INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 12, No. 3, p. 378-391, 2018
http://www.innspub.net

REVIEW PAPER OPEN ACCESS

Water, sanitation and hygiene practices and its impact on infectious diseases and under-nutrition among children below five years of age in low income countries

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Article published on March 30, 2018

Key words: WASH, Infectious diseases, Under-nutrition, Under-five children, Low income countries

Abstract

Under-nutrition among children aged below five years continuous to be a major public health threat despite numerous nutrition interventions taking place in low income countries. In 2016, about 23% of under-five children were stunted worldwide. Essentially, nutrition interventions have gained much attention although it can address only 20% of stunting in this age group. The awareness that the problem cannot solely be eliminated through optimization of diets has led to the theory that infectious diseases have potential impact to the problem and need attention as well. These diseases emanate from poor water, sanitation and hygiene practices and may affect the nutritional status of under-five children through different ways; may lead to malabsorption, poor villi function, leaking of mucosa, inflammation of the gut and even compromised immune system. Worms for example tend to compete for nutrients with the child. Furthermore, costs incurred for treating infections could affect food budget of the family. Also, when a child falls sick, whatever little food is taken is used for body recovery rather than growth. It is therefore, important to critically conceptualize the relationship between these risk factors for child mortality and morbidity and propose solutions through which such problems could be eliminated. This review paper therefore, suggests incooperating WASH interventions to nutrition and disease prevention interventions to address the problem of under-nutrition and infectious diseases among children below five years of age in developing countries and finally reduce child mortality.

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Introduction

Under-nutrition and infectious diseases are fundamental risk factors for morbidity and mortality among children aged below five years in developing countries and have been linked with poor water, sanitation and hygiene practices (WASH) by a number of studies (Arnold *et al.*, 2013; Lim *et al.*, 2013; Walker *et al.*, 2007). Regardless of global efforts to reduce such poverty related risks, still majority of children are born in poor environmental conditions that affect their health status (Waddington *et al.*, 2009a; WHO/UNICEF, 2015). Again, repeated exposure to infectious diseases and under-nutrition in the first thousand days of life continuous to impact negatively to the growth performance and potential development of children (Cairncross, 2010a; Cravioto, 1979). Under-nutrition among under-five children alone contributes to 11% of global disease barden and 45% of all deaths this age group (Too-Kong, 2014) while infectious diseases such as diarrhea associated infections continuous to be the second leading cause of mortality among that particular age group globally and the first in SSA (Bado, 2016; UNICEF, 2009). Nevertheless, improved WASH conditions may help improve the nutritional status and reduce infectious diseases among this age group. It may also break a bridge between these problems and cut down the rate of child mortality.

WASH is an acronym for water, sanitation and hygiene. The term is used in public health campaigns to address issues regarding access to adequate, safe and clean water for drinking/domestic purposes, sanitation and hygiene behaviors. WHO and UNICEF reports state that access to drinking water means that, water source is less than a kilometer away from its place of use and it is possible to obtain at least 20 liters per member of household per day for general use purposes (WHO, 2004; WHO/UNICEF, 2015). Safe and clean drinking water refers to water with microbial, chemical and physical characteristics that meets guidelines or international standards respecting drinking water quality (WHO, 2004).

Access to safe water means the proportion of people using improved drinking water sources such as household connections, public standpipes, protected boreholes, protected wells or springs and rainwater (WHO/UNICEF, 2004, 2015). Sanitation means measures necessary for improving and protecting health and wellbeing of the people through proper disposal of human and animal waste, proper use of toilets and avoiding open defecation (Feachem *et al.*, 1983). WHO state sanitation as provision of facilities and services for the safe disposal of human urine and fecal excreta (WHO, 2004). Basic sanitation means the lowest cost technology for ensuring hygienic excreta and sludge disposal, clean and healthful living environments both at home and in the neighborhood users (Chambers and Von Medeazza, 2013). It also includes safety and privacy in the use of such services (MDGs report, 2012).

Hygiene refers to a set of practices performed for the preservation of people's health (Freeman *et al.*, 2014). It is the practice of keeping oneself and his/her surroundings clean including food to avoid illnesses or spread of preventable diseases. It also includes all circumstances and practices, lifestyle issues, premises and commodities that engender safe and healthy environments. Hygiene practices include personal hygiene, food hygiene, proper waste disposal and environmental cleanliness (Chege *et al.*, 2015; Fewtrell *et al.*, 2007). However, there is lack of demarcation between the definition of the terms sanitation and hygiene especially when it comes to the issue of environmental cleanliness and waste disposal. Nevertheless, the WHO definition for sanitation is more specific and independent from that of hygiene. It is therefore, recommended that stakeholders dealing with WASH should come up with a clear definition for the two terms to avoid misconceptions of such terms.

The link between Infectious diseases and Under-nutrition

Under-nutrition among under-five children is directly contributed by infectious diseases particularly diarrhea associated diseases and the two health conditions forms a synergetic relationship (Bloss, 2004; Brown, 2013; Dewey, 2011).

While studies shows the potentiality of dietary intake in causing under-nutrition it has also been revealed that nutrition interventions such as promortion of breastfeeding, improving complementary feeding practices and food supplementation with 90% coverage may reduce the problem of under-nutrition only by 20% (Dangour *et al.*, 2013; Ngure *et al.*, 2014; USAID, 2015). This evidence shows that infectious diseases may have significant contribution to under-nutrition among under-five children and the problem need to be addressed along with nutrition interventions for better achievement of improved child health. Such infections include diarrhea associated infections, upper respiratory infections, environmental enteropathy and helminthes, the conditions which are very common to under-five children (Humphrey, 2009). Diarrhea associated infections emanating from poor WASH tends to inhibits absorption of nutrients by the body resulting into low nutrients intake followed by compromised immunity (Morris *et al.*, 1994; Cairncross, 2010b). Likewise, undernourished child becomes vulnerable to infections due to deteriorated immune system (Chase and Ngure, 2016). Some studies also show a strong link between under-nutrition and poor WASH (Bloss *et al.*, 2004; Checkley *et al.*, 2004; Humphrey, 2009; Bartram and Cairncross, 2010; UNICEF, 2013; Chambers and Von Medeazza, 2013) through a condition known as environmental enteropathy. This condition tend to interfere absorption of food by the body and lead into malabsorption and other gastrointestinal complications including poor villi functioning and leaking of mucosa followed by poor nutrient status and compromised immunity (Lunn *et al.*, 1991; Ngure *et al.*, 2014).

Furthermore, worms after invading the gastrointestinal system of an individual, tends to compete for nutrients with the host and whatever little nutrients are consumed by a child are largely taken by these parasites (Morris *et al.*, 1994). Other diseases such as respiratory infections may lower child appetite and compromise the immune system therefore, whatever little food is taken by the child are directed into body recovery from illnesses rather than growth. Skin and eye infections may also affect households` food budget through treatment costs incurred when children fall sick (UNICEF, 2014; Burton *et al.*, 2015). Fig. 1 below shows the direct and indirect causes of under-nutrition.

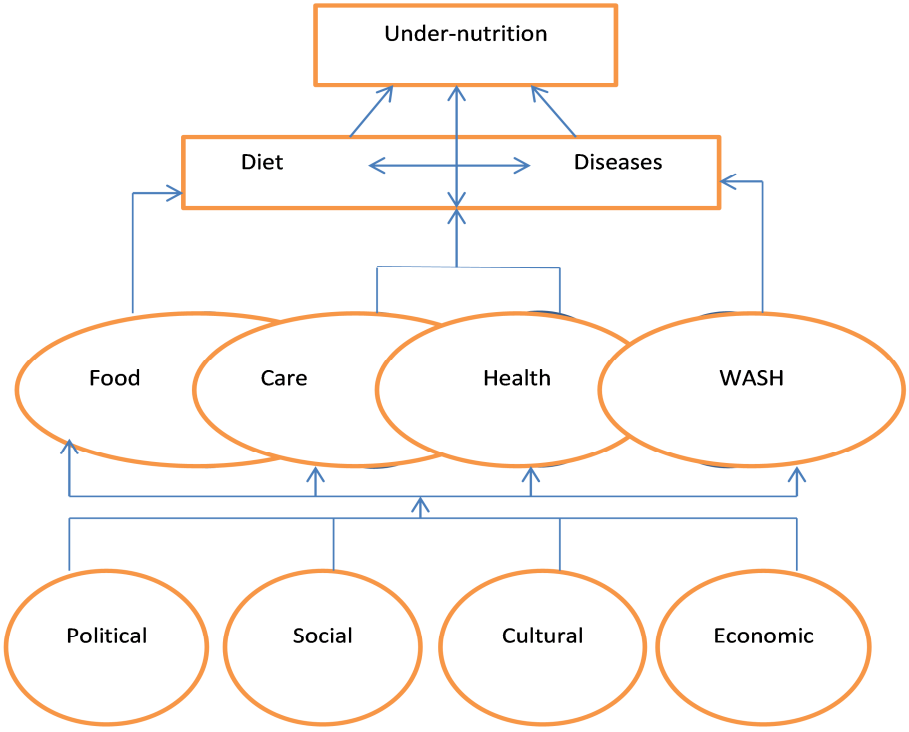

Fig. 1. Underlying causes of under nutrition as adapted from UNICEF, (1990) and modified accordingly.

How WASH practices impact on child health

(i) Access to safe and clean drinking water

Globally, it is estimated that 780 million people depend on unimproved water sources for domestic purposes and 1.8 billion (28%) people use water which is unsafe (UNICEF/WHO, 2012). The use of unsafe water for domestic purposes may expose people into water-borne diseases (Devoto *et al.,* 2012; Chirande *et al.,* 2015). To reduce the barden of water-borne diseases among individuals, it is therefore important to treat water at the point of use to improve the microbial quality of household drinking water and reduce diarrhea associated diseases (Fewtrell *et al.,* 2005; Arnold *et al.,* 2007; Clasen T. *et al.,* 2007). Study done in Burundi revealed that water treatment at the point of use particularly boiling may reduce diarrhea prevalence by 61% (Diouf *et al.,* 2014) although treatment of water from the source did not reveal any impact on reduction of diarrhea. The reason could be due to the fact that after treating water at the source it could be contaminated along the value chain or water may be contaminated by handlers or storage containers during collection and make it unsafe for domestic purposes. Therefore, treating water at the point of use could be more valuable and safer than treating water at the source. Nevertheless, both water quality and quantity is crucial for reduction of water-borne diseases (Conroy *et al.,* 1996, 1999). Improving water quality alone may not solve the problem of water-borne diseases because when there is no adequate water for domestic purposes it could be a nightmare for people to practice good hygiene including hand washing and this may increase the chances of contracting water/food-borne diseases. Therefore, interventions aiming at improving water quality and quantity should be promoted at household and community levels. Likewise, distance from the water source to the household may have an impact on both water-borne diseases as well as worm infestation. According to Gascon *et al.,* (2000) and Diouf *et al,* (2014), increasing distance from the water source may reduce risk of diarrhea by reducing risks of water contamination at the source. However, WHO report stated that increasing distance from water source to the household may increase prevalence of diarrhea as it may affect water quantity and water consumption habits in the household and hygiene practices as well. These inconsistent findings might be due to the fact that when the water source is too close to the households, there could be an interaction between the water and sanitation facilities especially when the source is surface water or underground water which could lead to water contamination. Again when the water source is too far it may affect the hygiene behavior of individuals due to lack of enough water to practice hygiene. WHO recommends that distance to/from water source to the point of use should not exceed a kilometer or thirty minutes walking distance (WHO, 2010).

However, when recommending on the issue of distance of water source from the household should take into account other issues like type of water source and sanitation facilities commonly used in that specific locality to avoid water contamination along the value chain.

(ii) Sanitation practices

Sanitation plays significant role in disease causation and transmission. However, improved sanitation practices have been a major challenge in developing countries due to limited resources for constructing sanitation facilities among other things. As a result people dispose human excreta in different ways depending on the availability and affordability of sanitation facilities. WHO, UNICEF, JMP and other WASH stakeholders have been emphasizing on the importance of practicing good sanitation by everyone (WHO/UNICEF/JMP report, 2014).

However, lack of awareness on the importance of practicing good sanitation including construction of improved latrines seems to be a major problem compared to limited resources. Study done in Ifakara, Tanzania reported low prevalence of diarrhea in the households having latrines compared to households without latrines (Gascon *et al.,* 2000). Systematic review done on the impact of improved sanitation on people's health reported a mean reduction of diarrhea prevalence by 32-36% (Brown *et al.,* 2013).

Also a comparison study done in Brazil revealed that community having improved sanitary facilities had a declined prevalence of ascariasis of up to 40% compared to the community having unimproved sanitation facilities. Other studies done in India and Ethiopia reported reduction on stunting among under-five children coming from families with sanitation facilities when compared with those without such facilities (Chambers and Von Medeazza, 2013; Teshale Fikadu1, 2014).

Poor sanitation practices in any community could lead to water/food contamination via contaminated hands or flies which could lead to oral-fecal bacteria infections particularly *Escherichia coli* infections and finally poor nutritional status among individuals. Again communities practicing poor sanitation are likely to be practicing open defecation and other unsanitary behaviors which could lead to contamination of soil and water especially during rainy season by worms which could later infect individuals especially children in the community. Knowing the burden of poor sanitation in causing diseases it is therefore important to promote improved sanitation among individuals and communities at large (Cumming, 2016).

(iii) Hygiene practices

Hygiene practices including food hygiene, personal hygiene, child feces disposal and hand washing with soap during critical moments plays a fundamental role on infectious disease occurrence. Child feces disposal in particular contribute significantly to fecal-oral disease causation and transmission. Marginalized communities pastoralists believe that child feces are not harmful compared to those of adults due to the reason that their feces are small, smells less, do not contain many food residuals and are stainless (Mshida *et al.,* 2017). Also in many families, latrines are not designed to accommodate children, some smell bad, some are in dark spaces and children may fall in. Due to such reasons, people use alternative means including children potties, open defecation normally on the floor or even in the nappies therefore, latrines are rarely used by children and chances of contamination from child feces are high.

Study done in semi-pastoral communities in northern Tanzania reported that about 20% of under-five children were using latrine to defecate whereas more than 50% were practicing open defecation and feces were left on the ground for the dogs to feed on it (Mshida *et al.,* 2017). Study done in Peru revealed that less than 25% of children under-five years old used toilets (Checkley *et al.*, 2004). Another study done in Bukinafaso reported that more than 60% of children below five years of age were practicing open defecation and it was observed that feces were not removed but left where they were and in some areas dogs were seen eating the feces (Huttly *et. al.,* 2002). The reported percentages of children using toilets and those practicing open defecation seems to be similar in the reviewed studies indicating that there could be some similarities in child feces disposal behavior in most of developing countries. Therefore, global strategies to eliminate such unhygienic practices could apply to all developing countries. Again poor disposal of child feces and unawareness on the harmfulness of the feces may pose a high risk of fecal contamination of hands, food or water which may increase risks of developing fecal-oral infections to individuals. However, hygiene behavior change interventions to raise awareness on the harmfulness of child feces and the danger of open defecation are recommended to reduce fecal-oral infections among under-five children.

Again hands could be a good vehicle for disease transmission when they are not washed thoroughly with soap after coming into contact with dirty. WHO recommend hand washing with soap during the four critical moments which are before eating/feeding a child, after coming from the toilet, before preparing food and after attending a child (Curtis and Cairncross, 2003). However, studies shows that hand washing with soap could be a big problem than people knows and it might be under estimated (WHO/JMP, 2017). People respond easily that they do wash hands with soap when they are asked but the truth is majority do not practice hand washing (Curtis, 2003). Hands are good vehicles for transmitting diarrhea causing pathogens particularly *E. coli* in case they get contaminated. Furthermore, interventions on hand washing with soap may significantly reduce the prevalence of diarrhea more than improved sanitation do (Asudi, 2016).

This study proof that hands are potential transmission route for pathogenic bacteria from our environments to the mouth and interventions on hand washing during critical moment could break the fecal-oral routes infections more than improved sanitation do. However, integration of more than one WASH practices could reduce prevalence of diarrhea more effectively than single intervention. Study done in Tanzania where handwashing and sanitation promotion campaigns were done in rural wards revealed a reduction in infectious diseases and improvement in under-nutrition among under-five children when compared to children from control group (Briceño, 2015). Another study done in Tanzania to look for association between contamination on people's hands and stored drinking water revealed a strong association between the two parameters indicating the importance of handwashing to individuals on disease prevention measures (Briceño, 2012). Epidemiological evidence shows that handwashing with soap may reduce infectious diseases specifically child diarrhea by 30-47%. However a review study done in 11 developing countries showed that only 17% of people wash their hands with soap after using the toilets and fear of disease did not have any influence on handwashing behavior (Curtis 2003, 2009).

The findings highlight the importance of promoting handwashing practices with soap during critical moments through behavior change campaigns as well as construction of hand washing facilities at household level and communities at large. However, the campaigns should go hand in hand with health education to create awareness on the relationship between infectious diseases and WASH practices to the communities. Again studies to determine the actual number of people practicing handwashing with soap during critical moments should focus much on observation rather than interviews to come up with the status of the actual practice. Unhygienic behavior among individuals remains as a potential source of water/food-borne diseases therefore; promoting hygiene behavior change may be effective means of reducing these diseases in developing countries.

Factors contributing to poor WASH

Water, sanitation and hygiene practices are among the basic human needs although it is given less priority by the majority in developing countries. Poor WASH practices among individuals and communities could be due to various factors including socio-economic, cultural, demographic, behavioral and geographical factors as well as poverty. Study done in Nigeria revealed that, low priority on funding WASH programs by the government, lack of well-defined institutional framework for WASH, unfavorable policy environments, weak and poorly enforced public health laws, poorly motivated sector professionals were among the factors contributed to poor WASH practices (Onugba, 2005). Study done in Cambodia revealed that socio-economic, cultural and demographic factors were among the factors contributed to poor WASH practices (Fewtrell *et al.*, 2007). For the case of Tanzania lack of clear policies and regulations with respect to sanitation and hygiene together with limited resources are among the contributing factors to poor WASH (Thomas *et al.*, 2013). The problem of poor WASH practices in developing countries is critical and has been contributing significantly to child mortality and morbidity. To solve the problem, multi-displinary approach kind of strategies which involve different sectors within the government are crucial. Again given the burden of poor WASH practices on disease causation, it is therefore important for the developing countries to priotize WASH issues so as to reduce disease burden due to poor WASH

Initiatives to combat poor WASH

The SDGs targets zero population without WASH facilities by 2030. However, for this target to be achieved, it is crucial for stakeholders responsible on WASH to commit themselves to this target by priotizing the issue so as to come up with compelling solutions for improving health and quality of life through implementation of appropriate programmes. The MDGs estimated that, by 2015 people without sustainable access to improved drinking water and basic sanitation had to be halved (Waage *et al.*, 2010).

Therefore an estimate of 784 million people had to gain access to an improved water source while an estimated 173 million people on average per year had to begin using improved sanitation facilities. However, it was further expected that about 790 million people which is 11% of the world population had to remain without access to an improved water supply and 1.8 billion people which is 25% of the world`s population without access to adequate sanitation (Too-Kong, 2014). Tanzania is among the East and Southern African countries that did not meet the millennium development goals 3 and 7 targets 7C to halve by 2015 child mortality and proportion of people without sustainable access to water supply and basic sanitation (WHO, 2015). This failure could be due to population growth characterized by rapid urbanization, which the Government could not service due to limited capacity and resources (Thomas *et al.*, 2013). Even though Tanzania has implemented a number of national hygiene and sanitation campaigns since its independence as a way of reducing WASH-associated infections yet majority of its people do not practice good WASH (Malebo and Tenu, 2012). It is therefore, argued that to achieve the global goals of combating infectious diseases and reducing child mortality, initiatives should start at individual level to community level due to the fact that some WASH practices are habitual in nature. However, the national sanitation and hygiene campaigns should be evaluated and reviewed to make it more valuable and productive. Again, multi displinary kind of strategies which integrate ideas from different stakeholders are encouraged for achieving significant improvement on WASH practices and reduction of child mortality.

Impact of WASH on common infections

Lack of adequate and safe water, sanitation services, coupled with poor hygiene practices, causes deaths and illnesses to thousands of children every day (Bosch *et al.,* 2002). It also contributes to almost 30% of the total burden of disease in developing countries and 75% of all life years lost (Aziz *et al.,* 1990). It is further estimated that in developing countries each year, about 801,000 children under-five years old die from infectious diseases particularly diarrhea and most of these infections are due to poor WASH. This contributes to 11% of the 7.6 million deaths of children under the age of five years which is equivalent to about 2,200 deaths per day (UNICEF, 2009). Also, poor WASH practices together contribute to about 88% of deaths from diarrheal diseases globally (Gsrus-Pakowska, 2013). It is therefore, crucial to address WASH concerns and ensure strategies for improving such practices are in place to reduce global burden of infectious diseases. A number of studies have associated the high prevalence of infectious diseases particularly diarrhea with poor WASH practices (Cairncross *et al.*, 2010; Bado *et al.*, 2016; Nuhu, 2016). Soil-transmitted infections such as Ascariasis, whipworms and hookworms that affect about 1.2 billion, 800 million and 750 million people worldwide, respectively, have also been associated with poor WASH practices (Mascarini-Serra, 2011). Similarly, environmental enteropathy which is mainly a result of regular ingestion of fecal bacteria due to poor sanitation and hygiene conditions has been reported in under-five children (Humphrey, 2009, Ngure *et al.*, 2014). Factors such as unhygienic handling and storage of complementary foods, poor handwashing practices and disposal of child feces, open defecation, lack of safe water sources for domestic use by the majority as well as poor solid and liquid waste disposal continue to be major health threats among under-five children (Cairncross, 2010; Gautam, 2015, 2017). However, improved WASH practices could be a solution to minimize the incidences of WASH associated infections among under-five children (Fewtrell *et al.*, 2005; Waddington *et al.*, 2009). Again integrating more than one WASH intervention could reveal significant outcome on reduction of infectious diseases among under-five children and reduced mortality.

Impact of WASH on child nutritional status

The nutritional status of children under-five years of age depend much on improved WASH practices such as hygiene conditions of the household members and their surroundings, proper disposal of waste as well

as availability of adequate and safe water in the household among other things. Poor WASH practices may affect the health status of children and may also affect their growth performance. A report from UNICEF stated that poor WASH accounts as much as 50% of maternal and childhood underweight taking into account the relationship between diarrhea diseases and under nutrition (UNICEF, 2013). Again, WASH interventions implemented with 99% coverage may reduce stunting prevalence by 2.4% at 36 months of age (Bhutta *et al.,* 2008) and 860,000 child deaths due to under nutrition (Prüss-Üstün *et al.*, 2008). Study done in Ethiopia also revealed a reduced prevalence of stunting by 12% as a result of WASH interventions (Fenn *et al*., 2012). It was also reported that children living in the environments with improved sanitation and hygiene conditions were taller for their age and less stunted than those living in unsanitary and unhygienic conditions (Lin *et al*., 2013). Also handwashing with soap and 15 minute reduction in water collection time were confirmed to improve child nutritional status significantly (Curtis and Cairncross, 2003; Pickering *et al*., 2015).

Currently there is no sufficient research done on the impact of WASH on the nutritional status of under-five children although studies on the contribution of WASH on infectious diseases are many. Again few researches have reported the link between poor WASH practices and under-nutrition although the relative contributions of poor WASH to under nutrition remains controversial. Improved child health and good growth performance may not depend solely on improved WASH practices but also on improved maternal care, good child feeding practices including exclusive breastfeeding as well as health education interventions with emphasis on individual hygiene behavior change, change in believes and norms that may have negative impact on health and as well as change in health care seeking behaviors.

Conclusion and recommendation

Developing countries particularly Sub Sahara African countries are still facing the problem of under-nutrition which contribute significantly to morbidity and mortality of under-five children.

The immediate causes of under-nutrition include inadequate dietary intake and diseases. Other factors are underline causes which include food insecurity, poor child feeding practices, lack of health care services and poor WASH conditions embedded with political, social, cultural and economic factors. Having known the nature of the problem of under-nutrition and its causes, it is therefore recommended that multi displinary strategies targeting on improved WASH and disease prevention interventions should be incooperated into nutrition interventions to solve the problem of child mortality in developing countries.

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