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*Review*

# Persistent child malnutrition in Tanzania: Risks associated with traditional complementary foods (A review)

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**Despite numerous nutritional interventions that have taken place in Tanzania, the Country still experiences a high rate of child malnutrition. Millions of children suffer from one or more forms of malnutrition resulting in stunting, underweight, wasting and anemia. The growth of children often declines with the introduction of complementary foods around the age of 6 months and continues to decline up to 24 months that have greater implications for health during adult-hood. Poor breastfeeding and child feeding practices augmented by very early introduction of nutritionally inadequate and contaminated complementary foods are major factors contributing to persistent child malnutrition in Tanzania. These complementary foods comprise mainly cereal-based porridges with little or no vegetables and often lacking animal proteins. The promotion of exclusive breastfeeding during the first 6 months and appropriate feeding practices has been the integral parts of the intervention processes taking place in Tanzania. Food safety education is a critical prerequisite in the child health programs and is a cost effective intervention with long term positive impacts. This paper reviews the persistent child malnutrition in Tanzania and the causative factors to highlight risks associated with use of complimentary.**

**Key words:** Child malnutrition, complementary foods, feeding practices, microbial contamination and energy density.

## INTRODUCTION

Chronic malnutrition has been and still remains a persistent problem for young children in sub-Saharan Africa (FAO, 2008). A high percentage of these children fail to reach the normal international standard height for their age often associated with stunted growth. Moreover, the number of undernourished children in sub-Saharan Africa continues to increase and the region has shown little improvement over the past decades (FAO, 2008). Tanzania is faced with the same problem and ranks as the 3rd worst affected Country in Africa with respect to malnutrition after Ethiopia and the Democratic Republic of Congo (DRC). The Country ranks 10th in its contribution to the World's chronically undernourished children (UNICEF, 2009a). According to UNICEF (2009a), 44% of children under 5 years old suffer from stunted growth (low height-for-age) indicating chronic under nutrition, about 4% are wasted (low weight-for-height); a sign of acute under-nutrition and 22% are underweight (low weight-for-age) while an astounding 72% are anemic.

Low adherence to exclusive breastfeeding and very early or delayed introduction of complementary foods is a common occurrence among children in Tanzania. Only an estimated 41% of infants below 6 months of age are exclusively breastfed (NBS and ORC Macro, 2005). Majority of the infants are introduced to cereal-based complementary foods well before the recommended 6 months age for the introduction of 'safe and nutritionally adequate' complementary foods or in rare instances do not receive these until the second year (Onyango, 2003). In Tanzania, complementary feeding generally starts

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early with 7% of children below 2 months, 32% of children between 2 to 3 months and 58% of children between 4 to 5 months (NBS and ORC Macro, 2005). Similarly, about 9% of the children do not receive complementary foods at the critical age of 6 to 9 months. According to a 2004/2005 Tanzania demographic and health survey (TDHS), a number of children below 2 years (24 months) of age do not appropriately receive complementary food, further increasing risks of malnutrition.

Although, the causes of malnutrition have been highlighted by different stakeholders such as United Nations Children Education Fund (UNICEF), the relationship between persistent malnutrition and poor breasting feeding practices, timing of complementary food introduction, low-nutrient dense complementary foods and their safety still remains under reviewed. The present review critically explores factors contributing to malnutrition in Tanzania including poor breastfeeding practices and timing of introduction of complementary foods, their low nutrient density and high level of microbial contamination as a major factor to the persistent child malnutrition in Tanzania.

## THE KEY CONTRIBUTING FACTORS TO THE PERSISTENT CHILD MALNUTRITION IN TANZANIA

### Poor breast feeding practices

Adequate nutrition during infancy and early childhood is fundamental to the development of each child's full human potential. Rapid growth of infants during the first year of life and specifically the first 6 postnatal months requires an adequate supply of nutrients to cope with the rapid development of body muscles and other tissues (Domellof et al., 2002). The first two year postanal period is a "critical window" for the promotion of optimal growth, health and behavioural development. Longitudinal studies have consistently shown that this is the peak age for growth faltering, deficiencies of certain micronutrients and common childhood illnesses such as diarrhea which augment the problem of malnutrition in children (Neumann and Harrison, 1994; Ibrahim et al., 1998; Shrimpton et al., 2001). After the age of 2, earlier stunting is often irreversible (Martorell et al., 1994). Poor breastfeeding and complementary feeding practices, coupled with high rates of infectious diseases, have been reported as the principal proximate causes of malnutrition during the first two year postnatal period.

The world health organization (WHO) recommends that infants should be exclusively breastfed for the first 6 months of life to achieve optimal growth, development and health. Thereafter, to meet their evolving nutritional requirements, infants should receive nutritionally adequate and safe complementary foods with breastfeeding continuing for up to two years of age and beyond (WHO/UNICEF, 2003). Exclusive breast feeding is associated with multiple advantages including child's acquisition of passive immunity against infection, nutrients for physical and mental development, emotional security and closeness to the mother. Breastfeeding drastically reduces deaths from acute respiratory infections and diarrhea which are the two major causes of infant mortality worldwide and in addition to protection from other infectious diseases. Despite these advantages, only 39% of all infants aged 0 to 5 months in the developing world are exclusively breastfed while < 60% of those aged 6 to 9 months continues to be breastfed while receiving complementary foods (UNICEF, 2009b). According to UNICEF (2009b), during 2000 to 2007, the percentage of infants aged 0 to 5 months exclusively breastfed in Sub-Saharan Africa was only 31%. Such a scenario is typical in Tanzania where exclusive breastfeeding during the first 6 months is rarely practiced. The 2004/2005 TDHS shows that only 41% of infants below 6 months of age are exclusively breastfed. Among children under 6 months, younger children are more likely to be exclusively breastfed. For example 70% of infants < 2 months of age received breast milk only compared to 14% of infants aged 4 to 5 months (NBS and ORC Macro, 2005).

Moreover, the exclusive breastfeeding has previously been reported as rare in South Western Tanzania (Poggensee et al., 2004). In Igunga and Mbulu districts exclusive breastfeeding was only practiced for the first two and four postnatal months respectively (Sellen, 1998; Agnasson et al., 2001). In addition to low adherence to exclusive breast feeding, many infants begin to receive cereal-based complementary foods well before the 6-months (Onyango, 2003), the situation that is very common in Tanzania as evident in Table 1 and reported by Hussein (2005). Low adherence to exclusive breast feeding for the first 6 month and risk of diarrhea disease from contaminated complementary foods given to infants well before 6 months of age is believed to contribute to malnutrition observed in infants at this age (< 6months). For instance, 2004/2005 TDHS reports that about 8% of infants below 6 month of age are stunted while about 2.4% are under weight (Table 3) indicating that indubitably malnutrition exists at this age.

## TIMING OF INTRODUCTION OF COMPLEMENTARY FOODS

Complementary feeding is the process of introducing other foods and liquids into the child's diet when breast milk alone is no longer sufficient to meet nutritional requirements and therefore other foods and liquids are needed, along with breast milk. The target age range for complementary feeding is generally 6 to 24 months of age although breastfeeding may continue well beyond the second year. Timely introduction of appropriate

**Table 1.** Exclusive breast feeding and early introduction of complementary foods in Tanzania by age groups for the years 1992, 1996, 1999 and 2005.

| Practice | Year | Age in months | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0-1 | 2-3 | 4-5 | 6-7 | 8-9 | 10-11 |
| Not breast feeding (%) | 1992 | 0.8 | 0.8 | 0 | 2.5 | 0.2 | 0.8 |
| | 1996 | 0.6 | 1.3 | 2.7 | 0.7 | 2.3 | 3.6 |
| | 1999 | 1.1 | 3 | 3 | 1.9 | 3.6 | 4.9 |
| | 2005 | 2.4 | 0.3 | 3.8 | 2 | 1.9 | 3.7 |
| Exclusive breast feeding (%) | 1992 | 42.5 | 23.5 | 7.6 | 5.6 | 1.4 | 0 |
| | 1996 | 55.2 | 27.5 | 8 | 4.1 | 1.7 | 2 |
| | 1999 | 57.8 | 25.4 | 15.5 | 1.5 | 2.9 | 0 |
| | 2005 | 70 | 42.4 | 13.5 | 1.7 | 0.9 | 0.4 |
| Complementary feeding (%) | 1992 | 21.6 | 47 | 76.6 | 84.1 | 94.3 | 96.6 |
| | 1996 | 19.9 | 50.2 | 77 | 91.3 | 85.1 | 93.8 |
| | 1999 | 18.5 | 47.6 | 70.3 | 91 | 89 | 90.1 |
| | 2005 | 7.2 | 32.1 | 57.9 | 88.5 | 93.3 | 94.3 |

Source: TDHS, 1992, 1996, 1999, 2005.

complementary foods promotes good nutritional status and growth in infants and young children (Michaelsen et al., 2000). Too early or too late introduction of complementary foods is not appropriate feeding practice as it carries many risks which contributes to persistent child malnutrition. Unfortunately, both too early introduction of complementary foods (< 6month) and delayed introduction have been reported in Sub-Saharan Africa (Onyango, 2003) and Tanzania in particular (Hussein, 2005; NBS and ORC Macro, 2005).

Although, the introduction of complementary foods in Tanzania has improved as shown by available statistics from 1992 through 2005 (Table 1), however, there are still numerous cases of too early complementary feeding practices in Tanzania. The variations in trends of feeding practices by age (months) in Tanzania are shown Tables 1 and 2. According to TDHS 2004/2005, complementary feeding generally starts at an early age and is recorded in 7% of children under the age of 2 months, 32% of children aged 2 to 3 months and 58% of children aged 4 to 5 months (Table 1) (NBS and ORC Macro, 2005). Previous studies have also shown that complementary foods are usually introduced at an early age in Tanzania (Mabilia, 2003; Sellen, 1998; Serventi et al., 1994). The age at which complementary foods are introduced depends on many factors including social and economic issues, geographical locality and ethnicity. For instance, among nomadic tribes such as the Wadatoga of Mbulu district, animal milk and milk products are commonly introduced before the age of two months while grain based solids are introduced at the age of nine months (Sellen, 1998). In the neighbouring Dodoma, the introduction of complementary foods was reported to start at three to four months of age (Mabilia, 1996; 2003).

Furthermore in Morogoro, mothers from medium and high-income groups introduced complementary foods to children at an early age compared to those in lower income groups that is, 1 to 2 months in the medium and 5 to 6 months in the high-income group (Shirima et al., 2001). Similar complementary feeding practices and timings have been reported (Hotz and Gibson, 2001; Onyango et al., 1998, 2002) with some evidence that introducing cereal gruel before the age 4 months poses potential risks to the infant that may trigger early malnutrition (Getaneh et al., 1998; Onyango et al., 1998). This is because too early introduction of complementary foods is reported to stress the immature gut, kidneys and immune system, increased allergies and morbidity due to diarrhea (Mila, 1986; Kelly et al., 1989; Fergusson et al., 1990; Wilson et al., 1998). Further, the early introduction of complementary foods pre-disposes the infants to reduced protective benefits of the breast milk. Moreover, risks of microbial contamination as a result of poor hygiene that results to gastrointestinal infections are higher with complementary foods (Trowbridge, 2002).

In addition, the micronutrients in complementary foods are not absorbed as well as those in breast milk (Trowbridge, 2002) thus increasing the chances of slow growth pattern among infants. Similarly, a cohort study of infants in Vietnam found that the early introduction of complementary foods resulted in the slow down of growth (Hop et al., 2000). A downward trend in mean weight of age (WA) was also observed from approximately the age of 3 months, following the initiation of complementary feeding since the fluids and solids introduced to infants early tend to be of lower nutritional quality than the breast

**Table 2.** Percentage by age group of children not received the complementary food in Tanzania.

| | Year | Age in months | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **6-7** | **8-9** | **10-11** | **12-13** | **14-15** | **16-17** | **18-19** | **20-21** | **22-23** | **6-9*** |
| Complementary feeding (%) | 1992 | 84.1 | 94.3 | 96.6 | 90.7 | 90.1 | 84.2 | 75.5 | 65.9 | 45.5 | 89.2 |
| | 1996 | 91.3 | 95.1 | 93.8 | 95.3 | 90.8 | 87.5 | 80.4 | 60.6 | 45.6 | 93.2 |
| | 1999 | 91 | 89 | 90.1 | 88.6 | 84.8 | 85 | 80.8 | 62.2 | 35.9 | 90 |
| Not complementary feeding (%) | 1992 | 15.9 | 5.7 | 3.4 | 9.3 | 9.9 | 15.8 | 24.5 | 34.1 | 54.5 | 10.8 |
| | 1996 | 8.7 | 4.9 | 6.2 | 4.7 | 9.2 | 12.5 | 19.6 | 39.4 | 54.4 | 68 |
| | 1999 | 9 | 11 | 9.9 | 11.4 | 15.2 | 15 | 19.2 | 37.8 | 64.1 | 10 |
| | | **6-7** | **8-9** | **10-11** | **12-15** | **16-19** | **20-23** | | | | **6-9*** |
| Complemented feeding (%) | 2005 | 88.5 | 93.3 | 94.5 | 89 | 82 | 54.9 | | | | 90.9 |
| Not Complemented feeding (%) | | 11.5 | 6.7 | 5.7 | 11 | 18 | 45.1 | | | | 9.1 |

*Timely age group of complementary food introduction as recommended by WHO, 2001. Source: TDHS 1992, 1996, 1999, 2005.

**Table 3.** Nutrition status of children in Tanzania by age group.

| Background characteristics | Height -for-age (stunting) | | | Weight -for-height | | | Weight -for age | | |
|---|---|---|---|---|---|---|---|---|---|
| | Percentage below -3 SD | Percentage below -2 SD 1 | Mean Z-score (SD) | Percentage below -3 SD | Percentage below -2 SD 1 | Mean Z-score (SD) | Percentage below -3 SD | Percentage below -2 SD 1 | Mean Z-score (SD) |
| Age in months | | | | | | | | | |
| <6 | 1.4 | 8.0 | (0.5) | 0.0 | 1.2 | 0.7 | 0.2 | 2.4 | 0.2 |
| 6-9 | 3.9 | 18.9 | (1.1) | 0.4 | 2.3 | 0.1 | 2.1 | 14.8 | (0.8) |
| 10-11 | 7.1 | 33.5 | (1.4) | 0.3 | 3.5 | (0.2) | 5.7 | 29.5 | (1.3) |
| 12-23 | 15.4 | 45.2 | (1.8) | 0.9 | 6.3 | (0.4) | 6.0 | 29.0 | (1.4) |
| 24-35 | 13.8 | 39.2 | (1.7) | 0.1 | 3.1 | (0.3) | 3.8 | 24.5 | (1.3) |
| 36-47 | 16.4 | 45.2 | (1.8) | 0.2 | 1.4 | (0.2) | 3.6 | 22.1 | (1.3) |
| 48-59 | 15.6 | 43.3 | (1.8) | 0. 4 | 1.9 | (0.2) | 3.2 | 21.5 | (1.3) |
| Total | 12.8 | 37.7 | (1.6) | 0.4 | 3.0 | (0.1) | 3.7 | 21.8 | (1.1) |

Source: TDHS, 2004/2005.

milk they displace (Hop et al., 2000). Moreover, it ispossible that micronutrient-chelating agents in the complementary foods reduce the bioavailability of iron and zinc in breast milk (Gibson et al.,1998) and thus indirectly contribute to growth retardation. Studies show that iron absorption from breast milk in the proximal small-bowels in infants is depressed in the presence of other foods (Schmitz and McNeish, 1987). Therefore, the early use of complementary foods may increase the risk of iron depletion and anemia.

Cases of delayed introduction of complementary foods in children have also been reported in Tanzania (Hussein, 2005; NBS and ORC Macro, 2005). WHO/UNICEF (2000) recommends introducing complementary food after 6 months. At this age the mother's breast milk may not provide adequate calories and nutrients for the child's growth because this period is associated not only with increasing and changing nutrient requirements, but also with rapid growth, physiological maturation and development of the infant. Diversified diets are therefore required to supply the full range and quantities of nutrients required to support rapid growth at 6 months of age onwards. Delayed introduction of complementary food predisposes the child to increased risks of growth faltering, decreased immune protection, diarrheal disease, malnutrition (Dewey et al., 1995; Whitehead et al., 1986) and feeding problems (Paine and Spegiorin, 1983; Northston et al., 2000). Although, WHO standard recommends that all children aged 6 to 9 months should receive complementary foods, many children continue to experience delayed introduction of complementary foods. During the 1990 to 2005 period, Tanzania demographic and health survey data showed that only 89, 93, 90 and 91% of children in this age group received complementary foods during 1992, 1996, 1999 and 2005 respectively (Table 2). Although, the 2005 data shows an improvement when compared to previous years, it is clear that only 9% of children are adhering to WHO complementary feeding guidelines. Moreover, according to TDHS, a number of children < 2 years of age are not appropriately complemented. About 5.7, 11, 18 and 45.1% of children in the age group of 10 to 11, 12 to 15, 16 to 19 and 20 to 23 months, respectively, were not provided with complementary foods. According to TDHS data, many children also recorded neither exclusively breastfeeding nor received complementary foods. Such children are mainly dependent on the common family pot which is often filled with low energy density foods that fails to meet the energy and nutrients requirement of children below 2 years.

Delayed introduction of complementary foods to infants is also associated with local acceptance of the complementary foods because the infants become accustomed to only sucking from the breast or feeding bottle over a longer time. The infant also have difficulties feeding independently and thus end up taking inadequate amounts and/or varieties of much needed food to meet their nutritional needs (FNS, 2008). Consequently, it is no wonder that majority of these children are affected by stunting during their early growth, reflecting on inadequate nutrition over a prolonged period. These scenarios are frequent in populations under poor overall economic conditions which are characterized by chronic and/or repeated infections and consistently inadequate nutritional standards. According to TDHS 2004/2005, stunting, wasting and under weight are still prevalent in Tanzania where 38% of children are stunted with13% being severely stunted (Table 3). The stunting has been reported in children as young as 6 months at 8% prevalence and increases with the age during the first year. After the first 6 months, deterioration of nutritional status is evident with up to 45% of the children stunted children at 12 to 23 months and at 36 to 47 months (Table 3). Kulwa et al. (2006) in a cross-sectional study in the urban area of the capital city Dar es Salaam also reported stunting, underweight and wasting of 43, 22 and 3% among children aged 6 to 24 months, respectively. Therefore, persistent chronic malnutrition in children is very evident in Tanzania children as supported by TDHS 2004/2005 and UNICEF (2009a) data and appears to be closely linked to the late introduction of complementary foods.

## NUTRITIONALLY POOR COMPLEMENTARY FOODS

Poor nutritional quality and inadequate quantity of complementary foods is reported to have negative impacts on the child: they affect growth (Dewey et al., 1992; Umeta et al., 2000; Rivera et al., 2003), hamper mental development (Berkman et al., 2002 Hamadani et al., 2001) and increase infant morbidity (Brown et al., 1989; Bhandari et al., 2002; Kalanda et al., 2006) and mortality (Edmond et al., 2006). Guidelines for good complementary feeding practices and optimal nutrition for infants and young children was published by WHO and outlines the hard consequences of poor complementary foods (Dewey, 2003).

Studies have shown that majority of the children in Tanzania are born with weights well above the recommended level of 2.5 kg and start their life in sound health (Mosha et al., 1998). Growth, however, starts to falter during and/or after introduction of complementary foods, time during which protein, energy and micronutrient deficiencies also become a serious problem as most of these complementary foods consumed do not supply adequate amounts of these nutrients. In most developing countries, complementary foods are mostly porridges based on local staple foods including cereals and root crops. Moreover, the high cost and inaccessibility of commercially formulated complementary foods puts them out of reach to low-income households characterizing the populations in these countries. Similarly, Tanzania is dependent on cereal and non-cereal based traditional weaning foods from maize, sorghum, millet, rice, cassava, potatoes, yams and plantains (Mosha et al., 2000; Mamiro et al., 2005). While assessing complementary feeding patterns among children aged 3 to 23 months in Kilosa district of Morogoro region, Mamiro et al. (2005) reported plain maize porridge, finger millet, rice and peanut composite flour porridge, beans and sardines as the main complementary foods given to children in the district.

Nutritional problems associated with the use of starch staples in weaning foods are widely reported (Mosha et al., 2000). Traditional infant foods made of cereals or tubers are known for their high bulkiness and concentrations of fiber and inhibitors which reduce their nutritional benefits (Michaelsen and Friis, 1998; Urga and Narasimha, 1998; Hurrell, 2003; Mbithi et al., 2002). Bulkiness, often associated with gelatinization of the starch during boiling is a key problem in cereal-based complementary foods (Bennet et al., 1999). To obtain a reasonable viscosity, it is therefore necessary to add large amounts of water during preparation. The energy density of such porridges is typically below 2 kJ/g (0.5 kcal/g) (Michaelsen and Friis, 1998). The energy requirement of a 12-month-old infant weighing 10 kg is about 4000 kJ/day (950 kcal/day). Therefore, assuming that the infant is fed only on this porridge, 2000 to 4000 g would be required to meet its daily energy requirements. These amounts are equal 200 to 400 mL/kg or 20 to 40% of the body weight. It has been shown that a malnourished infant during nutritional rehabilitation can eat as much as 220 mL/kg body weight, if the frequency of feeding on the palatability of the porridge and the enthusiasm of the caregiver is optimal (Sanchez-Grin˜an et al., 1992). The situation in the developing world is far from this ideal setting and intakes above 220 mL/kg may not be achieved. Consequently, infants fed on these low energy-density porridges cannot meet their daily energy needs.

Apart from their bulkiness reported as a probable factor in the aetiology of malnutrition (Ljungqvist et al., 1981), cereal-based gruels are nutritionally poor further increasing incidences of protein–energy malnutrition which is a major cause of infant mortality in developing countries. The low nutrient density including protein and fat and bioavailability of various nutrients such as vitamin A, iron, Ca and Zinc presents additional problems associated with typical cereal-based porridges. Studies have shown that growth faltering in children often coincides with introduction of low-nutrient-density weaning foods, improper feeding practices and gastrointestinal infections (WHO/UNICEF, 2001).

Similarly, majority of locally formulated complementary foods, as well as some commercial complementary foods used in Tanzania does not meet the quality attributes especially in terms of energy and micronutrient density as laid out in Tanzania standard (TZS 180:1983) for processed cereal-based weaning foods (TBS, 1983) and Codex Alimentarius standards for cereal/milk based weaning/follow-up foods (FAO/WHO, 1994). While some efforts directed at the improvement of protein and energy densities of these foods have shown considerable success (Mamiro et al., 2004), little has been done to improve the micronutrient concentrations of these foods. Several cereal and roots based complementary foods including maize, cassava, millet, sorghum, millet-sardine-peanut composite gruels and plantain pap, were assessed by Mosha et al. (2000) for their nutrient density. The study found out that most of the home-made and commercial complementary foods assessed were low in fat, iron, calcium, zinc and Phosphorus but high in crude fiber, carbohydrate and magnesium. Calcium, iron and zinc were the most common deficient micronutrients in the home made weaning foods. The energy densities in maize, cassava, millet, sorghum gruels and in the plantain pap were also lower than the minimum level specified in the Codex Alimentarius standards (483.9 kcal/100 g dry weight). Commercial milk-cereal blends, wheat-based and rice-based also had significantly lower energy densities than the recommended level as specified in the TBS and Codex Alimentarius standards. Similar low energy density in home-made complimentary foods was reported by Mosha and Vincent (2004) with different maize/sorghum based foods supplemented with bean flour, sardines and peanut paste. All assessed complimentary foods in their study had maximum energy density of 404 Kcal/100 g dry matter which is lower than the minimum level specified in the Codex Alimentarius standards. Similarly, nutritive values of corn-based (corn: kidney bean: pumpkin) and kocho-based (kocho: kidney bean: pumpkin) complementary foods were assessed by Abebe et al. (2006) in southern Ethiopia in which energy densities of corn-based and kocho-based porridges were 0.48 and 0.46 kcal/g as served, respectively. Such low density complementary foods would require three to four servings per day to meet the energy need from complementary foods for 6 to 8 months old breast-fed infants with average breast milk intake as recommended by WHO and outlined by Dewey and Brown (2003). The updated guidelines for feeding of 6 to 8 months old infants with average breast milk intakes suggests 202 kcal per day should come from complementary foods (Dewey and Brown, 2003). To provide 202 kcal per day, more than 420 g per day of the legume-supplemented complementary porridges (as served) would be required which is way above the bowel capacities of 6 to 8 months old infants.

The amount of protein and other nutrients that should be provided by complementary foods is dependent on the level of breast feeding (WHO/UNICEF, 1998; Dewey and Brown, 2003). Inadequate protein intake leads to child malnutrition. Low protein concentrations in home-made complementary foods (maize and cassava-based gruels) were reported by Mosha et al. (2000). This was lower than the minimum amount (15.20 g/100 g dry weight) specified in the Tanzania standard for processed cereal-based weaning foods (TBS, 1983) suggesting that children fed the home made cereal-based weaning foods would have poor growth performance. Similar non-adherence pattern in protein densities were reported in corn-based and kocho-based complementary foods (Abebe et al., 2006). The protein density of 14.7 and 14.9% were respectively reported for corn-based and kocho-based and were higher than recommended protein density (Reeds and Garlick, 2003). For instance, a 6 to 8 months old child weighing 6.4 kg with average breast milk intake needs to obtain approximately 4.2 g of protein from cereal-based complementary foods (WHO/UNICEF, 1998). Therefore, on a dry-weight basis, 30 g of the corn-based or kocho-based would meet this requirement, but 47 g of corn or 286 g of kocho would be needed. As the porridges are served, approximately 240 g of the corn-based or kocho-based would be required and might feasibly be fed (Abebe et al., 2006). However, more than 2 kg of traditional kocho porridge (un-supplemented, only 1.5% protein) required to meet the protein needs would provide more than 1100 kcal and be an impossible volume for a 6 to 8 months old infant to consume, illustrating why feeding young children tuber-based complementary foods contributes to severe malnutrition.

Micronutrients needs per unit body weight of infants and young children are very high. Breast milk can make a substantial contribution; however, breast milk is relatively low in several minerals such as iron and zinc, even after accounting for bioavailability (WHO, 2001). For example, at 9 to 11 months of age, the proportion of the Recommended Nutrient Intake (RNI) that needs to be supplied by complementary foods is 97% for iron, 86% for zinc, 81% for phosphorus, 7% for magnesium, 73% for sodium and 72% for calcium (Dewey, 2001). Given the relatively small amount of complementary foods consumed at 6 to 24 months of age, their nutrient density needs to be very high to meet this recommendation. However, most of the assessed gruels consumed in Tanzania contain concentrations of iron (Fe) lower than the 10.87 mg/100 g minimum recommended level (Mosha et al., 2000). Consequently, unless other food rich in iron are included in the formulations, infants and young children are at risk of anemia, growth failure and delay in psychomotor development (Mosha et al., 2000). Iron in the cereal based complementary foods is present in inorganic non-heme form, thus severely impairing the absorption of iron and zinc due to the high content of phytate, fibers and polyphenols in unrefined cereals. Furthermore, the content of compounds enhancing absorption of non-heme iron such as organic acids and vitamin C is low (Michaelsen and Friss, 1998). Mamiro et al. (2004) in a study done in Kilosa district in Morogoro region reported low iron and high phytate content in locally processed complementary foods. Maize and millet-sardine-peanut composite gruels and the plantain pap have significantly lower zinc (Zn) concentrations (Mosha et al., 2000) than the standard minimum levels stated in TBS and Codex Alimentarius standards. Consequently, unless other zinc-rich foods are provided, many of the infants fed these foods would be at risk of impaired growth and development. Symptoms such as growth retardation, mental underdevelopment (apathy), skin diseases, persistent diarrhea, anemia, blindness, goiter, cretinism, infections and sometimes death, prevalent among infants and young children in Tanzania, could be directly or indirectly associated with micronutrient deficiencies (Mosha et al., 2000) reported in complementary foods. This in turn propagates malnutrition, a persistent problem in Tanzania.

## MICROBIAL CONTAMINATION OF THE TRADITIONAL COMPLEMENTARY FOODS

### Overview

Beyond the age of 6 months, breast milk alone is no longer sufficient to meet the nutritional demands of the growing infant calling for introduction of complementary foods. However, introduction of complementary foods that are often nutritionally inadequate and microbiologically unsafe increasing the risks of multiple nutrient deficiencies (Kimmons et al., 2005; Dewey and Brown, 2003; Hotz and Gibson, 2001) and gastrointestinal illnesses associated with food-borne pathogens (Motarjemi et al., 1993; Sheth and Dwivedi, 2006; Lanata, 2003; Mosha et al., 2000). In many developing countries including Tanzania, complementary foods formulated from local grains/cereals are dominant. From 10 months onwards, complementary foods made from local tubers and green vegetables are incorporated, though to a small extent.

## COMPLEMENTARY FOODS AND SOURCES OF CONTAMINATION

Infants and young children are very susceptible to food borne diseases and if they consume contaminated foods, they are likely to contract infections or intoxications leading to illness and often death. Numerous studies in developing countries have shown that weaning foods prepared under unhygienic conditions are heavily contaminated with pathogenic agents and are a major risk factor in the transmission of diseases, especially diarrhea. It is generally recognized that contamination of complementary foods may occur as a result of poor hygiene of food handlers, household equipments and the environment where the preparation of food takes place (Sheth et al., 2000). Other possible sources of contamination of complementary foods are shown in Figure 1. Raw foods themselves are frequently the source of contaminants, since some foodstuffs may naturally harbour pathogenic agents or have been obtained from infected animals and if they are not properly processed, would pose great risk to the infants. Water used for the preparation of food itself is a source of pathogenic agents and in almost all regions of Tanzania, water is often contaminated. For example, an assessment of the microbiological quality of water used for reconstitution of complementary foods in Zanzibar indicated that the water was highly contaminated with pathogens (Kung'u et al., 2009) and failed to meet the guidelines of the World Health Organization for quality of drinking-water (WHO, 1997). Improper storage and handling of cooked food is equally responsible for food-borne illnesses, as during storage especially at ambient temperature (28 to 35°C) there is the risks of multiplication of pathogenic organisms. Under favourable conditions, a single bacterium can multiply to 500 million bacteria in 10 h. Considering that the minimum infective dose of pathogens varies from a few (10 or less) to as many as 104 or 106, the survival of even a small number of pathogens in freshly prepared food can become health threatening, particularly if the food is stored at ambient temperature for several hours or overnight, as is often the case.

Various pathogens have been identified as causing diarrhea diseases and most of these pathogens have been isolated from complementary foods commonly consumed in developing countries. These include bacteria such as *Escherichia coli*, *Shigella* spp., *Salmonella* spp., *Vibrio cholera*, *Campylobacter jejuni* (Black et al., 1989; Gomes, 1991), *Bacillus cereus*, *Staphylococcus aureus* and *Clostridium perfringens*. Infections due to pathogenic *E. coli* are the commonest illnesses in developing countries and produce up to 25% of all diarrhoeal episodes (Motarjem et al., 1993) and *E. coli* transmission has been substantially associated with complementary foods. The severity of different pathogens associated with complementary foods in developing countries is shown in Table 4. From the data, it is evident that most of complementary foods consumed in many developing countries including Tanzania are highly contaminated with pathogens exceeding the minimum acceptable limits. Although, studies on microbial contamination of complementary foods commonly used in Tanzania are limited to strictly quantifying the level of contamination, available information shows that thousands of children under the age of 5 years still suffer

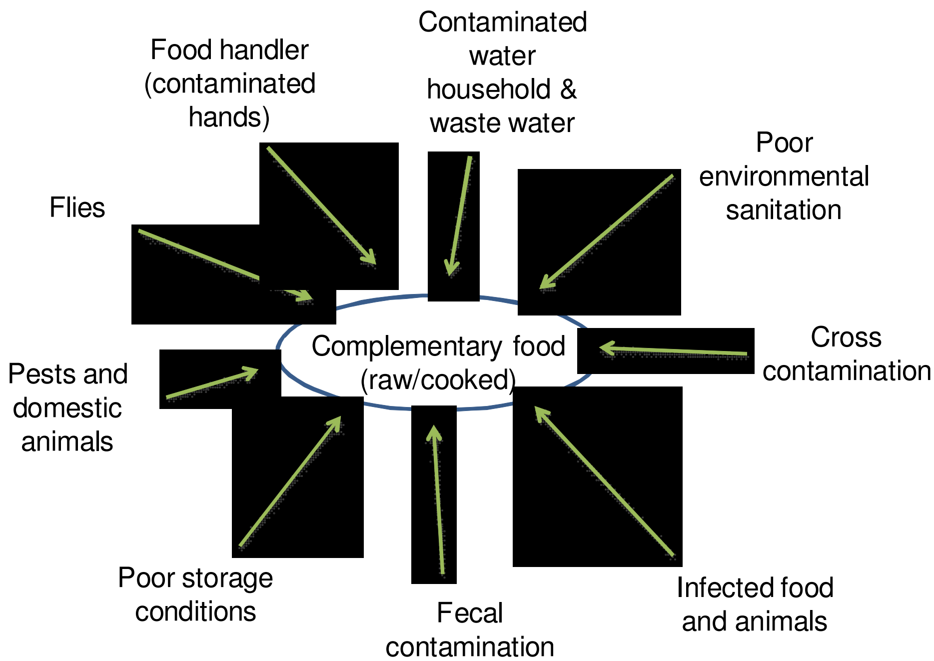


**Figure 1.** Sources of contamination for complimentary foods. Source: Authors.

from frequent episodes of diarrhea. It is therefore evident that contaminated complimented foods partly account for diarrhea and consequent impair nutritional status of infants and children. A study done by Kung'u et al. (2009) in Zanzibar, Tanzania showed a high level of bacterial contamination (aerobic bacteria, coliform and Enterobacteriaceae) among formulated weaning food samples as well as the benchmark traditionally produced weaning foods commonly used in Zanzibar. Results showed that the percentage of complementary foods and water samples with aerobic bacteria, coliform and Enterobacteriaceae exceeded the criteria for assessing the bacterial quality of ready-to-eat foods and was highest for soy rice porridge 4 h after preparation, with 92.5, 92.5 and 98.1%, respectively.

Also about half of assessed cereal mix (*lishe bora*) samples (49.1% aerobic bacterial contamination, 52.8% coliform contamination, 58.5% Enterobacteriaceae contamination) exceeded the cut-offs after a four-hour period in the households (Kungu's et al., 2009). High bacterial numbers in infant porridges held for four hours after preparation as compared to freshly prepared ones suggest possible household contamination during this time period or the presence of spores or other bacteria capable of reproducing in hydrated flours. Previous studies on the microbial quality of complementary foods in other developing countries have also reported the presence of food-borne pathogens in commercial infant complementary foods (Estuningsih et al., 2006; Forsythe, 2005; Becker et al., 1994), in home-prepared complementary foods and water used for reconstitution (Iroegbu et al., 2000; Potgieter et al., 2005; Morais et al., 2005).

## COMPLEMENTARY FOOD ASSOCIATED WITH DIARRHEA AND CHILD MALNUTRITION

Contaminated complementary foods have been linked to the occurrence of diarrheal diseases. Millions of children in the world die each year from diarrheal diseases and more suffer from persistent diarrhea leading to impairment of nutritional status. Global mortality among children under the age of 5 years is estimated at 9.7 to 10.6 million deaths each year with 18% or 1.9 million per year (over 5000 deaths daily) attributable to diarrhea. Moreover, an estimated 53% of these diarrheal cases (5.6 million) are associated with malnutrition (Bryce et al., 2005; UNICEF, 2008; Dahl and Yamada, 2008; Yamada, 2008). It is estimated that maternal and childhood under nutrition is the underlying cause of 3.5 million deaths and 35% of the disease burden in children under 5 years of age (Black et al., 2008). Contaminated complementary foods have been linked to the occurrence of diarrheal diseases. Many studies report that the incidence of diarrhea diseases is especially high after weaning is initiated (Sheth and Dwivedi, 2006) further signaling that contaminated complementary foods introduced are often contaminated with diarrhea causing pathogens. Diarrhea has been reported to have serious effects on nutritional status (Motarjemi et al., 1993). The association between diarrhea diseases and malnutrition has been the subject of discussion and despite a complex inter-relationship, it is generally accepted that diarrhea has a serious effect on child's growth. Guerrant et al. (2008) reported the mechanisms of enteric infectious disease on malnutrition and its long-term effects on child development. While

**Table 4.** Different pathogens associated with complementary foods commonly consumed in developing countries.

| Study place | Type of food | Pathogens isolated | Contaminated sample/ contamination level | References |
|---|---|---|---|---|
| Bangladeshi | Weaning milk | *E. coli* | 41% of all tested complementary food samples were contaminated. | Black et al. (1981, 1982) |
| Bangladeshi | Milk and rice | Fecal colform | Highest level of coliform were detected in samples | Henry et al. (1990 |
| Gambia | Traditional complementary foods | Pathogens (unspecified) | 96% of all tested samples were contaminated with pathogen | Barrel and Rowland (1979) |
| Myanmar | Traditional complementary foods | *E. coli*<br>*V. cholerae*<br>*Salmonella spp.* | 65% of samples were positive to E. coli, 3.6% positive to *V. cholerae* | Khin New et al. (1989) |
| Peru | Milk and cereals purees | *Salmonella spp*<br>*Aeromonas*<br>*Hyrophilla*<br>*V. cholerae*<br>*E. coli* | Contamination level was compared to family food, it was higher to weaning foods than family foods | Black et al. (1989) |
| Dominican Republic | Local made weaning foods (dried rice and milk) | *Fecal colform*<br>*B. cereus*<br>*S. aureus* | High level of contamination was found | Michanie et al. (1987, 1988) |
| Guatemala | Complementary foods | *B. cereus*<br>*Staphylococci*<br>*E. coli* | Heavy contamination was found | Caparalli and Mata (1975) |
| Elsalvador | Weaning foods | *E. coli* | 18% of total food were contaminated | Sound and Rivera (1992) |
| Cairo | Home made weaning foods | *E. coli*<br>*B. cereus* | 43.7% of samples were contaminated by *E. coli* and 21.4% by *B. cereus* | Zainab et al. (1998) |
| Nigeria | Cooked ogi (femented cereal weaning food) | *Fecal colform* | 31.3% of the tested samples were contaminated with *E. coli* | Odugbemi et al. (1992) |
| Chadigath | Traditional home made weaning foods | *E. coli* | 56% of the samples were contaminated with *E. coli* | Ghulian and Kauli (1995) |
| India | Rice, dai (pulses), banana | Aerobic mesophilic count (AMC)<br>Yeast and mould (YM)<br>*Staphylococcus aureus* (SA)<br>Baccilus cereus (BC) | Raw rice was contaminated with *AMC:* 4logCFU/g<br>*Y&M:* 3logCFU/g<br>*SA:* 3logCFU/ g<br>*BC:* 7logCFU/ g | Sheth et al. (2000) |
| Zanzibar-Tanzania | Lishe boral (LB)<br>Soy rice porridge (SRP)<br>Traditional weaning food (TF) | Aerobic bacteria<br>Total *coliform*<br>*Enterobacteriacea* | Aerobic bacteria: 2.24-3.84 log CFU/g:LB<br>4.36-4.63 CFU/g:SRP<br>4.58 log CFU/g:TF<br>*Coliform*: 1.71-2.4 log CFU/g:LB<br>2.8-3.6 log CFU/g:SRP<br>2.4 log CFU/g:TF<br>*Enterobacteriacea:* 1.72-2.5 log CFU/g:LB<br>3.1-3.9 log CFU/g:SRP<br>2.6 log CFU/g:TF | Kungu et al. (2009) |
| Zimbabwe | Maize porridge, fresh milk, beans, sour milk etc. | *E. coli* | 60% of the samples were contaminated with *E. coli* of these 13.8% had enteropathogenic *E. coli* (EPEC) | Nyatoti et al. (1997) |
| South Africa | Vhuswa-traditional maize based weaning foods | *E. coli, Campylobacter jejui, Salmonella Shigelle* | 70, 5, 5 and 2% of the Vhuswa samples were contaminated with *E. coli, Salmonella Shigelle* and *C. jejui* respectively | Potgieter et al. (2005) |

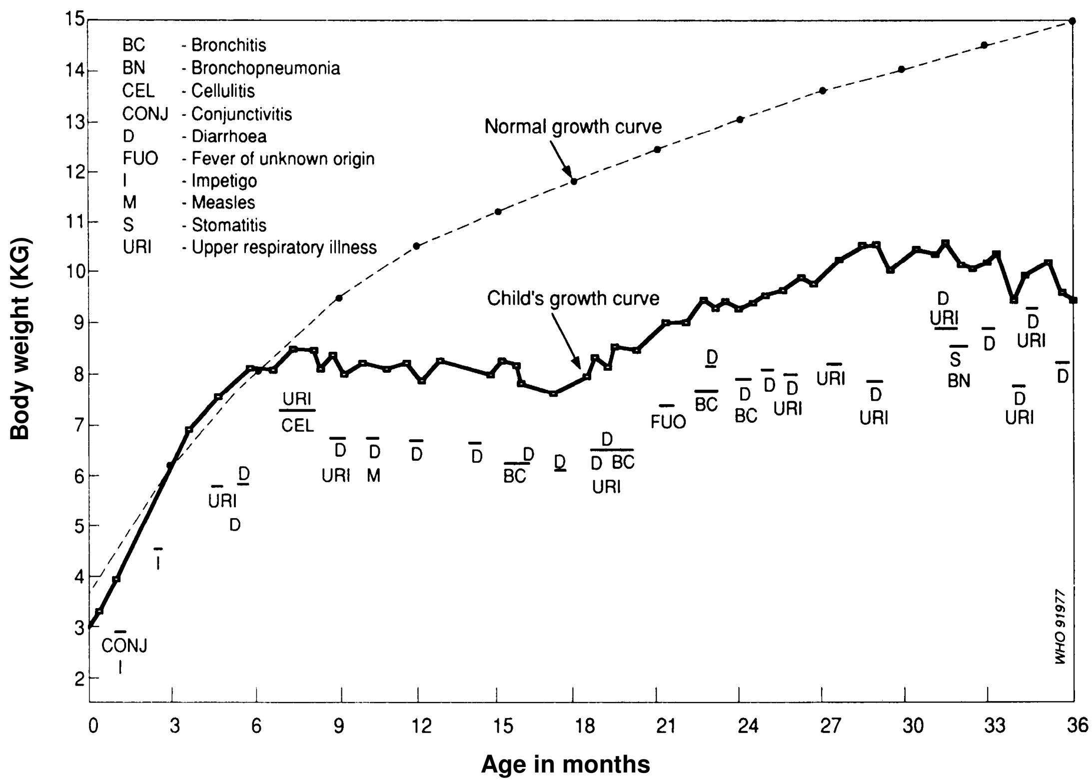


**Figure 2.** Effect of repeated episodes of diarrhea on growth of children (0-36 months) following introduction of complementary foods. Source: Motarjemi et al., 1993.

diarrheal illnesses and even enteric infections without obvious diarrhea, predispose children to malnutrition and growth shortfalls, malnutrition additionally predisposes to both increased incidence and duration of diarrhea. Repeated diarrheal episodes have shown serious effect on growth as portrayed in the affected childhood growth curves as a result of diarrhea and other infectious disease (Figure 2). It can be clearly seen that, the dwindling of growth starts at around 6 months of age corresponding to the age of introduction of complementary foods. Studies have also been carried out on the effect of infections and dietary intakes on children; for example, Martorell et al. (1994) reported a greater reduction in dietary intake during diarrheal illnesses than during respiratory illnesses and indicated that of all the common childhood illnesses, only diarrheal diseases have a significant negative effect on growth.

Diarrhea and other infectious disease can lead to a reduction in food intake owing to anorexia. A poor food intake, aggravated by loss of nutrients from diarrhea, leads to nutritional deficiencies with serious consequences for the growth and immune system of the infants and children. Guerrant et al. (2008) suggested that a substantial proportion of global malnutrition is due to impaired intestinal absorptive function resulting from multiple and repeated enteric infections. These include recurrent acute and persistent infections even in cases without obvious liquid diarrhea. Furthermore, impaired innate and adaptive host immune responses and disrupted intestinal barrier function due to malnutrition and diarrheal illnesses render weaning children susceptible to repeated bouts of enteric infections. Such repetitive diarrheal diseases may lead to intestinal injuries and consequently, nutrient malabsorption especially during the critical 2-years postnatal period. Therefore, infants with suppressed resistance are exposed to opportunistic diseases including respiratory infections and are subsequently caught in a vicious cycle of malnutrition and diarrhea (Figure 3) that may lead to death.

Diarrheal illnesses predispose children to malnutrition and growth shortfall in return malnutrition additionally predisposes to both increased incidence and duration of diarrhea. The vicious cycle of diarrhea and malnutrition can be broken by interventions to minimize incidences of infection thus reducing malnutrition (Keusch and Scrimshaw, 1986). Improving nutritional status to reduce the burden of infection can also break the diarrhea-malnutrition-diarrhea cycle (Victora et al., 1999). Therefore, improved feeding practices and prevention and/or treatment of malnutrition could save up to 800,000 children lost to diarrheal diseases and malnutrition each year (Jones et al., 2003). Motarjemi et al. (1993) reported that infections caused by enterotoxigenic *E. coli* and

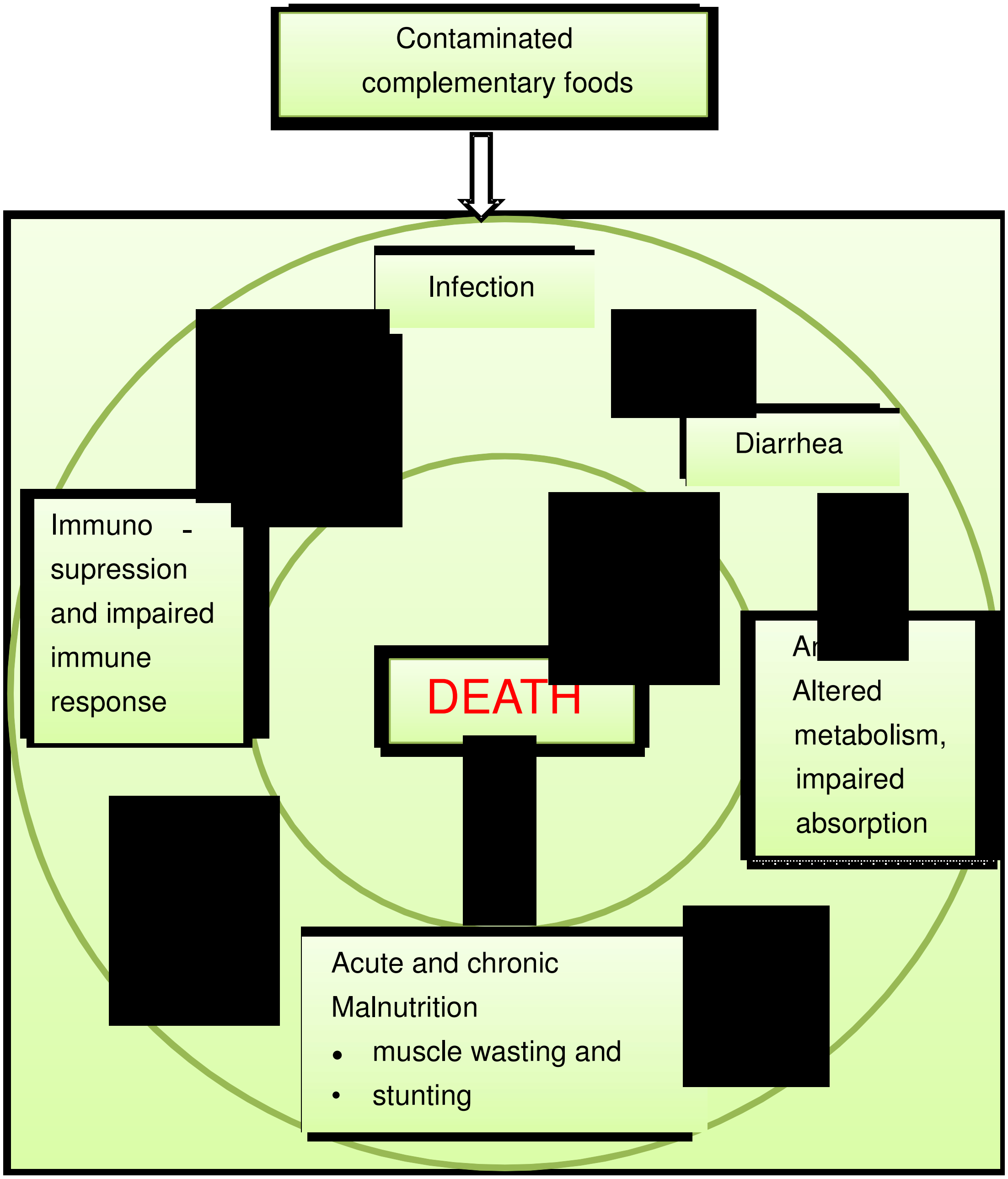


**Figure 3.** Diarrhea and malnutrition combine to form a vicious cycle that ultimately may result to death. Source: Authors.

*Shigella* spp had the greatest impact on nutritional status.

Diarrhea associated with *E. coli* constituted 30% of diarrhoeal disease episodes and greatly impacted bimonthly weight gain. Shigellosis, with 15% prevalence had a negative effect both on bimonthly and annual linear growth. *E. coli* is a common pathogen isolated to complimentary foods consumed in Tanzania (Table 4) and elsewhere in developing country further indicating that persisting child malnutrition in Tanzania is highly linked to feeding contaminated complimentary foods.

## CONCLUSION AND RECOMMENDATIONS

Tanzania is still faced with challenges of malnutrition problems as it contributes to more death of children under five years of age, affecting children's strength and making illness more dangerous. The main causes of malnutrition are poor feeding practices, poor quality complementary foods aggravated by diarrheal diseases due to poor hygiene practice, lack of clean water and adequate sanitation. Majority of the children who survive are often locked in a cycle of recurring illness and growth faltering. The situation is worse for children under age of 2 years since it diminishes the ability to learn thus impacting negatively on their entire lives. Promotion of exclusive breastfeeding for the first 6 months andcontinued breastfeeding together with safe food of high nutritional quality and quantity impacts positively on child survival, growth and development. Fortifications of complementary foods with micronutrients especially vitamin A (boosts disease resistance), zinc (treats diarrhea), iodine and Iron can further reduce child mortality. The government and relevant stakeholders directly involved in public health should be more proactive in creating awareness and tackling issues such as poverty which augment the malnutrition problem in the country. The promotion and protection of exclusive breast-feeding, community health education of mothers on good complementary feeding practices and food safety principles are the most urgent interventions required to promote the health and nutrition status of infants and children countrywide. It is recommend that development of complementary food recipe brochures, books, public advertisements and campaigns as well as feeding guidelines to mothers and care takers presents a useful tool in the fight against persistent malnutrition in Tanzania.

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