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Mshida, Hoyce Amini

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Water, Sanitation, and Hygiene Practices Associated with Nutritional Status of Under-Five Children in Semi-Pastoral Communities Tanzania

Hoyce Amini Mshida,[1] Neema Kassim,[1]* Emmanuel Mpolya,[1] and Martin Kimanya[1,2]

[1]*School of Life Sciences and Bio-Engineering, Nelson Mandela African Institution of Science and Technology (NM-AIST), Tengeru, Arusha, Tanzania;* [2]*Department of Rural Economy and Agriculture, African Union Commission, Addis Ababa, Ethiopia*

Abstract. Undernutrition among under-five children is a public health concern in developing countries and has been linked with poor water, sanitation, and hygiene (WASH) practices. This study aimed at assessing WASH practices and its association with nutritional status of under-five children in semi-pastoral communities of Arusha. The study was cross-sectional in design. Mother–child pairs from 310 households in four villages of Monduli and Longido were involved. Weight and height of children were measured using weighing scale and length/height board, respectively. Children's age was recorded using clinic cards. Hemoglobin level of each child was tested using Hemo Cue® Hb 201 + photometer (HemoCue AB, Ängelholm, Sweden) machine. Structured questionnaire was used to gather information on WASH, child morbidity, demographic, and sociocultural characteristics. Prevalence of stunted, underweight, wasted, anemia, and diarrhea were 31.6%, 15.5%, 4.5% 61.2%, and 15.5%, respectively. Children with diarrhea 2 weeks preceding the survey ($P = 0.004$), children using surface water for domestic purposes ($P < 0.001$), and those with uneducated mothers ($P = 0.001$) had increased risk of being stunted and underweight. Children introduced to complementary foods before 6 months of age ($P = 0.02$) or belonging to polygamous families ($P = 0.03$) had increased risk of being stunted. Consumption of cow's milk that is not boiled ($P = 0.05$) or being a boy ($P = 0.03$) was associated with underweight. Prevalence of undernutrition among under-five children in the population under study was alarming and it could be associated with poor WASH practices and other sociocultural factors. This study underlines the importance of incorporating WASH strategies in formulation of interventions targeting on promotion of nutrition and disease prevention in pastoral communities.

INTRODUCTION

Poor nutritional status among under-five children is a public health concern in developing regions, and it is responsible for more than one-third of under-five children deaths globally.[1] The problem may impact negatively on child physical and mental development, increase vulnerability to infectious diseases, and increase severity and delay recovery from illnesses.[2] It may also lead to chronic child morbidities and disabilities, including impaired mental development.[3] Poor nutrition during early stage of a child's life may also lead to stunting, a condition which is irreversible and associated with a number of complications, including poor school performance.[4] In some severe cases, it may lead to clinical conditions such as kwashiorkor, marasmus, and even death.

Globally, one in every five under-five children are stunted.[5] Despite the fact that the rate of stunting had declined in some regions, including Asia, by one-third from 1990 to 2015, this has not been the case for sub-Saharan Africa (SSA).[6] Also, one of 13 under-five children were wasted,[7] whereas one in every seven under-five children remained underweight of which SSA and Southern Asia accounted for nearly 90% of all cases. The current Demographic and Health Survey of Tanzania reported that 34.7% of under-five children were stunted, 13.7% underweight, and 4.4% were wasted.[8]

A number of environmental, social, demographic, cultural, and economic factors contribute to poor nutritional status among children younger than 5 years of age.[9] The indirect causes of undernutrition include food insecurity, improper child-care practices, lack of access to health-care services, low maternal education, and environmental conditions such as poor water, sanitation, and hygiene (WASH) practices.[2] Likewise, undernutrition is directly associated with inadequate dietary intake and diseases such as cholera and intestinal worms; the conditions which are believed to be associated with poor WASH practices. Diarrhea-associated infections, for example, tend to inhibit absorption of nutrients by the body and may lead to compromised immunity. Also, undernourished children become vulnerable to infections due to deteriorated immune system,[9,10] leading to a vicious cycle of infections and undernutrition.[6] Other infections, including intestinal worms, may interfere with digestion process by competing with the host for nutrients.[11,12] The overall disease burden and treatment costs of diarrhea-associated infections and its consequences may affect the households' food budget, which may limit the amount of food available, resulting in risk of insufficient nutrient intake and undernutrition among vulnerable groups, particularly under-five children.[13–15]

On the other hand, studies have reported that children living in unsanitary and unhygienic environments may become undernourished even in the absence of diarrhea or intestinal worms.[10] A child may develop a condition known as environmental enteropathy as a result of repeated ingestion of fecal bacteria, which in turn may overload to the gut and cause malabsorption, leaking mucosa, poor villi functioning, and inflammation of gut cells, the conditions that may lead to body faltering.[11,13,16] A study carried out in India documented that even children coming from wealthy families where balanced meals were available were often stunted.[17] It has also been estimated that improved WASH practices may rescue up to 45% of child deaths a year globally that are due to undernutrition.[18,19] Furthermore, the global efforts to combat child malnutrition are presently focusing on multidisciplinary interventions due to the fact that nutritional interventions with

* Address correspondence to Neema Kassim, Department of Food Biotechnology and Nutritional Sciences (FBNS), School of Life Sciences and Bio-Engineering (LiSBE), Nelson Mandela African Institution of Science and Technology, P.O. Box 447, Tengeru, Arusha, Tanzania. E-mail: neema.kassim@nm-aist.ac.tz

a coverage of 90% can only achieve 20% improvement in growth faltering.[9] However, most of the people in developing countries still follow poor WASH practices.[20,21] For the case of Tanzania, 42.7% of its people rely on unsafe water sources for their domestic uses, only 36.8% have access to piped/tap water, 14% still practice open defecation, and 76.4% use traditional pit latrines.[22,23] Likewise, some people have to walk long distances to fetch water that may limit the amount of water available in the household for practicing good hygiene. The task of fetching water is the responsibility of women and children and may also affect time for mothers to feed and take care of the youngest children.[24]

Water, sanitation, and hygiene practices are fundamental human rights and contribute significantly to the nutritional status of under-five children. However, these practices are hampered by poor infrastructure and low socioeconomic status of many households in low-income countries. Water for domestic purposes is scarce among pastoral communities and majority rely on surface water which is unsafe for human consumption.[25] In addition, this water source is shared between human and both wild and domestic animals.[26] Water treatment measures such as boiling are yet to be implemented because of financial and cultural barriers.[27] Furthermore, open defecation is still practiced in most communities and the few with sanitation facilities own traditional pit latrines, which can pose a risk of fecal contamination.[28] At the same time, foods are unhygienically prepared, stored, and consumed in open environments that can be contaminated by various flies. Kitchen wares and clothes are unhygienically handled, and handwashing is rarely practiced.[29] Cold chains, including refrigeration, are not feasible because of limited infrastructure and unaffordability.[30] In addition to using unsafe water, hygiene-sensitive household facilities such as kitchen and latrine surfaces are not easily and frequently washed, increasing susceptibility to harbor pathogens.

Furthermore, World Health Organization (WHO) recommends exclusively breastfeeding children for 6 months[2]; however, most of the children in developing countries are introduced to complementary foods before the recommended age.[31] Such practice has been reported as one of the major contributing factors to diarrhea-associated diseases and undernutrition among under-five children.[32] In addition, most complementary foods are unhygienically prepared and stored and may pose a risk of food-borne diseases to children.[33]

Several studies have reported a strong correlation between WASH practices and nutritional status among under-five children. Likewise, WASH practices in semi-pastoral communities may be poor but the extent such practices influence nutritional status of under-five children has not been investigated. As a result, efforts to combat undernutrition among under-five children in the semi-pastoral and pastoral communities do not incorporate WASH interventions into nutrition interventions. This study, therefore, intended to assess the influence of WASH practices on nutritional status among children younger than 5 years of age in semi-pastoral communities of Longido and Monduli Districts of Arusha. Findings from this study are crucial in supporting WASH interventions, including hygiene behavioral change initiatives, in addition to vaccination, supplementation, and fortification interventions that have received much attention in developing countries, particularly Tanzania.

MATERIALS AND METHODS

Study area. The study involved semi-pastoral communities of Longido and Monduli districts of Arusha region, in the northeastern corner of Tanzania. The two districts were selected based on the recommendation made by a previous survey that recommended an evaluation of a correlation between nutrition and environmental conditions.[34,35] Longido district has an area of 7,885.01 km^2 and a population of 123,153, and is divided into 18 wards. The Maasai tribe is the dominant ethnic group in both districts and majority are semi-pastoralists in nature. To the north, the districts are boarded with Kenya; to the east, the Kilimanjaro region; to the south, the Manyara region; and to the west, the Simiyu and Mara regions. Monduli district has an area of 6,992.67 km^2 and a population of 158, 929 people, and it is divided into 20 wards.[36]

Study design, sample size, and sampling protocol. The study design was cross-sectional. Sample size was calculated based on the cross-sectional study sample size calculation formula of $n = z^2P\,(100 - P)/\varepsilon^2$, where n is a minimum sample size, z is a value corresponding to the confidence level = 1.96, P is prevalence of stunting in Arusha region which is 36%,[36] and ε is a margin of error which is 5% with confidence interval of 95%. With the formula aforementioned, a total of 354 children aged between 6 and 59 months inclusive were determined as the adequate sample size. However, the number was increased to 373 to carter for 5% attrition rate (or a response rate of 95%). During data management and cleaning, a total of 310 observations were eligible for further analysis. This change of sample size from 373 to 310 causes an increase of about 10% in the margin of error (from 5% to 5.48%), which is considered safe for our purpose.

The sampling frame for this study was under-five children aged between 6 and 59 months, inclusive. Simple random sampling technique was used to obtain four wards, two from each district. Four villages, one from each ward, were randomly selected, whereby Orbomba and Kimokouwa villages from Longido, and Meserani and Makuyuni villages from Monduli were selected to participate in the study. All households with under-five children were sorted from the household's register book available from the local government authority with the help of village executive officers. The list of households was then entered to the excel software for randomization. Households to be surveyed were sorted using computer-generated random numbers. Selected households were then identified by sub-village executive officers before the survey. For households with more than one under-five child or twins, only one child was randomly selected for the study.

Assessment of child's nutritional status and hemoglobin levels. Anthropometric measurements of height and weight were taken from each index child. Length of each child aged 6–23 months was measured using the United Nations International Children's Education Fund (UNICEF) length board and weight was measured using a hang-up weighing scale (Seca Model 881; Seca Corporation, Chino, CA). For children aged between 24 and 59 months, the UNICEF height board and a stand-weighing scale were used, respectively. Age was recorded from the child clinic card. World Health Organization z score indices were used as reference where z score of < -3, between < -2 and ≥ -3 were regarded as severe and moderate undernutrition, respectively, and ≥ -2 was regarded as normal.[37] Hemoglobin levels of the index children were measured using Hemo Cue Hb 201 + photometer machine, cuvette, and disposable lancet and recorded in g/dL. Categorization of Hb levels was carried out based on WHO standards where Hb level > 11 was regarded as normal, whereas < 7, 10–10.9, and 7–9.9 were regarded as severe, mild, and moderate anemia, respectively.[38]

Survey of WASH practices. A standardized questionnaire adopted from the UNICEF survey on monitoring WASH practices at household level in Gaza in 2009 was customized to fit the semi-pastoral communities and administered to mothers/caregivers of the index children. The questionnaire was used to collect data on WASH, sociodemographic characteristics, morbidity, and child-feeding practices. Diarrhea-associated infections were regarded as a proxy for common infections. The questionnaire was pretested in semi-pastoral communities of Arusha district by well-trained enumerators and technicians thereafter improved accordingly. During the survey, other tools, including Hb machine, length/height board, and weighing scale, were validated regularly using standardized tools from the respective district hospitals.

Ethical clearance and informed consent. Ethical clearance was obtained from National Institute for Medical Research of Tanzania. Informed written consent was sought from mothers or caregivers of children under study, before administration of the questionnaire, taking anthropometric measurements, and testing for child hemoglobin levels. Confidentiality regarding the information collected from the survey was ensured.

Data analysis. Data cleaning was performed daily during the survey by exchanging questionnaires among enumerators to see if there was any missing data and in case of missing data, the respective household was consulted. Information about WASH, sociodemographic, morbidity, and child-feeding data were then double-entered into Epi-data version 3.3.1. by two different qualified personnel and then transferred into Statistical Package for Social Sciences (SPSS) version 20 (IBM, Armonk, NY) for analysis. For anthropometric data, Emergence Nutrition Assessment for SMART software was used to calculate z scores, including weight-for-height, weight-for-age, and height-for-age z scores.[39] After calculating z scores, data were transferred into SPSS for further analysis. Descriptive statistical analysis such as mean, range, standard deviations, frequencies, and percentages was performed to determine the sociodemographic characteristics of the population. Logistics regression analysis was performed to find out the relationship between nutritional status of under-five children (dependent variables) and WASH practices and child morbidity (independent variables). Multivariable analysis, specifically the backward Wald method for control of confounders, was used to look for factors associated with undernutrition among children less than 5 years of age. Confounders, including child deworming, vaccination against rotavirus, handwashing with soap, water treatment, birth weight, child-feeding frequency, and breastfeeding status, were controlled through multivariate analysis. Any variable with P value < 0.05 were regarded as a significant factor associated with undernutrition.

RESULTS

Sociodemographic characteristics of the study participants. The study engaged 310 mothers/caregiver–child pairs. Forty-eight percent of the households were from Longido and the rest from Monduli. Mothers aged 16–19 years constituted the smallest group (3%), whereas those aged 20–29 years constituted the largest group (56%). About half (51%) of the mothers had formal education. Also, 95.6% of the households were headed by the father and more than half (52%) of the households had more than one child younger than 5 years of age. The age distribution included 19% children aged 6–11 months, 20.6% aged 12–23 months, 20% aged 24–35, 19% aged 36–47 months, and 21.6% aged 48–59 months. The maximum number of under-five children in the households visited was four and the minimum was one (Supplemental Table 1).

Child-feeding practices. A total of 79% mothers reported breastfeeding ad libitum. About 82% of the children were started on complimentary foods before 6 months of age. More than half of the children (56%) were fed up to three times per day, whereby 52% consumed cooked cereal-based foods in the form of porridge and 49% consumed fat and fat products twice per day. Sugar/sugar products and milk/milk products were consumed once per day by 90% and 60% of the children, respectively. Beans and nuts were also consumed once per day by 36% of the under-five children. The majority of the children reported not consuming eggs (52%), juice and fruits (98%), vegetables (61%), potatoes (63%), or tubers (52%).

Water safety and accessibility, sanitation, and hygiene practices. Forty-six percent of respondents reported depending mainly on surface water for domestic purposes, 50% had access to tap water, whereas the rest were using other sources including shallow wells. The majority (72%) of respondents were not sure of the safety of the water, 90% of them reported not treating water at the point of use, whereas only 4% reported treating water by boiling before drinking, although no observation was carried out on how drinking water was boiled and stored. Again, the condition of the cooking water storage containers was generally poor in 65% and 57% of the households in Longido and Monduli districts, respectively. Figure 1 shows the condition of cooking water storage containers in one of the households in Meserani village, Monduli.

However 86% of respondents who reported using surface water reported sharing the same water sources with animals. Of the two categories, only 16% of respondents reported access to the recommended amount of water per person per day of 20 L[40] for general use purposes. In addition, water sources were visited and observation on the hygiene condition of these sources was noted. Figure 2 shows one of the unprotected boreholes in Orbomba village in Longido district.

Regarding sanitation, 87% of the households did not have toilets. The majority (52%) of these households did not build toilets because their culture restricts Maasai men from being seen to have visited toilets. Ninety-six percent of those who did not have toilets practiced open defecation and the rest used other means, including defecating in cattle's traditional *boma*. Eighty-eight percent of those reported to have toilets were using traditional pit latrines and 70% of the toilets were shared by more than one family. Sixty-five percent of respondents reported giving children feces to dogs as food. About 8% of respondents used cow dung as charcoal in cooking, whereas 5.5% used it as manure for their farms. Five percent of respondents reported using garbage to feed animals, whereas 4% reported disposing to the garbage pits.

The majority (97%) of the participants reported washing hands at different moments, although only 11% of them

FIGURE 1. Households' cooking water storage containers in one of the surveyed households. This figure appears in color at www.ajtmh.org.

reported use of soap during the four critical moments, which are before eating/feeding the child, after visiting toilets, after touching dirty things, and before preparing food. Eighty-six percent of the respondents reported washing hands only before/after meals. However, no observation was carried out to confirm how it was practiced or whether the handwashing facilities were available or types of materials used for handwashing. All respondents reported feeding their under-five children with cows' milk out of which 22% were using unboiled cows' milk. Sixty-nine percent of the respondents were using vacuum flasks/hotpots and 31% were using calabash (traditionally known as *kibuyu*) to store already prepared complementary foods. The majority (94%) of them were feeding their children using hands, cups, and spoons interchangeably based on the convenience specific to the form of food, whereas very few (4%) reported to serve slightly hot food to children. Only 3% of respondents reported washing children's utensils with hot water and soap, drying, and covering them. The majority of children (89%) wore dirty clothes, 81.3% had long dirty nails, and 40% were barefoot.

FIGURE 2. Unprotected borehole in Orbomba village at Longido District. This figure appears in color at www.ajtmh.org.

Nutritional status, hemoglobin levels, and diarrhea among under-five children. Table 1 shows the percentage of distribution of undernutrition and diarrhea-associated problems in the population under study (Supplemental Figures 1–3).

Factors associated with underweight among under-five children. Multivariate analysis showed that children in households relying on surface water for domestic purposes were nine times more likely to be underweight than those in households with access to tap water, after been adjusted for water treatment at the point of use (adjusted odds ratio [AOR]: 9.2; 95% confidence interval [CI]: 9.1–60.5). Children having diarrhea in the past 2 weeks were 2.5 times more likely to be underweight than those who did not have diarrhea (AOR: 2.5; 95% CI: 1.1–6). Children fed on unboiled cow's milk were 2.5 times more likely to be underweight than those fed on boiled cow's milk (AOR: 2.5; 95% CI: 1–6.7). Children from mothers with no formal education were three times more likely to be underweight (AOR: 2.9; 95% CI: 1.5–5.4) than children from mothers with formal education. Boys were two times more likely to be underweight than girls (AOR: 2.1; 95% CI: 1.1–3.9) (Table 2).

Factors associated with stunting among under-five children. Children from households using surface water for domestic purposes were 13 times more likely to be stunted than children from households using tap water for domestic purposes after been adjusted for water treatment at the point of use (AOR: 13; 95% CI: 5.8–30). Children introduced to complementary foods before the age of 6 months were about three times more likely to be stunted than those introduced to complementary foods at the age of 6 months and older (AOR: 2.8; 95% CI: 1.2–6.5). Children with diarrhea during the past 2 weeks were about three times more likely to become stunted than those reported not having diarrhea (AOR: 2.6; 95% CI: 1.4–5). Children who belong to polygamy families were 2.5 times more likely to be stunted than those who belong to monogamous/single wife families (AOR: 2.5; 95% CI: 1.4–4.4) (Table 3).

DISCUSSION

This study shows that in the semi-pastoral communities of Longido and Monduli, the use of surface water for domestic purposes was associated with stunting and underweight among under-five children. This could be due to high contamination of surface water resulting from unsanitary practices such as open defecation or pollution by animals drinking from or defecating inside the water sources,[25,41] which was

TABLE 1

Current status of undernutrition and diarrhea problems among under-five children

Variable	*n*	Percentages
Stunting	98	31.6
Underweight	48	15.5
Wasting	14	4.5
Hemoglobin levels	190	61.2
Diarrhea	48	15.5

TABLE 2
Underweight among under-five children and its associated factors

Variable	*n*	Underweight %	COR (95% CI)	*P* value	AOR (95% CI)	*P* value
Use of surface water	144	32.2	7 (3.5–14.1)	0.000	9.2 (9.1–60.5)	0.000*
Introduction of CF before 6 months	278	18.8	0.8 (0.3–2.2)	0.7	1.9 (0.7–5.9)	0.3
Having diarrhea 2 weeks before survey	88	19.3	1.3 (0.7–2.5)	0.4	2.5 (1.1–6)	0.004*
Consuming unboiled cow's milk	67	17.7	1.6 (0.7–3.6)	0.3	2.5 (1–6.7)	0.05
Keeping CF in kibuyu	97	17.4	1.3 (0.6–2.4)	0.5	1.5 (0.7–3.8)	0.4
Mothers with no education	145	23.4	2.6 (1.3–5.1)	0.002	2.9 (1.5–5.4)	0.001*
Being a boy	155	18.2	2.1 (1.1–4.2)	0.04	2.1 (1.1–3.9)	0.03*

CF = complementary foods; COR= crude odds ratio. This is a summary table of Supplemental Table 3.
* P value ≤ 0.05.

also reported by most of the respondents. Furthermore, during the rainy season, water runoffs from surroundings can carry garbage and fecal matters and find its way through streams to the ponds and contaminate surface water. People using surface water for domestic purposes may be infected with waterborne diseases if measures to treat such water before consumption are not taken. On the other hand, piped water sources such as tap water may be comparatively less contaminated and, therefore, reduced the risks of waterborne diseases.[42] The finding was mirrored by a study carried out in Tanzania,[43] which reported that children using unsafe drinking water sources had increased risk of being stunted than those who had access to tap water. Another study carried out in Bangladesh reported that children belonging to wealthy families, where clean and safe water is reliable, were less undernourished than those belonging to the poor wealth quantum who do not have access to safe water.[44] However, interventions to improve water quality and supply could significantly improve nutritional status among children less than 5 years of age.[45]

Poor WASH practices have been reported to contribute to diarrhea-associated infections, which contribute to 50% of undernutrition among under-five children globally.[6] Findings from this study showed that children who had diarrhea-associated infections for the past 2 weeks before the survey date had increased risk of being stunted and underweight compared with those who had not. This could be due to the fact that diarrhea tends to affect absorption of nutrients by the body because of limited time the food spend in the stomach lowers appetite and whatever little food taken is directed into recovery from the infection.[32,46] Likewise, undernutrition may prolong duration and frequency of diarrhea and worsen the overall health condition of the child.[11] Diarrhea may also have indirect contribution to undernutrition through the costs for medication that households spend in treatment that may affect their food budget.[9] The findings from this study are similar to those of a study carried out in Tabora, which reported an association between diarrhea and undernutrition.[47] A study carried out in Ethiopia also confirmed that 12% of stunting among under-five children could be eliminated by preventing diarrhea-associated infections through WASH interventions.[48] Black[49] also reported that up to 25% of stunting among under-five children may be due to diarrhea episodes[50] and reported an association between childhood diarrhea and stunting. Therefore, it is possible that improved WASH practices serves as a means of improving child nutritional status through reduction in diarrhea-associated infections and other WASH-related infections.

The study further confirmed that introduction of complementary food before 6 months of age is a common practice to the semi-pastoral communities. Normally, the gut of the child is not well established to digest semisolid foods. Therefore, a child may be vulnerable to gastrointestinal infections due to increased gut permeability.[51] Early introduction of complementary foods to children may also cause food-borne infections, environmental enteropathy, and parasitic infections as a result of unhygienic handling of such foods, including storage of such foods in ambient temperatures, use of unsafe water to wash storage containers, use of unhygienic kitchen clothes to dry child utensils, or not washing hands with soap when preparing such foods.[30] Study from Kenya reported an association between stunting and early introduction of complementary foods to children younger than 6 months of age.[52] Another study from Mali revealed that about 55% of complementary food samples had fecal coliform bacteria and could be the main contributing factor to poor nutritional status and infections among under-five children.[53] It is therefore important to promote food hygiene practices and exclusive

TABLE 3
Factors associated with stunting among under-five children

Variable	*n*	Stunting %	COR (95% CI)	*P* value	AOR (95% CI)	*P* value
Use of surface water	144	48.8	3.5 (2.2–5.8)	0.000	13 (5.8–30)	0.000*
Introduction of CF before 6 months	278	50	2.3 (1.1–4.9)	0.02	2.8 (1.2–6.5)	0.02*
Diarrhea in the 2 weeks before survey	88	41	1.8 (1.1–2.9)	0.03	2.6 (1.4–5)	0.004*
Consuming unboiled cow's milk	67	32.8	1.1 (0.6–1.9)	0.9	1.8 (1–3.8)	0.1
Keeping CF in kibuyu	97	36.1	1.3 (0.8–2.2)	0.3	1.2 (0.6–2.4)	0.7
Mother having more than two under-five children	41	45	2 (1.1–3.5)	0.03	1.5 (0.9–2.1)	0.4
Polygamous marriage	278	50	2.3 (1.1–4.9)	0.02	2.5 (1.4–4.4)	0.003*
Children aged 2 years and younger	132	56.5	3.4 (1.3–8.6)	0.01	1.7 (1–2.6)	0.2
Mother being younger than 30 years of age	68	37.2	1.1 (0.6–1.9)	0.2	1.2 (0.7–2.3)	0.1
Mothers with no education	145	43.4	3.4 (1.6–5.9)	0.000	2.8 (1.4–4.8)	0.001*

CF = complementary foods. This is a summary table of Supplemental Table 2.
* P value ≤ 0.05.

breastfeeding for 6 months as per WHO recommendations as means of reducing food- or waterborne infections among under-five children.[46,49,54]

Furthermore, the findings revealed that children from mothers with no formal education had increased risk of being stunted and underweight compared with children from mothers with formal education. This could be due to the fact that educated mothers often have better understanding of food, nutrition, and hygiene aspects, which enhance appropriate child feeding and child care than their counterpart.[50,55] In addition, educated mothers may contribute directly and indirectly to the socioeconomic condition of the households,[56,57] a situation that may contribute to the increase in food choices, accessibility, and affordability within the households. It has also been reported that every additional year of education to a mother reduces child mortality by 5–10% and education is the best investment for reducing poverty, improving health and well-being of the household, and the entire community.[2]

Polygamous marriage is a common practice among pastoral and semi-pastoral communities of Arusha. Findings from this study revealed that children who belong to polygamous families had increased risk of being stunted compared with children who belong to monogamous families. The reason could be the fact that polygamous families are normally large in size; therefore, whatever resources that are available in the family have to be divided among the large number of family members, and this may have an impact on the nutritional status of children. The findings are in line with studies carried out in Zambia and Ethiopia that revealed an association between stunting and polygamous/large family size.[32,48]

Findings from this study also revealed that being a boy increased the risk of being underweight than being a girl. The findings are in line with findings from a comparison study carried out in six sub-Saharan African countries, which reported higher prevalence of undernutrition in boys than girls.[58,59] In the case of semi-pastoral communities, young girls are always closer to their mothers and, therefore, may be fed more frequently than boys. In addition, young girls from of 3 years and older are sometimes assigned to take care of younger children, including feeding them and hence feed themselves the leftovers. The other possible reason is that young boys spend most of their time outside their homes with their elders grazing cattle and, therefore, may rarely have access to food compared with girls.

Underweight among under-five children was also associated with feeding children on cow's milk that was not boiled. It is likely that during milking, the milk could be contaminated by the host or by the handler and increase the risk of food-borne diseases such as salmonellosis to the users, especially when consumed unboiled. The findings are mirrored by a study carried out in Kenya, which revealed high prevalence of infections among under-five children consuming cow's milk that was not boiled.[60,61]

Prevalence of underweight and stunting among under-five children in the semi-pastoral communities under study was alarming and could be due to poor WASH practices. As previously reported in other studies, diarrhea-associated infections are mainly contributed by poor WASH practices and could contribute to stunting or underweight. The poor WASH practices in this community were the use of surface water for domestic purposes, feeding children on untreated cow's milk, and storing complementary food in *kibuyu*. The study also identified sociocultural practices associated with stunting or underweight. These are polygamy, lack of any formal education, and introduction of complementary foods to children before 6 months of age. This study, therefore, underlines the importance of incorporating WASH practices, including hygiene behavior changing strategies in formulation of interventions that target promotion of nutrition and diseases prevention in pastoralists' communities and similar settings. It also recommends further research to determine and quantify the role of WASH interventions in improving nutritional status among under-five children in pastoral communities.

Study limitations. This study was a cross-sectional design; therefore, the cause–effect relationship between undernutrition and inadequate WASH practices or other studied factors could not be established. Some of the information was obtained through questionnaires and relied on mothers' self-report. This implies that mother's views may be subjected to recall bias. The findings from this study cannot be generalized for all pastoralists' communities as it is based on small sample size from one region. Furthermore, this study neither directly observed any hygiene behaviors nor quantified the microbiological contamination in water, milk, or food to conclude its association with undernutrition. Also, diarrhea-associated infections prevalence was measured once and it may have seasonal effect and reporting bias.

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Note: Supplemental text, figures and table appear at www.ajtmh.org.

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Authors' addresses: Hoyce Amini Mshida and Neema Kassim, Department of Food Biotechnology and Nutritional Sciences (FBNS), School of Life Sciences and Bio-Engineering (LiSBE), Nelson Mandela African Institution of Science and Technology, Tengeru, Arusha, Tanzania, E-mails: mshidah@nm-aist.ac.tz and neema.kassim@nm-aist.ac.tz. Emmanuel Mpolya, Department of Global Health and Biomedical Sciences, School of Life Sciences and Bio-Engineering (LiSBE), Nelson Mandela African Institution of Science and Technology, Tengeru, Arusha, Tanzania, E-mail: emmanuel.mpolya@nm-aist.ac.tz. Martin Kimanya, Department of Rural Economy and Agriculture, African Union Commission, Addis Ababa, Ethiopia, E-mail: martin.kimanya@nm-aist.ac.tz.

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