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Review Article

Determinants of Child Undernutrition in Tanzania: Agriculture and Season Perspective: A Review

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Abstract: The causes of undernutrition are known to be complex and interrelated which need responses and solutions from different sectors to effectively design proper nutrition interventions. The UNICEF conceptual framework is a useful tool for understanding the causes of undernutrition and serves as a guide for assessing and analysing the causes, particularly among children in developing countries. Identifying determinants of child nutrition status is a necessary step in designing interventions, policies and programme that can support the scaling up of nutrition. This review scrutinizes undernutrition and its determinants based on the UNICEF conceptual framework on malnutrition. Poor feeding practices and characteristic of complementary foods were observed as immediate causes while household's food insecurity, environmental factors such as agricultural practices and seasonal influences as underlying determinants particularly in rural households. The highlight from this review suggests that seasons had significant impact on both immediate and underlying determinants of undernutrition and therefore intervention to improve nutrition status should consider variation in agriculture seasons. Lastly, multicomponent interventions focusing on agricultural interventions and practices that are affecting immediate changes in nutrition status among infants and young children are emphasized. Future attempt to improve children nutrition status in rural households should be multicomponent addressing nutrition sensitives farming practices including rural livestock intensification, poverty alleviation and considering agricultural seasons in all planning.

Keywords: Undernutrition, Feeding Practices, Nutrition-Sensitive Agriculture, Food Security, Seasons

1. Introduction

Child undernutrition remains a major global problem and is an underlying cause of 3.1 million child deaths annually [25, 160]. In an analysis accounting for several nutrition risks factors including; intrauterine growth restriction, stunting, wasting, deficiencies of vitamin A, Calcium, selenium, iron, folate and zinc and sub-optimum breastfeeding, 45% of all child deaths were attributed to undernutrition [25]. The root cause of most undernutrition and morbidity among infants and young children is poverty leading to an increasing burden of stunting and micronutrient deficiencies [13]. Undernutrition and micronutrient deficiencies often coexist, which is particularly detrimental to a child's life resulting in poor cognition, health and physical growth [12].

Child undernutrition results from a combination of interrelated factors; however, the common denominator among all types of undernutrition is poor food and nutrition security, which includes poor infant feeding practices and poor dietary quality in early life [84]. In Tanzania, as in many developing countries, children consume and poor diet, mainly, cereal-based porridge with low nutrient densities [43, 52, 83]. Poor nutrition weakens children's immune systems, cognitive, and physiological growth, and is associated with increased child morbidity and mortality [38]. Climate variability, including seasonal food availability and poor rainfall distribution, increases the risk of morbidity and food insecurity, thereby affecting feeding practices and dietary patterns [13]. Additionally, poor maternal nutritional status during pregnancy and lactation has significant implications for poor nutrition outcome for children [21, 94]

The role of nutrition-sensitive agriculture in improving

nutrition particularly targeting the "first 1000 days", has been a global focus Rural household are an ideal target for this type of intervention given the high rates of undernutrition and high dependency on agriculture for food consumption and livelihoods [101, 112]. Efforts to reduce undernutrition have been largely focused on nutrition specific interventions which reflect Western medical model, while agricultural, environmental and social factors which underpin the root cause of undernutrition has not been given much attention [28]. Although there is a strong relationship between agriculture and nutrition, there is a need to identify agricultural practices that can effect changes within the 1000 days when designing appropriate interventions. Tanzania is an agriculturally diverse country and there is substantial regional variation in the prevalence of undernutrition particularly in young children therefore it is important that interventions aimed at improving nutrition status of women and children are specific considering regional agricultural practices and seasonal differences.

This review examined undernutrition and its determinants based on the UNICEF conceptual framework on malnutrition. The underlying determinants including food security, environmental factors such as agricultural practices and seasons were also considered. Lastly, multicomponent interventions focusing on agricultural interventions and practices that are affecting immediate changes in nutrition status among infants and young children are emphasized.

2. Global Prevalence of Child Undernutrition

Globally, undernutrition affects a significant number of children below the age of five. An estimated 22.3% (148.1 million) of children are stunted and 6.5% are wasted in 2022 [164]. The rates of undernutrition vary worldwide with highest rates noted in the African and South-East Asia regions. UNICEF reported the prevalence of stunting in Africa at about 43% and wasting at about 27% These statistics can be broken down further by region with stunting rates in Southern Africa at 22.8%, followed by 30% in West Africa, East Africa at 30.6% and the highest recorded rates (37.4%) in Central Africa [164]. Within East-Africa, countries with the highest rates of stunting include Burundi 56.5%, Malawi 34%, Congo 40.3%, Ethiopia 34.4% and Tanzania 30.6% [164]. This shows that undernutrition continues to be a major public health problem in developing countries and that East Africa in particular has very high rates of chronic undernutrition.

Globally, micronutrient deficiencies (hidden hunger) are highly prevalent affecting 56% (372 million) among preschool-aged children, and 69% (1.2 billion) among non-pregnant women of reproductive age. Regionally, three-quarters of preschool-aged children with micronutrient deficiencies live in south Asia (99 million) and sub-Saharan Africa (98 million) [148].

According to the World Health Organization (WHO), the most common nutrient deficiencies are vitamin A, folate, iron, iodine, zinc and Vitamin D [148] and the burdens of iodine deficiency and vitamin A deficiency remain high in Central Sub-Saharan Africa. Iron deficiency anaemia is the most common type of anaemia worldwide, which normally coexists with other deficiencies such as folic acid, vitamin B12 and vitamin C [61, 102]. According to WHO 40% of women of reproductive age of children below the age five years are anaemic [128, 149] and about 39% of children are vitamin A deficient [12]. The prevalence of anaemia, iodine and Vitamin A deficiency among under 5 children was reported to high in Southern Africa, East Africa, West and Central Africa [61] Vitamin A deficiency are persistently affecting children under 5 years of age in sub-Saharan Africa and this is due to insufficient dietary diversification, unsuccessful food fortification, and the restricted effect of vitamin A capsule supplementation on serum retinol [61].

3. Child Undernutrition in Tanzania

Tanzania has made progress in reducing child undernutrition from the past years according to the Tanzania Demographics Household Survey reports [114] (Table 1). There is a steady decline in child underweight and stunting from 1992 to 2022. Nevertheless, the prevalence of child underweight and stunting in 2022 was still high according to the criteria set by WHO [175]. About 35% of children below 5 years of age were stunted, 12% were underweight and 3% wasted ICF&MACRO, 2022. There are rural-urban and regional disparities in chronic undernutrition in Tanzania. In 2011, 33.4% of children in rural areas were stunted compared to 20.5% of children in urban areas. Despite a decrease in the proportions, there was a similar trend in 2015 with 45% of stunted children in rural Tanzania, compared to 32% in urban areas. In addition, to urban and rural differences there are differences between different regions in Tanzania (Table 2). According to WHO criteria to classify stunting prevalence, three regions had a very high severity of stunting (>40%), of 56.9, 49.8 and 50.4 recorded in Iringa, Rukwa and Njombe respectively [175]. In addition to the DHS reports, several regional studies have reported prevalence rates with highest rates of stunting (56%), underweight (46%) and wasting (24%) reported in Kilimanjaro region [106, 143] (Table 2).

Table 1. *Nutrition status trends in Tanzania according to TDHS and TNNS.*

Status	1992	1996	1999	2004/05	2010/11	2015/16	TNNS (2018)	2022
Stunting (%)	47	43	44	38	42	35	31.8	30
Underweight (%)	29	31	29	22	16	14	14.6	12
Wasting (%)	6	7	5	3	5	5	3.5	3

Source: Tanzania National bureau of statistics reports (NBS); Tanzania National Nutrition Survey (TNNS-2018)

Prevalence rates of micronutrient deficiencies are also high in Tanzania, particularly for children and pregnant women. Like stunting rates, the prevalence of anaemia mainly due to iron deficiencies has also declined from 2010-2016 (Figure 1). The prevalence of any anaemia ranged from ~85% in 2005 to 76% in 2016 with the highest rates among infants aged 9-11 months olds (81%) [114]. About 42% of children under age 2 years had moderate anaemia in 2016. This is a critical age during which undernutrition including essential micronutrient deficiencies have irreversible lifelong impact on child health and development [12]. In addition to the age-related differences, there are also differences in prevalence between urban and rural children. There is slight variation in anaemia prevalence among rural and urban children, the prevalence of anaemia was slightly higher among rural children (73%) compared to urban children (67%) with rural children showing remarkable improvement in 2016 with the prevalence at 44.8% and urban 44.5% [114].

Table 2. *Regional disparities in the prevalence of stunting, underweight and wasting.*

Author	Region/District	Age group	Stunting	Underweight	Wasting
TDHS 2022	Geita	6-59mo	38.6	10.3	3.3
TDHS 2022	Njombe	6-59mo	50.4	12.2	2.1
TDHS 2022	Rukwa	6-59mo	49.8	19.4	8.3
TDHS 2022	Iringa	6-59mo	56.9	10.7	1,9
(Mrema et al., 2021)	Kilosa-Morogoro	6-59	41	11.5	2.5
Muhimbula et al., 2019	Shinyanga/Morogoro	0-24	40-42		
(Mgongo et al., 2017)	Kilimanjaro	0-24mo	42	46	24
(Munisi et al., 2016)	Rorya District		38	–	14
(Altare et al., 2016)	Southern highland	6-59mo	47	–	–
(Nordang et al., 2015)	Rukwa	6-59mo	64	34	–
(Kulwa et al., 2015)	Mpwapwa district	<1yrs	34	–	–
(Semali et al., 2015)	Kongwa district	< 5 yrs	49.7	–	–
(Shirima et al., 2015)	Tabora, Kilimanjaro and Iringa	<5yrs	56	–	–
(Chirande et al., 2015)	DHS data	0-5yrs	35.5	–	–
(Abubakar et al., 2012)	Kilimanjaro	1-35mo	44	19	5

Source: Author, 2023

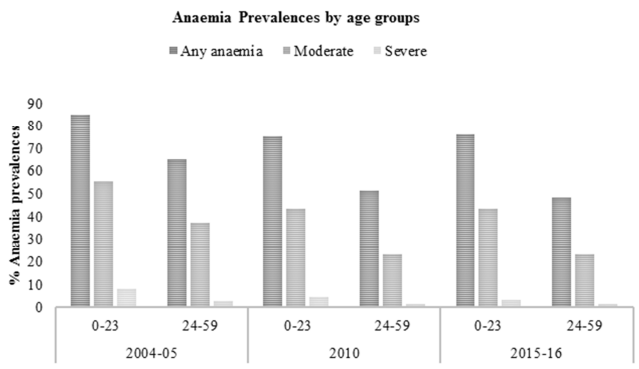

Figure 1. *Anaemia prevalence by age (months)-TDHS, 2005-2016.*

4. UNICEF Framework for Undernutrition

The UNICEF conceptual framework remains the international preferred framework that illustrates the causes and consequences of malnutrition. It is a useful tool for understanding the determinants of undernutrition and serves as a guide in analysing the causes of undernutrition and planning interventions [158]. The framework explains the relationship between poverty as a root cause of undernutrition, food insecurity, among other immediate and underlying causes of maternal and child undernutrition (Figure 2). The framework has three levels of causality: immediate, underlying and basics, which should guide interventions from a multi-sectoral viewpoint. The framework was developed further in the 2013 Lancet Nutrition Series (Figure.3) pointing out the determinants of nutritional status at different levels and outlining different sectors that are essential to respond effectively toward optimum fetal and child nutrition and development other than reducing undernutrition only [23].

4.1. The Immediate Causes of Undernutrition

The immediate causes occur at individual levels and are due to an imbalance between the nutrients absorbed by the body and nutrients required by the body due to inadequate food intake, poor nutrient utilization in the body or infections. Poor quality and quantity of food intake including inadequate intakes of protein, energy and essential micronutrients, lead to increased susceptibility to infections and undernutrition [23, 39]. In a vicious cycle, infections can cause poor appetite, and poor absorption of nutrients leading to reduced food intakes and hence undernutrition. The immediate causes affect children directly and can lead to short-term consequences, such as morbidity, mortality and disability, as well as long-term consequences, such as short adult stature, poor cognition and chronic diseases of a lifestyle (Figure 2). Infections such as malaria, diarrhoea, pneumonia and measles affect undernutrition by compromising immunity, leading to underweight and stunting [3, 30, 139]. In addition, poor maternal nutrition status before and during pregnancy has significant effect on child nutrition status therefore must be considered as part of the immediate impacts on child undernutrition [125].

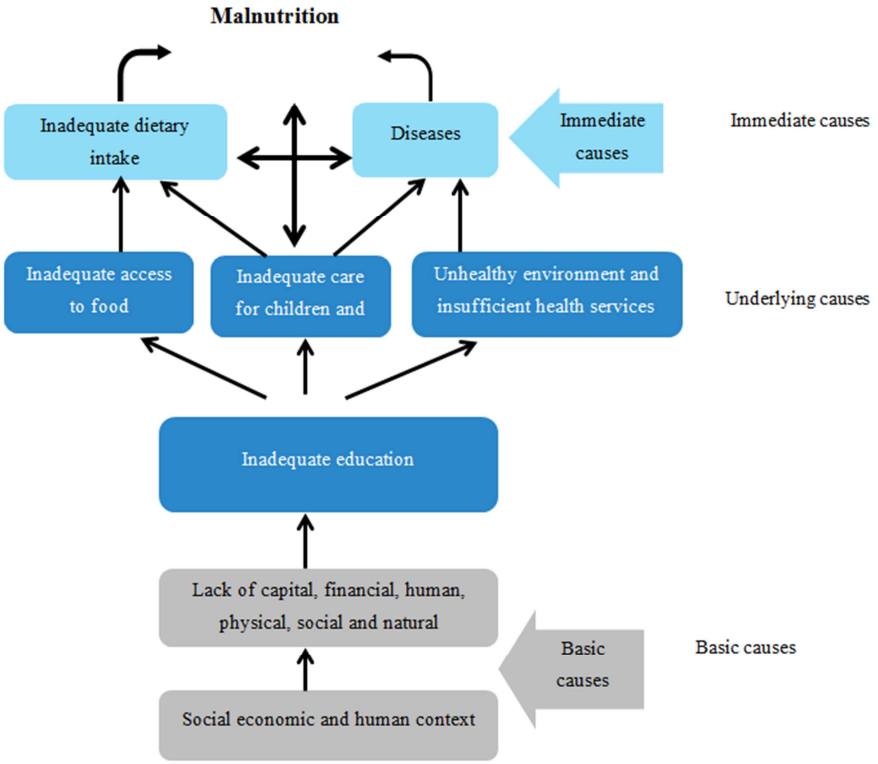

Figure 2. *UNICEF conceptual framework adapted from UNICEF 1990.*

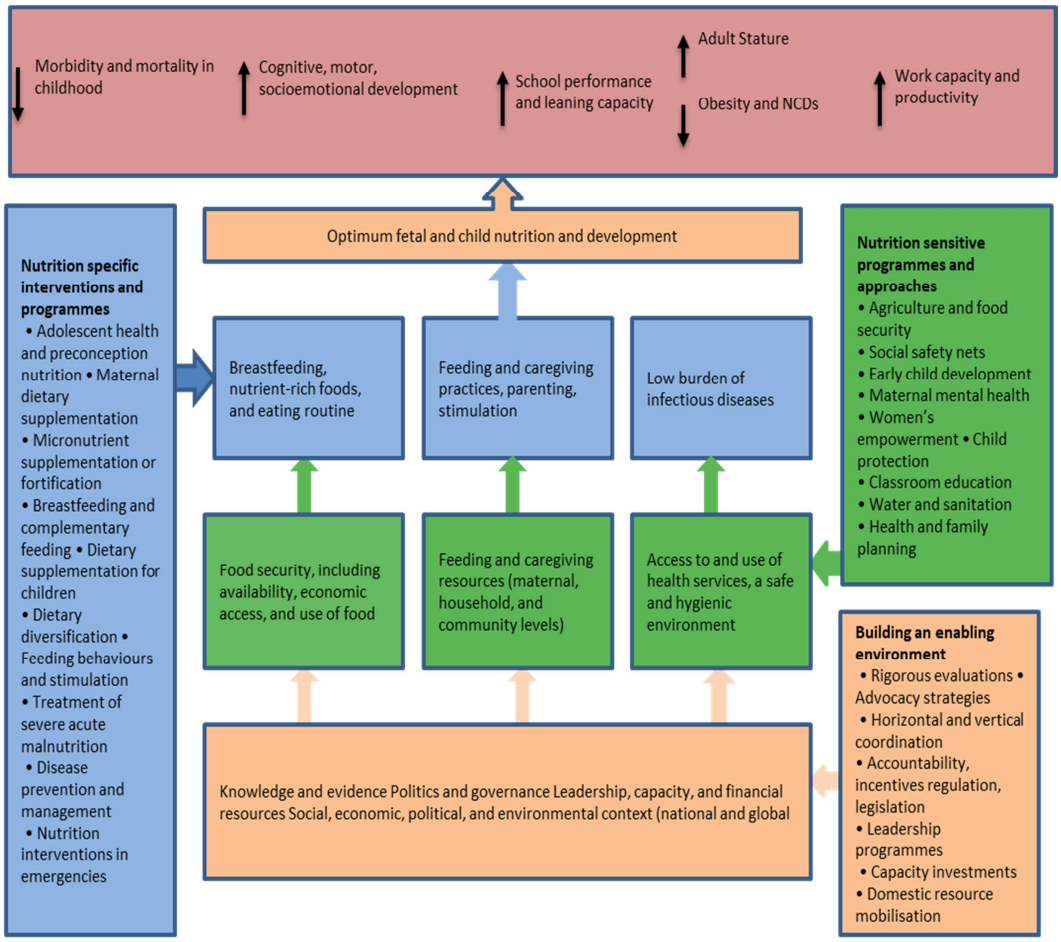

Figure 3. *Framework for actions to achieve optimum fetal and child nutrition and development.*

4.2. The Underlying Causes of Undernutrition

The underlying causes of undernutrition can be grouped under the three broad categories including; household food insecurity, inadequate care and feeding practices for children, and poor health and sanitation. Households food insecurity in terms of low availability and poor access was identified as an underlying cause of undernutrition in several studies [121, 137]. Inadequate care, poor health and sanitation was identified as causes of infectious diseases such a diarrhoeal diseases and respiratory infections increasing the risk of mortality [54, 82, 119]. Caring practices for young children and mothers during pregnancy and lactation with adequate nutrition and health, including proper medication, can lead to good nutrition. All these factors are underpinned by poverty due to lack of employment, remittances, and assets. Moreover, seasonal availability of food, agro-ecology and farming systems plays major roles as underlying determinant of household food insecurity, mainly due to the impact on access and availability of food.

4.3. Basic Causes of Undernutrition

The basic causes of undernutrition are structures and processes around society that intensify poverty, particularly for vulnerable groups of society through limited and poor access to essential resources available. The complex interaction between socio-cultural, economic and political environment affect undernutrition in such a way that it impacts the environment in which individual lives (Figure 2). This can lead to poor financial, human and social capital mostly for women in the society. Poor socio-economic and political environments make it difficult for households to access land for farming, education, lack of employment, income and poor technology. However, high-level political commitment can make it easier for multisector actions to reduce undernutrition. Further, supportive policy environment across sectors are essential for improving nutrition by scaling-up of proven interventions as the key driver for changes. In order to attain food and nutrition security, national food and nutrition policies should increase access to services and credit, food safety, food market, on farm and off farm employment, irrigation and climate change mitigation [161]. All these rely on, government commitments to increase investment in these priority areas [116, 147].

For the sustainable impact on scaling up nutrition, there is a need for multiple sectors in agriculture, public health, water, sanitation and hygiene and social protection working together to combat undernutrition; [55]. The framework (Figure 3) shows this multisectorality and the multi-level nature of responses. It explains the nutrition-specific interventions (delivered by the health sector), and nutrition-sensitive interventions (delivered by other sectors), both depending on enabling policy environments that are needed to provide support for nutrition programmes [23]. Nutrition-sensitive programs in agriculture, social safety nets, early child development and education have potential, to augment the coverage and effectiveness of nutrition-specific actions although its potentials have not been adequately unleashed [131]. Additionally, nutrition-sensitive interventions can create a stimulating and health environment for optimum fetal and child growth and developments to their full potential (Figure.3).

5. WHO Infant and Young Child Feeding (IYCF) Practices

UNICEF and other child nutrition and health experts agree that optimal IYCF has the single greatest potential impact on child survival, compared to all proven preventive health and nutrition interventions [26, 159, 177]. Therefore, reduction of child undernutrition, morbidity and mortality can be reached when nutrition in early infancy and IYCF specifically are highly prioritized in national policies and programme strategies. The benefits of breastfeeding and optimal complementary feeding for child survival, growth, and development are well known and are estimated to prevent 823,000 child annual deaths in low-income and middle-income countries [166]. Studies show that exclusive breastfeeding is the best form of nutrition for children up to 6 months, the composition is dynamic and personalised for each child; it lowers infectious morbidity and increases intelligence and cognition, persisting to adulthood [166].Appropriate complementary feeding practices are important to maintain a child's growth potential when requirements for energy, protein and other nutrients (particularly iron and zinc) cannot be met by breast milk alone from the age of 6 months [115]. If appropriate complementary feeding practices could be scaled up to nearly universal levels, ~100,000 deaths in children under five could be prevented each year [27]. Additionally, the benefit of optimal complementary feeding practices as a preventive measure of stunting among 6-24 months has been as important [150]. Therefore, complementary foods should be of high nutrients density due to increased nutrients requirements for metabolic processes, rapid developmental processes, and limited gastric capacity for infants from 6-24 months failure to deliver on this guideline which leads to growth faltering [39, 58]. The next section describes the WHO IYCF indicators and recommendations and discuss the relationships between feeding practices and nutrition outcomes.

5.1. IYCF Indicators and Adherence to Recommendations

WHO/UNICEF developed simple and valid age appropriate indicators to assess breastfeeding and complementary feeding practices among children less than 2 years old which are amenable to population-level measurement [176]. There are 8 core indicators and 7 optional indicators used a means of monitoring adherence to IYCF recommendations worldwide (Table 3).

Table 3. *WHO-recommended core indicators for measuring IYCF practices (WHO, 2008).*

Core indicators	Description of indicator
1. Early initiation of breastfeeding*	Proportion of children born in the last 24 months, breastfed within 1 hour of delivery.
2. Exclusive breastfeeding under 6 months	Proportion of infants 0–5 months of age who received only breast milk during the previous day.
3. Continued breastfeeding at 1 year	Proportion of children 12–15 months of age who received breast milk during the previous day.
4. Introduction of solid, semi-solid or soft foods	Infants 6–8 months of age who received solid, semi-solid or soft foods during the previous day.
5. Minimum dietary diversity	Proportion of children 6–23 months of age who received foods from 4 food groups during the previous day.
6. Minimum meal frequency	Proportion of breastfed of children 6–23 months of age who received solid, semi-solid or soft foods the minimum number of times or more during the previous day.
7. Minimum acceptable diet	Proportion of breastfed of children 6–23 months of age who received at least the minimum dietary diversity and the minimum meal frequency on the previous day (apart from breast milk).
8. Consumption of iron-rich or iron-fortified food	Proportion of children 6–23 months of age who received an iron-rich food or an iron-fortified food on the previous day.
Optional indicators	Description of indicator
Ever breastfed	Proportion of children born in the last 24 months who were ever breastfed.
Continued breastfeeding at 2 years	Proportion of children 20–23 months of age who are fed breast milk.
Age-appropriate breastfeeding	Proportion of children 0–23 months of age who are fed according to guidelines.
Predominant breastfeeding under 6 months	Infants 0–5 months of age who received breast milk as the predominant source of nourishment during the previous day
Duration of breastfeeding	The median age in months when 50% of children 0–35 months did not receive breast milk during the previous day.
Bottle feeding	Proportion of children 0–23 months of age who are fed with a bottle during previous day.
Milk feeding frequency for non-breastfed children:	Proportion of non-breastfed children 6–23 months of age who receive at least 2 milk feedings during the previous day

Source: Indicators for assessing infant and young child feeding practices, conclusions of a consensus meeting held 6–8 November 2007 in Washington DC, USA (Working Group on Infant and Young Child Feeding Indicators 2007. [176]
*Provision of mother's breast milk to infants within one hour of birth is referred as "early initiation of breastfeeding"

Globally, 47% of infant are put to the breast within 1 hour of delivery and only 43% are exclusively breastfed 0-5 months [178]. Breastfeeding is commonly practiced in developing countries and nearly all infants are put to the breast, however, sub-optimal adherences to recommended practices are common. According to UNICEF statistics, the prevalence of early initiation in Eastern and Southern Africa was 65% and exclusive breastfeeding for 0-5months was 55% In [178]. Tanzania, almost 99% of infants are breastfed, regardless of socio- economic categories; however, early initiation and exclusive breastfeeding are persistently suboptimal (Table 4). The proportions of initiation of breastfeeding have not changed considerably since 1996 and it shows decline in 2010. There is improvement with exclusively breastfeeding 0-5 yearly but the target has not been reached, more than 40% of infants are not exclusively breastfed. This indicates that a substantial proportion of infants 0-5 months are given other fluids and solid foods before the recommended age of 6 months, which hinders the benefit of breastmilk to the majority [166]. Additionally, there are regional disparities and rural urban differences with regards to exclusive breastfeeding practices where high rates and very low rates were reported, which need to be considered when planning interventions [114].

Table 4. *Trends in initiation and exclusive breastfeeding in Tanzania.*

Months	Initiation	0-1	2-3	4-5	6-7	0-5
Year	%	%	%	%	%	%
1996	59.0	55.2	27.4	8.0	4.1	28.9
1999	NA	57.8	25.4	15.5	1.9	NA
2005	59.3	70.0	42.4	13.5	1.7	41.3
2010	46.1	80.5	51.1	22.9	2.3	49.8
2015-16	51.2	84.0	58.8	26.6	3.0	59.0

Source: Tanzania National Bureau of Statistics (NBS), Data from Demographic and health survey (TDHS)

Globally, only 29% of infants are fed from at least 4 food groups and 16% have a minimum adequate diet [162]. About 21% of infants aged 6-23 months had met minimum dietary diversity and only 10% met minimum adequate diet in Eastern and Southern Africa [162]. In Tanzania, 97% infants 6-8 months received solid foods which ties in with early introduction of solid foods, which is a common practise over the years [109, 114]. In addition, only 8% received a minimum acceptable diet and less than 40% had minimum meal frequency [114]. Low adherences to complementary feeding recommendations were observed among rural children (7%) compared to urban children (12%), with 39% of urban children and 19% of rural children meeting minimum dietary diversity. [114]. There are limited published studies in Tanzania that reported on complementary feeding practices per WHO IYCF guidelines

[176]. One local study revealed poor compliance to complementary feeding recommendations [99] (Table 5).

The characteristics of the complementary diet in developing countries are widely reported, however, there are limited published data on nutrient contents of complementary foods in Tanzania. The diet is characterized by low intakes of animal and dairy products and higher intakes of cereal based porridge and legumes [1, 6, 39]. Foods consumed have low nutrient density, are unlikely to meet the requirements for energy, protein and fat and key nutrients for growth particularly iron, zinc and calcium, vitamin A, vitamin B12 and niacin. Ideally, complementary foods should supply up to 95% of iron, 55% riboflavin, 60% calcium, 70% thiamine, 85% niacin and 85% vitamin B6 (Allen, 2012). Given the low intakes of costly animal source foods in the diet of infants, it is challenging to meet nutrient needs in the critical period for growth without including animal source food [39, 6, 1].

Table 5. *Adherence to IYCF recommendations.*

Year	Age (months)	DDS (4+ food groups)	Minimum meal frequency	Minimum acceptable diet
2010*	6-8	41.6	64.6	27.7
	9-11	57.7	24.9	18.0
	12-17	69.5	32.5	23.1
	18-23	68.0	38.5	29.1
Urban		68.1	42.4	27.1
Rural		59.5	37.6	23.6
2015-16	6-8	11.3	66.0	9.3
	9-11	24.0	35.8	8.4
	12-17	29.9	38.0	12.1
	18-23	25.6	34.7	7.0
Urban		36.4	37.3	13.2
Rural		19.6	44.9	8.6
Kulwa et al., 2015 (Rural)	6-11	4.6		
Vital et al.,2016 (Urban)	6-23	49.3	70.3	38.4
Victor et al., 2014	6-23	38.2	38.6	15.9
(Masuke et al., 2021)	6-24		40.4	

For breastfed children, minimum meal frequency is receiving solid or semi-solid food at least twice a day for infants age 6-8 months and at least three times a day for children age 9-23 months. * TDHS 2010 used 3+ food groups for dietary diversity indicator: DDS=Dietary diversity score
Source: Author(s); Tanzania National Bureau of Statistics (NBS)

5.2. Factors Associated with Meeting IYCF Recommendations

The global strategy on infant and young child nutrition (IYCN) highlighted that inadequate knowledge regarding proper feeding practices and cultural beliefs are major constraints to successful feeding practices other than food availability [163]. Studies have reported that social and cultural factors influence a mothers adherence with IYCF guidelines, including; 1) mothers perceive their infant to be "thirsty" and believe that breast milk contains insufficient water; 2) mothers believe that breastfeeding should be stopped immediately when one becomes pregnant again as the milk of a pregnant mother can harm the infant; and 3) mothers fear that breastfeeding too long will lead to the infant to becoming addicted to breast milk, which will cause them rejecting solid food at the time of introduction [34]. Other studies have reported inadequate breastfeeding skills, peer pressure and influences of other family members as major constraints to successful breastfeeding [80]. Furthermore, mothers' beliefs that they have insufficient milk to feed infants exclusively up to 6 months, HIV status hindering mothers to choose breastfeeding as an option and maternal employment forcing mothers to leave the child early for work/business were also reported [34, 79, 90]. On the other hand, mothers who delivered at the hospital were likely to practice early initiation compared to home delivery [42]. Lower maternal education, young maternal age and lack of professional assistance at birth where also determinants to poor feeding practices [63, 76, 165] Household food insecurity was identified as a determinant of poor complementary feeding practices and also mothers who experienced household hunger had early cessation of exclusive breastfeeding and believed that they need adequate foods to breastfeed up to 6 months [37, 172, 181]. This means that education interventions for proper feeding practices are not reaching most mothers/caregivers. Comparing to urban, rural mothers have poor breastfeeding and complementary feeding practices in Tanzania [114]. The rural-urban differences are partly explained by insufficient resource allocation where families in rural areas have poor access to health services, clean water, nutrient-dense foods and nutrition information.

5.3. IYCF Practices and Child Nutrition Outcomes

Age aprropriare IYCF practices are some of the major determinants of good nutrition status and growth among infants and young children [20]. For example, early initiation of breastfeeding was reported to lower the risk of underweight and stunting [64, 93, 92]. In addition, exclusively breastfeeding was associated with reduced risk of underweight and wasting [85,93]. However, some studies found no relationship with early initiation of breastfeeding and exclusive breastfeeding[40,104]. The possible

explanation of the relationship between proper breastfeeding practices and weight gain could be related to more frequent breastfeeding at a young age enabling infants to get enough breast milk and adequate nutrients for growth. On the contrary, continued breast feeding at 12-15 months was linked to higher risk of underweight [93, 85]. This could be related to inadeqaute complementary feeding practices with poor quality and fewer meal frequencies, the relationship that has been reported earlier [49, 95].

Timely consumption of solid foods at 6-8 months and proper meal frequency was repoterd to lower the risk of underweight [92] and was associated with higher WAZ and WHZ [135, 157, 182] and higher LAZ [40]. Proper meal frequency is associated with adequate energy and the type of solid foods given to infants could be related to infant weight gain or weight loss. However in many developing countries, usually infants start with thin maize porridge, low in energy and with low intakes of vitamin A-rich and animal source foods which could be related to poor weight gain. This is supported with findings in Sri Lanka where the late introduction of fat and oils into the diet of infants after 8 months of age was associated with underweight and wasting indicating the importance of timely introduction of a high quality diet for proper weight gain [156]. Finally, the relationship between diet diversity and nutrition status has been reported frequently; for example, diet diversity score is assocaited with a reduced risk of stunting [9, 36, 43, 56, 88, 89, 124, 130]. Both dietary diversity and the consumption of iron rich foods were associated with a reduced risk of both underweight and stunting [64, 85, 92] Furthermore, dietary diversity correlated with adequate energy intakes [9,14] and improved haemoglobin concentrations particularly if animal source foods were included [81, 134]. This shows that dietary diversity is an indicator of diet quality [132].

6. Maternal Nutrition Status

Women's health and wellbeing depend on the complex interaction of a number of different factors including, social and cultural environment, access to health services, and life-stage [107]. The foetus depends on the mother throughout pregnancy for their nutrient supply, therefore maternal nutrition status is a good indicator of her own health and reproductive ability and is a good predictor of new born health and nutrition status [154]. Research suggests that poor nutrition before and during pregnancy accounts for 50% of infant growth failure, which has long-term implications for the child into adulthood [160, 25]. Two major concerns in Tanzania are thinness, and anaemia. Thinness (BMI <17 kg/m^2) affects 10% of women of reproductive age and about 57% of pregnant women are anaemic [114]. Acute nutrition deficiencies during pregnancy increase the risk of abnormal delivery and lowers immunity of both mother and child [91]. Improving nutrition status and health of women and children is a priority area for action [20].

Maternal Nutrition Status and Child Nutrition Outcomes

Poor maternal nutrition status impacts foetal growth leading to increased risk of small for gestational age births (SGA), LBW and preterm birth [20-22]. Infants born SGA or with LBW are more likely to be stunted, have a higher risk of poor-quality life and poor cognitive outcomes (Prendergast and Humphrey, 2014). Moreover, LBW is the biggest risk factors for mortality and morbidity in the first few months of life, particularly in developing countries [127]. Poor weight gain during pregnancy due to inadequate dietary intakes and maternal workload are known risk factor for LBW (Beilly & Kurland, 1945; [18, 22, 35, 87, 100]. Conversely, higher energy and protein intakes, and maternal haemoglobin status are associated with normal birthweight [105, 153, 155].

Other research has looked at the relationship between maternal anthropometrics post-partum and infant nutrition status. Acknowledging that the relationship between maternal height and child height is partly due to genetics [154]; in resource, poor settings where food insecurity and nutrition are major concerns there are several other factors that influence maternal height and weight and the relationship with infant anthropometrics is clear. Studies report relationships between maternal BMI and height, and higher WHZ scores and lower risk of stunting and wasting [104]. Another study reported that mothers' diet during pregnancy was related to her weight gain during pregnancy and subsequently the child's weight and height [53]. Altogether, this gives promising results in fighting undernutrition through investing in mothers and addressing the devastating impact of undernutrition during the first 1000 days. More emphasis on nutrition intervention from adolescence through early pregnancy and lactation is therefore needed. It is important to address maternal feeding and health during pregnancy and lactation and to identify mothers with poor weight gain during pregnancy and provide support where possible.

7. Food and Nutrition Security

Food and nutrition security (FNS) combine two concepts, food security and nutrition security. Adopted from the 1996 World Food Summit "food security exists when all people at all times have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" [44, 45]. Unlike food security, nutrition security (built from the UNICEF conceptual framework) is defined as "having a nutritionally adequate diet that is biologically utilized to maintain growth, resisting or recovering from disease, pregnancy, lactation and physical work" [51]. Food and nutrition security is in turn defined as a condition under which adequate food is available and accessible and satisfactorily utilized by all individuals at all times to live a healthy and happy life [173].

Food Security and Child Nutrition Outcomes

Food security exists when all people always have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life [45, 46]. Food insecurity at global, national

and household levels has devastating effects on health and human development which is aggravated by climate changes [47] Despite the progress made in increasing world food production, 3.1 billion people are unable to afford a healthy diet globally [48]. Persistent undernutrition (particularly hidden hunger) in Sub-Saharan Africa are due to food insecurity and poor diet quality and it affect 220 million people [78]. Moreover, changes in global environments, weather pattern and climate variability have impacted food production and food access for subsistence farmers, increasing the risk of food insecurity, infectious disease and undernutrition particularly for young children [48, 126].

Food insecurity, hidden hunger and undernutrition are still challenging in Tanzania, underpinned by seasonal and regional food shortages. The United Republic of Tanzania ranked 160 out of 191 (Human Development Index (2022) and 95th out of 121 on the 2022 Global Hunger Index with scores 23.6 which indicate serious population undernourishment [170]. The majority of food insecure households live in rural areas where agriculture is major source of livelihood. They rely on subsistence farming which is vulnerable to climatic, economic and seasonal shocks and they are battling hunger [74, 174].

Informing policy making and planning for interventions for child undernutrition is suitable but requires better understanding of several factors that influences children's health and nutrition. The relationship between household's food insecurity and certain nutrition status parameters among children below five years of age has widely been established and yielded mixed results. It is known that children from food insecure households can have lower food consumption, including fewer numbers of food groups, poor nutrient intakes and nutritional status [110]. However, other research shows that within food insecure households, children are better nourished because available foods will be given to young children as one of the coping strategies, while others argue that in food insecure households' young children receive more benefit from breast milk because of reduced food availability [57].

For example, in Nepal, children from severely food insecure households were highly stunted and underweight compared to children from food secure households, however, the rate of undernutrition among children from food-secure households was also high [145]. This indicates other determinants of poor nutrition than food insecurity, which could be related to poor feeding and care practices, frequent infection, poor sanitation, poor nutritional knowledge leading to nutrition deterioration. Similarly, within food insecure households children were more underweight, stunted but not wasted compared to food secure counterparts [4, 17, 145]. Wasting is an indicator of hunger or food/nutrition insecurity and low food intakes, while stunting is the results of chronic food shortage, poverty, infections and overall low social economic status. The impact of food insecurity on height and weight in the reported studies could indicate multiple problems in food insecure households. Some researchers reported underweight among children from food insecure households [110, 134-135] whereas other reported lower risk of stunting among infants from food secure households [113, 123, 133]. Both stunting and underweight were reported in food insecure households [136]. On the contrary, other studies found no relationship between households' food insecurity and child anthropometry, only households wealth index was associated with undernutrition among children aged 6 to 23 months [121]. Some studies reported dietary diversity as a good predictor of stunting compared to household food insecurity particularly in communities where dietary diversity is high. It is therefore likely that the indicator is a stronger predictor of stunting than household food security.

8. Agriculture and Livelihoods in Africa

Worldwide, the livelihood of 2.5 billion people particularly small-scale farmers, herders, fishers depends on agriculture [47]. Africa mainly Sub-Saharan Africa is still facing great challenges of food insecurity with relatively low levels of agricultural productivity, low incomes among rural farmers and, high rates of undernutrition (AGRA, 2016). Agriculture is linked to nutrition particularly among subsistence farmers in developing countries as a source of income for food and non-food expenditures which is possible through employment in agricultural sector and selling agricultural produce, which can be translated into expenditure on nutrition-enhancing goods and services [55]. Therefore, agriculture is an important sector, critical to the economies of all African countries, where about 70% of population dependent on agriculture for livelihoods with possibilities of eradicating poverty and hunger (NEPAD, 2013). At the African Union Summit in Malabo, Equatorial Guinea in June 2014, Heads of State and Government adopted a remarkable set of concrete agriculture goals to be achieved by 2025. The Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods is a set of new targeted approach to achieve the agricultural vision for the continent which is shared prosperity and improved livelihoods. The member state was commitment to Zero hunger – Ending Hunger by 2025 by at least double agricultural productivity by improving irrigation and mechanization and reducing post-harvest losses. The Malabo declaration set ambitious targets for African children there aiming to improve children's nutrition status by reducing stunting to 10 percent and underweight to just 5 percent by 2025 with agriculture as a key strategy. The Malabo Summit reconfirmed that "agriculture should remain high on the development agenda of the African continent and is a critical policy initiative for African economic growth and poverty reduction" (Malabo Declaration, 2014).

8.1. Agriculture and Season

Agricultural production depends on weather patterns throughout the year. In subsistence farming systems where food consumption is dependent on production, seasons and

rainfall, changes in weather patterns have an impact on production and therefore food consumption (Kaminski et al., 2016). The pre-harvest season is characterized by rainfall, intensive agricultural labour and low food stocks among all the farming households, affecting food security and livelihoods (Ali et al., 2016). Recently, climate change has had an impact on seasonal stress among rural farming households affecting quantity and types of food grown, nutrition status and lack of water [5]. Over the past number of years there have been an increased focus on the relationship between agriculture production and nutrition [59,103]. The attention on agriculture was emphasised in the recent Zero Hunger Challenge [152] and Sustainable Development Goals (SDG), which aims to "end hunger, achieve food and nutrition security and promote sustainable agriculture" [86, 97].

8.2. Agriculture and Child Nutrition Status

Agriculture is the primary source of livelihoods for food and income and is a strong driver of food and nutrition security [142]. It is therefore imperative to consider agriculture production and child nutrition through its influence on dietary intakes and feeding practices as immediate causes of undernutrition, household food insecurity and income as underlying determinants of nutrition status [55]. The pathway in which agriculture is linked to food security and nutrition outcomes is summarized below [41, 55]

1. Agriculture is a source of food (nutrients rich) for households' consumption: this is the most direct pathway whereby household increase food availability and accessibility from own production.
2. Agriculture provides a source of income for food and non-food expenditures: income is generated through employment in agricultural sector and/or selling agricultural produce, which can be translated into expenditure on nutrition-enhancing goods and services (including health, education, and social services).
3. Agriculture affect food price: effects of agriculture policy and food prices on food consumption, which in turn affect purchasing power of net buyers particularly rural subsistence farmers if the price of is high.
4. Effects of women's employment in agriculture on intra-household decision-making and resource allocation: agricultural labour conditions can influence the empowerment of women and thus their control over nutrition-relevant resources and decision making, particularly regarding food and healthcare.
5. Effects of women's employment in agriculture over time allocation: time allocation can challenge women to balance time spent in income generating activities, household management and maintenance, caregiving, and their own leisure
6. Effects on agricultural labour on women's own nutritional and health status: relates to the energy intensive nature of agricultural labour and effects on maternal nutrition and health status including high energy expenditure and exposure to agriculture-associated diseases through zoonotic diseases and waste water irrigation

Although the agriculture-nutrition pathways overlap, the first pathway (agriculture as a source of food (nutrients rich) for households' consumption is important for rural agricultural dependent households due to consumption of own production with its influence on child nutrition [29, 75]. Although there is limited evidence for a link between agriculture and nutrition, particularly with children [98, 131]. Carleto and colleagues reviewed some evidences on the link between livestock farming, dietary diversity and nutrition status of children [29, 117]. The link between agriculture and nutrition outcomes depends on the type of farming practices. Nutrition sensitive farming practices are likely to influence positive nutrition outcomes; for example, β-carotene-rich orange sweet potato was shown to improve vitamin A status of pre-school children in Mozambique and Uganda [70,122]. Integrated homestead food production coupled with a behaviour change communication programme, targeting women and children documented positive effects on child nutrition outcomes [120]. Other reseach found a positive relationship betweeen agriculture production diversity and dietary diversity among children aged 6–23 months and higher LAZ among older children aged 24–59 months in Zambia [31,84]. In addition, livestock farming impacted nutrition outcomes of young children; for example, cow ownership and child milk consumption was associated with higher LAZ and reduced odds of stunting among children aged 6–24 months in Ethiopia (Hetherington et al., 2017; Hoddinott et al., 2015). On the other hand, agricultural interventions to increase vegetables and fruits showed less impact on nutrition status, however livestock ownership and milk consumption were associated with improved WAZ and HAZ among children below the age of 5 years in Kenya [171]. The ownership of small ruminants was linked to lower wasting and underweight among 24–59 months old in Uganda [11]. Additionally, crop output value had small effects on anthropometric outcomes of pre-schoolers and children 5–9 years old while livestock ownership had positive outcome on the nutrition of children in Tanzania [146]. Few studies have confirmed the strength of agriculture production and food consumption to effect changes among infants and young children 6-24moths in rural farming households.

8.3. Season and Child Nutrition Status

Seasonal fluctuations in food availability is an important factor influencing child growth, particularly in rural farming households where season impacts food availability (Wijesinha-Bettoni et al., 2013). The effect of season on food availability and child anthropometrics has been observed in literature, with studies reporting better nutrition during the post-harvest season [50, 62, 67]. The typical drop in food stock prior to the harvest season results in a decrease in food consumption. At the same time, the time dedicated to farming increases, which has an impact on energy

expenditure. The combination of the drop-in food availability and the increased workload means a mismatch in energy balance and a higher risk of undernutrition [32, 68]. In line with decreased food consumption, incomes and food prices change with the agricultural seasons which puts additional pressure on vulnerable groups [68]. In addition, seasonal weather fluctuations affect food availability and environmental sanitation and health thereby affecting diet, infant feeding and morbidity [15, 118, 179]. Pre-harvest seasons, lower WAZ and WLZ was reported among children in farming households [72]. A decrease in wasting and underweight was reported during post-harvest in Ethiopia indicating increased food intakes during this time [129]. On the contrary, seasonal morbidity was a significant cause of seasonal fluctuation in nutrition status among children under the age of five years in Malawi compared to food availability [32]. Some authors have linked variation in child nutrition status across agricultural seasons as lack of care from mothers due to high agricultural labour during pre-harvest and post-harvest and not necessarily with food availability [118,151]. From the documented studies, the link between seasonal food availability, dietary intake and infant feeding practices among infants and young children is lacking, and it is not clear if variation in feeding practices indicators, nutrients intakes and nutrition status follow seasonal patterns of food availability, creating the necessity of examining children's diets at different times of the year.

9. Targeting Improvements in Child Nutrition Status

The analysis of early growth patterns in children from resource-poor countries shows a rapid decline in the Length for age Z-score during the first 2 years of life with no recovery until 5 years. This observation brought attention to the first years of life as a window of opportunity for targeting interventions against stunting [144] (Victora et al., 2010). Although some studies have presented other windows of opportunity for intervention to curb stunting outside the 1000 days windows (Prentice et al., 2013), the adverse effect of undernutrition during this period was established [21-22]. Women particularly in low-income countries enter pregnancy when they are young and in a state of poor nutrition. The additional demands of pregnancy increase the risk for undernutrition for these women and their infants [96]. This chronic, inter-generational state of undernutrition is hampering the potential of future generations in developing countries. Dietary diversification and consumption of nutrient-rich foods among women, coupled with proper feeding practices for infants and young children is the primary long-term goal for improving nutrition during the target periods [39]. Policy-makers need to focus on multicomponent interventions that target the immediate and underlying causes of undernutrition in order to affect long-term change in nutrition status outcomes in developing countries [77, 168].

10. Multi-Component Interventions to Improve Child Nutrition Status

There are various determinants of undernutrition reviewed prior to this section (figure 2), however, lack of connection between different sectors including agriculture, public health, education, water and sanitation, social protection, individual and household decision making lead to poor improvement in child nutrition [60]. Therefore, multicomponent interventions are necessary to improve child nutrition status in the long term. This has been analysed in figure 3 addressing the multisector responses to fight undernutrition [26]. Acknowledging the importance of adequate nutrition during the formative years has caused tremendous increases in political commitment for the reduction of under-nutrition at the global and national level, focusing on the first 1000 days of life. This commitment includes the global effort on improving nutrition through agriculture particularly targeting the first 1000 days [131, 138]. This was emphasised through the Sustainable Development Goals which aims of "end hunger, achieve food and nutrition security and promote sustainable agriculture" [86]. While agriculture is a key underlying sector, its effectiveness depends on collaboration with other sectors like education, water and sanitation, social protection, early child development and nutrition. This has led to the reorientation of many programs to focus on nutrition sensitive interventions to address the underlying determinants of foetal and child nutrition. Nutrition-sensitive programs in agriculture, social safety nets, early child development and education have potential, to augment the coverage and effectiveness of nutrition-specific actions although its potentials have not been adequately unleashed [131]. Additionally, nutrition-sensitive interventions can create a stimulating environment for optimum foetal and child growth and developments to their full potential (Figure 3). Agricultural intervention particularly, has a potential to improve livelihoods, food security and diet quality and can reach vulnerable population in large scale [181].

For a long time, in Tanzania, nutrition specific interventions (aimed at the immediate causes) have been in place addressing both maternal and child nutrition (Table 6). These include health interventions that impact nutrition outcomes such as iron and folic acid supplementation for pregnant mothers, vitamin A supplementation deworming and promotion of exclusive breastfeeding. However, the coverage of nutrition-specific interventions is low, indicating the needs for multicomponent interventions. For example, interventions based on nutrition sensitive agriculture, health, social protection, education, and water and sanitation including poverty reduction, can be implemented at large scale and can effectively reach poor populations and vulnerable groups [41, 132]. Additionally, policies and programmes that improve agriculture, health, education, social protection, water, sanitation and hygiene reduce stunting by 80%, compared to a 20% reduction with direct nutrition interventions [73]. Accordingly, it is important to focus on agriculture as a key sector in producing healthy and

nutritious diets that address both immediate and underlying determinants of undernutrition through coverage of large rural poor populations who depend on agriculture for food and livelihoods.

Despite strong evidence to support links between agriculture, growth and a reduction in under-nutrition [29, 55] there is limited evidence to show the impact of nutrition sensitive agricultural interventions on child nutrition outcomes in Tanzania. This is calling out more research on nutrition farming practices and child nutrition outcome.

Table 6. *Nutrition specific interventions in Tanzania targeting young children.*

Type of interventions	Demographic & Health surveys	
	2010 (%) *	2015-16 (%)
Exclusive breastfeedi0ng (0-5months)	49.8	59.2
Complementary feeding with at least 4 groups per day (6-23 months)	56.4	23.9
Zinc treatment for diarrhoea	4.7	17.5
Pregnant women attending 4 or more ANC visits	42.7	50.6
De-worming (12-590 months)	49.6	37.6
Vitamin A supplementation (6-59 months)	60.8	41.2
Households with adequately iodised salt (15+ ppm)	55.2	60.6
Postpartum women with Vitamin A supplementation	25.8	–
Insecticide-treated nets	73.9	54.4
Malaria prophylaxis for pregnant women	26.3	34.6
Folic and iron supplementation	40.0	21.0
Deworming for mothers	–	63.1

TDHS 2010 used 3 food groups for DDS, ANC: Antenatal care ANC=Antenatal care
Sources: Tanzania National Bureau of Statistics: TDHS 2010 and TDHS 2015-16

In conclusion, undernutrition remains a major global problem and an underlying cause child deaths annually. Proper nutrition is critical for child growth and survival particularly in infancy and early childhood when failure to grow can have lifetime consequences. Therefore, the "first 1000 days" is the ideal target for interventions aimed at reducing all forms of undernutrition in children. Efforts to reduce undernutrition in Tanzania have been largely focused on healthcare, including measures such as vaccination programmes, nutrition rehabilitation and micronutrient supplementation, which reflect Western medical practices and the medical model. Agricultural, environmental and social factors, which underpin the root cause of undernutrition have not been given much attention. Focusing on agriculture to improve nutrition, particularly targeting the "first 1000 days", moving away from the traditional single nutrient approach to a food-based, comprehensive approach is the global emphasis globally [8, 55, 180]. Rural vulnerable households in Tanzania are an ideal target for this type of intervention given the high rates of undernutrition, poor breastfeeding and complementary feeding practices and high dependency on agriculture for livelihoods. Although we recognize the relationship between agriculture and nutrition, we need to identify targets before we can design appropriate interventions. In addition, Tanzania is an agriculturally diverse country with substantial regional variation in the prevalence of undernutrition. It is important that interventions aimed at improving nutrition status of women and children are specific and consider regional agricultural practices and the impact of season. While previous studies reported the determinants of child undernutrition, very few studies have taken a comprehensive approach including factors from the environment right through to infant feeding practice. This information is important to provide the evidence-base to inform policy-making and practice. One of the key questions that remain. Does agriculture have the strength to affect immediate change in nutrition status during the first 1000 days? In an attempt to answer this question, the need to study the immediate, underlying and environmental factors that determine undernutrition among infants and young children and identified nutrition sensitive agricultural practices that can potentially form the basis of future intervention targets is warranted.

Conflicts of Interest

The author declares no conflicts of interest.

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