, wasting 14.3 % and underweight 33.2 %. In the North-West, 51.7 % stunting, 16.8 % wasting and 37.0 % underweight. In the South-East, the prevalence of malnutrition was lower with 20.8 % stunting, 3.3 % wasting and 11.6 % underweight. Likewise, the South-South was also recorded a lower prevalence of stunting (22.9 %), wasting (5.1%) and underweight (14.8%). Furthermore, the South-West was also reported a lower prevalence of stunting (13.4%), wasting (4.0 %) and 8.4 % underweight. NDHS [10] reported that the prevalence of undernutrition is higher in rural areas and among children from poorer households. Additionally, the prevalence of undernutrition varies by age group, with the highest rates observed among children under the age of 2 years.

To prevent or reduce children's undernutrition, children must be exclusively breastfed for at least 4-6 months and hygiene, nutritious food, and health care services must be improved. Poverty and food insecurity earnestly constrain the accessibility of nutritious foods that have high protein quality, adequate micronutrient content and bioavailability, low anti-nutritional factors and high nutrient density [11]. A diet based mainly on plant-based ingredients without fortification and animal-based protein is hardly to meet the nutritional needs of children under five years old. Based on the aforementioned, several studies have been conducted on the processing and production of complementary foods, especially from plant-based ingredients for children below the age of five as a means to prevent or reduce malnutrition in children. Such as the production and testing of soybeans, lipid-based supplements and a corn-soy blend were studied to feed on the incident of stunting and linear growth in 6 to 18 months old children [12]. In addition, a blend of maize, soybeans and peanuts was processed and fortified with Moringa oleifera as a complementary food [12]. Similarly, an energy-dense, lipid-based paste, commonly known as Ready-to-Use Therapeutics Foods (RUTFs), which was composed of a mixture of milk powder, sugar, vegetable oil, peanut butter, pre-mix vitamins and minerals, has been produced in the form of a paste and biscuits and has been reported to be an effective therapy for the treatment of severely acutely malnourished children [13, 14]. Most developing countries such as Nigeria, Ethiopia and Malawi now use RUTFs (produced locally or supplied by UNICEF) to prevent or treat severe acute malnutrition in children under the age of five [11].

Ready-to-use therapeutic foods (RUTFs)

Ready-to-use therapeutic foods (RUTFs) are energy-dense, nutrient-rich foods that have been produced to treat severe acute malnutrition (SAM) in children under the age of 5 years [15]. RUTFs were first developed in the 1990s by researchers at the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) in response to the need for a more practical and effective treatment for SAM in resource-limited settings [14]. Traditional treatment methods, such as inpatient care and feeding programs were often expensive and impractical, with little success in treating severe acute malnutrition in children [16]. In 1993, a French company called Nutriset developed a new product called Plumpy nut, which was an innovative type of RUTF made from a blend of peanuts, milk powder and sugar [16]. Plumpy nut was designed to be easy to use and transport and did not require refrigeration or cooking. Plumpy nut was first used in the field in 1999 by Medicines San Frontieres in Angola and later in Ethiopia, where it proved to be highly effective in treating severe acute malnutrition. Since then, other companies and organizations have developed their versions of RUTF, which have been used to treat undernutrition in numerous countries [17]. Today, RUTF is a widely accepted and effective treatment option for severe acute malnutrition and has been used in many emergency and development programs around the world [18]. It has helped save countless lives and has been a breakthrough in the fight against undernutrition. The main ingredients for the formulation of RUTFs are presented in Table 1.

Table 1. A typical recipe for RUTFs (Source: Vijay [20])

Ingredient	% weight
Full-fat milk	30
Sugar	28
Vegetable oil	15
Peanut butter	25
Mineral vitamin mix	1.6

RUTFs are designed to be ready-to-use with a long shelf-life, easy to digest and provide the high energy and nutrient density required to rapidly improve the nutritional status of SAM children under the age of five [19]. Since 2007, the United Nations has recommended the use of ready-to-use therapeutic food at the community level for the treatment of children with severe acute malnutrition in low-income countries. The reasons are that RUTF does not need preparation or addition of water before eating, it can be stored at ambient temperature for a longer time, permits individual packaging and can therefore be used effectively in non-optimal hygienic conditions [20]. In addition, RUTF meets the specification for type I and II micronutrient densities [20], which have been reported to contribute to the effective treatment of SAM in children [21]. Different forms of RUTF have been produced such as biscuits, candies, paste / plumpy nut and liquid forms. Plumpy nut is the most common commercial brand that has been clinically tested [21]. Numerous studies have reported the efficacy of RUTFs in the treatment of SAM in children, as presented in Table 2.

The key advantage of RUTF is that it is ready-to-use, which does not need to be mixed with water and avoids the risk of bacteria proliferation in case of accidental contamination [27]. The product provides sufficient nutrient intake for the complete recovery of SAM children. Additionally, it could be stored for 3-4 months without refrigeration, even at tropical temperatures [28]. Plant-based ingredients such as corn, maize, soybeans, peanuts, and groundnuts have been used for the production of RUTF. Similarly, the ingredients and several other plant-based foods have been used to produce complementary food for preschool children, as summarized in Table 3.

Micronutrients in RUTF

RUTF is a carefully designed therapeutic food that provides a comprehensive range of vitamins and minerals necessary for the rapid recovery of malnourished individuals. Due to the differences in concentration balance and bioavailability of these nutrients compared to standard diets or supplements, RUTF is uniquely suited for the treatment of severe acute malnutrition. The formulation ensures that all nutritional needs are met in a way that supports quick rehabilitation, immune function and overall health [33]. The multivitamins contained in RUTF include vitamin A, which is at high level to rapidly replenish depleted stores and support immune function. Vitamin D; to prevent rickets and other bone deformities, which are common in malnourished children. Vitamin E; to combat oxidative stress, which is often elevated in children with malnutrition. Vitamin K; to ensure proper blood clotting, especially important in children who may be prone to bleeding due to a deficiency. High levels of vitamin B-complex to ensure that metabolic processes are restored and neurological development is supported to address deficiencies caused by malnutrition, and vitamin C, which helps in recovery from infections and supports tissue repair[33].

Some of the minerals included in RUTF are iron, zinc, iodine, calcium, magnesium, potassium, phosphorus and selenium [34].

Diseases related to malnutrition

Severe Acute Malnutrition (SAM): SAM is a life-threatening condition characterized by extreme weight loss and wasting (marasmus) or edema (kwashiorkor). It often occurs due to insufficient nutrient intake or repeated infections. Children with SAM are highly susceptible to

Table 2. Previous studies on the effectiveness of RUTFs in severe acute malnourished children

Formulation	Success reported	Reference
Oats, high oleic or peanuts and encapsulated or oil-based docosahexanoic acid (DHA)	Study shows that most of the DHA in the RUTF are retained in the final product and DHA is best retained when added at the latest manufacturing stage.	[22]
Soy, Maize and Sorghum-amino acid	Milk, soy, Maize, and Sorghum RUTF (FSMS-RUTF) without milk is efficacious in the treatment of severe acute malnutrition in the ages 6-23 and 24-59 months. It is also better at correcting iron deficiency anaemia than peanut milk (PM-RUTF).	[23]
Comparison of the effectiveness of Milk Free, Soy, Maize, Sorghum-RUTF (FSMS-RUTF), Milk, Soy Maize Sorghum-RUTF(MSMS- RUTF) and Peanut Milk-RUTF (PM-RUTF)	The findings indicate that treatment with either FSMS-RUTF, MSMS-RUTF or PM-RUTF is associated with adequate protein synthesis and that all formulations provided sufficient functional metabolites of plasma amino acids to support nutritional recovery from SAM.	[24]
Nutritional value of two different formulations: peanut butter and sesame paste	The study found that both formulations were effective in treating SAM, but the peanut-based RUTF was slightly more effective in promoting weight gain than the sesame paste.	[25]
Comparison of the effectiveness of RUTF made with soybean oil and sunflower oil	The study found that both formulations were equally effective in treating SAM but the soybean oil-based RUTF was associated with a lower risk of diarrhea.	[26]
Chickpea flour and soybean oil	The study found that the locally-produced RUTF was as effective as a commercially-produced RUTF in treating SAM.	[27]

Table 3. Plant-based complementary foods

Formulation	Findings	Reference
Soybeans, groundnut, maize, fluted pumpkin green leaves, catfish/crayfish	Feeding of kwashiorkor-induced rats with 16% and 20% of the formulated diets caused an improvement in growth performance, serum albumin, packed cell volume and net protein utilization.	[28]
Maize, soybeans, and peanuts fortified with Moringa oleifera leaf	Fortification increased quantity, quality and availability as indicated by improvement in protein quality indices in rats.	[10]
Amaranth-sorghum diets	The food product was high in nutrient availability with 5kcal/g sufficient to meet the energy requirement of children aged 6-23 months at 2-3 servings per day and also low in anti-nutritional contents.	[29]
Maize, soybean protein concentrate and cassava starch blend	The production process and extrusion cooking significantly reduced the anti-nutritional factors and improved the protein and starch digestibility of the food.	[30]
A blend of germinated sorghum, peanut and Irish potato flour	The complementary food products met the macro-nutritional needs of children between six months and two years old. However, the mineral requirement of children was not met.	[31]
Fermented sorghum, soybean and orange-fleshed sweet potato	Fermentation significantly improved the protein content, nutritional indices (biological value, nitrogen retention, true digestibility and net protein utilization) and haematological parameters such as packed cell volume, haemoglobin concentration, red blood cell, lymphocytes and white blood cell counts.	[32]

infections, impaired cognitive development and increased mortality [35].

Micronutrient Deficiencies: Deficiencies in vitamins and minerals such as iron, vitamin A, iodine and zinc can lead to anemia, blindness and impaired immune function. These deficiencies can also exacerbate the severity of infections and lead to developmental delays [35].

Treatment using RUTF

RUTF has revolutionized the treatment of severe acute malnutrition, particularly in children. Its ability to provide comprehensive nutrition in a form that is easy to use and store makes it an invaluable tool in the treatment of malnutrition-related diseases. By supporting rapid nutritional rehabilitation, enhancing immune function, and promoting gut health, RUTF plays a crucial role in the recovery and long-term health of malnourished individuals [36]. UNICEF recommends the following amounts of RUTF, based on the weight of child:

- 5 - 6.9 kg: 2.5 sachets per day
- 7 - 9.9 kg: 3 sachets per day
- 10 - 14.9 kg : 4sachets per day
- 15 - 29.9 kg : 5 sachets per day [37]

Prevalence of under-nutrition in Nigeria

Nigeria has the second highest proportion of stunted children in the world, with a national prevalence rate of 32 % of children under the age of five. An estimated 2 million children in Nigeria suffer from severe acute malnutrition (SAM), but only two out of every 10 affected children are treated [7]. The geographic disparities related to undernutrition are significant. Children from the North-West and North-East geopolitical zones are more at risk of malnutrition than children from other geopolitical zones. The prevalence of underweight in these two zones is nearly four times higher than in the three southern zones [7]. The results for the prevalence of stunting and wasting are similar [7]. In eight states from the North-West and North-East zones -Yobe, Katsina, Zamfara, Jigawa, Bauchi, Gombe, Kebbi and Kano, more than half of children under the age of 5 are stunted and one in every three is severely stunted [6]. In 2013, there was a peak of wasting prevalence in two states, Kaduna and Kano, where 40 % of children were wasted and 25 % were severely wasted [7]. The prevalence of undernutrition of children in Kwara State was reported as 23.6 % stunted, 22.0 % underweight and 14.2 % wasted [4]. In Nigeria, childhood stunting declined from 42 % in 2003 to 36 % in 2013, while wasting and underweight increased from 11 % and 24 % to 18 % and 29 %, respectively [38]. Akombi et al. [38] found that the North-Eastern part of Nigeria had the highest percentage prevalence of stunting, wasting and underweight among children under five years old compared to the other five geopolitical zones.

The prevalence of malnutrition varies with the age of children [7]. The prevalence of stunting was found to be high among children aged 24 - 47 months, underweight among children aged 12 - 23 months and wasting among children aged 6 - 11 months [7]. In 2015, the prevalence of stunting in North-Central was 28 %, north-east 40 %, North-West 42 %, South-East 11 %, South-South 10 % and South-West 21 % and the prevalence of underweight in North-Central was reported as 19 %, in north-east 35 %. Likewise, in the North-West 38 %. However, it was 10 % in the South-East, 12 % in the South-South, and 13 % in the South-West as indicated in Figure 1 [7]. Jude et al. [39] reported that the prevalence of under-nutrition in South-Eastern Nigeria was 5.9 %, with wasting accounting for 2.4 % and stunting for 3.5 %.

According to the World Bank, the prevalence of undernourishment in Nigeria in 2021 was approximately 22.1 %, which means that about 44 million people in the country were undernourished. In Nigeria, the regional prevalence of undernutrition varies, with the highest rates found in the northern part of the country. According to a survey in 2018 conducted by the National Bureau of Statistics, the prevalence of stunting among children under five years old was 43.6 % in the North-Central region of Nigeria and 49.9 % in the North-East region. However, the prevalence was 37 % in the South-West, and 29 % in the South-South. Furthermore, the prevalence of wasting was high in the Northeast –region at 14.3 % compared to 12.9 % in the North-Central region. As shown in Figure 2, the 2018 Nigeria Demographic and Health Survey (NDHS) reported the prevalence rates of stunting, wasting and underweight in the six geopolitical regions of Nigeria. In the South-South, the prevalence of stunting, wasting and underweight were 22.9 %, 5.1 % and 14.8 %, respectively. In the South-West, the prevalence of stunting was 13.4 %, wasting 4.0 % and underweight 8.4 %. In the South-East, the prevalence of stunting was 20.8 %, wasting 3.3 % and underweight 11.6 % which were comparably lower than prevalence in the northern regions. The North-Central region reported a prevalence of 37.4 % stunting, 12.9 % wasting and 28.0 % underweight. However, the prevalence in the North-East was higher in comparison to the aforementioned regions, with reported 51.9 % stunting, 14.3 % wasting and 33.2 % underweight. Likewise, the North-West region also had a higher prevalence of 51.7 % stunting, 16.8 % wasting and 37.0 % underweight [39].

Measures of undernutrition

Nutritional status can be measured by a variety of indicators, such as nutritional consumption or dietary intake, physical function, biochemical assessment, clinical deficiencies and anthropometric measurements [31]. Body size/weight is commonly used in community studies of protein-energy malnutrition as it is easily measurable and a sensitive indicator of nutritional status and health.

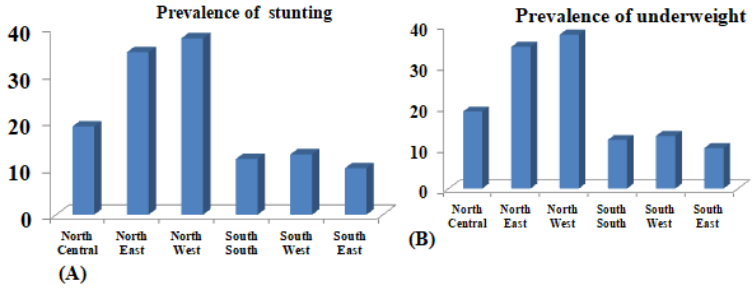

Figure 1. Prevalence of undernutrition in the six geopolitical regions in Nigeria according to UNICEF [7] (a). prevalence of stunting; (b). prevalence of underweight

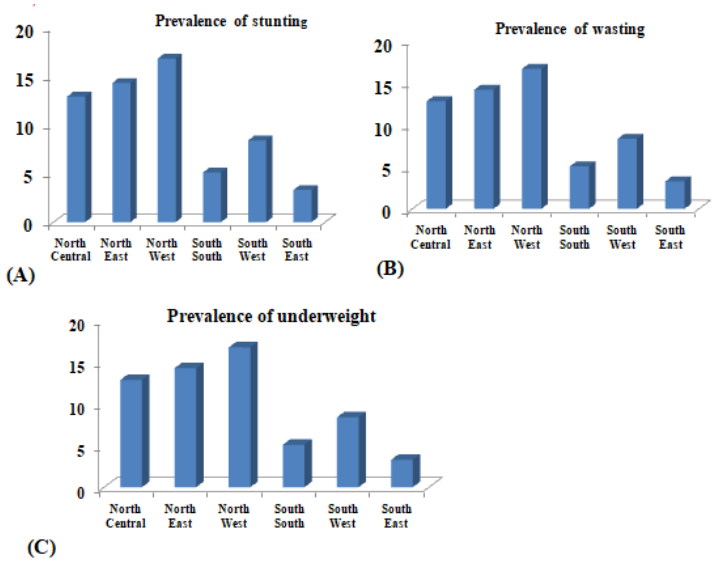

Figure 2. Prevalence of undernutrition in the six geopolitical regions in Nigeria according to NHDS [10] (a). prevalence of stunting; (b). prevalence of wasting; (c). prevalence of underweight

In clinical settings, it is common practice to combine qualitative and quantitative descriptions of undernutrition, such as marasmus and kwashiorkor [35]. The most common anthropometric measurements are weight, length (height), age and gender. Indicators and indices that describe the nutritional status of individuals or populations are created using these measurements. Different body circumferences (mid-upper arm, head, chest, and abdomen) and skin folds are employed as additional indicators of body composition (biceps, triceps, and subscapula) [31].

There are three fundamental indices of nutritional status in children, which are presented in Table 4.

Weight for age Z score (WAZ): Defined as the weight of a child relative to the weight of a child of the same age in a reference population, expressed either as a Z score or as a percentage relative to the median of the reference population. Qualitatively, children who have a low weight for their age are referred to as underweight [35].

Length/height for age Z score (LAZ / HAZ): Defined as the height or length of a child relative to the length or height of a child of the same age in a reference population, expressed either as a Z score or as a percentage relative to the median of the reference population. Qualitatively, children who are short in height relative to their age are referred to as stunted [35].

Weight for length/height Z score (WLZ / WHZ): Defined as the weight of a child relative to the weight of the same height or length in a reference population, expressed either as a Z score or as a percentage relative to the median of the reference population. Qualitatively, children who are low in weight relative to their height are referred to as wasted. Wasting is sometimes also called global undernutrition or global acute malnutrition (GAM) [35].

Table 4. Indices of undernutrition

		Normal	Mild	Moderate	Severe
Weight for height	%	90 - 100	80 - 89	70 - 79	< 70%
wasting	Z score	2.0 to - 0.99	-1 to - 1.99	-2 to - 2.99	< -3.0
Height for age	%	95 - 110	90 - 94	85 - 89	< 85
Stunting	Z score	2.0 to - 0.99	-1 to - 1.99	-2 to - 2.99	< -3.0

Classification of undernutrition

Primary malnutrition: This is purely due to a nutritional deficiency.

Secondary undernutrition: This type of undernutrition often accompanies other diseases that interfere with appetite, digestion, absorption or utilization of nutrients rather than the availability of nutrients. It is common in adults, for example disorders in the gastrointestinal tracts, infections, hyperthyroidism, trauma, burns and other critical illnesses. Undernutrition is further classified into acute and chronic undernutrition.

Acute undernutrition: Results from a sudden reduction in food intake or diet quality and is often combined with pathological causes. It is divided into moderate, severe and global acute malnutrition [36]

Chronic undernutrition: It is due to insufficient intake or absorption of essential nutrients over a protracted period [36].

Factors affecting pre-school children's nutritional status

Studies have shown that several factors lead to the high prevalence of undernutrition in Nigeria, especially in the northern part of the country, as shown in Figure 3. The factors include inadequate breastfeeding which contributes to high rates of illness and poor nutrition in children under 2 years old, lack of access to healthcare, water, armed conflict, irregular rainfall and climate change, high unemployment, inadequate dietary intake, inappropriate feeding, fetal growth restriction, inadequate sanitation, lack of parental education, large family size, incomplete vaccination, poverty and low socio-economic status, desire for more children and lack of birth spacing [40].

Poverty: Nigeria has a high poverty rate, with many families living below the poverty line. Poverty can limit access to adequate food, healthcare, and other resources that are necessary for good health.

Inadequate food intake: Many Nigerians do not have access to enough food or they may not be able to afford a varied and nutritious diet. This can lead to undernutrition and nutritional deficiencies.

Poor sanitation and hygiene: Poor sanitation and hygiene practices can lead to the spread of diseases such as diarrhoea, which can cause malnutrition and hinder growth and development.

Limited access to healthcare: Many Nigerians do not have access to basic healthcare services, which can make it difficult to prevent and treat malnutrition.

Insufficient knowledge about nutrition: Many Nigerians do not have sufficient knowledge about nutrition and do not know how to make healthy food choices.

Inadequate breastfeeding practices: Inadequate breastfeeding practices can contribute to undernutrition in infants and young children.

Food insecurity: Food insecurity is a common problem in Nigeria, and it can lead to undernutrition and other health problems.

Conflict and displacement: This can disrupt food supplies and limit access to healthcare, which can contribute to undernutrition [41].

Nutritional interventions for undernutrition

Several nutritional interventions have been put in place to prevent or cure undernutrition in preschool children. Here are some examples: Promotion of exclusive breastfeeding, micronutrient supplementation, food fortification, nutrition education, complementary feeding and cash transfer programs: cash transfer programs that provide financial support to families with young children help alleviate poverty and improve access to food, thereby reducing the prevalence of undernutrition in children. Furthermore, nutritional interventions have been in practice in Nigeria since 1977 to cure/prevent undernutrition in preschool children. The Nigerian government has launched several programs aimed at reducing malnutrition and improving the nutritional status of its citizens, including ready-to-use therapeutic foods (RUTFs), nutrition rehabilitation centres, micronutrient supplementation, parenteral nutrition, nutrition counselling and education [42]. The nutrition interventions that have been used in developing countries to prevent/cure the undernutrition in preschool children are presented in Table 5.

Conclusion

This review article highlights the global prevalence of undernutrition in preschool children. It also highlights the prevalence of under-five children's nutritional status in the six geopolitical regions in Nigeria. The North-West and the East were found to have the highest prevalence of undernutrition among preschool children. Several nutritional interventions used in developing countries to

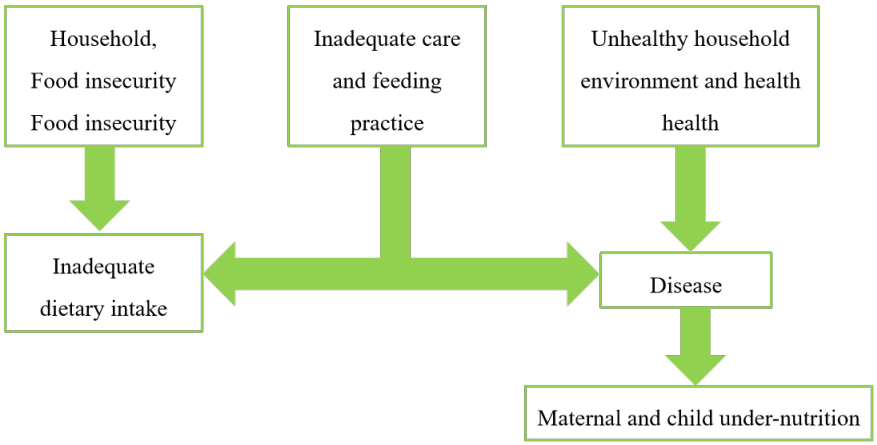

Figure 3. Underlying factors of under-nutrition

Table 5. Some nutritional interventions used in developing countries to prevent or cure undernutrition in preschool children

Raw materials	Outcomes of the studies	Reference
Peanut, omega-3-fatty acid-rich vegetable oil, milk powder, sugar	Small Quantity-Lipid base Nutrient Supplement (SQ-LNS) reduced the prevalence of stunting by 12% to 14 % and the prevalence of severe wasting by 31 %. Also, it lowers micronutrient deficiencies including anemia by 16 %.	[43]
Micronutrients intervention: such as vitamin A, zinc and iron supplements	The intervention reduced stunting at 36 months by 36 %, mortality between birth and 3 months by 25 % and micronutrient deficiencies by about 25 %.	[44]
Fortified foods: such as rice, flour, salt and oil; Flour, iron and folic acid	The study found that micronutrient status and cognitive function were improved. Also, the prevalence of anaemia was reduced.	[45]
Nutrition education: In Ethiopia, nutrition education has been provided to mothers to improve the dietary intake of their children	It has been shown that nutrition education improves dietary practices and reduces the prevalence of undernutrition.	[46]

prevent or cure preschool undernutrition were presented. Additionally, various studies on the effectiveness of RUTF developed from different plant seeds in the treatment of SAM were reported. RUTF is therefore a promising agent to prevent and cure undernutrition in preschool children.

Authors' contributions

Shafatu Giwa Ibrahim: Conceptualization (lead); Funding acquisition (equal); Investigation (equal); Methodology (lead); Project administration (lead); Resources (equal); Supervision (lead); Writing original draft (equal); Writing– review & editing (equal). Mustapha Yauri Sani: Conceptualization (equal); Methodology (equal); Data curation (lead); Formal analysis (lead); Investigation (lead); Writing– original draft (lead); Writing– review & editing (lead). Hauwa'u Umar Mungadi: Conceptualization (equal); Data curation (equal); Investigation (equal); Supervision (equal). Suleiman Ahmed Isa: Conceptualization (supporting); Project administration (equal); Funding acquisition (lead); Supervision (equal). Hamidat Oluwatoyin Ajiboye: Writing– review & editing (equal). Fatima Ibrahim Jumare: Writing introduction & editing (equal). Rabi'u Aliyu Umar: Resources (lead); Funding acquisition (equal).

Conflicts of interest

The authors have no relevant financial or non-financial interests to disclose.

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