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Factors influencing stunting among children in rural Tanzania: an agro-climatic zone perspective

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Abstract This paper analyzed stunting in children in Tanzania and its linkages to agro-climatic conditions and related factors, unraveling the complex interactions of determinants of under-nutrition in two contrasting regions of Tanzania. We used logistic regression models to establish relationships between stunting and multiple variables belonging to different domains. The prevalence of stunting and severe stunting in children was 41% and 21% respectively, while 11% of women had a Body Mass Index of below 18.5. Results also indicate that 17% of children and 16% of women were anaemic. Regression analysis showed that major determinants of child stunting in the semi-arid Dodoma region are cultivated land size, gender and age of the child, duration of breastfeeding, household size, use of iodized salt and the distance to a water source. In sub-humid Morogoro, cultivated land size, a child's age, duration of breastfeeding, literacy status of the mother and Body Mass Index of the mother predict stunting. We discuss how these factors influence the nutrition status of children in each agro-climatic region. The pooled model provided strong evidence to link agro-climatic zone characteristics to stunting among children. It is recommended that nutrition interventions should be specific to agro-climatic environments. Implementing agro-climatic sensitive interventional actions may help to reduce undernutrition and food insecurity in specific areas.

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Background

Undernutrition and food insecurity are major problems faced by Tanzania and many other countries in Sub-Saharan Africa (Das and Sahoo 2011; Dereje 2014; National Bureau of Statistics and ICF Macro 2010). Among the most nutrient- and food-insecure populations, children below five years of age and women of reproductive age are the most vulnerable. Their vulnerability can be attributed to low dietary intakes, inequitable distribution of food within the household, improper storage and preparation of food, dietary taboos, infectious diseases and inadequate care (Goudet et al. 2011). Additional factors that may contribute to undernutrition among women include high nutritional requirements during pregnancy and lactation, which are seldom met due to inadequate diets. Poor nutritional status is a sign of an inadequate dietary intake and is linked to infectious diseases; consequently it is influenced by numerous environmental and socioeconomic factors (Suhrcke et al. 2011). Undernutrition has an effect on health, educational attainment, and on the economic development of affected individuals and countries. Causes of undernutrition are multi-factorial and interrelated. They include economic, environmental, educational, cultural and gender-related factors, food security, feeding practices and infections (Masibo 2013). The degree of influence of these factors varies among communities.

In Tanzania, about 42% of children younger than 59 months of age are stunted and 17% are severely stunted (NBS and ICF Macro 2010). Around 16% are underweight and 5% wasted. With these high rates of undernutrition, the physical and mental development of Tanzanian children is severely at risk; a

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disadvantage from which they cannot recover. The high prevalence of stunting reflects the existence of chronic undernutrition and highlights an urgent need to prioritize interventions that prevent stunting and undernutrition in Tanzania. There is also substantial regional variation with stunting. For example, the stunting rate for children below five years of age was 19.6% in Town West region of Zanzibar but reached 56% in Dodoma region of central Tanzania during the same period of time (NBS and ICF Macro 2010). The prevalence of nutritional insecurity is conditioned by environmental factors including those related to climate (Campbell-Lendrum and Woodruff 2006). Accordingly, the substantial regional variation in stunting found in Tanzania can be explained by the agro-ecological settings of a region. Agro-climatic variation may affect nutritional status through different pathways including by altering the types and timing of food availability (Lobell et al. 2011), and by influencing access to food and its utilization (Confalonieri et al. 2007).

Additional to deficiencies of macro-nutrients, deficiencies of vitamins and minerals are also prevalent in Tanzania. A significant percentage of children aged 6–59 months (34%) and women of reproductive age (15–49 years) (37%) are deficient in vitamin A (NBS and ICF Macro 2011). The prevalence of iron-deficiency anaemia among children is 24%, while that with women is 30% (NBS and ICF Macro 2011). For iodine, tests of urinary iodine concentration in women indicated that 48% had a urinary iodine concentration below the optimal range. Results of a rapid test for iodine indicated that 17% of households used salt that did not contain iodine, 23% used salt with inadequate iodine, and 60% used salt with iodine levels required for optimal iodine nutrition (NBS and ICF Macro 2011).

Available studies on factors associated with child undernutrition have focused mainly on feeding practices and socio-economic determinants (Dereje 2014; Linnemayr et al. 2008; Mamiro et al. 2005b), but rarely paid attention to the differences in agro-climatic conditions that affect agricultural production and food availability, which may actively contribute to the determination of nutritional status. There is a paucity of information on factors influencing malnutrition in distinct climate zones in Tanzania. Studies that investigate factors at the levels of the individual, the household, community and the agro-climatic zone are required in order to devise effective intervention strategies and policy initiatives to ensure child and maternal nutrition security in rural areas. This study therefore sought to establish the relative importance of differences in agro-climatic conditions on factors that determine child nutritional status in rural Tanzania. Specifically, it assessed the nutritional status of children and their caregivers, assessed maternal knowledge on nutrition and analyzed factors that influence stunting in rural areas of two agro-ecologically contrasting regions in Tanzania; Morogoro and Dodoma.

The conceptual framework

This study reflects the UNICEF framework which describes the causes of childhood undernutrition ranging from basic causes (quantity, quality, and control of human, economic and organizational resources) to underlying causes (insufficient access, inadequate child care practices, poor sanitation, inadequate health services), and then to immediate causes (diseases and inadequate dietary intake) (UNICEF 1998). The prime load of existing undernutrition is caused by calorie and micronutrient shortage caused by inadequate intake of food (Black et al. 2008). Variation in weather conditions, climate inconsistencies, and catastrophic weather events such as floods and droughts determine the quantity, quality and stability of crop production (Porter and Semenov 2005). Unfavourable and extreme weather conditions are highly likely to negatively affect food production in smallholder farming communities that are already food insecure, which can lead to insufficient food intake and hence undernutrition. Communities tend to develop different coping strategies which form the basis of varied eating and caring practices that are observed in the communities. Thus the level of undernutrition is a complex construct of interactions among factors at the level of the individual, the household and community, further interacting with conditions in the agricultural, weather and environmental framework. This study aimed to establish the role of agro-climatic and weather differences in determining childhood malnutrition, particularly stunting, in Tanzania.

Study areas

The study was conducted in four villages from two contrasting agro-climatic zones in Tanzania (the sub-humid Morogoro region and the semi-arid Dodoma region), selected for Trans-SEC (Innovating Strategies to Safeguard Food Security using Technology and Knowledge Transfer Project). Trans-SEC aims to improve food security for the most vulnerable rural populations in Tanzania by applying a range of food-securing up-grading strategies along local and regional food value chains. Morogoro and Dodoma represent two different food systems and have sufficiently diverse environmental and socio-economic conditions for investigating causative factors for food and nutrition insecurity, thus allowing for the transfer of results to many other regions in Tanzania. In sub-humid Morogoro, Changarawe and Nyali villages were selected from within Kilosa district. The food systems in Kilosa are varied, mainly relying on sorghum, maize and rice as staples; legumes such as common bean, pigeonpea, green pea, cowpea, chickpea and green gram; horticulture crops such as carrot, cucumber and tomato; oil crops such as simsim and sunflower; fruits such as mango, pawpaw, orange, pineapple and water melon, and livestock (Mnenwa and Maliti 2010). Kilosa is a bimodal rainfall area with short

(October–February) and long (March–May) rainy seasons, with an average of 600–800 mm rainfall per annum. The long rainy season forms the main production season while production during the short rainy season is used to smooth out the supply of food over the year. In addition, Kilosa imports food produce from other regions during deficit months and these are sold in local markets. They include cereals such as maize and rice and legumes such as cowpea, beans, pigeonpea and peas. The consumption of food in Kilosa is shaped by local food cultural preferences. The food menu is based on cereals, with maize and rice as major staples. Legumes are served as relish within the food menu. Vegetables are also consumed; predominantly leafy vegetables such as cowpea leaves and several wild vegetables (Mutabazi 2013).

In semi-arid Dodoma region, Ilolo and Ndebwe villages were selected from Chamwino district. Food production in Chamwino is predominantly rain fed. Dodoma region receives rainfall in one season with an average of 350–500 mm rainfall per annum. Dodoma is characterized by a prevalence of highly food-insecure areas. Crops produced include cereals (sorghum, pearl millet and maize), roots/tubers (cassava and sweet potato), legumes (cowpea, pigeon pea, bambara nut, groundnut, chickpea, green gram and lablab bean), oil crops (sunflower, sesame, groundnuts) and fruits (pawpaw, guava, mango, grape, lemon and dates). There is also a widespread collection of edible wild fruits and vegetables. The food system in Dodoma is mainly based on cereals with pearl millet as the preferred staple. Groundnuts are normally mixed in most relishes used with the main dish. Edible wild products, particularly vegetables and fruits, are important in local food menus (Mutabazi 2013). The Chamwino district imports food crops from other regions during deficit months. These foods include maize, beans and pigeonpea. During deficit months, imported food is sold at a price more than three times its price during the months of plenty. This is because there are no structured local markets in the case study villages, only small grain and pulse traders. The two regions together account for 70–80% of the types of farming system found in Tanzania (Ronner and Giller 2013).

Methodology

Study population

The study population comprised all children aged between 6 and 59 months and their mothers/caregivers in the sampled households. The respondent was the mother/woman or any other person responsible for the preparation and serving of food within the household.

Sampling procedure and design

Data were collected from January to April, 2015. The study was cross sectional. A cluster sampling method was used to select four villages in Kilosa and Chamwino districts. The households were randomly selected from lists of village households provided by the Agricultural Research Institutes (ARI) Kilosa and Hombolo. These lists contained information on the names of heads of households and the corresponding sub-village they lived in. After sorting the lists alphabetically for each sub-village, 150 households were selected randomly from each village (proportionally with regard to the size of the sub-village), summing up to a total of 600 households for Dodoma and Morogoro. From this sample, 30 households with children below five years of age were purposively selected to be included in the study making a total of 120 households. This was done to ensure sampling space for other innovation groups within Trans-SEC and to avoid interactions among the intervention groups. Household heads and spouses were informed of the purpose, objectives and activities of the study. Household representatives were required to sign or apply a thumb print (in ink) to a form, marking their consent to participate in the study. Permission to conduct the study was obtained from Sokoine University of Agriculture and the offices of the District Commissioners. Ethical clearance was obtained from the Tanzania National Institute for Medical Research (NIMR/HQ/R.8a/Vol.IX/2226).

Data collection and anthropometric measurements

An interviewer-administered questionnaire was used to collect demographic and socioeconomic information and to assess the knowledge of mothers or caregivers in nutrition and kitchen gardening in the selected households. Five interviewers (specialized as nutritionists) were trained to take anthropometric measurements and interview caregivers to assess their knowledge on nutrition and kitchen gardening. To standardize the survey and measurement practices, each interviewer measured and weighed seven children aged below five years and their caregivers. They also interviewed the caregivers from one village that was not part of the current study. Data were checked in the field by a fieldwork coordinator and confirmed or re-collected as necessary.

The age of the children was obtained from parents and verified from their clinic cards, where available. The height (in cm) and weight (in kg) of 120 children and their caregivers in the sampled households were measured. Weight was measured to the nearest 0.1 kg using a SECA electronic bathroom scale (A SECA, Vogel and Haike, Hamburg, Germany). For children below two years old or those that could not stand on their own, weight was measured using a SECA scale with a tare facility. Both children and their caregivers were in minimal clothing and without footwear when measurements were taken. Height was measured using a stadiometer (Shorr Productions, Perspective Enterprises, and Portage, Missouri, USA). Measurements were taken while the subject was standing without shoes on a horizontal flat plate attached to the base of the stadiometer with heels together; and stretched upwards to a full extent and their head in the Frankfurt horizontal plane.[1] Recumbent length was measured on children below 24 months old.

The anthropometric results reported are based on World Health Organization (WHO) standards (WHO 2006). Z scores as an expression for anthropometric indicators, is the difference between the value for an individual and the median value of the reference population for the same age or height, divided by the standard deviation of the reference population. A Z-score of −2 is generally considered as the cut-off point for the screening of individuals likely to be malnourished. Therefore acute undernutrition is defined as <−2 Z scores and severe acute undernutrition is defined as <−3 Z scores of weight for height. A well-nourished child is one whose weight and height measurements balance very well with the standard normal distribution of heights and weights of healthy children of the same age and sex (Mahgoub et al. 2006; WHO 2006).

Biochemical measurements (haemoglobin concentration)

Haemoglobin concentration of children and their caregivers was measured using a portable battery-operated electronic HemoCue Hemoglobinometer (HemoCueHb 201+, Angelhom, Sweden). A capillary blood sample was obtained from a finger prick of each individual using a sterile lancet. A drop of blood was placed in a single-use Hemocue micro-cuvette and inserted in the Hemoglobinometer for immediate reading in g/dL. Anaemia in children was defined with a haemoglobin concentration lower than 11.0 g/dL and the threshold concentration in non-pregnant women was <12.0 g/dL (WHO 2011).

Data analysis and statistical methods

The Statistical Product and Service Solution (SPSS) software version 17 (SPSS Inc., Chicago, IL, USA) was used to analyze the collected data. Emergency Nutrition Assessment (ENA) for Standardized Monitoring and Assessment of Relief and Transitions (SMART) 2011 (www.nutrisurvey.de/ena2011/) was used to classify the study children into categories of nutritional status by converting the anthropometric measurements into Z-scores viz. weight for age Z scores (WAZ), height for age Z scores (HAZ) and weight for height Z scores (WHZ). These were compared with the WHO guidelines and standards (WHO 2006), and were used to define stunting, underweight and wasting in children. For women, the indicator used to assess nutritional status was the Body Mass Index (BMI). This indicator is the most frequently used standardized indicator of thinness (wasting) to assess the progressive loss of body energy in developing countries. Descriptive statistics were computed wherever necessary. The net effects of each independent variable were estimated by logistic regression multivariate analysis while controlling other factors. Odds ratio was used to assess the chance (increased or decreased) of stunting, in relation to independent variables in the models. Significance was considered when the P value was ≤0.05. Three logistic models were performed separately, i.e. two regional models (for Morogoro and for Dodoma) and one pooled model (for both Morogoro and Dodoma). The dependent variable in this model was the level of child stunting. Stunting (the height of a child relative to its age) is one key sign of malnutrition and is considered a good indicator of poverty, indicating inadequate food consumption over a long term (UNICEF et al. 2012). Stunting is a commonly used indicator of chronic undernutrition associated with environmental and socio-economic conditions (Awoyemi et al. 2012). The independent variables considered in the regression were household size, cultivated land size, gender of the child, age of a child, literacy status of a mother, use of iodized salt, body mass index of the mother, breastfeeding duration, distance to a water source, region of residence, marital status of the mother, age of the mother and gender of the household head.

[1] This is the position of an imaginary line passing through the external ear canal and across the top of the lower bone of the eye socket, immediately under the eye. It is the correct positioning of the body for measurements of height.

Results

Demographic and socio-economic characteristics of households

Among the sample households, 62% of households cultivated two acres of land or less. Ninety percent of household heads were males and 80% were married. For 75% of the households, household size was between three and five people. The level of illiteracy was higher in Dodoma (43%) compared to Morogoro (24%) and Dodoma had more caregivers with no education (38%) compared to Morogoro (24%). Other key demographic information of the households and respondents is in Table 1. Regarding the child population, 57% were male and 43% female, indicating more male representation. The mean age of children was 32.6 months. The distribution of age and sex of the child population for Morogoro and Dodoma is given in Table 2.

Nutritional status of children and caregivers

The overall prevalence of stunting based on HAZ for the total population was 41%, with 21% of the population considered severely stunted. The prevalence of

Table 1 Demographic characteristics of households (n = 120) in two contrasting agro-ecological regions of Tanzania

Characteristics	Dodoma (n = 61) %	Morogoro (n = 59) %	Total %
Sex of household head			
Male	86.9	96.6	91.7
Female	13.1	3.4	8.3
Marital status of household head			
Married-monogamous	73.8	88.1	79.5
Married-polygamous	9.8	3.4	6.6
Widowed	6.6	1.7	4.1
Divorced	3.3	1.7	2.5
Single	1.6	1.7	1.6
cohabitation	4.9	3.4	4.1
Level of literacy of caregiver/mother			
Not able to read or write	42.6	23.7	32.8
Can read and write to some extent	14.8	20.3	17.2
Can read and write	42.6	55.9	48.4
Occupation of respondent			
Farmer	95.1	100	95.9
Self employed	1.6	0.0	0.8
Other	3.3	0.0	1.6
Total number of people living in the household			
3 to 5	59.5	62.7	61.4
6 to 8	27.8	28.8	28.7
9 to 12	12.7	8.5	9.9
Education level of respondent			
No education	37.7	23.8	22.1
Primary education	60.7	69.5	63.9
Secondary education	1.6	6.8	4.1
Distance to water source			
≤ 30 min walk	24.3	52.0	35.8
30–60 min walk	36.0	38.0	15.0
≥ 60 min walk	39.7	10.0	32.5
Cultivated land size			
< 2 ha	35.0	27.0	
≥ 2 ha	18.0	20.0	

underweight and wasting based on WAZ and WHZ were 20.2% and 3.4% respectively and the prevalence of severely underweight persons was 2.5%. The prevalence of stunting and underweight individuals in specific villages is in Table 3. In Dodoma region, the prevalence of stunting based on height-for-age z-scores was 56.7% in Ilolo and 45.5% in Ndebwe. Information on the prevalence of severe stunting and underweight based on weight-for-age z-scores is in Table 3. In Morogoro region, the prevalence of stunting based on height-for-age z-scores was 31% in Changarawe village and 33.3% in Nyali. The prevalence of severe stunting and underweight based on weight-for-age z-scores are also indicated in Table 3. Results further indicated that 17% of children were anaemic. The prevalence of anaemia in children for specific villages was 22% in Ilolo, 16% in Nyali, 19% for Ndebwe and 12% in Changarawe. Among caregivers, the prevalence of underweight in the overall population of women was 11% (BMI below 18.5) while 16% had haemoglobin levels below 12.0 g/dl. The prevalence of anaemia and wasting in mothers/caregivers for specific villages are in Table 4.

Table 2 Distribution of age and gender within the total child sample in two regions of Tanzania

AGE (months)	Dodoma				Morogoro				Total (%)	
	Boys		Girls		Boys		Girls		Boys	Girls
	Frequency	%	Frequency	%	Frequency	%	Frequency	%		
6–17	4	44.4	5	55.6	12	66.7	6	33.3	57.7	42.3
18–29	12	66.7	6	33.3	7	58.3	5	41.7	63.3	36.7
30–41	6	50.0	6	50.0	6	85.7	1	14.3	63.2	36.8
42–53	11	47.8	12	52.2	9	50.0	9	50.0	48.8	51.2
54–59	1	100	0	0.0	1	50.0	1	50.0	66.7	33.3
Total	34	54	29	46.0	35	61.4	22	38.6	57.1	42.9

Caregiver's knowledge on nutrition, pocket gardening and iron deficiency anaemia

More than half (60%) of the caregivers indicated that they are compelled to consume particular foods in a meal because of their availability. Around 69% of caregivers had never heard about pocket/sack vegetable gardening.[2] Sack gardens allow diets to be diversified and help address micronutrient deficiencies (Rinck 2008). A high proportion (89%) of the caregivers had never received any kind of nutrition training or education and 78% indicated that they knew nothing about food groups (Table 5).

When women were asked to mention any foods rich in iron, about 51% of caregivers/mothers mentioned dark green vegetables and 21% of the mothers/caregivers did not know of any sources of iron. When asked if they knew any foods that when eaten help the body to absorb and use iron, 53% said no and almost half (46.7%) did not know any foods that decrease the absorption of iron. More than half (58%) of caregivers indicated they did not know what causes iron deficiency anaemia (Table 6). There were no statistically significant differences between the mothers from Morogoro and mothers from Dodoma in terms of their nutritional knowledge.

About 48% of the participating households in Dodoma and 41% in Morogoro consume salt that is not iodized. The majority mentioned that the reason for using this type of salt was because it is cheaper and easily accessible compared to iodized salt.

Factors influencing nutritional status of children

For Morogoro, the analysis showed that a child's age, duration of breastfeeding, cultivated land size, literacy status and BMI of the mother were important predictors of nutrition status (Table 7). For Dodoma region, a child's gender and age, duration of breastfeeding, household size, cultivated land size, use of iodized salt and the distance to a water source were found to be important predictors of nutrition status (Table 7). The combined Morogoro and Dodoma model indicated that the important determinants of stunting were age of the child, duration of breastfeeding, literacy status of the mother, cultivated land size, use of iodized salt, distance to a water source and the region of residence. The risk of stunting in children increases with age from seven to 24 months. The risk falls to some extent when a child is 25–36 months old and increases again when a child reaches 37–59 months. Across the two regions, stunting rates varied significantly. Children from Dodoma region were 3.8 times more likely to be stunted compared to children from Morogoro.

Discussion

The purpose of this study was to assess the nutritional status and its demographic, individual, household, community and regional determinants for children under five years of age in rural areas in Tanzania. One hundred and twenty households and mother + child pairs from the semi-arid rural Dodoma region and sub-humid rural Morogoro region participated in the study. The study villages we selected may allow our results to be transferred to other regions in Tanzania because they well-represent a majority of farming systems in Tanzania.

Comparing our data to the Tanzania Demographic and Health Survey (TDHS) (2010), the prevalence of severely stunted children in our study was relatively higher (21%) than that reported in the national data, where it was 17%. Similarly, the prevalence of underweight individuals was relatively higher (20.2%) compared to the national data, which reported 16%. The levels of stunting were also higher in Dodoma region (57% in Ilolo and 46% in Ndebwe) compared to Morogoro (31% in Changarawe and 33% in Nyali). This may reflect the lower production of food and its scarcity in semi-arid areas like Dodoma compared to sub-humid areas

[2] Pocket/sack gardening in Tanzania involves growing vegetables in earth-filled sacks which are placed on doorsteps; it requires little water and hence is a highly suitable option for areas with water scarcity.

Table 3 Prevalence of stunting and underweight in children in Ilolo, Ndebwe, Changarawe and Nyali villages, Tanzania

Prevalence	Dodoma		Morogoro	
	Ilolo *n* = 30	Ndebwe *n* = 33	Nyali *n* = 28	Changarawe *n* = 29
Stunting (<−2 z-score)	56.7	45.5	33.3	31.0
Moderate stunting (<−2 z-score and > = −3 z-score)	30.0	24.2	11.1	13.8
Severe stunting (<−3 z-score)	26.7	21.2	22.2	17.2
Underweight (<−2 z-score)	23.3	21.2	22.2	17.2
Moderate underweight (<−2 z-score and > = −3 z-score)	20.0	21.2	18.5	13.8
Severe underweight (<−3 z-score)	3.3	0.0	3.7	3.4

Values are percentages

such as Morogoro (Liwenga 2003; Mnenwa and Maliti, 2010). When we compared child growth in these villages with the WHO standard growth of the reference population, children in the study villages clearly lagged behind in their growth (Fig. 1). The calculated distributions of Z scores were skewed in the area below −2 SD indicating widespread undernutrition, especially in Dodoma.

Anaemia in children was defined as haemoglobin concentrations below 11.0 g/dl (WHO 2011). We noted that children in villages in Dodoma region have a higher prevalence of anaemia compared to those in villages in Morogoro. This could be because Dodoma is drier than Morogoro which may result in fewer income opportunities in the agricultural sector and consequently a lower consumption of foods that contain iron. An additional cause may be the lower availability of indigenous vegetables in Dodoma that, in contrast, are commonly grown elsewhere during rainy seasons. These vegetables are rich in iron and other nutrients (FAO 2010). A higher prevalence of anaemia was shown in children aged 6–24 months compared to those aged 25–59 months. This could be because younger children require a comparatively higher intake of iron to meet their requirements for rapid growth. Also, in rural areas in Tanzania most complementary foods do not supply sufficient iron for children aged 6–24 months (Mamiro et al. 2005b). Comparing these results with those of the 2010 TDHS, our child population had a lower prevalence of anaemia than that given in the national data where 24% of children were considered iron-deficiency anaemic (NBS and ICF Macro 2011). Women in Dodoma appeared to be more malnourished (in terms of BMI and low Hb levels) compared to women from Morogoro. Similar to these results, a study by Eweh (2013) reported higher rates of anaemia in women that lived in upper elevation lands which are drier (as in Dodoma) than those who lived in lower lands which are more humid (as in Morogoro). Irregular and scarce rainfall in drier areas may lead to water shortages and constitute a more frequent threat to food production. Households in these areas have inadequate access to food through their own production and the utilization of those food supplies is inappropriate to meet the specific dietary needs of individuals (Food and Agriculture Organization [FAO] 2008). Again comparing our results with those of the 2010 TDHS, we found our population to have a higher prevalence of anaemia than the national data which reported only 14% of women with iron deficiency anaemia (NBS and ICF Macro 2011). A likely reason for the higher prevalence of anaemia in our study sample than the national averages is that the work capacity of adults of this population is likely to be reduced because iron deficiency anaemia leads to tiredness, lethargy and fatigue. This causes a reduction in physical activity which in turn may lead to less food production (Grantham-Mcgregor and Ani 2001; Kinabo et al. 2011).

Table 4 Nutritional status of women in two regions of Tanzania

Nutrition status	Dodoma		Morogoro	
	Ilolo %	Ndebwe %	Nyali %	Changarawe %
BMI ≤ 18.5	11	13	9	10
Hb ≤ <12.0 g/dL	18	21	14	12

Mothers' knowledge in nutrition and pocket gardening was limited in our study population. Accordingly, the nutrition status of children and other household members may be negatively affected because good maternal knowledge is expected to improve the health and nutritional status of household members through better practices which are influenced by awareness and the skills of individuals (Saaka 2014). Other studies have reported maternal nutritional knowledge to be positively associated with indices of child growth, especially the height for age index, and maternal knowledge was also an important predictor of child growth (Müller and Krawinkel

Table 5 Caregivers'knowledge on nutrition and kitchen gardening (n = 120) in Tanzania

Question asked	Response	n	%
Factors influencing consumption of different foods in a meal?	Availability	67	60.3
	Appearance	2	1.6
	Good for health	11	9.0
	Accessibility	5	4.1
	Taste	12	9.8
	Cost	8	6.6
Do you grow any fruits and vegetables?	Yes	68	55.7
	No	46	37.7
	Not applicable	6	4.9
Have you ever heard about bag/pocket gardening?	Yes	37	30.8
	No	83	69.2
Have you ever cultivated vegetables in a bag/pocket garden?	Yes	13	10.8
	Not applicable	107	89.2
Have you received any training about nutrition before?	Yes	13	10.8
	No	107	89.2
How often should children 2–5 years be fed per day?	Once	4	3.3
	Twice	26	21.3
	Thrice	76	62.3
	More than three times	10	8.2
	Do not know	4	3.2
How many servings of fruits and vegetables a day are advised for people to eat?	One	40	33.3
	Two	36	30.0
	Three	25	20.8
	Four	3	2.5
	Five	2	1.6
	Do not know	14	11.5
Do you know any kinds of food groups?	Yes	26	21.7
	No	94	78.3

Table 6 Mothers'/caregivers knowledge on iron deficiency anaemia (n = 120) in Tanzania

Question asked	Response	n	%
Have you ever heard about iron deficiency anaemia?	Yes	101	84.2
	No	19	15.8
What do you think causes iron deficiency anaemia?	Lack of iron in the diet	30	25
	Inability to absorb iron	2	1.7
	Blood loss	5	4.2
	Does not know	70	58.3
	Not applicable	13	10.8
Has child (6–59) months old used iron tablets in the last six months?	Yes	12	9.8
	No	106	86.9
	Not applicable	12	9.8
Have mother/caregivers used iron tablets in the last six months?	Yes	13	10.7
	No	105	86.1
	Not applicable	2	1.6
Has child 6–59 months ever used anti-helminthes drugs?	Yes	79	64.8
	No	41	34.2

Table 7 Multivariate logistic regression estimates of the effect of the explanatory variables on stunting in Kilosa and Chamwino, Tanzania

Independent variables	Morogoro		Dodoma		Both regions	
	P- value	Odds ratio	P- value	Odds ratio	P- value	Odds ratio
Sex of a child						
Female		1.00		1.00		1.00
Male	0.0890	1.2182	0.0038*	2.3918	0.0781	1.2110
Child's age						
7–12 months	0.0000*	1.2312	0.0021*	2.2418	0.0015*	1.8235
13–24 months	0.0216	1.8583	0.0231	1.8765	0.2235	1.8326
25–36 months	0.1634	1. 0023	0.1667	1.2361	0.1643	1.3412
37–59 months		1.00		1.00		1.00
Duration of breastfeeding						
< 12 months	0.0431*	2.6532	0.0089*	2.8921	0.0260*	2.7215
12–24 months		1.00		1.00		1.00
Household size						
< 5		1.00		1.00		1.00
6–9	0.1126	1.5378	0.0986	1.4371	0.1042	1.2654
> 10	0.1248	1.6318	0.0492*	1.8936	0.0967	1.7853
Literacy status of mother						
Can read and write		1.00		1.00		1.00
Cannot read and write	0.0020*	1.8923	0.8289	1.9825	0.0032*	1.8932
BMI of mother						
< 18.5	0.0010*	2.4539	0.0743	1.2369	0.0008	1.0458
18.5–24.9		1.00		1.00		1.00
≥ 25	0.2340	0.8523	0.4873	0.9921	0.3640	0.8851
Anaemia of mother						
Severe	0.0601	2.3456	0.0892	3.4563	0.07534	3.1209
Moderate	0.0681	1.8720	0.1482	2.5673	0.19324	2.1693
Mild	0.0742	1.6434	0.1543	1.8642	0.0937	1.7854
Normal		1.00		1.00		1.00
Use of iodized salt						
Yes		1.00		1.00		1.00
No	0.1972	0.9451	0.0039*	1.9537	0.0049*	1.6729
Distance to water source						
≤ 30 min walk		1.00		1.00		1.00
30–60 min walk	0.1092	1.0271	0.0962	1.6743	0.0790	1.3250
≥ 60 min walk [RC]	0.0937	1.0824	0.0000*	3.2189	0.0410*	2.8317
Marital status of mother						
Married – monogamous		1.00		1.00		1.00
Married – polygamous	0.0601	2.3958	0.0982	2.8429	0.0742	2.5419
Widowed	0.0710	2.2172	0.1286	3.6734	0.0985	2.9846
Divorced	0.1285	2.6312	0.2183	3.9228	0.1827	3.3518
Single	0.2190	1.98234	1.4211	2.2301	0.3791	2.1007
Sex of household head						
Female		1.00		1.00		1.00
Male	0.0962	2.4521	0.1476	2.4196	0.1009	2.4302
Region of residence						
Dodoma					0.0000*	3.8052
Morogoro						1.00
Constant	1.5302					
Model Chi^2	0.0000					

*Significant at *P*< 005, unmarked= not significant

2005; Saaka 2014). The remarkably low level of knowledge about iron deficiency anaemia among caregivers is likely related to the low educational attainment of the study group (most subjects had no formal education or were educated only to primary level). Likewise, a study by Upadhyay et al. (2011) reported that mothers had poor knowledge of foods rich in iron and their level of education was significantly related to their knowledge about nutrition.

The high number of households consuming salt that is not iodized may imply that half of our study population is exposed to iodine deficiency disorder. This is known to cause significant damage to child development, including decreased cognitive ability due to adverse effects of its absence on the central nervous system (Müller and Krawinkel 2005). Comparing these results with those of the Tanzania national survey on iodine deficiency (Assey et al. 2009), households in our

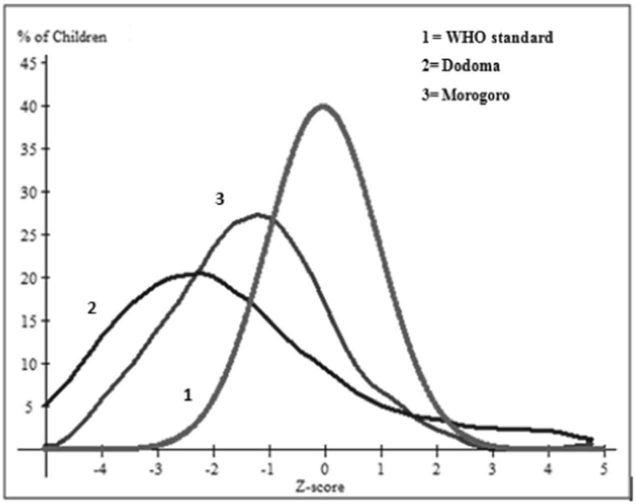

Fig. 1 Comparison of child stunting in Tanzania with WHO standards

survey population showed lower rates of use of iodized salt compared to the national rate of 81% in rural areas. Even though Dodoma and Morogoro were indicated to have adequate salt iodation (Assey et al. 2009), the reason for lower household consumption of iodated salt in these areas could be the complex process of supplying potassium iodate, especially to small-scale salt producers. Increasing the supply of potassium iodate to small-scale salt producers in remote areas like the villages of this study and provision of community education on the adverse health effects of consuming salt that is not iodized should improve the situation. There are current attempts by the Government of Tanzania to fortify iodine in wheat flour, edible oil and in complementary foods to address this nutritional problem (Assey et al. 2009).

Factors influencing child nutritional status for the study sample from villages in Morogoro region included a child's age, duration of breastfeeding, cultivated land size, literacy and BMI of the mother. These were important predictors of nutrition status. Children born to mothers with a BMI of less than 18.5 are 2.5 times more likely to be stunted than children born to mothers with a BMI above 18.5. Stunting in children born to underourished mothers can also be explained by the lack of attention to the importance of the first 1000 days of an infant's life where optimal nutrition and healthcare for both the mother and infant can ensure growth and neurodevelopment of the children and their long term growth outcomes (UNICEF 2012). In addition, the nutritional status of the mother affects the growth of the unborn baby and determines birth weight (Kapil 2007). Similarly, studies by Kapil (2007) and Maberly et al. (2003) observed an association between maternal BMI and child stunting.

For the study samples from villages in Dodoma region, a child's sex and age, duration of breastfeeding, household size, cultivated land size, use of iodized salt and the distance to a water source were important predictors of nutrition status of the child. Boys were found to be 2.4 times more likely to be stunted than girls. Sex related differences in child growth have been reported in other studies in Africa. For example, more boys than girls aged one year were stunted in Ethiopia (Mekonnen et al. 2005). This is best explained as a biologically determined rather than socially-determined difference.

Results from these two regions with different agro-ecological conditions (semi-humid Morogoro and semi-arid Dodoma) suggest that determinants of undernutrition in children may differ based on prevailing conditions in the region. The combined model (using both Morogoro and Dodoma data) identified the following factors: age of the child, duration of breastfeeding, literacy status of the mother, cultivated land size, use of iodized salt, distance to a water source and the agro-climatic region. It was shown that the risk of stunting in children increases with age from seven to 24 months but the risk falls to some extent when a child reaches 25–36 months and then increases again when a child is 37–59 months old. The lower level of stunting in children below seven months may be due to the benefits of exclusive breastfeeding in the first months of a child's life. An increased risk of stunting at age seven to 24 months could be due to the challenges associated with the introduction of complementary foods. Some complementary foods may not be nutrient dense, less diversified and the level of hygiene associated with their use may inadequate (Mamiro et al. 2005a, b). Reduction of risk at age 25 to 36 months could be explained because at that age the child has stopped breastfeeding completely and is newly exposed to a variety of foods in increased quantity compared to the period of breastfeeding.

Children who were breastfed for less than 12 months were 2.7 times more likely to be stunted than their counterparts breastfed for 12–24 months. This is likely due to the benefits of breast milk at infancy. Breastfeeding offers anti-microbial, nutritional and hygienic benefits to infants which have large impacts on child survival and help prevent poor growth and stunting. Breastfeeding reduces the risk of illness and complements nutrient levels in complementary foods (Leon-Cava et al. 2002). Other studies (Fikadu et al. 2014; Simondon et al. 2001) have reported non-breastfed children to be more stunted compared to those that are breastfed, due to the benefits of breast milk enhancing growth. Results further indicated that children born to mothers who cannot read and write were 1.9 times more likely to be stunted than children born to mothers that can. A possible reason for this is that literate mothers can directly understand and follow health related messages in print media; they can also read medical instructions for the treatment of child illnesses and act upon them. This is consistent with other studies which reported that children born to literate mothers were less likely to be stunted compared to those born to other mothers (Ali et al. 2005; Joshi et al. 2011). This may be because literate mothers have learnt some of the practices in school or from other sources of knowledge and awareness campaigns. Children from larger households (with more than ten members) were more likely to be stunted compared to children from households with fewer than ten. Other studies (Kavosi et al. 2014; Saxena et al. 1997) also indicated an increased risk of child malnutrition in larger families. This could be because the quantity and quality of food intake and the ability to access quality healthcare are usually difficult to maintain in larger families, especially of lower income strata. The likelihood of being stunted was also found to be 1.7 times higher in children coming from households that consume unfortified/non-iodized salt compared to children from households that consumed iodized salt. This is likely to be because of the benefits of iodine in growth since good iodine status has been shown to increase child growth (Zimmermann 2008). Similarly a study by Semba et al. (2008), reported that households utilizing inadequately iodized salt were more likely to have children who were stunted, underweight and wasted compared to households that used salt with sufficient iodine. This may also be explained because iodine is required for the synthesis of thyroid hormones that are critical for development and growth of the foetus. If maternal iodine is inadequate and supplemental iodine not provided, gestational growth retardation and low birth weight are likely to result (Ozdemir et al. 2013). The implication for adequate salt iodation in Tanzania is that thousands of child deaths will be prevented and millions of children will be spared from mental retardation.

The probability of being stunted was found to be 3.1 times higher in children from households that had a cultivated land size of two acres or less compared to children from households with more than 2 acres. The close relationship we found between cultivated land size and child stunting is probably because households that cultivate larger areas of land are better able to produce enough food to feed their family members. Similarly, a study in Ethiopia reported increased risk of malnutrition in participants that had smaller farm lands compared to those with larger ones (Haileslassie et al. 2013). Cultivated land size influences crop yields and the diversity of cropping and hence the levels and diversity of consumption. In addition, larger farms cultivate some cash crops (for income) which in turn may raise the likelihood of adequate food consumption within households, especially during drier seasons (Fischer et al. 2005).

Children of households that walk more than sixty minutes to a source of water were 2.8 times more likely to be stunted than children from households that are within thirty minutes of the water source. This may be associated with an unfavourable health environment caused by insufficient water supply and hygiene which can raise the likelihood of infectious diseases and indirectly lead to certain types of malnutrition. Longer walking distances to water sources also reduces the quality of care and feeding frequency because of a lack of time for care and food preparation; most time is spent in fetching water for household and other uses. Reports also suggest that infectious diseases and other negative impacts caused by an insufficient supply of water are increased when the water sources are located away from the households (World Vision 2011). The observed higher risk of child stunting in Dodoma may be due to differences in agro-climatic conditions, with Dodoma being drier than Morogoro, food production is limited and more vulnerable to climatic variation. Climatic conditions may affect the stability of food supplies in semi-arid areas where crop yield is likely to be lower due to a scarcity of rainfall, especially where small-scale irrigation and rainwater harvesting technologies are absent. In such areas, rainfed agriculture is sensitive to temperature and rainfall conditions and prone to frequent droughts that lead to crop failures (Liwenga 2003; Ludi 2009), which in turn affects the diversity and amount of food available for consumption (Amjath-Babu et al. 2016). In contrast, in sub-humid climates, rain fed agriculture is more reliable and favours food production ((Ludi 2009). Nevertheless, even under favourable conditions, differences in economic status, and in cultural and dietary patterns may be decisive in determining nutritional status (Liwenga 2003).

Conclusions and recommendations

This study analyzed the nutritional status of children and their care givers and examined the factors influencing stunting among children in two rural districts of Tanzania with differing agro-climatic conditions. The level of undernutrition was high in both study areas; about 41% of children were stunted and 17% anaemic. A high proportion of mothers/caregivers in this study were less knowledgeable about matters related to nutrition. The relationship of malnutrition to agro-ecological conditions was evident in this study. In semi-humid Morogoro, determinants of stunting were a child's age, duration of breastfeeding, cultivated land size, literacy status of the mother and BMI of the mother. In semi-arid Dodoma, sex and age of a child, duration of breastfeeding, household size, cultivated land size, use of iodized salt, and the distance to a water source were identified as important determinants of childhood stunting. A combined model clearly showed the overall effect of agro-ecological zones on nutritional status. How weather and agro-climatic variations cause more nutritional insecurity and hence a higher rate of stunting in Dodoma region was explained. In summary, our study shows that agro-climatic variations can partially but significantly predict observed variation in child stunting.

From our study we recommend the following:

- Interdisciplinary interventions will be needed to ensure adequate nutrition. Changes to children's diets, feeding schedules and the feeding environment are required in order for these children to catch up to normal growth.
- Nutritional recommendations and interventions should not be too general and should take conditions specific to agro-climatic environments into consideration. Therefore, providing public and household-based nutrition training to women in rural areas while taking into account the agro-climatic conditions of the localities may help to reduce the problem of food and nutrition insecurity. To accomplish this, collaboration is essential among different agencies such as local government, non-governmental organizations, medical personnel and the local communities. Land reform plans that encourage the re-allocation of land could be supported to help farmers who do not own enough land for cultivation.
- Behaviour Change Communication (BCC) activities should be employed to address knowledge gaps, attitudes and beliefs in order to improve poor nutritional knowledge identified in the study. Special programmes to encourage breastfeeding up to 24 months and improve the health status of breastfeeding mothers can also be devised.
- There is a need to improve the coverage of micronutrient supplementation programmes, including iron-folate and vitamin A supplementation. Currently, Vitamin A supplementation is delivered twice-a-year among children aged 6–59 months and is linked with de-worming. Vitamin A supplementation is also being implemented among postpartum women. The current approach, that decentralizes the activity to health facilities, excludes villages like Ilolo in our study area since it does not have a health care facility.
- There is a need to improve access to potable and portable water through the provision of common bore-wells that can cater for the drinking water and household water needs of residents in areas where there is currently a need to walk 60 min or more to fetch water.
- General programmes to increase literacy among women could complement and facilitate the initiatives to reduce stunting.
- An in-depth micronutrient survey should be planned to understand the full impacts of the high prevalence of stunting observed in the survey, especially in Dodoma region, and to inform a longer term plan that may include new programmes on food fortification.
- There is need for further research to document the determinants of stunting, wasting and underweight across all agro-ecological zones.
- Finally, increased support to improve production conditions in rain fed regions such as by promoting water harvesting practices and providing irrigation facilities can be advocated to raise the amount, stability and diversity of foods produced in these regions.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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