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Burden of Diarrhoeal Diseases through Complementary Foods: A Review

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ABSTRACT

Diarrhoeal disease is considered a public health problem with high morbidity and mortality worldwide, especially among children under the age of five years. In India, like other developing countries, diarrhoeal diseases are important child health problem. Food is an important factor in transmitting pathogens that cause diarrheal illness. Diarrhea can be caused by numerous pathogens and transmitted through multiple vehicles. Complementary foods prepared under unhygienic conditions are frequently heavily contaminated with pathogens and may thus be a major factor in causing diarrhoea diseases. Diarrheal diseases are major causes of malnutrition, delayed physical development *and* early childhood mortality. Diarrhea can cause acute wasting and is the most important infectious determinant of stunting of children's linear growth. The prevention of diarrhoea in infants and children requires a multidisciplinary approach, including the promotion of safe preparation and handling of complementary food. Food contamination can be reduced using a Hazard Analysis and Critical Control Point (HACCP) methodology at the household level. Mothers and caregivers must wash their hands before feeding children and preparing food.

Key words: Children, Complementary foods, Diarrhoeal disease, Malnutrition, Pathogens.

Complementary feeding is essential if children are to grow and develop properly. Adequate complementary feeding entails feeding children aged between 6 and 23 months with foods from four or more food groups at least twice a day (WHO, 2014; WHO 2007). It is the process starting when breast milk alone is no longer sufficient to meet the nutritional requirements of infants. Complementary foods play vital role for children growth and development and complements for both nutritional and developmental needs of the infant when breast milk alone is no longer sufficient (Temesgen, 2013).

The early year period also reflects a time of high vulnerability of the child to various adverse health outcomes such as diarrhoea (Chan *et al*. 2017). Complementary foods prepared under unhygienic conditions are frequently heavily contaminated with pathogens and may thus be a major factor in causing diarrhoea diseases and associated malnutrition (Oluwafemi and Ibeh, 2011).

Global perspective on burden of diarrhea

Diarrhoeal disease (DD) is considered a public health problem with high morbidity and mortality worldwide (Wardlaw *et al*., 2010). It is one of the leading causes of morbidity and mortality, especially among children under the age of five years. Globally, there are nearly 1.7 billion cases of childhood diarrhoeal disease and estimated 525000 deaths occur each year among children under five years of age (WHO, 2018). According to statistics by World Health Organization (2013), children under three years of age in developing countries experience on average about three episodes of diarrhea every year. As a result diarrhea is a major cause of malnutrition and the most severe threat posed by diarrhea is dehydration. Death can follow severe dehydration if the lost body fluids and electrolytes are not replenished. Fig 1 shows the regional burden of diarrhea among children aged 0-4 Years.

These diseases are a major cause of hospitalization and child's death globally. Together they account for approximately one in six deaths among children younger than five year's (WHO, 2009).

Indian perspective on burden of diarrhea

In India, like other developing countries, diarrhoeal diseases are important child health problem. National Family Health Survey 2015-16 (NFHS-4) conducted using a two week recall period revealed that a diarrhea prevalence among under five children 9.6% in rural and 8.2% in urban areas, with a average rate of 9.2%. (IIPS, 2015-16). Diarrhoea is the passage of loose or watery stools occurring three or more times in a 24-hour period which means an increased frequency or decreased consistency of bowel movements and it affects people of all ages (Mohamed Ali, 2016). It is

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usually a symptom of an infection in the intestinal tract, which can be caused by a variety of bacterial, viral and parasitic organisms (Dawit *et al*., 2016).

Among children aged 1-4 years, acute watery diarrhoea accounted for 31-69% of diarrhoeal deaths, acute bloody diarrhoea for 12-28% and persistent diarrhoea for 12-56% (Rahman, 2014). Major risk for diarrhoea includes environment contamination and increased exposure to enter pathogens. Additional risk include young age, malnutrition, lower socioeconomic status and lack of exclusive or predominant feeding (Monica *et al*., 2012; Yilgwan and Okolo, 2012; Archna *et al*.,2012; Sachdev, 1991).

Contamination of complementary foods

Epidemiological data demonstrate that food is an important factor in transmitting pathogens that cause diarrheal illness (Motarjemi *et al*. 2012). More than 120 important viral, bacterial and parasitic agents transmitted by food have been identified (Motarjemi *et al*. 2014). While some pathogens can survive in the environment, the main reservoirs for these agents are domestic animals, household pests such as rats and mice and humans. When animals and their products are used as food, these agents may be present in or on the food. Pathogens are usually present on the surface of food due to direct or indirect contamination from the animal, pest, or human reservoir. In the case of many parasites and certain bacteria, such as Salmonella Enteriditis in eggs, the agent is present within the food. Many pathogens known to cause diarrhea are spread by the fecal-oral route.

Moreover, most of the child diarrhoeal cases could be due to foods and water that children consume in their homes as most foodborne transmission in developing countries takes place within the home (Toure *et al*, 2011). While a wide range of pathogens can cause foodborne diseases, viruses, bacteria and parasites pose the greatest share of preventable foodborne threats (Lee *et al*. 2014; Fischer-Walker *et al*. 2013). Food serves as a vehicle for virus and parasite transmission to a new host; however, for many bacteria, food offers an opportunity to grow exponentially to infectious levels. Some bacteria, such as *Staphylococcus aureus* and *Bacillus cereus*, will produce toxins while growing in food, resulting in foodborne intoxications or food poisoning. More than 120 important viral, bacterial and parasitic agents transmitted by food have been identified. Thirty-two of these are significant public health problems and more than half cause diarrhea, either alone or in combination with other adverse symptoms (Motarjemi *et al*. 2013).

In rural and urban Bangladesh, 18 per cent of tested complementary food samples for children were contaminated with high levels of fecal coliforms (≥100 CFU/g of food) and 29 per cent were positive for *E. coli*. A number of pathogenic *E. coli* strains, including enterotoxigenic, enteropathogenic and Shiga-toxin E. coli, also were detected in complementary food samples in Bangladesh (Islam *et al*. 2012). The report also indicated that elevated aerobic plate counts were associated with the presence of *E. coli* in CF as well as with the frequency of feeding the same food for multiple meals over time (Wolf *et al*. 2014).

Diarrhea can be caused by numerous pathogens and transmitted through multiple vehicles. Some of the most common pathogenic causes of severe and fatal diarrhea in young children globally are rotavirus and shigella. Rotavirus takes the lives of over 3,600 children under five years and accounts for approximately 40% of all deaths caused by diarrhea (CIDRZ, 2013). Contaminated hands and cooking utensils contribute greatly to the contamination of weaning foods, especially among mothers who do not observe proper hygienic conditions (Michaelsen *et al*., 2003).

Risk factors for the development of diarrhoea

Morbidity and illness in young children is particularly problematic because early childhood is a critical period in terms of development (MacIntyre, 2014). Factors that are involved in the occurrence of diarrhoea in children are complex and the relative contribution of each factor varies as a function of interaction between socio-economic,

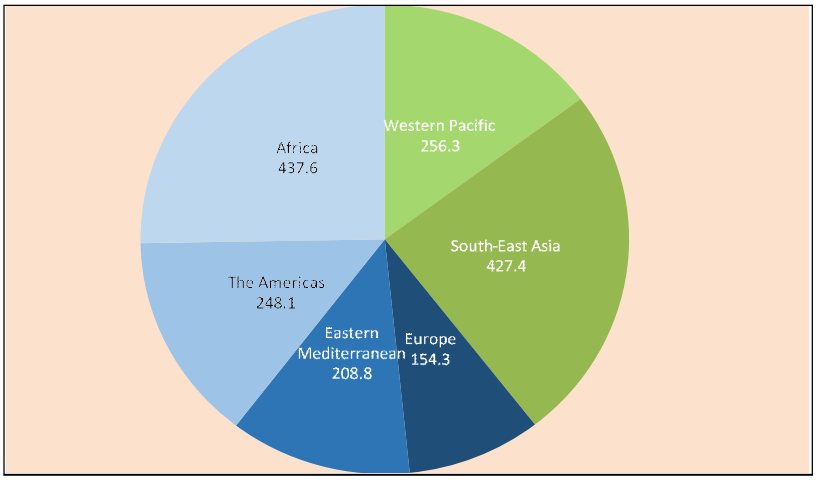

Fig 1: Regional burden of diarrhea, Ages 0-4 Years, 2010.
Source: Fischer Walker *et al*., 2013.

environmental and behavioural variables (Mengistie *et al*., 2013). The documented risk factors for diarrhoea include younger age, malnutrition, early weaning, seasonal patterns, low maternal education, lack of piped water supply, poor water-storage practices, lack of vigilant hand washing, poor sanitation and not treating water in the home (George *et al*., 2014; Arvelo *et al*., 2010). The challenges during complementary feeding are context specific, but many are common across settings. They are often characterized by poor feeding practices and poor dietary quality of homemade complementary foods (Krebs, 2011; Plessis *et al*. 2013).

The safe food handling practices was not followed appropriately during food preparation which resulted in higher levels of microbial contamination in their food produce (Krishnasree *et al*., 2018). Diarrheal diseases are major causes of malnutrition, delayed physical development and early childhood mortality in developing countries and poor communities and the major cause of death in children with diarrhea is loss of water and essential minerals (Dodicho, 2016).

Preventive strategies for diarrhoeal diseases

Contamination of food is a major cause of diarrhoeal diseases in both the developed and developing world. Foods which are nutritious should also be wholesome and safe to prevent infection. Food should therefore be prepared hygienically and safely (Onyangore *et al*., 2015).

HACCP approach

Food contamination can be reduced using a Hazard Analysis and Critical Control Point (HACCP) methodology at the household level. This is a management system in which food safety is addressed through the analysis and control of biological, chemical and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product (Islam *et al*, 2013). Food should therefore be prepared hygienically and safely (Onyangore *et al*., 2015).

In Bangladesh, 30 mothers were assigned to an intervention group and 30 to a control group. After identification of critical control points, three field workers trained mothers/caregivers in the intervention group for 4 weeks in key behaviors to prevent bacterial contamination of complementary food. Complementary food and water were tested for contamination with pathogenic microorganisms at baseline, after the 4-week training and 3 months after the intervention. The baseline results demonstrated substantial contamination of complementary food in the study population. The intervention, which involved mothers and caregivers applying the critical actions identified through the HACCP approach, significantly reduced fecal bacterial contamination in complementary food and water (Islam *et al*. 2013). Toure *et al*. (2011, 2013) in Mali also determined the effectiveness of implementation of defined critical actions to reduce pathogenic contamination in complementary food. In 2011 researchers worked with 15 randomly selected mothers from a health center nutrition education group in a peri-urban area of Bamako to identify key problems and critical control points in the preparation of two common complementary foods. Trained field staff worked with the mothers over several days to adopt the critical actions to reduce pathogenic contamination. The results showed that the critical actions, when followed diligently, were successful in eliminating pathogens from the complementary food. In 2013 field workers worked with 30 mothers over a longer period of time, 9 months, to practice adopting the actions. Results demonstrated a statistically significant reduction in fecal coliform contamination of complementary food between the baseline study and immediately after the training and between baseline and 3 months after the training among mothers in the intervention group ($p<0.008$), while mothers in the control group had no reduction in fecal coliform contamination of complementary food during the same time period. These intervention studies that identify critical control points and key actions and test actions with potential users are important to ensure that identified actions, when practiced as intended, do eliminate or minimize bacterial contamination. If they do not, more observations may be necessary to see whether critical actions are implemented as intended or whether other critical actions need to be added to the recommended behaviors.

Water, sanitation and hygiene interventions

Acute diarrhea is one of the main problems affecting children under- five in the world, reducing their wellbeing and this leads to a considerable demand for health care services. There is a strong relationship between diarrhea, poverty and unhygienic environmental conditions (Mohammed, 2013).

According to WHO (2014) risk of diarrheal disease can be reduced by 28 per cent through improved sanitation, including sewer connections; reduced by 45 per cent through effective water treatment at the household level (such as boiling water or treating water with chlorine or other appropriate agents) and safe water storage; and reduced by about 23 per cent through handwashing with soap. Household filters generally outperformed household chlorination and in each case, safe storage provided significant additional protection (on the order of an additional 12 to 15 per cent risk reduction) (Wolf *et al*. 2014).

Keeping food free of fecal contamination is one of the key ways to prevent the fecal-oral transmission of disease (Curtis *et al*. 2011). A Significant proportion of diarrhea can be prevented through safe drinking water, good sanitation and hygiene (WHO, 2013). A central element of safe food preparation is handwashing, but this is not the only component requiring improvement for weaning food hygiene (Islam *et al*., 2013; Toure *et al*. 2013). Handwashing before food preparation and/or child feeding is a frequently missed opportunity for habituating hygienic behaviors (Halder *et al*. 2010; Nizame *et al*. 2013) and reducing childhood diarrhea. Handwashing with water before food preparation was associated with reduced risk of diarrhea among Bangladeshi children (Luby *et al*. 2006). Handwashing with soap can reduce diarrhea around 23 percent (WHO 2014).

Water, Sanitation and Hygiene (WASH) are three basic dimensions of Public Health and any compromise in them has adverse consequences on health. WASH could potentially affect childhood nutrition via at least three pathways: intestinal worms, EED and repeated bouts of diarrhoea (Dangour *et al*., 2013). All three of these pathways are mediated by enteric pathogen exposure that can be prevented with WASH (Fig 2).

Personal hygiene plays an important role in feeding infants. If sanitation is not observed, weaning feeding may do more harm than good to the infant by introducing infections to the infant (Satter *et al*., 2013). The agents of acute gastroenteritis are transmitted mainly by the faecal-oral route, either through direct person-to-person contact or through contaminated food or water; therefore, sanitation, good hand washing and hygienic measures prevent spread (Revelas, 2012).

Safe preparation and storage of complementary foods

Formulation of the milk-based weaning food is a good approach to alleviate the malnutrition associated with conventional stipulated cereal-based weaning flour mixtures given in liquid-gruel form (Srivastava *et al*., 2016). During formulation of any weaning foods made from locally available raw materials; the techniques of food preparation process, handling, storage, sanitation, sensory properties and food quality and safety issues in general should be taken in to account (Amuna *et al*., 2000; Ifediora, *et al*. 2006). Careful hygienic preparation and storage of weaning food is important. The food stuffs should be freshly prepared.

Safe food hygiene practices include the following: those who handle the food, during preparation or feeding, should wash their hands properly with soap and water, after using the toilet and before meals and the infants' hands should be washed likewise; kitchen utensils and cooking surfaces should be kept clean; only healthy-looking foods should be used and they should be kept in a safe place; an amount of food that suffices one meal only should be prepared and it should be served immediately after preparation; the infant should be fed from a glass or cup, spoon and plate, avoiding the use of baby bottles; infants should not be given leftovers from the previous meal and, if using a fridge, it should be cleaned regularly and any spoilt foods should be thrown away. If complementary foods need to be stored after preparation, they should be reheated at 70°C. Otherwise, there is a high risk of contamination. (WHO, 2000).

Basic recommendations for the preparation of safe foods (WHO, 2001) are summarized as below.

Five keys to safer food.

- Keep clean.
- Separate raw and cooked.
- Cook thoroughly.
- Keep food at safe temperatures.
- Use safe water and raw materials.

community level interventions

Health education interventions can be delivered to individuals or groups, face to face or by telephone in communities, hospitals, homes, schools, or organisations. They may be delivered by verbal, written, or audiovisual means such as printed materials, multimedia (video messages, PowerPoint presentations), counselling sessions, practical demonstrations, lectures and role plays (Ciciriello 2013; Nkhoma 2013). Caregivers with improved knowledge, skills and self efficacy are more likely to practice better hygiene in food preparation as well as ensure proper composition of complementary diets. Improved complementary foods will lead to reduced incidence of undernutrition, diarrhoea and growth faltering (Monte 1997; Shi 2011). Zinc supplementation during diarrhoea is known to reduce the duration and severity of treated episodes Zinc supplementation during diarrhoea is known to reduce the duration and severity of treated episodes (Black and Sazawal, 2001).

Fundamentally, community level interventions should be short, simple, culturally acceptable, low cost and involve

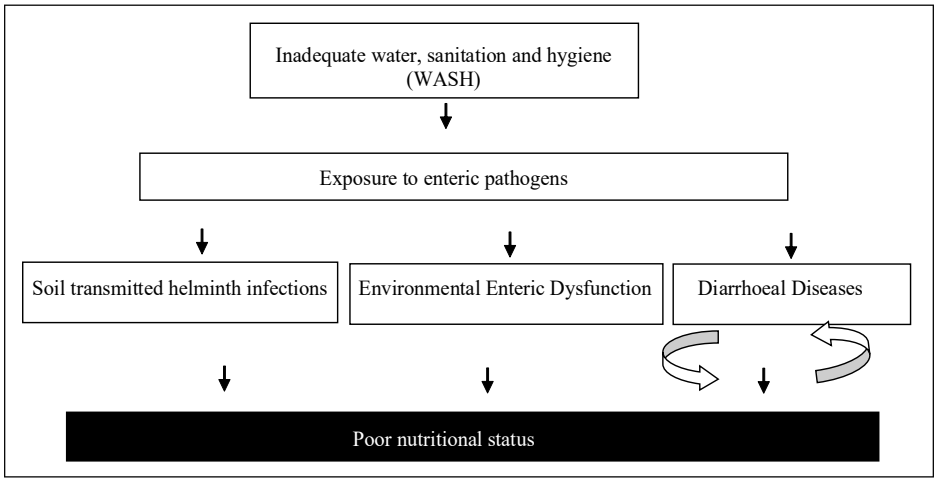

Fig 2: How wash can affect childhood undernutrition.

Source: Apdate wast can affet childhood undernutrition.

existing structures. In Vietnam, Takanashi *et al*. (2013) developed 17 food hygiene messages that were transmitted through five SBC channels, including workshops, newsletters, loudspeaker announcements, bulletin board announcements and flip charts for use in community meetings and home visits. The study included an intervention phase for 1 year, followed by a self-sustaining phase for 1 year during which activities were maintained by water management unions. Among the various SBC channels, flip chart communication via community groups and home visits were significantly associated with a greater number of good food hygiene behaviors. The authors attributed this to the quality of the flip charts in terms of the level of information provided, their colorful images, ease of use and portability and to the high level of interpersonal communication that they encouraged.

In Vietnam, Takanashi *et al*. (2013) also found that interpersonal communication via flip charts used during home visits was associated with the adoption of a greater number of positive food hygiene behaviors than the study's other methods for communicating messages; the study attributed this to the flip charts and the level of interpersonal communication achieved during a home visit. Treatment and prevention of diarrhea can be done at home by primary caregivers and their role is vital in health promotion, disease prevention and patient care (Dodicho, 2016).

CONCLUSION

In conclusion, the prevention of diarrhoea in infants and children requires a multidisciplinary approach, including the promotion of safe preparation and handling of complementary food. It is therefore, important that all foods prepared for young infants are handled in a way that they are free from any contamination. Interventions to reduce the risk factors should focus on the critical control points in food preparation, storage and reheating and the contributing factors to post-cooking contamination such as hand hygiene, clean utensils and reducing contact with flies and animals. Mothers and caregivers must wash their hands before feeding children and preparing food. Hand washing with soap is the most effective way of reducing diarrhoeal disease.

Appropriate and sustainable household food-processing, preparation and storage techniques must be developed and adapted to local conditions to reduce the microbial contamination of complementary foods. In view of this, the education of mothers on food safety principles is one of the most important interventions in promoting the health and nutritional status of infants and children. It can prevent diarrhea-related child morbidity and mortality.

Conflict of interest: None.

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