

Combating diarrhoea in Nigeria: the way forward

Abstract

The Millennium Development Goals (MDGs) calls for a reduction of child mortality by two third between 1990 and 2015, the reality is that although progress is been made, much more remains to be done. The prevalence rate of diarrhoea in Nigeria is 18.8% and is a menace in sub-Sahara Africa; and in this part of West African it accounts for an estimated 150,000 deaths yearly amongst children under five due to poor hygienic and sanitary practices. Diarrhoea's status as the second leading killer of children under five is an alarming reminder of the vulnerability of children in Nigeria, saving the lives of millions of children at risk of death from diarrhoea is possible with a comprehensive strategy that ensures all children in need receive critical prevention and treatment measures. This report is written with the intent to let our government re-focus her attention on the prevention and management of diarrhoeal diseases as central to improving child survival in the country and justify the need to embrace Sustainability Development Goals (SDGs) set by WHO to achieve universal access to clean water and basic sanitation, which is the primary preventive measures to reduce the burden of diarrhea in the country.

keywords: public health, mdgs, sdgs, under-age children

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Akinrotoye Kehinde Peter,¹ Uzal Umar²

¹Department of Microbiology, College of Biosciences, Federal University of Agriculture, Nigeria

²Department of Microbiology, Abubakar Tafawa Balewa University, Nigeria

Correspondence: Akinrotoye Kehinde Peter, Department of Microbiology, College of Biosciences, Federal University of Agriculture, P.M.B 2240, I10001, Abeokuta, Ogun State, Nigeria, Tel +2348182913048, Email captkennypeter@gmail.com

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Introduction

Diarrhoea is a form of gastrointestinal infection caused by a variety of bacterial, viral and parasitic organisms or through contaminated food or drinking water, or from person to person as a result of poor hygienic practices. If Left untreated, diarrhea can typically last several days. Diarrhoea remains a major cause of mortality among under-age children (mostly under 5years) around the world, especially in developing world.¹ The burden of Diarrheal disease seriously affects young children in developing countries whose incidence rates is high due to inadequate water, poor sanitation and suboptimal breastfeeding, zinc and vitamin A deficiency.²⁻⁴ Vulnerable children living in impoverished and undeveloped areas also have higher fatality rates compared to children living in developed countries due to lack of access to quality health care and timely intervention and effective treatment with oral rehydration solution (ORS) and zinc.^{5,6} Diarrhoea has been described as an increment in the volume, fluidity of stools and increased rate of defecation with slight changes in consistency. The measurement of stool fluid content is an indicator for diagnostic purposes and taking into account the assessment of stool frequency. World Health Organization (WHO) placed criteria for diarrhoea to occur if there is an excretion or passage of watery stools at least two-three times in a 24 h period, but factors such as stool consistency, stool frequency, and the usefulness of parental discernment in determining whether children have diarrhoea or not is clearly important to pin down if diarrhoea has occurred or not.⁷ Acute diarrhoeal illnesses or dysentery is often easily recognized by appearance of blood in the stool, irrespective of frequency or consistency.^{8,9} A diarrhoeal disorder is often divided into acute, chronic and persistent. The most common of diarrhoea disorders, acute diarrhoea often starts abruptly, are caused by infections and are subdue/resolved within 14 days. Chronic diarrhoea is majorly a product of congenital defects of digestion and absorption in the body system and last for at least 14 days.⁷ Persistent diarrhoea usually arises due to secondary infections in the presence of complications such as malnutrition.

Each year, an estimated 2.5 billion cases of diarrhoea occur among children under five years of age, and estimates suggest that overall incidence has remained relatively stable over the past two decades.¹⁰

More than half of these cases are in Africa and South Asia where bouts of diarrhoea are more likely to result in death or other severe outcomes. The incidence of diarrhoeal diseases varies greatly with the seasons and a child's age. The youngest children are most vulnerable: Incidence is highest in the first two years of life and declines as a child grows older. The leading cause of childhood morbidity and mortality in developing countries remains diarrhoea. Diarrhoea diseases, a third leading cause of child mortality and infant deaths in low and middle income countries is a major cause of illness and death among young children, even though the condition can be easily treated with oral rehydration therapy (ORT). Exposure to diarrhoea-causing pathogens is frequently related to the consumption of contaminated water and to unhygienic practices in food preparation and disposal of excreta. The combination of high cause-specific mortality and the existence of an effective remedy make diarrhoea and its treatment a priority concern for health services.

According to the World Health Organization, Globally, there are nearly 1.7 billion cases of diarrhoea every year among children under five, diarrhoea is the second-leading cause of death in children under five and is responsible for killing around 760,000 children every year. Diarrhoea kills more children than AIDS, malaria and measles combined; diarrhoea is a leading cause of malnutrition and stunting in children. Mortality from diarrhoea has declined over the past two decades from an estimated 5 million deaths among children fewer than five to 1.5 million deaths in 2004, despite these declines, diarrhoea remains the second most common cause of death among children under five globally.

The burden of diarrhoea in Nigeria—a battle not yet won!

The country's 2006 Population and Housing Census placed the country's population at 140,431,790. Nigeria marked its centenary in 2014, having begun its existence as a nation-state in 1914 through the amalgamation of the northern and southern protectorates by Lord Lugard. Nigeria formulated a national health policy targeted at achieving quality health for all Nigerians in 1988. As a result of emerging issues and the need to focus on realities and trends, a review of the policy became necessary. The new policy, referred to as the

Revised National Health Policy and launched in September 2004, outlined the goals, structure, strategy, and policy direction of the health care delivery system in Nigeria.^{11–13} According to the African CDC report (2014), made up of an African CDC Coordinating Centre in Addis Ababa, recent mortality rate estimates in the country stood at; Malaria 20% , Lower Respiratory Infections 9% , HIV 9% , Diarrheal Diseases 5% , Road Injuries 5% , Protein-Energy, Malnutrition 4% , Cancer 4% , Meningitis 3% , Stroke 4% , Tuberculosis 4%.

Diarrheal disease is the third leading cause of infant and child mortality in developing countries^{1,14} and about 1.8 million children die per annum from this disease.¹⁵ The number of diarrhoeal deaths is ridiculously on the high side despite a fall in childhood diarrhoeal diseases from 4.6 million to 0.8 million over the last three decades.^{1,16,17} The prevalence of childhood diarrhea in Nigeria is 18.8%, with 26% of cases treated with oral rehydration salts (ORS) solution.^{18,19} Amongst children below five years old, diarrhoea accounts for over 16 % of deaths, estimated at 150,000 annually.^{20,21} Exposure to diarrhoea-causing pathogens is frequently related to the consumption of contaminated water and to unhygienic practices in food preparation and disposal of excreta. The combination of high cause-specific mortality and the existence of an effective remedy make diarrhoea and its treatment a priority concern for health services.²¹

The country fails to achieve or meet the Millennium Development Goal 4 (MDG 4) in 2015; in which it must attain a two-thirds reduction in the under-five mortality rate from 230 deaths per 1000 live births from 1990 to 76 in 2015.^{22,23} The 2013 Nigeria Demographic and Health Survey²¹ gave a conclusion that if under-five mortality rate of 128 deaths per 1000 live births is to be achieved, then an additional annual 20% reduction is needed to meet the target. Although the federal government along with various NGOs make concerted effort to reduce the burden over the last decades as evidenced by the recent ranking in which Nigeria drop from 2nd to 4th position trailing Pakistan, Bangladesh and India in the rating of countries with the highest number of child death due to diarrhoea; but still there is room for improvement in order to achieve the set goals of Sustainability Development Goal 1 (SDGs) for thriving lives and livelihoods which have a time-frame of 15 years (2015-030).

The Sustainability Development Goals (SDGs) was enacted by W.H.O after the MDGs time-frame elapsed and still some countries couldn't meet up. SDGs becomes useful tool in focusing achievement of specific development gains for the development activities of a country, for national priority-setting and for mobilization of stakeholders and resources towards common goals, therefore remaining firmly committed to its goals and achievement. Now the era of MDGs has come and gone and a blue print of SDGs initiated by WHO²⁴ is laid out for every government to achieve within a time frame. These goals address and incorporate in a balanced way all three dimensions of sustainable development and their inter linkages which is coherent with and integrated into the United Nations development agenda beyond the time frame. The development of these goals should not divert government focus or effort from the achievement of the Millennium Development Goals, however it will be inhumane and deceptive on the part of the government to neglect the blue print of SDGs laid down by WHO, if truly the country want to win the war against the burden of diarrhoeal diseases claiming the lives of innocent children each year.

Risk factor for diarrhoeal diseases

Risk factor according to World Health Organization,²⁴ is any attribute, characteristics or exposure of an individual that increases the like hood of developing a diseases or injury. Some examples of the more important risk factor for diarrhoeal affecting children under age 5 includes unsafe water, humanitarian crises, contaminated foods, direct contact with causative microorganisms (bacteria, viruses & protozoan) and unhygienic environment etc.

Diarrhoea has been killing children for several decades and it has attained an endemic status according to data suggested by Kosek et al.,²⁵ & WHO,²⁶. The burden of diarrhoeal illness sits firmly in the developing world, both for morbidity (6–7 episodes per child per year compared with 1 or 2 in the developed world²⁷ and mortality. Malnutrition and the wholly inadequate provision of safe water, sanitation, and hygiene highlight the stark inequalities that exist within our world. A quarter of children in developing countries are still malnourished, 1.1 billion people do not have access to safe drinking water, and 2.4 billion are without adequate sanitation.^{28–30} Deaths caused by diarrhoeal illness in developed nations are rare accounting for 4% of all hospital admissions.²⁷

Humanitarian crises

Diarrhoea is a leading cause of death during complex emergencies and natural disasters. Natural or Man-made disaster often leads to displacement of populations into temporary and overcrowded shelters; which is often associated with polluted water sources, inadequate sanitation, poor hygiene practices and contaminated food. This all affect the spread and severity of diarrhoea in the country. At the same time, the lack of adequate health services and transport reduces the likelihood of prompt and appropriate treatment of diarrhoea cases. Nigeria as a case study is battling with “Boko haram” insurgency in the North-East region, which have led to the displacement of many families leading to the creation of IDP camp all around the region. According to Medecins Sans Frontieres/Doctors without border (MSF) in 2016,³¹ a report on Dalori IDP camp in Maiduguri, the capital city of Borno State was given in which women with long faces were seen seated outside a two-room clinic that serve about 19,000 Internally Displaced People (IDP), holding their weak and dying children in their hand. The children looked weak and dehydrated from severe diarrhea triggered by cholera outbreak in the camp, 16 children were reported to have died due to acute diarrhea while 172 others were left in critical condition battling for their life. Hence, reducing the burden of childhood diarrhoeal in the country depend on the readiness of the government to tackle the insurgency and take the “bull by the horn”.

Lack of adequate breastfeeding

The literature on breastfeeding practices and risk of diarrhoea has been extensive. Generally, the lowest morbidity of diarrhoea is recorded in adequately breast-fed children while the highest morbidity is clearly marked in partially weaned children.^{32–36} A particular risk of diarrhoea is also recorded with bottle-feeding.^{37,38} Numerous studies have shown the stern defensive effect of breast feeding; the risk of diarrhoea following the colonization with enteric pathogens is reduced by a concentration of antibodies, cells and other mediators in breast milk.³⁸ Nutrients, antioxidants, hormones and antibodies needed for the survival and development of a child are contained in breast milk; government effort should therefore be doubled on campaigns relating to adequate breast feeding by engaging different NGOs in the country.

Poor personal, domestic hygiene

As a result of efforts put into meeting the MDG sanitation target which the country fails to achieve (to halve, by 2015, the proportion of the population without sustainable access to basic sanitation). About 30million people (67% of whom are concentrated in the Northern part of the country) still use unimproved sanitation facilities, practice open defecation which increases the risks of diarrhoeal diseases. Some sanitation factors, like indiscriminate or improper disposal of children's stool and household garbage,^{37,39-42} no existence of latrine⁴³⁻⁴⁵ or unhygienic toilet,^{40,46} sharing latrine,⁴⁷ house without sewage system,⁴² increased the risk for diarrhea in children under five years.

Diarrhoeal deaths attributable to inadequate sanitation has been shown to be higher in several studies, since improved sanitation and even sewer connections may not include full safe management of human waste. Exposure to untreated sewage and faecal sludge in wider populations is likely to cause significant amounts of disease especially diarrhoeal diseases amongst children less than five years. Hence government should formulate policies which must have implication on all housing unit in the country such as; Provision of improved sanitation in households (flushing to a pit or septic tank, dry pit latrine with slab, or composting toilet) which will significantly reduce diarrhoea in the country at large.

Lack of access to safe drinking-water supplies

Drinking-water, even from an improved source, is not necessarily free of faecal pathogens and safe for health.^{48,49} Water was considered as non-contaminated when complying with the guideline values for microbial quality,⁵⁰ i.e. containing zero *E. coli* or thermo tolerant coliforms in 100mL water sample. In order to conceptualize the risk of diarrhoea from drinking-water, drinking-water sources were categorized into five groups, namely⁵¹ viz Unimproved, Improved source (other than piped), Basic piped water on premises, systematically managed piped water (continuous and safe supply) and Effective household water treatment and safe storage. Based on the distribution of use of the different types of water sources and the associated risks of diarrhoea, about 502,000 diarrhoeal deaths in LMICs (Low and Middle Income Countries) can be attributed to inadequate drinking water. Somewhat larger health gains can be gained by shifting to basic schemes for piped water on premises. Effective household water treatment combined with safe storage can provide significant protection against diarrhoeal diseases in the country. Sustained and consistent application is necessary to realize these gains.

Eating habits

This is also a significant risk factor.⁴⁷ Diarrhea can also be acquired by eating contaminated foods such as fruits, vegetables, seafood, raw meat, water, and ice cubes.⁵² Eating with the hands; eating raw foods; or drinking unboiled water, may increase the risk of diarrhea in children.

Effects of diarrhoea disease on children

The number of deaths caused by diarrhoea, 2.5 million yearly is a large burden. In addition, many time this number have long-term, lasting effects on nutritional status, growth, fitness, cognition, and school performance.^{15,25,41} Some studies have revealed the impact of diarrhoea on growth.^{32,53-55} It is believed that diarrhoea have a

significant impact on growth due to reduction in appetite, altered feeding practices and decreased absorption of nutrients.³² Patwari⁵³ quoted that there was a marked negative relationship between diarrhoea and physical growth and development of a child. Each day of illness due to diarrhoea produces a weight deficit of 20-40grams. Molbak et al.,³⁸ found that infants who spent more than 20% of their time with diarrhoea had a weight deficit of approximately 370 grams at follow-up after 1 year of age.

According to Checkley et al.,⁵⁷ children ill with diarrhoea in the first 24months of birth were 1.5cm shorter than children who never had diarrhoea. Hence, the adverse impact of diarrhoea on a nation like Nigeria cannot be farfetched with various scientific findings and correlation over the years.

Prevention and treatment of diarrhoea

The goals of treatment are to maintain hydration, treat the underlying causes and relieve the symptoms of diarrhoea. Rehydration and its correction of any electrolyte imbalance are critical in the treatment of diarrhoea while WHO's control of diarrheal deaths (CDD) programme and other organizations (UNICEF, USAID) have given first priority to the prevention of diarrheal deaths, rather than prevention of cases, and focused on promotion of ORT. It is estimated that 90% of the child diarrheal disease burden is the result of poor sanitation conditions and inadequate personal, household and community hygiene behaviors.⁵⁸ Therefore, understanding environmental, behavioral risk factors and their interactions is a prerequisite for devising effective preventive approaches.⁵⁹

Treatment package

Since the 1970s, oral rehydration therapy, pioneered by the International Centre for Diarrhoeal Disease Research, Bangladesh,⁵⁸⁻⁶¹ has been at the forefront for fighting diarrhoeal diseases and proposing treatment packages. The treatment package focuses on two main elements, as laid out in the UNICEF & WHO⁶² joint statement viz Fluid replacement to prevent dehydration and Zinc treatment.

Oral rehydration therapy: The greatest medical invention of the 20th century is the ORT which exemplifies the transfer of technology from developing to developed countries.^{27,63} Based on instructions; ORT solutions are produced by adding sodium, glucose, potassium, chloride, and alkali (bicarbonate or citrate) in specific concentrations in clean/pure water.^{64,65} Using the WHO formula, ORT is useful for the management of all types of dehydration.⁶⁶ It has contributed a great deal to the reduction of childhood mortality from diarrhoeal disease because it's extreme effectiveness in treating acute, persistent and watery diarrhoea.⁶⁰ ORS-WHO (oral rehydration salts) can be regarded as a universal and all-purpose solution; nevertheless, it is pertinent to have a conventional formula that can be recommended and as well promoted globally.

ORS-WHO is an extremely safe therapeutic tool. More than two billion units of ORS have been administered without serious complications. Symptomatic anti-diarrheal drugs should not be recommended for the treatment of acute diarrhoea in children.^{66,67} Antimicrobials are also not effective in uncomplicated acute diarrhoea and their use should be discouraged. In contrast, antimicrobials are indicated in dysentery, cholera, typhoid fever and diarrhoea caused by parasites, such as *Giardia lamblia*, *Cyclospora spp* and *E. histolytica*.⁵² ORT administered through mouth or nasogastric tube has shown to be effective in the treatment of chronic dehydration

caused by diarrhoea;⁶⁸ even though the intravenous route is always recommended in the presence of shock. A sodium content of single oral rehydration solution (ORS) is now recommended by W.H.O (75mmol/L)

Homemade fluids: If ORS are not available to treat diarrhoea, a set of appropriate homemade fluids are also effective in preventing dehydration. Different countries have different policies on what constitutes an appropriate homemade fluid, and these policies are not always clearly defined. For example, the general acceptable homemade fluids in Nigeria are the mixture of salt and sugar in a solution. Other fluids will also serve in prevention of dehydration among children with diarrhoea, even though they are not as effective in treating children who have become dehydrated. A homemade fluid is always made at home using available and ready-made low-cost solutes. Cereal-based oral therapies and Home-made fluids has proven to be effective in checkmating diarrhoeal dehydration.^{69–72}

Probiotics: Probiotics are microorganisms that are claimed to provide health benefits when consumed, they are considered generally safe, but may cause bacteria-host interactions mostly strains of *lactobacillus spp.* This live microbe works to improve intestinal-microbial balance by creating unfavourable environment through the production of antimicrobials and thereby compete with pathogens for essential nutrients and binding sites in the intestinal mucosa for the metabolism of nutrients and bile acids. This kind of immune action induced by probiotics is generally regarded as mucosa-associated immune defences.^{73–76}

Lactobacillus GG, a probiotics involved and associated with a reduced risk of contracting traveller's diarrhoea^{77,78} has been a major probiotics researcher have identified as the best microbe to induce defences in an host. Two research studies which focus on *in-vitro* study of fermented Palm wine on diarrhoeagenic bacteria showed that it had antibacterial activities against those organisms;^{79,80} hence it is suggested that it can be used as an alternative measure for the control of the diarrhoea produced by these organisms in the absence of antibiotics. It has also been proven that Probiotics reduced the frequency of diarrhoea in children under five of age.^{81,82}

Zinc treatment: Zinc is critical for overall health, growth and development. It also supports proper functioning of the immune system. Though widely found in protein-rich and other food sources, zinc deficiency is widespread throughout the developing world and has been associated with higher rates of infectious diseases, including diarrhoea, and deaths from these illnesses. Zinc supplementation as a part of treatment programmes is critical for replenishing the body's reserves—helping children to recover from illness and stay healthy afterwards.⁸³ Relation between poor feeding and diarrhoeal illnesses has been correlated over time and it is evident that many of the affected children suffering from diarrhoea shows deficiency in vital vitamins and trace elements required by the body system,⁸⁴ which are relevant to reducing the burden of diarrhoea in the world. Zinc play a major role in the healing process of damaged skin and it also help to boost the immunity of children less than 5 years; while vitamin A participates in maintaining the epithelium cross-linkage.⁸⁵ It has been shown that children who receive zinc supplementation earlier do record low incidence, frequency and persistence of diarrhoeal illnesses;^{86–89} zinc also appears to increase ORS uptake and reduces inappropriate drug use with antibiotics and anti-diarrhoeal medications. Children receiving zinc tablets appeared to recover more quickly, had increased

strength and appetites, and were less ill than other children in their communities.^{90–92}

Prevention package

Diarrhoeal disease is caused by ingestion of pathogens, principally through faecal-oral pathways. Three separate but inter-related risk factors were considered as part of the burden of this disease analysis. In developing countries, such as Nigeria; preventive guidelines are largely hampered by social, cultural and economic factors; the government has done little to improve the situation, especially in Northern part of the country which have a high record of diarrhoeal deaths due partially to the insurgency in that region. It has been shown that appropriate water, hygiene, and sanitation interventions can decrease diarrhoea incidence by 26% and mortality by 65%.¹⁹ The prevention package focuses on some main elements to reduce diarrhoea in the medium to long term given an acronym “WASH” by the World Health Organisation meaning water, sanitation and hygiene in the late 90's. New aspects of this approach include rotavirus vaccination, which was recently recommended for global introduction into routine schedules for immunization procedures; promotion of early and exclusive breastfeeding and vitamin A supplementation; promotion of hand washing with soap in terms of community-wide sanitation. Implementation of the prevention package (WASH) if approached in a concerted way may result to greater overall impact on the populace; hence prevention should be accompanied by clear, targeted and integrated behaviour and social change communication strategies to improve health of our children on a larger scale in the country.

Conclusion

Estimates of diarrhoea disease attributable to inadequate water, sanitation, lack of breastfeeding, under use of probiotics and hygiene are sensitive to the main assumptions made above, W.H.O predicts 5million deaths in children younger than five years is still expected by 2025, in which 97% of this mortality rate will still be recorded in developing world (mostly Africa and parts of Asia); in which diarrhoea will contribute a major part of the burden. Reduction in deaths due to diarrhoeal is probably at least in part to improved access to health care, oral rehydration and good nutrition, which means much more still need to be done by the Nigeria government to achieve the Sustainability Development Goals (SDGs) which aim to end preventable deaths of newborn and children under 5years of age (with all countries aiming) to reduce neonatal mortality to at least as low as 12per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births in which the deadline is 2030.

Recommendation

Recognizing the importance of hygiene promotion especially hand washing to the overall child survival and development, government need to step up her partnership with private sector and NGOs in the promotion of hand washing campaigns at State, Local government and Community levels including in schools. Educating health-care providers' i.e nurse, midwife, doctors, and medical microbiologist will remain the vital final pathway for dissemination of any interventions. Cultural and religious barrier remain an obstacle to the use of ORT in some communities mostly in the Northern part hence hampering its benefits to the populace. Interventional programmes on local and national scales should be step up such as educating the rural dwellers

on the availability of homemade fluids and Probiotics (fluid therapy) in combating the diarrhoea diseases when ORT is not readily available.

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Conflict of interest

The author declares no conflict of interest.

References

- Black RE, Cousens S, Johnson HL, et al. Global, regional, and national causes of child mortality in 2008: A systematic analysis. *Lancet*. 2010;375(9730):1969–1987.
- Lamberti LM, Fischer Walker CL, Noiman A, et al. Breast feeding and the risk for diarrhoea morbidity and mortality. *BMC Public Health*. 2011;11(Suppl 3):S15.
- Brown KH, Peerson JM, Baker SK, et al. Preventive zinc supplementation among infants, pre-schoolers, and older pre-pubertal children. *Food Nutrition Bulletin*. 2009;30(Suppl 1):S12–40.
- Beaton GH, Martorell R, L'Abbe. Effectiveness of vitamin A supplementation in the control of young child morbidity and mortality in developing countries Toronto, USA: International Nutrition Program; 1993.
- Santosham M, Chandran A, Fitzwater S, et al. Progress and barriers for the control of diarrhoeal disease. *Lancet*, 2010;376(9734):63–67.
- Fischer-Walker C, Jamie Perin, Martin J Aryee, et al. Diarrhea incidence in low- and middle-income countries in 1990 and 2010: a systematic review. *BMC Public Health*. 2012;12:220.
- WHO. Persistent diarrhoea in children: CCD/DDM/85.1. Geneva, Switzerland: World Health Organization; 1985.
- Baqui AH, Black RE, Yunus M, et al. Methodological issues in diarrhoeal diseases epidemiology: definition of diarrhoeal episodes. *Int J Epidemiol*. 1991;20:1057–1063.
- WHO. The management of bloody diarrhoea in young children: WHO/CDD/94-49. Geneva, Switzerland: World Health Organization; 1994.
- Boschi Pinto C, Ehiri JE, Meremikwu M. The Global Burden of Childhood Diarrhoea. *International Maternal and Child Health*. 2009. p. 225–243.
- Federal Republic of Nigeria. MDG report 2010: Nigeria Millennium Development Goals. Abuja, Nigeria: Government of the Federal Republic of Nigeria; 2010a. p. 64.
- Federal Republic of Nigeria. Countdown strategy 2010 to 2015, Millennium Development Goals (MDGs). Abuja, Nigeria: Government of the Federal Republic of Nigeria; 2010b. p. 79.
- Federal Ministry of Health. *Revised national health policy*. Abuja, Nigeria: Federal Ministry of Health; 2004.
- Black RE, Morris S, Bryce J. Where and why is 10 Million Children Dying Every Year? *Lancet*. 2003;361(9376):2226–2234.
- WHO. Fact sheets on Diarrheal disease. Geneva, Switzerland: World Health Organization; 2013.
- Bryce J, Terreri N, Victora CG, et al. Countdown to 2015: Tracking intervention coverage for child survival. *Lancet*. 2006;368(9541):1067–1076.
- Fontaine O, Kosek M, Bhatnagar S, et al. Setting research priorities to reduce global mortality from childhood diarrhoea by 2015. *PLoS Medicine*. 2009;6(3):e1000041.
- World Health Organization. Diarrhoea: why children are still dying and what can be done. Geneva, Switzerland: UNICEF/WHO Report; 2009.
- <https://www.unicef.org/where-we-work>
- Nigeria demographic and health survey. Abuja, Nigeria: National Population Commission and ICF Macro; 2013.
- UNICEF. The state of the world's children in 2013: Child survival. New York, USA: Unicef; 2013.
- Federal Ministry of Health. Save the Children, ACCESS. Saving new born lives in Nigeria: Newborn health in the context of the Integrated Maternal, Newborn and Child Health Strategy. Abuja, Nigeri: Federal Ministry of Health; 2011.
- Griggs D. From MDGs to SDGs: Key challenges and opportunities Rio+20 Future We Want - Outcome document. 2015.
- WHO. Global Health Observatory. Geneva, Switzerland: World Health Organization; 2014.
- Kosek M, Bern C, Guerrant RL. The global burden of diarrhoeal disease, as estimated from studies published between 1992 and 2000. *Bull World Health Organ*. 2013;81(3):197–204.
- WHO. Global health risks: mortality and burden of diseases attributable to selected major risks. Geneva, Switzerland: World Health Organization; 2009.
- Santosham M, Keenan EM, Tulloch J, et al. Oral rehydration therapy for diarrhoea: an example of reverse transfer of technology. *Pediatrics*; 1997;100(5):E10.
- Boschi-Pinto C, Velebit L, Shibuya K. Estimating child mortality due to diarrhoea in developing countries. *Bull World Health Organ*. 2008;86(9):710–717.
- UNICEF. The State of the World's Children in 2002. New York: UNICEF; 2002.
- United Nations. Johannesburg World Summit. 2002.
- Medecins Sans Frontieres/Doctors without border (MSF) Report; 2016.
- Molbak K. The epidemiology of diarrheal diseases in early childhood: A review of community studies in Guinea-Bissau. *Dan Med Bull*. 2000; 47(5):340–358.
- Karim AS, Akhter S, Rahman MA, et al. Risk factors of persistent diarrhea in children below five years of age. *Indian J Gastroenterol*; 2001;20(2):59–61.
- Long K, Vasquez-Garibay E, Mathewson J, et al. The impact of infant feeding patterns on infection and diarrheal disease due to enterotoxigenic *Escherichia Coli*. *Salud Publica Mex*. 1999;41(4):263–270.
- Van Derslice J, Popkin B, Briscoe J. Drinking-water quality, sanitation, and breastfeeding: their interactive effects on infant health. *Bull World Health Organ*. 1994;72(4):589–601.
- Public Health News Center. Johns Hopkins University; Exclusive Breastfeeding Training For Mothers Helps Reduce Diarrheal Disease Among Infants. The University Press; 2005.
- Ghosh S, Sengupta PG, Mondal SK, et al. Risk behavioural practices of rural mothers as determinants of childhood diarrhoea. *J Commun Dis*. 1997;29(1):7–14.
- Molbak K, Jensen H, Ingholt L, et al. Risk factors for diarrheal disease incidence in early childhood: A community cohort study from Guinea-Bissau. *Am Journal of Epidemiology*. 1997;146(3):273–282.

39. Jinadu MK, Olusi SO, Agun JI, et al. Childhood diarrhoea in rural Nigeria: Studies on prevalence, mortality and socio-environmental factors. *J Diarrhoeal Dis Res.* 1991;9(4):323–327.
40. Wijewardene K, Fonseka P, Wijayasiri WA. Risk factors contributing to acute diarrhoeal disease in children below five years. *Ceylon Med J.* 1992;37(4):116–119.
41. Tumwine JK, Thompson J, Katua-Katua M, et al. Diarrhoea and effects of different water sources, sanitation and hygiene behaviour in East Africa. *Trop Med Int Health.* 2002;7(9):750–756.
42. Aulia H, Surapaty SC, Bahar E, et al. Personal and domestic hygiene and its relationship to the incidence of diarrhoea in south Sumatera. *J Diarrhoeal Dis Res.* 1994;12(1):42–48.
43. Woldemicael G. Diarrheal morbidity among children in Eritrea: environmental and socio-economic determinants. *J Health Popul Nutr.* 2001;19(2):83–90.
44. Marjatta BS. Water supply and diarrhoea in East African community. A case control study on the quality of water supplies and the occurrence of diarrhoea among small children in a rural area of Western Kenya. *University of Oulu Printing Center.* 1994;315:37–57.
45. Sobel J, Gomes TA, Ramos RT, et al. Pathogen-Specific Risk Factors and Protective Factors for Acute Diarrheal Illness in Children Aged 12–59 Months in Sao Paulo, Brazil. *Clin Infect Dis.* 2014;38(11):1545–1551.
46. Etiler N, Velipasaoglu S, Aktekin M. Risk factors for overall and persistent diarrhoea in infancy in Antalya, Turkey. *Public Health.* 2004;118(1):62–69.
47. Brooks JT, Shapiro RL, Kumar L, et al. Epidemiology of sporadic bloody diarrhoea in rural western Kenya. *Am J Trop Med Hyg.* 2003;68(6):671–677.
48. Bain R, Cronk R, Hossain R, et al. Global assessment of exposure to faecal contamination through drinking water based on a systematic review. *Trop Med Int Health.* 2014;19(8):917–927.
49. WHO. Guidelines for drinking-water quality. 4th edn. Geneva, Switzerland: World Health Organization; 2011.
50. Clasen T, McLaughlin C, Nayaar N, et al. Microbiological effectiveness and cost of disinfecting water by boiling in semi-urban India. *Am J Trop Med Hyg.* 2008a;79(3):407–413.
51. Clasen TF, Do HT, Boisson S, et al. Microbiological effectiveness and cost of boiling to disinfect drinking water in rural Vietnam. *Environ Sci Technol.* 2008b;42(12):4255–4260.
52. Gracey M. Diarrhea and malnutrition: a challenge for pediatricians. *J Pediatr Gastroenterol Nutr.* 1996;22(1):6–16.
53. Patwari AK. Diarrhoea and malnutrition interaction. *Indian J Pediatr.* 1999;66(1):S124–134.
54. Checkley W, Epstein LD, Gilman RH, et al. Effects of acute diarrhea on linear growth in Peruvian children. *Am J Epidemiol.* 2003;157(2):166–175.
55. Moffat T. Diarrhea, respiratory infections, protozoan gastrointestinal parasites and child growth in Kathmandu, Nepal. *American Am J Phys Anthropol.* 2003;122(1):85–97.
56. Checkley W, Buckley G, Gilman RH, et al. Multicountry analysis of the effects of diarrhoea on childhood stunting. *Int J Epidemiol.* 2008;37:816–830.
57. UNICEF. Launch of hand washing campaign in Abuja. 2010.
58. Pascual M, Rodo X, Ellner SP, et al. Cholera Dynamics and El Nino-Southern Oscillation. *Science.* 2000;289(5485):1766–1769.
59. <https://www.unicef.org/sowc/>
60. Victora CG, Bryce J, Fontaine O, et al. Reduce Deaths Through Oral Rehydration Therapy. *Bull World Health Organ.* 2000;78(10):1246–1255.
61. United Nations Children’s Fund and World Health Organization. WHO/UNICEF Joint Statement: Clinical management of acute diarrhoea. UNICEF, New York: United Nations Children’s Fund and World Health Organization; 2004.
62. De Zoysa I, Feachem RG. Interventions for the control of diarrhoeal diseases among young children: rotavirus and cholera immunization. *Bull World Health Organ.* 1985;63(3):569–583.
63. Nikhil Thapar, Ian R Sanderson. Diarrhoea in children: an interface between developing and developed countries. *Lancet.* 2004;363(9409):641–53.
64. Pierce NF. How much has ORT reduced child mortality? *J Health Popul Nutr.* 2001;19(1):1–3.
65. Vesikari T, Torun B. Diarrheal diseases. In: Kari SL, Staffan B, editors. Health and Disease in developing countries. London: Macmillan Education Ltd; 1994:136–146.
66. Warren PB. Diarrhea in childhood. Department of Pediatrics. The University of Iowa, USA; 2003.
67. Nager AL, Wang VJ. Comparison of nasogastric and intravenous methods of rehydration in pediatric patients with acute dehydration. *Pediatrics.* 2002;109(4):566–572.
68. Gore SM, Fontaine O, Pierce NF. Impact of rice based oral rehydration solution on stool output and duration of diarrhoea: Meta-analysis of 13 clinical trials. *BMJ.* 1992;304(6822):287–291.
69. Fontaine O, Gore SM, Pierce NF. Rice-based oral rehydration solution for treating diarrhoea. *Cochrane Database Syst Rev.* 2000;(2):CD001264.
70. Dutta D, Bhattacharya MK, Deb AK. Evaluation of oral hypo-osmolar glucose-based and rice-based oral rehydration solutions in the treatment of cholera in children. *Acta Paediatrica.* 2000;89(7):787–90.
71. WHO. The selection of fluids and foods for home therapy to prevent dehydration from diarrhoea WHO/CDD/93-44. Geneva, Switzerland: World Health Organization; 1993.
72. Isolauri E. Probiotics in human disease. *Am J Clin Nutr.* 2001;73(6):S1142–1146.
73. Hooper LV, Midtvedt T, Gordon JI. How host-microbial interactions shape the nutrient environment of the mammalian intestine. *Annu Rev Nutr.* 2002;22:283–307.
74. Lu L, Walker WA. Pathologic and physiologic interactions of bacteria with the gastrointestinal epithelium. *Am J Clin Nutr.* 2001;73:S1124–1130.
75. Elmer GW, McFarland LV. Biotherapeutic agents in the treatment of infectious diarrhea. *Gastroenterol Clin North Am.* 2001;30(3): 837–854.
76. Hilton E, Kolakowski P, Singer C, et al. Efficacy of *Lactobacillus* GG as a Diarrheal Preventive in Travelers. *J Travel Med.* 1997;4(1):41–43.
77. Oksanen PJ, Salminen S, Saxelin M. Prevention of travelers’ diarrhoea by *Lactobacillus* GG. *Ann Med.* 1990;22(1):53–56.
78. Akinrotoyee KP. Effects of fermented palm wine on some diarrheagenic bacteria. *Elite Research Journal of Biotechnology and Microbiology.* 2014;2(1):4–14.
79. Kigigha LT, Izah SC, Okitah LB. Antibacterial activity of palm wine against *Pseudomonas*, *Bacillus*, *Staphylococcus*, *Escherichia*, and *Proteus* spp. *Point Journal of Botany and Microbiology Research.* 2016;2(1):46–52.
80. Szajewska H, Mrukowicz JZ. Probiotics in the treatment and prevention

- of acute infectious diarrhea in infants and children: A systematic review of published randomized, double-blind, placebo controlled trials. *J Pediatr Gastroenterol Nutr*. 2001;33(2):S17–25.
81. Van Niel CW, Feudtner C, Garrison MM. *Lactobacillus* therapy for acute infectious diarrhea in children: A meta-analysis. *Pediatrics*. 2002;109(4):678–684.
82. Bhandari N, Mazumder S, Taneja S, et al. Effectiveness of zinc supplementation plus oral rehydration salts compared with oral rehydration salts alone as a treatment for acute diarrhea in a primary care setting: a cluster randomized trial. *Pediatrics*. 2008;121(5):e1279–1285.
83. Rahman MM, Vermund SH, Wahed MA, et al. Simultaneous zinc and vitamin A supplementation in Bangladeshi children: Randomised double blind controlled trial. *BMJ*. 2001;323(7308):314–318.
84. Kumarchandra R. Trace elements in nutrition of children. Volume 23. New York: Nestle Nutrition Workshop; 1991.
85. Strand TA, Chandyo RK, Bahl R. Effectiveness and efficacy of zinc for the treatment of acute diarrhea in young children. *Pediatrics*. 2002;109(5):898–903.
86. Bhandari N, Bahl R, Taneja S. Substantial reduction in severe diarrhoeal morbidity by daily zinc supplementation in young north Indian children. *Pediatrics*. 2002;109(6):e86.
87. Baqui AH, Black RE, El Arifeen S. Effect of zinc supplementation started during diarrhoea on morbidity and mortality in Bangladeshi children: community randomized trial. *BMJ*. 2002;325(7372):1059.
88. Bhatnagar S, Bahl R, Sharma PK. Zinc with oral rehydration therapy reduces stool output and duration of diarrhea in hospitalized children: a randomized controlled trial. *J Pediatr Gastroenterol Nutr*. 2004;38(1):34–40.
89. Winch PJ. Cluster-randomized programme effectiveness study of community case management with zinc for childhood diarrhoea in southern mali. *Bulletin of the World Health Organization*. 2009.
90. Walker CLF, Perin J, Aryee MJ, et al. Diarrhoea incidence in low and middle income countries in 1990 and 2010: A systematic review. *BMC Public Health*. 2012;12(1):220.
91. Water with Sugar and Salt. *Lancet*. 1978;312(8084):300–301.
92. <http://rehydrate.org/rehydration/>