Household Determinants of Diarrheal Diseases in children in resource constrained settings: A Review of Literature and Design of an Action Plan

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Dedication

This work is dedicated to my fiancée, Barrister Omotade Susan Obayemi, who showed me so much love and affection and whose support and encouragement in the course of my study program have been immeasurable.

Abstract

Annually, diarrheal diseases kill about 2.2 million people globally. It is responsible for an estimated 25% of the total deaths seen in children. In Nigeria, 16% of all deaths seen in children less than 5 years of age is caused by diarrheal diseases.

Although diarrhea is no longer a significant cause of morbidity and mortality in Western Countries, the reverse is still the case in most sub saharan African countries where the burden of disease is said to be highest.

Strategies that have been used in richer countries to significantly reduce the incidence and burden of diarrheal diseases are either not technically feasible or economically viable in resource poor settings of the world, especially in sub saharan Africa.

However, there are feasible, cost effective and culturally sensitive determinants in the household that can be applied or reinforced to protect children from diarrheal morbidity, and when it does occur, from adverse outcomes.

We reviewed the literature for these determinants of diarrheal diseases, and with input from the country DHS data, designed a potentially cost effective intervention that could be implemented in a non-privileged setting in Africa that the author is familiar with.

Inferences were drawn and discussed on the probable findings from the suggested study. Implications of the study outcome on research, public policy and the local community were also discussed.

Introduction

This study will mainly look at the determinants of diarrheal diseases in the household that predispose children, especially those in resource-poor countries, to diarrheal diseases and subsequent mortality from a disease that is not only preventable but also curable with the interventions available to medical sciences even as at today. This work was stimulated by our experience in a non-privileged setting where patients, mostly young children are brought in dead in the health centres more often due to dehydration secondary to a poorly managed or untreated diarrheal disease. At this stage, it was simply too late to implement simple measures that would have otherwise saved the lives of the affected patients.

The study will review literatures that specifically relate to determinants that can be easily implemented in a deprived setting. There would be an emphasis on randomised controlled studies, to look for the effectiveness of important determinants of diarrheal diseases in children in a typical household, and the use of the World Health Organisation (WHO) and the United Nations Children Fund (UNICEF) Oral Rehydration Solution (ORS) to prevent fatalities where primary prevention measures have failed but lives could still be saved.

The insight gained from this review of literatures, combined with input from the country's Demographic and Health Survey (DHS), will be utilised to design an intervention study to evaluate one or more of the hypotheses in the literature that are cheap, feasible, and may be easily acceptable in resource-constrained settings where the needs are unarguably higher. The purpose of the Action Plan/ Intervention study is to apply some of the insights and knowledge gained to a country in Africa via measures that are likely to be feasible and relevant to the chosen community.

Background

Epidemiology and Burden of Disease

Diarrheal diseases killed an estimated 1.87 million children before their fifth birthdays in 2003 alone, making it a significant cause of deaths among children within this age group in resource constrained settings (WHO manual, n.d). In the 1999 World Health report of the WHO, it was estimated that globally, about 2.2 million deaths are caused by diarrheal diseases in a given year (WHO, 1999). However, these deaths disproportionately occur more in children, with diarrhea accounting for an estimated 25% of the total deaths seen in children (WHO, 1999). It then becomes apparent that the attainment of the reduction of the global child mortality by 75% of the 1990 rate by the year 2015 in line with the Millennium Development Goal on child health may be a mirage if urgent and critical measures are not consolidated to halt, and begin to reverse, the contribution of diarrheal diseases to the over all child mortality.

Again, the burden is more in the developing countries than in the developed world, and are sadly due to causes that are said to be "entirely" preventable (Curtis et al., 2000).This may then constitute an indictment of the relative neglect of the public health conditions in the poorest regions of the world. In Ethiopia alone, it is estimated that about 230,000 children less than five years die annually from diarrheal diseases (WHO, 1987).

In Nigeria, reports from the WHO reveals that at least 16% of deaths among children less than 5 years of age are caused by diarrheal diseases, and that this value excludes the proportion caused by diarrhea in the neonatal periods (WHO, 2006). But more disturbing is the outcome of an analysis from an extensive review of diarrheal morbidities and mortalities in Nigeria which reported that an estimated 83.2 million episodes of acute diarrhea alone occurred in children less than 5 years annually. It also stated that these episodes may have accounted for at least 314,200 deaths in this category of children in 1989 alone. This happened in spite of the implementation of the WHO global programme for the Control of Diarrheal Diseases (CDD), which went nationwide in Nigeria since 1986 (Babaniyi, 1991).

Diarrhea is fast becoming an extinct cause of morbidity and mortality in children in the rich countries of the world, where researchers have found similarities in the

diarrheal morbidities and mortalities seen at the turn of the 19th century Stockholm city, for example, and what is now being seen in sub Saharan Africa of today (Macassa & Burstom, 2005). The rate of improvement seen those days can not even be said to be the lot of children living in resource constrained countries where their chances of celebrating their 5th birthday is significantly reduced by infectious but preventable and curable diseases.

Diarrhea is the leading cause of both mortality and morbidity after HIV/AIDS and respiratory infections, even well ahead of tuberculosis and malaria in these countries (Clasen et al, 2006). And it has now been reported that of all deaths seen in children less than 5 years of age, diarrhea accounts for 17% of these mortalities. (United Nations, 2005).

Although in some resource poor countries, child mortality has been reported declining, but in sub-saharan Africa, it is said to have been further increased by increased mortality from the consequences of HIV/AIDS (Black et al 2003; Jones et al, 2003). Again, one can argue that HIV/AIDS might not be the sole reason why sub Saharan Africa's child mortality rates have been stagnant on the average. Researchers have pointed to the fact that other curable and often preventable diseases like diarrhea and pneumonia contribute substantially to the over all child mortality (Macassa and Burstrom, 2005).

Cairncross (1990), while reviewing new evidences and prospects on health impacts in resource poor countries, revealed that most transmissions of pathogens that occur take place in the household or domestic domain, which is the "natural habitat" of children. The implication of this is that this process of transmission can be halted by improving household hygiene and adopting hygienic behavioural changes. But we know that hygiene is a complex subject and that it is not that easy to change people's behaviour (Curtis V et al, 2000).

However, studies have shown that it is possible to change people's hygienic behaviour behaviour. Positive impacts have been demonstrated on health outcomes after health promotion and intervention programmes well documented in Ahmed et al. (1994); Araya et al. (1994) and Haggerty et al. (1994). Strategies like provision of modern toilet systems in all households, and the supply of portable drinking water to every household, that have been used in resource rich countries to significantly reduce

the incidence and burden of diarrheal diseases are either not economically viable nor technically feasible in resource poor settings of the world, especially in sub saharan Africa. (Katherine et al., 2006).

International efforts

Since the early 1980s, many interventions have been instituted by global bodies to curb the increasing mortalities associated with diarrheal diseases. These strategies include the global guidelines for diarrhea management and program implementation by the WHO, UNICEF and other international organizations with the rallying point being the introduction of the ORS in the management of acute diarrheal diseases. In 1991, UNICEF and WHO introduced a new strategy for the control of diarrheal diseases in children in which one of the main targets was to increase the percentage of children with diarrhea who receive adequate fluids and whose feeding is not stopped, from 20% to 80% between 1992 and the year 2000. In fact, the decade starting from 1981-1990 was declared the International Drinking Water Supply and Sanitation Decade by the WHO (WHO website, n.d.)

Not withstanding all these novel strategies and programmes, diarrhea still remains a significant cause of mortality in children globally, accounting for an estimated 13% of all deaths within this age group. A view of the outcome of a recent analysis of the data from households in DHS from 40 resource limited countries between 1998 and 2003 (Forsberg et al., 2007) reveals that a significant majority of children in these countries still receive less than optimal treatment for diarrheal diseases. It was reported to be due to inadequate case management of diarrhea despite significant efforts and resources that have been channelled into this approach. It then becomes apparent that the neglect of determinants within the households that influence whether a child suffers from diarrheal diseases, including other presumably protective factors that may have prevented the children with similar exposures but who do not come up with diarrhea, need to be re-examined. This should be done with the hope of influencing programmes and policies to focus new and on- going strategies at specific people-oriented factors.

Diarrheal Disease: definition and clinical classification

Diarrhea is defined as the passage of three or more loose stool within a 24 hour period. More emphasis is better placed on the consistency of the stool than on the frequency as an increased passage of normally formed stool is not diarrhea. This definition is true irrespective of the age of the person concerned. The seemingly less formed stool known to be passed by breast fed babies should also not be mistaken as diarrhea. Health professionals are advised to pay attention to mothers as the mother often knows when her child has diarrhea (WHO document, n.d.).

There are different clinical types of diarrhea that require different approaches to treatment. The following clinical types of diarrheal diseases are widely known.

- Acute watery diarrhea lasting several hours or days but usually less than 14 days. This includes cholera. Major threat here is dehydration.
- Acute bloody diarrhea, popularly called dysentery, and usually less than 14 days. The threat here is mainly intestinal mucosal damage, sepsis, malnutrition, and dehydration.
- Persistent diarrhea usually lasting more than 14 days. The danger here is malnutrition and non-intestinal infections plus dehydration.
- Chronic diarrhea or diarrhea with severe malnutrition (kwashiorkor or merasmus). The main dangers here are heart failure, systemic infection, dehydration, vitamins and mineral deficiency. (WHO document, n.d., www.who.int).

Diarrheal pathogens and the causal pathways

It is already a well established scientific fact that majority of the disease-causing agents responsible for the symptoms and signs seen in diarrheal diseases are transmitted mainly by the faecal-oral route (Feachem, 1984; Byers, 2001). This makes the interruption of the transfer of faeces into the mouth, either through direct ingestion

in contaminated water or food, or fingers inadvertently stained with fecal materials, one of the most important steps in the prevention of diarrheal morbidities and consequent mortalities.

Although the causes of diarrheal diseases can also be due to metabolic disturbances or even chemical irritations, it is known that the majority of diarrheal episodes seen are caused by infectious disease-causing organisms (Gracey, 1985). In fact, majority of the bacterial, viruses and protozoa that are seen in human faeces are important causes of diarrheal diseases (Clasen et al, 2007). These include the *enterotoxigenic Escherichia coli, Salmonella sp., Campylobacter jejuni, Vibrio cholerae, Giardia lamblia, Entamoeba histolytica, rotavirus, and novovirus with Campylobacter jejuni, Salmonella sp. and Yersinia enterocolitica* seen in both animal and human faeces (Feachem, 1984; Leclerc, 2002).

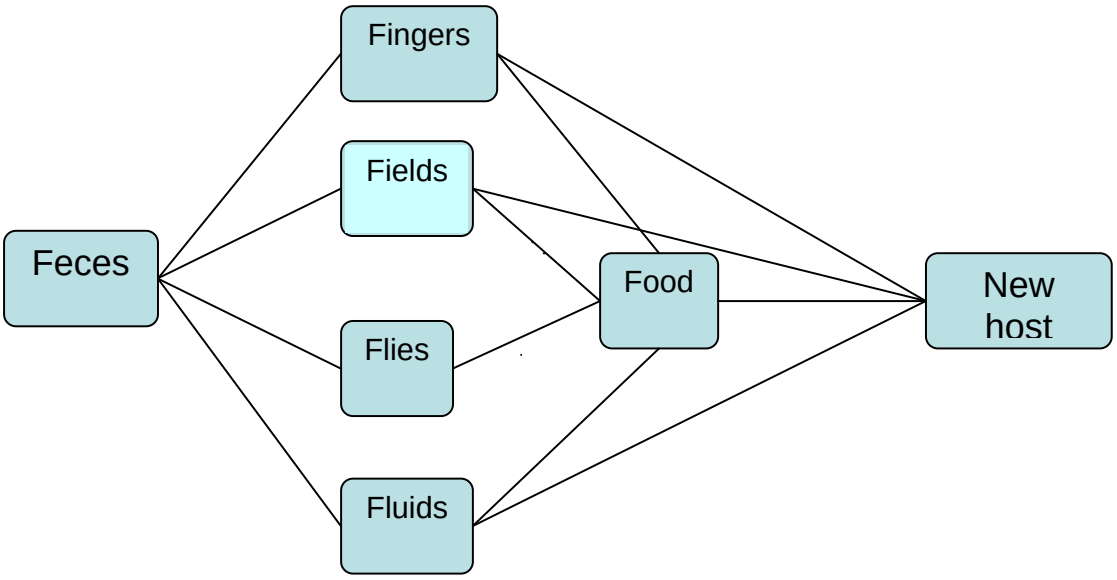
It is possible that the severity and potential mortality that may result from an episode of diarrheal disease may as well depend on the group of organisms that the pathogen belongs to, that is, whether the causative organism is either a virus or bacterium. A definitive knowledge of the causative organism may also influence the appropriate management of the disease. It is reported that bacterial pathogens are the main causes of diarrheal diseases in low-income countries while viral and protozoan agents are mainly implicated in resource-rich countries (Hunter, 1997).

The implication of the various routes or pathways through which diarrheal pathogens can get into humans and cause diseases is that the interventions aimed at interrupting this process would include a couple of actions aimed at improving the safe handling of human faeces, improved access to quality water and promotion of other hygienic practices both at the household and community levels (Clasen et al., 2006).
The best known pathway was described in the work done by Wagner and Lanoix (1958).

It is important to understand these routes so as to know where to direct programmes and strategies that will help combat diseases .The scholarly work done by Wagner & Lanoix in designing the F-Diagram (See Figure 1) close to 50 years ago rightly suggested that most diarrheal causing pathogens originate in stools. It also reveals that measures to control these pathogens and their effects on humans can either be primary or secondary (Curtis et al, 2000), depending on where the measures are targeted.

Primary measures will include all measures that seek to prevent fecal exposure to fingers and fields where crops may be grown, flies and fluids that may consequently contaminate foods that are eaten by humans. Therefore, any measure that prevents the transmission of diarrheal pathogens into humans is a primary preventive measure. An example will be the household filtration of pathogen contaminated water for domestic uses.

Secondary measures are measures aimed at averting adverse outcomes after the onset of diarrheal diseases. An example of secondary measure will be the prompt administration of ORS after the onset of a diarrheal episode. In the next sections, the effectiveness of each of these primary and secondary preventive measures in reducing disease morbidities and mortalities will be critically analysed vis-à-vis their relevance to public health programmes and policies with recommendations that will aid future program interventions.



The F-diagram for diarrheal disease causative pathway *adapted from Wagner and Lanoix (1958).*

STUDY AIM

The aim of this study is to review the literature with a view to highlighting the common household determinants of diarrheal diseases in children and to design, with input from a DHS data, an intervention and evaluative study that could be implemented in a non privileged community that the author is familiar with.

The specific objectives are to

- highlight and discuss, from the literature, at least four determinants within the household that either predispose or protect young children from diarrheal diseases
- generate input from the Nigerian DHS data that will enable the proper focus on the most affected age group of children
- suggest an intervention based on available evidence on or more of the determinants so discussed relevant to a specific community in Nigeria.
- outline an evaluative study on the impact of a household determinant on diarrheal diseases.

REVIEW OF LITERATURE

Methodology

The literatures included in this study were searched through the following processes and the named databases.

Sources of data/ information

1. The Databases searched include mainly the

- PUB/MEDLINE database and

- the database of the WHO.
- The Google database was also searched

2. The following websites were sought for more information on the outputs from the proceedings of various Expert meetings and conferences of international organisations for important outcomes of appropriate studies.

- The websites of the WHO
- The website of UN agencies

3. The author made attempts to get the published works of some researchers working on diarrheal diseases within the field of child health.

4. The reference lists of all the papers collated by the above methods were also checked and papers quoted were searched and included in the study where possible and relevant. The main findings from the papers were then categorised according to the major intervention or parameters that were studied. In all, the following interventions that are relevant to resource poor settings were discussed.

Types and number of Literatures

The following types of literatures were included in this review

1. Journal articles
2. Grey literature reports
3. Official Websites information

952 articles and literatures were original obtained through the general search using the search words and the sources stated. The abstracts of 431 were read by the author. After applying the inclusion and exclusion criteria designed, seventy seven (77) literatures were eventually included in this review. Thirteen (13) of these literatures were reports from conference proceedings and expert meetings and one (1) of them was information on a non-peer reviewed website. The list of articles and the sources are shown in table 1 below.

Inclusion criteria

The included citations were limited to studies that were controlled and had diarrhea episodes as the main health outcome. Emphasis was also laid on studies that were implemented in the community thus can measure effectiveness except other wise stated in the text. Mainly studies that were done in resource poor countries, especially in sub Saharan Africa, were focused on.

Exclusion criteria

Studies not written in English and those where the main articles were not accessible by the author and whose abstracts were not explicit enough were also excluded from the review. All articles whose health outcome indicator did not include diarrhea morbidity were not included in this review.

Literature review search words

- Diarrheal diseases in low and middle income countries
- Diarrheal diseases in children
- Determinants of diarrheal diseases + children
- Household determinants of diarrheal diseases
- Diarrheal diseases + randomised controlled studies
- Community based randomised controlled trials + diarrheal diseases
- Diarrheal diseases + water quality+ children
- Diarrheal diseases + latrine usage
- Diarrheal diseases + water purification
- Childhood vaccination + diarrheal diseases
- Diarrheal diseases + childhood vaccination
- Household fecal disposal with diarrheal diseases
- Diarrheal diseases + breast feeding practices
- Hand washing + diarrheal diseases
- Diarrheal diseases + Oral Rehydration Solution
- Maternal Education + diarrheal diseases

Table 1 Characteristics of included literatures

Authors and dates	Type of Literature
Aaby et al (2004)	Journal article
Alabi et al (1986)	``
Alam et al (1989)	``
Ashworth and Feachem (1985)	``
Avery and Snyder (1990)	``
Blum et al (1987)	``
Cairncross et al (1997)	``
Chavasse et al (1999)	``
Choice Study Group (2001)	``
Clasen and Bastable (2003)	``
Clasen and Cairncross (2004)	``
Clasen et al (2006)	``
Clasen et al 2004[a]	``

Clasen et al 2004b	``
Clasen et al 2004c	``
Clasen and Mintz 2004	``
Colford et al 2002	``
Colford et al 2005	``
Conroy et al 1996	``
Consen et al 1996	``
Curtis et al 2000	``
Curtis et al 1993	``
Crump et al 2005	``
du Preez 2004	``
de Villers 2002	``
El-Moughi et al 1994	``
Esrey et al1991	``
Feachem 1983	``
Feachem and Koblinsky 1983	``
Feachem and Koblinsky 1984	``
Fewtrell et al 2005	``
Forsberg et al 2007	``
Gilman and Skillicorn 1985	``
Gorter et al 1998	``
Graeff et al 1993	``
Guinea Bissau German Consulate website, 2007	Grey literature
Hahn et al 2001	Journal article
Han and Moe 1990	``
Hellard et al 2001	``
Huttly et al 1994	``
Ibiebele and Sokari 1989	``
International Study Group 1995	``
Khan 1982	``
Mahalanabis et al 1995	``
Manun` Ebo et al 1997	``
Mintz et al 1995	``
Mintz et al 2001	``

Table 1 Characteristics of included literatures

Authors and dates	Type of Literature
Ookin New et al 1989	Journal article
Pandey et al 1998	``
Payment et al 1991	``
Peterson et al 1998	``
Pracey 1982	``
Rahaman et al 1985	``
Rahaman et al 1979	``
Rautaren 1997	``
Salazar- Lindel et al 2007	``
Santosham et al 1996	``
Santosham et al 1997	``
Sarker et al 1995	``
Semenza et al 1998	``
Shahid et al 1996	``
Stanson and Clemens 1987	``
UNICEF n.d.	Peer reviewed report

UNDP 2003	``
UN Report 2006	``
Vanderslice and Briscoe 1995	Journal article
White 1999	``
WHO Afro 2006	Peer reviewed report
WHO document n.d.	``
WHO n.d.	``
WHO 1993	``
WHO 2004	``
WHO 2002	``
WHO/UNICEF 2000	``
WHO 2001	``
World Bank 2007	``
WHO Expert Meeting 2001	``

Results

Disposal of Fecal material

It is known in medical science that human feces are a rich source of pathogenic organisms that may also cause diarrheal diseases in humans in general and in children in particular. In fact, promiscuous defecation around human natural habitats is said to significantly increase the incidence of diarrheal diseases in humans (Han and Moe, 1990; Stanson and Clemens, 1987). It is therefore not surprising that the WHO consultation held in 1993 recommended that human feces should be safely disposed of and that particular attention should be given to the stools of children who are suffering from diarrheal diseases (WHO, 1993).

Many studies have demonstrated a link between diarrheal diseases in children and the degree of safety of stool disposal (Curtis et al., 2000) in households within a population. Moreover, while many studies have demonstrated strong relationship

between diarrheal morbidity and stool disposal, only few controlled studies have actually shown direct impacts on child mortality. One of such studies is the study carried out, again, in rural Bangladesh, which showed about 68% reduction in the post neonatal mortality rates in families with latrines as opposed to those without latrines (Rahaman et al., 1985). A major assumption here will be that the factors which make some families have latrines and some unable to afford latrines are not confounding factors in the process of acquisition of diarrheal causing pathogens.

However, another retrospective study carried out on children less than three years of age revealed that when child stools where left unduly exposed, there was an increase of 50% in the risk of hospitalization compared to when the feces are disposed of in the latrines. (Gorter et al., 1998). It will therefore be reasonably safe to state that when feces, and by extension other human wastes are properly disposed of, there is a positive impact on the risk and incidences on both diarrheal morbidity and mortality. But it is crucial for one to state that because fecal disposal information is personal, it is possible that most interview results will likely be biased towards safer behavioural practices of fecal disposal. This view is shared by Curtis and colleagues (1993); Cousen et al. (1996) and Manun`Ebo et al. (1997).

As important a factor as latrines and toilets for proper fecal disposal sounds, it is still a lot capital intensive and would require a strong inter-sectoral collaboration to advocate for its provision in under-served communities within low income economies. Other primary measures, like fly control, maternal educational status, breast feeding practices and childhood vaccinations that may have impacts on diarrheal disease transmission are also reviewed in subsequent paragraphs for evidences of their likely effectiveness at the individual or population level.

Household water purification- water filtration

Water purification as a method of preventing diarrheal diseases is actually a primary measure as indicated in the F diagram for the prevention of diarrheal diseases. It has been documented that more than one billion people in resource poor countries have inadequate access to quality water supply (UNDP, 2003).

Many studies (Mintz et al, 1995; Clasen and Cairncross, 2004; Mintz et al, 2001) have demonstrated the effectiveness of household treatment of water in the reduction of diarrheal diseases (Crump et al, 2005). In traditional African societies, many

relatively low cost methods have been used to purify household water. These include boiling, *filtration* using cloths as sieve, addition of *alum* (Lime stone) to water and more recently the exposure of water to *ultra violet radiation*.

Results from a cluster randomised controlled trial of household based treatment of drinking water in rural western Kenya revealed that, in clusters where the water was treated with a flocculant disinfectant or sodium hypochlorite; there was a significant reduction in episodes of diarrheal diseases among people of all ages than in the control clusters. (Crump et al, 2005). In another cluster randomised controlled study done in rural Uzbekistan, it was revealed that in households where home chlorination was introduced, the episodes of diarrhea in children less than 5 years of age was reported to be only 14, compared to 80 episodes in the controlled households in spite of the fact that these households were allowed to continue with their usual practice of boiling water and allowing it to settle before consumption (Semenza et al, 1998).

Many authors have argued that the age long campaign in health promotion of boiling drinking water may not be the most effective measure available as there is little evidence in support of the effectiveness of such a measure (Curtis et al, 2000). Some researchers have said that purifying drinking water by boiling as a measure to prevent diarrheal diseases is relatively expensive (Gilman and Skillicorn, 1985) especially in resource poor settings. This view is strongly shared by this author who is familiar with settings in Africa in general and in Nigeria in particular where there is scarce supply of electricity and woods for cooking are also expensive. It is also note worthy that cooking with woods apart from the cost, may also expose children and even adults to air pollutants that may also cause other health problems commonest being respiratory problems.

"Solar disinfection is a strong choice for effective disinfection of water in developing countries because it is cheap, simple, accessible, and does not affect the taste of the water" (White,1999). A controlled clinical trial on Masai children in Kenya showed that the exposure of water for drinking to sunlight for a full day led to a reduction of the incidence of life threatening diarrheal diseases over a period of 3 months by up to 26% (Conroy et al, 1996).

Cairncross and colleagues (1997), have argued that in developing countries, where there is likely to be scarcity of water, the quantity of water available for usage may have more impact on common endemic diarrheas than supply of highly purified

water. But the author believes that since the measures looked at here are relatively inexpensive, as most of them are even naturally available, like the solar energy, it is still worth while to integrate the attitude of providing pure water into public health programmes. This would enable the majority of the population in resource poor countries to benefit from the advantages of pathogen-free drinking water, no matter how little these may seem. More so, it is generally agreed that when other sources of diarrheal pathogens are removed from the environment, the provision of high quality water is much more important than the quantity of water in supply (Vanderslice and Briscoe, 1995), a situation which presently obtains in the developed countries of the world as of today (Curtis et al, 2000).

An up to date and comprehensive review of the interventions to improve water quality to reduce diarrheal morbidity concluded that all the household-based interventions, including household-based water filtration, significantly reduced diarrheal episodes across all age groups in the study population (Clasen 2006). It is also instructive that all the studies on water filtration (Colford 2002; Clasen 2004b; Clasen 2004c; du Preez 2004) included in the said review, reported statistically significant outcomes in favour of water filtration as an intervention in the household.

Of the methods reviewed above for household water purification, more attention will be paid to water filtration because it is a one-off measure in a way. It is often not immediately used up, and there is hardly additional cost involved in its usage after the initial procurement. This may be more sustainable in poor settings where the cash flow is often below even the national average. Also, its impact may be easier to measure unlike with sunlight where the exact dose of exposure still requires further vigorous research work. This is outside the fact that sunlight is seasonal in intensity and its intensity is far lower in the rainy seasons, a time when most diarrhea cases actually peak in these settings.

Micro-biological analysis of residue from water filters at the point of use indicate that in spite of the fact that at the point of distribution sampled waters were adjudged to be free of Thermotolerant Coliforms (TTC), follow-up analyses within the household showed a considerable contamination by disease causing pathogens in rates almost similar to those seen in untreated water sources (Clasen and Bastable, 2003). They went ahead to advocate the need for point of use treatment of water, participating

actively in the formation of the international network to promote household water treatment and storage at an international conference called for that purpose.

In a community based randomised controlled trial by Clasen and colleagues (2004a) in which they sought to evaluate the effectiveness of household ceramic water filters in the improvement of water micro biological quality, they found statistically significant differences between the intervention and control households. The series of samples of water they collected from the intervention households showed that 100% of the samples were free from TTC. In the control group who continued using their usual ways of getting storing and utilising water, there samples revealed an average TTC concentration of up to 1550. In a similar vein, a rural Bolivian randomised controlled study reported, children les than 5 years old were reported to have a reduction in the risk of diarrheal morbidity of up to 83%(95% CI=51-94%; $p<0.001$) compared to those in the control households (Clasen et al., 2004b).
However, a number of studies done in Australia, Canada and the United States have reported effects that were not statistically significant between the intervention (water filters) and the control household groups. One thing that these authors have in common in their studies is the blinding of both study participants and the field workers (Colford et al., 2005; Payment et al., 1991; Hellard et al., 2001).

The need to look for interventions that are potentially cost effective, easy to use, affordable and sustainable without drastically contrasting the cultural beliefs of the community further solidified the need for this study, especially in a country where more than half of the population are classified poor by the World Bank definition (World Bank 2007).

Another important concept related to water that was identified in the literature is the concept of hand washing after events like defecating, urinating and after disposing of feces of new born babies and children in the household. And very importantly, whether washing of hands especially before food preparation would have an effect on the rate of diarrheal disease transmission. The effectiveness of this is further looked into in view of evidences from randomised studies available in the literature.

Hand washing

Although hand washing is one of the most common hygienic practices that have been around for a while, a Peru observational study revealed that hand washing is still not

as universal as we thought. In the said study, only about 11% of the study population were observed to wash their hands after defecation (Huttly et al, 1994). It usually requires the availability of water and it can be done either with water only or with soap and water.

In some parts of Africa, hand washing is also done by the use of ashes to aid the chances of removal of particles and pathogens. While it may be desirable for people to wash hands after every contact with possible sources of contamination, it is usually not feasible to wash hands after every such contacts and this is further compounded by the seemingly impracticability of expecting people to wash their hands with soap on every suspected contact with contaminants (Curtis et al, 2000). A study carried out in Guatemala in 1993 revealed that when mothers are asked to wash their hands before routine measures like cooking, feeding babies and before eating, they would have washed their hands up to 32 times in a given 24 hour period coupled with the additional water that will be required and the time constraint this may pose (Graeff et al, 1993).

Water availability is said to have a direct relationship to the occurrence of hand washing. It was observed that the farther away the source of water is from the household, the fewer the frequency at which mothers washed their hands and vice versa. (Cairncross, 1997). It is therefore important for health promotional and intervention programmes to target hand washing messages at occasions when the chances of contamination and transmission of pathogens are highest in order to enhance the adoption of this strategy.

A study which introduced hand washing with soap after defecation and before eating reported a significant reduction in the incidence of shigellosis, achieving an 84% reduction and a 37% reduction in other forms of diarrheal diseases (Khan, 1982). A randomised-controlled study in Bangladesh suggested that the reduced incidence of diarrheal diseases seen in the intervention groups is largely due to hand washing among other factors (Alam, 1989).

Another study in a Bangladesh village showed a reduction in diarrheal incidence of more than 60% after the introduction of soap used for hand washing after toileting activities and before eating food (Shahid et al, 1996). In Malawi, it was reported that the availability of soap in households in Nyamiththu refugee camp led to a reduction of about 27% of the number of diarrheal diseases seen in that period (Peterson et al,

1998).To prevent the eventual transmission of pathogens to humans, it is important for emphasis to be placed on the primary prevention part of hand washing, by ensuring that messages target the promotion of hand washing after events like defecation and even urination (Curtis et al, 2000).

Again, the concept of hand washing is likely going to be very relevant to resource poor settings where the environmental and living conditions make it easier for people to get in contact with likely contaminants like fecal materials. Apart from the cost of the soap and the availability of water, it is a very cheap measure which may go a long way in mitigating the incidences of diarrheal diseases in these settings. It thus follows that if fecal materials are controlled in a way that there are only minimal chances of contact with humans, this may reduce the burden of the frequency of hand washing. In the previous paragraph we have looked at the effectiveness of disposal of fecal matter on the chances of getting diarrheal disease infection.

Fly control measures

Another look at the F diagram shows that Flies are an important factor in the transmission to humans of pathogenic organisms found in feces. They are thought to be capable of carrying disease causing organisms on their feet and transfer these to food substances eating by humans when they land on these food substances. Studies have shown that flies also carry pathogens in their feces and digestive juices which they later regurgitate onto human foods (Oo Kin New et al., 1989).

In a village in Pakistan with a reported high degree of fecal contamination, a fly control programme implemented produced a 23% reduction in the number of new episodes of diarrheal diseases in this village (Chavasse et al., 1999). Emerson et al. (in Curtis et al., 2000) found in his study a reduction of diarrheal incidence of up to 25% in a population sprayed with deltamethrin than in those not sprayed, but they quickly added that this may neither be sustainable nor cost effective in resource poor settings.

Issues that are very likely going to arise will include the consistency of funding, what the coverage will be for such intervention, where exactly will be sprayed, and if there are no other plausible and beneficial interventions that may likely cost less money and with innate potential for sustainability that the funds could be channelled to. In this light, focussing on primarily preventing flies from gaining access to stool by properly disposing fecal materials might be more beneficial in resource poor settings. This will

reduce the chances for flies to breed and thus reduced the number of circulating flies carrying pathogenic organisms. (Curtis et al., 2000).

Breastfeeding practices and diarrheal diseases

In Guinea Bissau, only 37% of all children born are exclusively breastfed up to the first 6 months of life. Available estimates indicate that 64% of children aged 6-9 months in this country are not having complementary food with breastfeeding between the years 1996 and 2005 (UNICEF country statistics, n.d). Since studies have shown that children fed breast milk alone after 6 months of age are more likely to be malnourished than their counterparts on complementary food (WHO?), and it is known that diarrhea rates and severity in malnourished children are more than in healthy children, it is therefore not surprising that diarrheal diseases account for 19% of the causes of death in children less than 5 years in Guinea Bissau, a value estimated to be more than the African regional average (WHO AFRO, 2006). This view is supported by studies that have shown strong evidence that breastfeeding reduces the morbidity, mortality and severity of diarrheal diseases in children (Feachem and Koblinsky, 1984).

Childhood Vaccination and diarrheal diseases

In recent years, there have been significant efforts towards the development of vaccines against the rota virus, which is implicated in as much as 15-25% of all diarrheal diseases seen in children aged 6-24 months visiting a health facility. (WHO Document, n.d.). In a well documented study, Aaby et al (2004), in a study carried out in Guinea-Bissau, found that their data suggested that vaccination status of a child may determine the severity of disease of an infection that the particular vaccine was not originally meant for.

They went further to suggest that the withdrawal of the Oral Polio vaccine from the public health system after Polio must have been eradicated, may actually lead to increased childhood mortality in areas that are known to have high rates of child mortality. Studies have also been carried out that stated that theoretically, measles immunization alone can avert up to 26% of diarrhea related mortalities in children less than 5 years of age, and that if this is the case, it is then probably a cost effective public health intervention (Feachem and Koblinsky, 1983).

Maternal education and diarrheal diseases

It has been variously shown that there is a relationship between literacy level and hygiene practices (Pracey, 1982) and since it has been shown that hygiene plays a crucial role in the transmission and survival of pathogenic organisms, it thus follows that maternal education will in turn have an impact on diarrheal disease rates. According to Pandey et al. (1998), improving the education of women has a significant positive correlation of a reduction in childhood mortality rates. In another review, Claeson et al. (2000) using the 1992-1993 National Family Health Survey data, reported that children born to illiterate mothers in India are more than 3 times more likely to die before their fifth birthdays having a mortality rate of 141 per thousand. This is unlike in the children born to mothers who completed high school or higher who have a lower mortality rate of 43 deaths per thousand. In Guinea Bissau, female literacy rate is estimated to be as low as 27% of the population greater than 15 years of age (Guinea-Bissau consulate website Germany, 2007). Apart from the literacy level of mothers, it has also been shown that education of mothers on practices such as weaning, supplementary feeding and breastfeeding promotion has an effect in the reduction of childhood mortality in resource constrained settings. (Ashworth and Feachem, 1985; Feachem and Koblinsky, 1984; Feachem, 1983).

In the course of the search and review of literatures, one intervention kept occurring. This is the much talked about use of the Oral Rehydration Fluid (ORS) as the main component of the Oral Rehydration Therapy (ORT). The next paragraph of this review will take a cursory look at the use of ORS in the course of diarrheal diseases, its evolvement over the years and the accompanied challenges including the now standard recommended composition by the major International Organisations. It is an intervention that can be referred to as a means of secondary prevention since it may not have an effect on the occurrence of a diarrhea episode, but certainly has a positive impact in the prevention of complications and severity of diarrheal disease.

Oral Rehydration Solution (ORS) and Diarrheal diseases

In the field of diarrheal disease study, Oral Rehydration Solutions (ORS) still remains one of the most valued discoveries made in the management of diarrheal diseases. Although it is known that ORS plays little or no role at all in the prevention of diarrheal diseases, its place in the reduction of potential fatalities in individuals suffering from diarrheal diseases, especially in the acute episodes in children, is no longer in any doubt (Salazar-Lindo et al, 2007). In fact, for about three decades now,

the WHO/UNICEF recommendation that all patients with diarrhea of any etiology, who are able to take orally, and are not having severe forms of diarrhea, be treated with ORS (Avery and Snyder, 1990) still subsists and is continuously being consolidated.

This single decision has been linked to the aversion of the deaths of millions of children in developing countries, primarily by preventing the adverse effect of dehydration (Rahaman et al, 1979), a consequence of untreated or poorly managed diarrheal disease.

Oral Rehydration Therapy (ORT) using the ORS is already a well established strategy for preventing or treating diarrheal induced dehydration (Santosham et al, 1997). The introduction and use of the ORS in the management of diarrheal diseases has not been without its challenges. Starting from the early 50s and 60s when physicians in the USA stopped the usage of ORS due to some incidences of hypernatremia and worsening of diarrheas due to inappropriate composition (Santosham et al, 2007), and lately to the debate often titled ‘ Hypo-osmolar ORS versus WHO standardised ORS’. This scientific debate was prompted by the desire to have a solution for treating diarrhea that will not only prevent mortality, but also provide other clinical benefits of reduced period of morbidity, hence less hospital stay, reduced stool output and a significant reduction in cases of treatment failure ultimately requiring unscheduled intravenous administration of fluids (WHO, 2002).

The formal WHO standard ORS with a total osmolar capacity of about 311 mOsmol/L, containing 90 mEq of sodium, Glucose 111 mOsmol/L, Potassium 20 mEq/L, Citrate 10mOsmol/L and Chloride of 80mEq/L, though has been shown to be highly effective in averting dehydration related mortalities over the years. However there have been worries about the increased stool output seen in the first 24hours of its administration due to the presence of high solute load it produces in the gastro-intestinal tract (El- moughi et al, 1994) and the fact that it does not necessarily reduce the duration of diarrheal episodes. These may pose challenges in its community based application by mothers and care givers if they do not see changes especially in the stool flow and volume in the first 24hours post-administration of the solution.

A good number of randomised controlled and blind trials that used various osmolar concentrations of fluid solutions hypotonic to plasma (ranging from 224-250

mOsmol/L) to check for desired effects that are not seen in the WHO standard ORS have been done in many countries on children suffering from acute non-cholera episodes of diarrhea (El-Moughi et al, 1994; International Study Group, 1995; Mahalanabis et al, 1995; Sarker et al, 1995; Santosham et al, 1996; Choice Group, 2001).

In 1995, the International Study group conducted a multicenter study in about four resource constrained settings with the aim of evaluating the effect of a reduced osmolarity ORS in young children after a decision has been taken on its use in European countries following the recommendations of the European Society for Pediatric Gastroenterology, Hepatology and Nutrition working group in 1992. In this randomised- controlled blind clinical trial, in which children aged 1-24 months were randomly allocated into either of the hypo-osmolar group or the then standard WHO ORS group, it was observed that the stool output, duration of an episode of diarrhea and the total quantity of ORS taken were all statistically significantly increased in the children on the WHO ORS when compared to the group on hypotonic concentration of ORS. Although the treatment failure rate, exemplified by the administration of unscheduled intravenous fluids after ORS was also greater in the children on WHO ORS, this was not statistically significant when the outcome in the four centers were pooled together.

Rautaren et al (1997), on their part, using a hypotonic ORS (224 mmol/L), in another randomised double blind study demonstrated a reduced stool output and a significant reduction in the volume of the total ORS consumed. In view of the various results from studies utilising various concentration of hypotonic fluids, the WHO, in need of a single solution that could be generally used world wide, constituted an expert committee which then suggested the conduct of more studies using a single solution containing 75 mmol/L of glucose and 75mEq/L of sodium with a total fluid concentration of 245 mOsm/L.

Another multicenter, randomised, double-blind clinical trial to evaluate the efficacy and safety of a reduced ORS in children with acute non-cholera diarrhea was then commissioned (WHO, 2001). This study, by the Choice Study Group (2001), reported a statistically significant reduction of about 33% in reduction of the unscheduled use of IVF, and thus, treatment failure rate when using the decreased osmolar concentration of 245 mOsmol/L. But the sample size used in this study gave a 50% power in respect of the change it was designed to measure (Choice Study Group,

2001). The outcome of a systematic review (meta-analysis) by Hahn and colleagues (2001) of all randomised trials at that time reported a statistically significant 35% reduction in treatment failure rates and a 20% reduction in stool output for all the studies analysed when they were subjected to pooled analysis. The increase in the incidence of hyponatremia seen in patients on the hypo-osmolar solution were however not statistically significant, with odds ratio of 1.45 but a confidence interval of 0.93-2.26 (WHO/UNICEF Expert Meeting, 2001).

In 2002, following the technical recommendations made in 2001 by the experts attending the Joint Expert Consultative Meeting on the use of hypo-osmolar concentration of ORS in children with acute non- cholera diarrhea and adults and children with cholera, the WHO and UNICEF replaced the previously standard 311 mOsmol/L ORS with the now standard hypo-osmolar concentration of 245mOsmol/L (WHO 2002).

In Africa, and possibly other resource constrained settings of the world, ORS is a necessary optional intervention that the health systems can not do without as a novel strategy that prevents deaths from dehydration due to diarrhea in people of all ages but especially in children less than 5 years of age. Unfortunately, the trends in the use of ORS in these settings are declining in terms of the use rate of increase. An analysis of DHS data from Low and Middle income countries by Forsberg and Colleagues (2007) showed an overall annual increase rate of 0.39% (p=0.089) in the percentage of children given ORT, an obviously increase in ORT use rate in these populations but one which displayed a 'weak association' between time and use rate'.

Therefore, one can justifiably say that up till now, ORS still remains a valuable intervention that is still under utilised in low and middle income countries whether it is applied programmatically in the community or employed in the process of a community based study that has the potential benefit of consolidating what we already know, probably also giving us new insights. But at the least beneficial to the community by decreasing mortality from diarrheal diseases, freeing desperately needed financial and human resources in terms of money and time spent on hospital visits, prolonged hospital stays and Quality Adjusted Life Years (QALYs) gained.

Table 2 showing the composition of the New and Old Standard WHO/UNICEF ORS (from the report of the WHO Expert meeting 2001)

Constituent	Old ORS (mmol/L)	New ORS (mmol/L)
Glucose	111	75
Sodium	90	75
Chloride	80	65
Potassium	20	20
Citrate	10	10
Total osmolarity	311	245

Highlight of Hypotheses generated

From the above review, the following hypotheses can be highlighted for implementation by relevant agencies and governments in non privileged communities.
Hypothesis one: Household water filtration is an effective means of reducing diarrheal morbidities in young children in resource constrained settings.
Hypothesis two: Education of women and care givers of children on the need to wash hands before preparing child's meals reduces the risk of diarrheal diseases in such children.
Hypothesis three: A combination of Hand washing and ORS usage will have more effect on diarrheal morbidity and mortality than a single intervention of household water filtration.
Hypothesis four: Provision of latrines in every household in a community will significantly reduce diarrheal morbidity and mortality in young children

The above hypotheses are relevant in many resource poor settings. It would have been appropriate to support the above postulations by analysis from the DHS data from the country in which the hypothesis would be implemented. Unfortunately, there is a paucity of studies that are addressing most of the hypotheses in Nigeria

THE NIGERIAN DEMOGRAPHIC AND HEALTH SURVEY

Introduction

Demographic and Health Survey is a nationally representative survey designed to collect information on indicators on Child and Maternal Health, Fertility levels, HIV/AIDS awareness and level of educational attainment in men and women of ages 15-59 and 15-49 years respectively, amongst other indicators. The DHS is a cross sectional study implemented with the use of face to face interviews. The DHS data set under study is the latest for Nigeria collected originally between March and August 2003. It is the third published Nigerian DHS at the moment, the first being in 1990 and the second in 1999.

Methods

In the Nigerian DHS of 2003, the sampling frame from which the sample clusters were systematically drawn was the list of enumeration areas delineated and used by the National Population Census in the Nigerian population census of 1991. A total of 365 clusters were selected. The listing of the households within these clusters was done by teams trained by the National Population Census. Households within these clusters were subsequently systematically chosen.

The number of households chosen per region in the index DHS was inversely proportional to the population size in order to ensure the number of cases reported was representative of the six geopolitical regions of Nigeria (North East, North West, North Central, South East, South West and the South South). 362 clusters were successfully sampled out of the 365 originally selected.

In all, 7,225 household interviews were reported completed. The relevant SAS programs were run for both age in months and diarrhea, and diarrhea last 2 weeks and sex while controlling for the age group. Appendix xxx shows the various SAS commands utilised in this process. Tables 2 and 3 below were computed from the 2003 Nigerian Demographic and Health Survey data.

Relevant output from the DHS data

The main message in tables 3 and 4 below is that children in the age group 6-35 months had the highest burden of diarrheal diseases. This is not contrary to what we already know (Bairagi et al., 1987). It is believed that children less than 6 months old in such settings are likely still being breastfed and breastfeeding is already known to have a protective effect against diarrhea in children. But the protective effect has been said to diminish with age and hardly felt once a child is older than 1 year of age (Feachem and Koblinsky, 1984).

Another reason which might increase the risk of diarrhea in this age group may not be unconnected with the fact that at age 6 months, majority of children would have started crawling and have already gained control on handling of objects. It is possible that because such children are very likely to put what ever comes in contact with their hands in their mouth, they may inadvertently transfer diarrhea causing pathogens into their mouth especially in settings where the environmental cleanliness is less than optimal. The general advice on infant feeding includes the introduction of various forms of family food and given of water to infants anytime from 6 months. It means that if the food handling processes within the household, or the source and treatment of household water is not optimal, this may be a means of introducing pathogens that cause diarrhea to the child. These events may then lead to an upsurge of diarrhea morbidities around this age group relative to others.

The parameter on sex in table 3 is illustrating the well known trend of diseases between male and female children. The male children are showing more frequency of diarrheal episodes than their female counterparts of same age group. It has been shown that between male and female children of same age and similar circumstances, the male children were more likely to suffer more morbidities and mortalities than their female counterparts (Renzaho, 2007).

Table 3 Frequency of having had diarrhea in the last 2 weeks by age group and sex

Age (months)	No	Yes (%)	Total	Male (Yes)	Female (Yes)
0-5	532	81(13)	613	44	37
6-11	463	168(27)	631	86	82
12-23	723	282(29)	1005	155	127
24-35	744	201(21)	945	111	90
36-47	839	132(14)	971	67	65
48-59	733	61(8)	794	32	29
Total	4034	925 (18.6)		495	430

Answer of the child's caretaker as recorded by the DHS for Nigeria 2003.

Table 4 showing the concentration of diarrhea in the age group 6-35 months

Age (months)	No	Yes (%)	Total
0-5	532	81(13.2)	613
6-35	1930	651**(25.2)**	2581
36-59	1572	193(7.4)	1765
Total	4034	925(18.6)	4964

Limitations to the use of the 2003 Nigerian DHS for this study

The Demographic and Health Survey data also did not provide enough information to justify an analysis in the light of the above generated hypotheses. When the SAS commands designed to generate the variables utilised in the Nigerian DHS was run, most of the relevant variable names found did not report data for the stated information. Few examples of such instances where no data was provided include, presence of latrine in the household or not, any form of household water purification or not, the use of ORS or the salt-sugar solution when a child has diarrhea and so on. There was a question on the presence of a place for hand washing in the house but that in the author's opinion does not imply that the respondent washes her hands and how often that is done.

However, from the available DHS data, one can get important information about the peak ages of diarrheal infection in the typical Nigeria setting. This will aid the design of intervention to target the age group that may bear the most burdens of the direct consequences of a poorly managed diarrheal disease episode.
Information on the highest level of education of the respondent was also provided but again, provision of formal education is beyond the scope of an interventional programme for the purpose of this study. In the next paragraph we will analyse age in relation to diarrhea in the last two weeks prior to the survey to generate an age group with possibly the highest frequency of diarrhea as discussed earlier.

ACTION PLAN FOR THE PROPOSED INTERVENTION STUDY

Project Name

The reality Project- 2008

Project Title

Interventions for the prevention of diarrhea morbidity in children: Household water filtration: a randomised controlled community based trial in a resource constrained setting.

Research Questions

Does household water filtration have a significant effect on the reduction of morbidity from diarrheal diseases in children aged 6-35 months?

Aim of the Project

Is to demonstrate the effectiveness of household intervention in the prevention of morbidity from diarrheal diseases in children within 6-35 months old in resource constrained settings

Project Justification

In many major cities of the world, it is a generally known fact that water meant for public consumption is made to pass through various physical and chemical processes before they are allowed into the homes of the final consumers. It is instructive to note that not many cities in Africa are connected to safe water supply distribution system. In fact, it is estimated that at least 22 countries in Africa are not providing safe water to about 50% of their inhabitants (de Villiers, 2002).

This act of providing treated water to households is what is often referred to as 'Point of distribution' as opposed to 'point of use' water treatment. But researches have shown that even in communities with safe point of distribution water system or

access, the water at the point of use is not free of Coliforms. Micro-biological analysis done on water at the point of use indicate that in spite of the fact that at the point of distribution sampled waters were adjudged to be free of Thermotolerant Coliforms (TTC), further follow up analyses within the household showed a considerable contamination by disease causing pathogens in rates almost similar to those seen in untreated water sources (Clasen and Bastable, 2003). They went ahead to advocate the need for point of use treatment of water, participating actively in the formation of the International Network to Promote Household water treatment and Storage at an international conference called for that purpose.

An up to date and comprehensive review of the interventions to improve water quality to reduce diarrhoea morbidity concluded that all the household-based interventions, including household-based water filtration, significantly reduced diarrhoeal episodes across all age groups in the study population (Clasen 2006). It is also instructive that all the studies on water filtration (Colford 2002; Clasen 2004b; Clasen 2004c; du Preez 2004) included in the said review, reported statistically significant outcomes in favour of water filtration as an intervention in the household.

The design of the index project is motivated partly by the analysis of the 2003 DHS results and the assertion of Clasen and colleagues(2006) in the conclusion of their review where they reiterated that the main burden posed by diarrhoeal is mainly in the fact that it causes significant mortality and not just morbidity, suggesting that further researches be carried out on the effectiveness of these household interventions in the reduction of diarrhoeal mortality, especially in groups more at risk like children under 5 years and people with compromised immune status.

Unfortunately, studies specifically designed to demonstrate this important effect of such interventions are almost non existent. The main motivation this author has for this project was from his experience working in the proposed research area where it was not uncommon to attend to children brought in technically dead into the Health Centres and hospitals from causes not unrelated to dehydration, a consequence of poorly managed diarrhoeal episodes.

In Nigeria, studies designed to test for morbidity and mortality outcomes after the use of household water quality interventions like household filtration, are even rarer. Available published studies mainly analysed the microbiological contents of filtered

water in the household (Blum et al 1987; Alabi et al 1986; Ibiebele and Sokari 1989), and did not look for the effectiveness of averting the health outcome of diarrhoea morbidity nor mortality in the context of their findings, although they all reported the positive efficacy of water filters in improving water quality.

The need to look for interventions that are potentially cost effective, easy to use, affordable and sustainable without drastically contrasting the cultural beliefs of the community further solidified the need for this study, especially in a country more than half of the population are classified poor according to the World Bank definition (World Bank 2007).

Therefore, this study will attempt to estimate the effectiveness of household water filtration in the prevention of diarrhoeal morbidity and mortality in children less than 5 years old and specifically those aged 6-35 months old, since available evidence from the 2003 Nigeria DHS and other sources suggests that they have the highest rates of both morbidity and mortality from diarrhoeal diseases. No previous study has been done on testing the effectiveness of household water filtration in the prevention of diarrhoeal morbidities and mortalities in the study areas

The role of water quality in diarrheal diseases

The United Nations, in its African water development report for 2006, asserted that the access to water of adequate quality and quantity is one of the basic needs of humans in life and that this is important if humans must maintain its optimal level of health (UN Report, 2006). This view is also shared and supported by the WHO which went ahead to produce the generally used guidelines for water quality that states that at the point of distribution, there should be no detectable quantity of disease causing organisms in water (WHO 2004) and in conjunction with UNICEF, it acknowledged, in the year 2000, that an estimated one-sixth of the world's population lacks access to safe water (WHO/UNICEF 2000).

Diarrhoeal diseases are believed to be endemic in areas without quality assured sources of water and its means of getting to the general consuming population (Clasen et al, 2006).In a series of reviews carried out by Esrey and colleagues in the 80s and early 90s, they reported that the combination of water quality and quantity improvement, sanitation and hygiene produced a reduction in diarrhoeal morbidities.

In fact they reported that water quality may only reduce diarrhoea morbidity only when combined with the above interventions (Esrey 1991). But this view was later contrasted by a later review by Fewtrell et al (2005) when they intimated that the measures had positive impacts even in the absence of sanitation.

However, it was a combination of these contrasting views and outcomes, combined with their earlier works in this field (Clasen and Bastable 2003; Clasen and Mintz 2004;Clasen et al, 2004) that stimulated Clasen et al to conduct a detailed and relatively most recent meta-analysis of the interventions aimed at improving water quality and their impacts on diarrhoea diseases in which they concluded that indeed, water quality is a significant determinant of diarrhoea diseases and thus has a positive effect on the reduction of diarrhoeal episodes (Clasen et al, 2006).

Characteristics of the Study areas

Geographic and Demographic information

Ipaja/Ayobo community is a semi-urban, mostly residential settlement within the Ipaja/Ayobo local government development area (LGDA) of Lagos state, which occupies a land mass of about 57,000km2. It was formally named a substantive local government area from the larger Alimosho local government but later reversed for political reasons. Ipaja/Ayobo LGDA is one of the local government authorities located at the outskirts of Lagos State, bounded in the North by Abesan River, in the South by Asipa, Olorunsola and Ijan Community, in the East by Baruwa Kodeso road and in the West by Ogun State. The vegetation is largely swampy forest. The annual rainfall is between 80 and 120 inches while the average annual temperature is around 28 degree Celsius. The area has a two-peak rainy season with peak periods around April and end of September of every year. Ipaja/Ayobo is the town that the natives first settled in the reason why the all development area is called Ipaja/Ayobo. The population of people living within the Ipaja/Ayobo town is estimated at about 110,000 inhabitants. The Yorubas of Western Nigeria are the major ethnic group in this area with the presence of the Hausas of Northern Nigeria and the Igbos of Eastern Nigeria in the minority.

Socioeconomic Statistics

Majority of the population are day workers. Most men in the town engage in businesses ranging from Bus driving and conductors. Some are labourers at construction sites while others are farmers. Most women in this community are petty

traders who engage in mainly food items. Generally speaking, the majority of the population can be said to be living on less than 1USD per day in line with the national average. The three main occupation practiced by the natives are farming, fishing and trading.

Health Status Statistics

The area is a highly endemic Malaria area. Vaccination coverage is reported to be around 85% while 70% of children are reported exclusively breastfed. The antenatal clinic attendance rate is put at 60%, although only 20% of all deliveries are said to take place at home. There are 4 Traditional Birth Attendants in this town.

Health Infrastructure and Living Conditions

Apart from the single health centre located around the administrative headquarters of the local government area, there is no other public owned health facility in this area. However, there are a few numbers of private clinics which are often overseen by lower cadre health workers. And most times these facilities have prohibitive charges when compared to the income of the majority of the community members. An average family of 4-6 lives in a room apartment. Although majority of the buildings in this area are in bricks, a good number of houses are made in thin sheets of zinc materials. Only about 55% of houses have access to Latrines of any kind in this area, while cooking either takes place within the living room or in the open surroundings around the houses.

The houses in this part of Lagos are not connected to the public owned source of water supply and there are no other commercial or private facilities connected to the houses. Hence water for drinking and cooking is usually bought from few home owners that have dug bore holes in their houses and thus only those who can afford to pay the charges get drinking water from this source. The majority, however, get water for household utilisation from shallow wells, most without covers, and the nearby rivers. The area is generally connected to the Egbin Power Station with an average of 2-3 hours per day.

As most houses in this area are built without latrines, it is not uncommon for people to defecate on farmlands and nearby bushes while the young children generally defecate around the house, especially children still less than 4 years old. The faeces are wrapped in paper or nylon material and thrown into the bushes on most occasions, but

may also be left unattended to for a long period of time. There is usual flooding of the surroundings in the raining seasons forming large pools of stagnant water sometimes making some areas hard to reach, with influx into some homes.

Although there is no available statistics on the quality of breastfeeding practices in this area, it may be safe to assume that the average duration of breastfeeding is not less than 6 months (70%) as most of the mothers either work around or in the house where they live. It is the exclusiveness or otherwise of the breastfeeding practice that may be a subject for further scrutiny.

Educational facilities and School enrolment

There are a total of 8 primary schools in this area and 4 secondary schools which are public owned. The average literacy rate for both men and women is said to be around 50%. Although the definition for literacy rate was readily available. In the 2006/2007 academic session, 4,366 pupils were registered in the various primary schools in this area out of which about 53% were females. The secondary school enrolment for the same session was estimated as 1397 students of which 48% were females.

Options considered, Feasibility and Cost effectiveness

From the above description of Ipaja/Ayobo community, it easily appears that some of the main interventions that could be implemented in this area should include the provision of latrines in all households, connection of the households to the public water system or provision of better sources of water infrastructure, simple hygiene education on the advantage of personal hygiene including safe fecal disposal, provision of simple locally made materials for household water filtration, and boiling of water for drinking purposes.

1. Construction of latrine in every household is a capital intensive project that often takes months or years to complete. It s design and construction usually requires inter-sectoral cooperation even among government ministries. It is also not feasible for the health sector to be constructing water infrastructural facilities to homes. It is within the scope of the works and housing ministries.

The community has water in relative abundance but the question is what household methods should be utilised in improving the quality of available water for domestic purposes. Use of chemical is hardly sustainable because of the need for frequent purchases. For example, addition of chlorine to water. Also there is a problem of

adherence to chlorinated water due to the additional taste effect. However, because of the rivers surrounding this area, water quality and not water quantity is the main water challenge faced by the residents.

2. This leaves us with household water filtration as a means of primary prevention of diarrheal diseases applicable to this environment. Although studies have demonstrated it efficacy in removing diarrheal pathogens from water ( ) and its effectiveness in preventing diarrheal morbidity ( ), unfortunately, there are no published studies yet designed to evaluate the cost effectiveness of household water filtration in the prevention of diarrheal diseases.

3. Water and Sanitation interventions have been shown to be also cost effective in line with the ORT. In the Cost Effectiveness Analysis (CEA) done by Varley et al. (1998) they found the following after using a model that separated the cost of infrastructural provision from the Health sector responsibility in Water and Sanitation (WS). They posited that the duties of health programs in WS are limited to promotion of personal hygiene and handling of water quality issues. Using their model, they found that the cost per DALY saved using WS is US$44 and this is well below the cut off point set in the word development report that states that any intervention that costs more than US$150 is probably not cost effective (World Bank, 1993). And it is even more cost effective in areas that already have physical infrastructures in place.

4. On the CEA of the use of the ORT, because ORT is a secondary intervention, they did their calculation based on the administration of ORT to 100% of diarrhea cases in children less than 5 years. They found that if the ORT is administered in the health sector, using the cost to the health sector of US$2 per case treated, the cost per DALY saved will be US$24 while the cost per death averted is US$800. Interestingly, when the same calculation was done when the ORT is administered outside the Health sector, like in the households, with a cost per case treated of US$0.5, the cost per DALY drastically reduced from US$24 to US$6 and the cost per death averted changed from US$800 to US$200. This makes the administration of ORT one of the most cost effective interventions known to the medical world today. It is important to note that the presence of WS measures would not have an impact on the cost effectives of the ORT since it does not cure diarrhea. It will however, reduce the number of cases of diarrhea episodes and thus the budget that would have been required at the population level (Varley et al. 1998).

Methodology

Study Design

This interventional study is designed to be a double blind randomised community based controlled trial that aims to measure the impact on diarrhoea morbidity of household based filtration of water used for both cooking and drinking on children between ages 6 and 35 months old in the Ipaja Ayobo Local Development Authority of Lagos State. Households will be randomly selected and allocated into either of two groups based on the exclusion and inclusion criteria designed for the purpose of this project.

Among the inclusion criteria will be the consent of the head of the household, the presence of at least a child less than 3 years and greater than 6 months old in the household. An important exclusion criterion is that the child in question must be adjudged immuno-competent or at least not suffering from any active immuno-compromising diseases. Other exclusion criteria will include households who already treat their water either by boiling or otherwise prior to the study, and those who source drinking water from outside the towns and communities under study.

The sampling process will involve the use of cluster sampling to recruit households for the trial. Due to the characteristics of this area, the enumeration areas delineated by the National Population Commission and used for the 2006 National Census will be utilised as our clusters and thus sampling frame. These enumeration areas will then be sampled by using cluster sampling proportionate to the population sizes of the enumeration areas.

Households will be recruited into the study using the WHO sampling methodologies designed for such settings where the arrangement of the buildings and general planning do not make it practical to utilise electronic records of population distribution for this purpose.

The first part of this study will include a Baseline survey on all study participants to document background characteristics and relevant information on health status, gender, socio economic status and the prevalence of diarrhoeal diseases in terms of

morbidity and mortality in each group. This will ensure both control and intervention participants are comparable and will also form a baseline to compare subsequent information on the study outcome at the end of the study.

Since diarrhea is a disease known to have seasonal variability, the Baseline survey will be conducted in April at the peak of the raining season periods while the post intervention survey will be done towards September, the 2nd peak of the raining season in Nigeria, in order to prevent the influence of the seasonal changes on the eventual outcome during analysis and subsequent interpretation of the results. Children within the target group who have had diarrhoeal in the last fortnight will be documented.

An episode of Diarrhea for the purpose of this study will be the WHO definition as already stated earlier on in this document. Other information on socioeconomic status, birth order, maternal educational level, household total income, history of previous medical conditions, sources of household drinking water, and volume of water consumed in a day, distance of water source from home, etc for both the control and intervention groups to ensure there is no statistically significant differences between the two groups. Details of the schedule of the study and the activity timeline is shown in tables 5 and 6 below.

Table 5 ***LOGICAL FRAMEWORK FOR THE INTERVENTION*** **PROJECT 2008**

NARRATIVE SUMMARY Goal / Purpose / Component Objectives / Outputs	OBJECTIVELY VERIFIABLE INDICATORS (OVI)	MEANS OF VERIFICATION (MOV)	IMPORTANT ASSUMPTIONS
7th August 2007			
Goal Reduce Child Morbidity from preventable diseases	By the end of 2008, morbidity from diarrheal diseases would have been demonstrated in the participating groups	Initial Baseline survey and the Post Intervention Survey later on.	Nil
Purpose To Demonstrate the impact of Household water purification, hygiene education and the use of ORS on diarrheal morbidities in Children	By the end of September 2008, at least 90% of the survey participating households would have utilized the household water filter for filtering water for domestic use and would have had basic hygiene education.	Monitoring and Evaluation record books for the Project	The health authorities will continue paying the health centre staff to be utilized for the project
Component Objectives 1. Conduct Base line survey on participants characteristics	At the end of March,2008, At least 90% of participating control and intervention households would have been interviewed as outlined in survey questionnaires	Project Record Books and Evaluation reports from the field	Nil
2. Conduct Post Intervention Survey to Measure effects of the Intervention	Latest mid April, 2008 All participating households would have been assigned and given water filters	Project Monitoring and Evaluation Books	Commercial suppliers of the product supply them as at when due Inflation remains close to the pre – study rate.

3. Dissemination of Study outcome to Stakeholders and Community Members including forwarding to Publishers of Peer reviewed Journals	At the end of December 2008, All mentioned stakeholders would have been fully debriefed of the outcome of the study	Attendance record books. Reports of program staff and over all project record books	That the authorities will be interested and available for the meetings
Outputs			
1. Results of the baseline characteristics of participating households and target participants available	The prevalence of diarrhea diseases and mortality established in the participating groups	Project Records and reports	
2. Survey Data of post intervention impact ready	By the end of October % difference in incidence/prevalence of diarrheal morbidity in the study population, intervention and control groups compared to baseline studies would have been verified	Project report and record books	
3. Study impact disseminated to stakeholders and other health authorities	By the end of December 2008, various meetings would have been held and reports written on the decisions of stakeholders	Project Reports, Attendance Books	Stakeholders will be interested and willing to know and attend post intervention meeting

Table 6 *PROJECT ACTIVITY TIME LINE*	**2008**				**2008**				**2008**				**2009**							
Activities	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**
1.1 Meeting with stakeholders(chiefs, health director, others)	*				*															
1.2 Ethical approval from ethical committee and local health authorities	*																			
1.3 Selection and training of survey core personnel(orientation and introductory meeting)	*																			
2.1 Adapt and translate questionnaires and other survey forms		*																		
2.2 Pre-test survey forms and revise them accordingly		*																		
2.3 Select enumeration areas within communities where surveys will be conducted		*																		
3.1 Prepare information and guidelines needed for selection of households in clusters		*	*																	
3.2 Make copies of the questionnaires		*	*																	

3.3 Train survey core personnel		*																		
3.4 Recruit survey volunteers	*	*					*													
3.5 Train volunteers			*					*												
4.1 Selection of households in clusters for intervention and control groups			*																	
4.2 Conduct baseline interviews				*																
4.3 Monitoring of performance of survey personnel			*	*																
4.4 Compilation of data					*															
4.5 Data analysis					*															
4.6 Interpretation of results					*															
4.7 Purchase of water filters and ORS sachets			*																	
5.0 Refresher training for survey core personnel and volunteers								*												
5.1 Distribution of water filters to group A and Group B households with instructions on the usage and application				*																
5.2 Fortnightly follow-up visits routine data collection					* *	* *	* *	* *												

5.3 Post intervention survey									*											
5.4 Monitoring and Evaluation	*	*	*	*	*	*	*	*	*											
5.5 Data collation										*										
6.1 Data analysis										*										
6.2 Distribution of authentic water filters to group B											*									
6.3 Interpretation of results and writing of papers(for publication)										*	*	*								
6.4 Feed back on survey results(Community, Local health authorities etc)												*								

The intervention

Locally made gravity ceramic water filters that are readily available in the Lagos main town centres and do not need electricity to function will be used for the purpose of this study. The filtration system consists of a water storage section with the capacity to hold 20L at any given time. The water filter is similar to what was used and reported effective in Clasen et al (2006). Another set of filters similar in physical appearance and design to the actual water filters will also be specifically designed without the real ceramic filters to be distributed to the control households to ensure adequate blinding of all subjects both in the intervention and the control groups.

The codes for the filters will be designed and known only to one member of the research team who will be unblinded throughout the course of the study, but s/he will not participate in the collation of data nor in the eventual analyses of the results. Even the field staff for the data collection and analyses will also be equally blinded to the allocation sequence. This will eliminate the tendency to either over report or under report events when subjects are aware of what group they belong to, an opinion that has been previously expressed by other researchers.

The blinding will also drastically reduce the influence of interviewer bias on the part of the research team. Blinding Index (BI) will be computed from study participants, and a BI more than 0.5 is adjudged successful. This process has been successfully demonstrated in similar studies (James et al, 1996, Colford et al 2002, Colford et al 2005). The study staff will give any member of both groups A and B ORS and instruction on its use in the case of an episode of diarrhea diseases during their fortnightly visits.

Study groups

The main importance of the findings from the DHS data is that it is guiding the choosing of the target group of children aged 6-35 months for the intervention study suggested to be implemented in a typical Nigerian community. The focus on this age group with the highest burden of disease is more likely going to reveal a statistically

significant effect when the impact of the intervention is analysed than in the general population of children less than 5 years old.

Households will be randomly selected and allocated into either of two groups A and B, and they will get the interventions allotted to the group. Households in Group A will get the sham filters while those in Group B will get the authentic filters. This categorisation is similar to what was done in Payment et al (1991) and Clasen et al (2004) in similar studies. Households will be deemed recruited for the study based on the exclusion and inclusion criteria designed.

Among the inclusion criteria will be the consent of the head of the household, the presence of at least a child less than 35 months and greater than 6 months old in the household. An important exclusion criterion is that the child in question must be adjudged immuno-competent or at least not suffering from any active immuno-compromising diseases. Other exclusion criteria will include households who already treat their water either by boiling or otherwise prior to the study, and those who source drinking water from outside the towns and communities under study.

Sample size Calculation, Data Collation and Analyses

The required sample size for a population based household survey determined usually by 3 factors namely:

(a) The estimated prevalence of the parameter to be surveyed, which is prevalence of diarrhoea morbidity or mortality in children less than 5 years
(b) The confidence level with which we want to get our results
(c) The acceptable margin of error with which we want our outcome to be measured

The formula for calculating the sample size required for a survey that is based on a simple random design is:

$$N = \frac{t2x\ p\ (1-p)}{m2}$$

Where

N will be the required sample size,

t will be the desired level of confidence, usually at 95% giving a standard value of 1.96

p= Estimated prevalence of diarrhoea morbidity or mortality in children less than 5 years in this study area from a previous survey

m= margin of error at 5% with a standard value of 0.05 (IFAD @www.ifad.org/gender/tools/hfs/anthropometry/ant_3.htm, accessed 20/07/07)

Here, the required sample size to survey the prevalence of diarrhoea morbidity in children less than 5 years if the survey will be a simple random survey will be as follows,

Where p will be 10% = 0.20 (previous study indicated 8-29% in the north east (Dixon and Thompson 1993) and 8.1% in the southwest (Jinadu et al 1991).

Sample size= $\frac{1.96 \times 1.96 \times 0.10 (1-0.10)}{0.05 \times 0.05}$

3.8416x0.09/0.0025= 138.3 ~138 children less than 5 years old

But this survey is not a simple random survey, but a cluster randomised survey, therefore, we will introduce the concept of Design Effect which has been defined as the factor used to compensate for the loss of precision which results from using a cluster sample rather than a simple random sample. (WHO/CDD, 1994). And according to the Household survey manual for diarrhoeal disease, the author recommended a design effect of 4 for diarrhoeal surveys, which they believed was calculated from years of experience.

Therefore, our sample size becomes 138 x 4= 553 children

To make provision for Non-responders and data entry error, we increase the sample by 5%,

Sample size for the cluster survey= (553x 0.05) + 553 = 28 + 553= 581

~ 600 children, the nearest higher whole number divisible by the cluster number 30.

For a mortality survey, the sample size using a mortality rate of 6.2% from a survey in rural Southwest Nigeria (Jinadu et al, 1991) will be:

3.8416x 0.062(1-0.062)/0.0025= 89.36x4 ~ 358 + 5%= 392~**420**(nearest higher whole number divisible by 30).

But since the sample size for the morbidity survey is larger than this, we will conduct the survey based on the value with higher sample size.

Distribution

Because there are roughly about 30 enumeration areas(clusters) in Ipaja/Ayobo town, we round off the figure to the nearest whole number divisible by 30 = 600 children less than 5 years.

Meaning that each cluster will have 600/30 children= **20 Observations per cluster.**

Participants consent

Each representative of the participating households will be required to consent to participate in the study before the commencement of the interviews/questionnaire distribution

Ethical consideration and ethical approval

The introduction of ORS to households with a child having diarrheal at the time of visits by study staff and volunteers is hoped will reduce the moral burden of only taking data from sick children without assisting in solving the immediate problems. This would not interfere with what the study is designed to measure since it has been said elsewhere in this document that ORS has little or no effect on diarrheal frequency.

Ethical approval will be sort from relevant government agencies under which the assignment falls. The supporting or a recognised academic institution with the power to give ethical approval will also be approached for this purpose. Those who drop out of the study will still be included in the final analysis, using the 'intention to treat' method of data analysis.

Data Collection

The data will be collected on the field by trained health volunteers after project training has been conducted. These volunteers will be supervised by each of the 8 health staff from the local health centre on the field. The means of data collection will be interviewer-administered questionnaires using the standard WHO/CDD (1994) developed questionnaires for household surveys for diarrhoea and respiratory diseases, after it is adapted for local use and pre tested on the community members.

The Parents or Guardian of the children under study will be the respondents in this study.

Data Analyses

All data will be coded and entered into the computer and converted into SAS data sets for onward uploading and analysis using the SAS v19 machine/Stata. The prevalence of children having diarrhoea in a 2 week period preceding the survey and the number of deaths since the intervention commenced will be calculated for statistical significance in relation to the intervention while controlling for other possible confounding factors like sex, ages, socioeconomic status, no of members in the household among others.

Basic information on households who decline participation will be collected to see if there will be any trend what so ever. Households who drop out of the study will be treated as part of the final analysis provided this drop is not because of family relocation. (*Intention-to-treat analysis*).The result of this study will then be statistically evaluated against the confidence interval that does not over lap to demonstrate statistical significance of any outcome measure.

The 2-weekly prevalence will be converted to 2 week incidence rate as suggested in the WHO/CDD manual and then converted to an annual incidence for programme and policy advocacy purposes. The result of this study will then be statistically evaluated against the confidence interval that does not over lap to demonstrate statistical significance of any outcome measure at 95% confidence limit. This basis will be used to either accept or reject the null hypothesis as per the study pre set hypotheses.

Annual incidence = 2-week diarrhea incidence rate / proportion of annual diarrheal episodes expected to have occurred in the 2-week recall period

Monitoring and Evaluation

The volunteers will make monthly visits to the households in their assigned clusters to check that there is no problem with the filters and to give the participants a sense of

belonging to prevent research fatigue and to ensure participants are still utilising the filters. Evaluation of the project will come up at the end of the intervention study while the monitoring will be on going.
Further details on budget implications, monitoring and evaluation processes will be as highlighted in appendix section.

Treatment of study outcome

The participants will be briefed on the outcome of the intervention study. The households with the sham water filters will be given the authentic filters at the end of the study period. A meeting of stakeholders and local health authorities will be called to discuss the study findings and same will be discussed and disseminated to government agencies relevant to the localities in different fora, to aid policy decisions and promulgation.

The findings of this study will enhance policies on water treatment and possible subsidies on cheap water filters that can be made affordable to low income earners.

Research and Policy Implications of the study Findings

The outcome of this study, which will be amongst the very few studies looking at a very simple, cheap, and sustainable measure to maintain water quality in a developing country, and in a semi-urban setting without access to public water supply, and the nearly only randomised controlled trial with triple blinding in this setting to date.

If the finding reveals a statistical significant effect on diarrhoeal morbidity and eventual outcome, this will contrast the findings of similar studies done in USA, Canada and Australia(Colford et al 2005; Payment et al, 1991; Hellard et al, 2001), regions with significant differences in many respects to under-served, resource-poor settings of Africa with high rates of both infant and under 5 mortality rates, and will support the assertion by Macassa and Burstrom (2005) that one of the major problems with such interventions are the fact that they are studied in areas where diarrhea is usually not endemic, and thus expected to produce little or no significant impact.

A meeting of stakeholders and local health authorities will be called to discuss the study findings and same will be discussed and disseminated to government agencies relevant to the localities in different for a, to aid policy decisions and promulgation. The findings of this study will enhance policies on water treatment and possible subsidies on cheap water filters that can be made affordable to low income earners, thereby reducing potential cost in DALYS and QUALYS associated with diarrhoea morbidities and subsequent mortalities.

Discussion

This thesis work combined systematic literature review, analysis of a given data set and the design of a community based project in a single work. It is likely going to be among the very few theses submitted at this level. Its major benefit to the student is that it allows for the application of most of the knowledge and skills that may have been acquired in the course of the masters program. It gave me the opportunity to reflect on the knowledge and skills I have gained from my study program and the possible translation of these into programs that would be beneficial. It provides an opportunity for students to produce meaningful thesis work especially in the absence of data sets that could be analysed by students within the allotted period for thesis writing and defence.

It comes with its own challenges. On the part of the student, it requires focus and ability to be innovative and the willingness to apply classroom work into practice. This kind of thesis work also requires close supervision by the assigned supervisors as the work is relatively large in scope. Because the approach is relatively new compared to the traditionally known approaches in thesis writing, there is need for adequate sensitization of students and the faculty on the thesis pattern to give a clearer picture of the final document. In spite of these challenges, I still strongly recommend the approach to students who which to experience how classroom work can be utilised similar to how it is used outside the academic arena while still in school.

In this thesis designed mainly to apply class room knowledge to practice, we have shown from the literatures that there are numerous factors within the household that have significant effects on whether a child will come down with diarrhea disease or

die from the disease. Most of the randomised controlled trials whose outcomes were considered reported positive impacts of simple and affordable measures, some of which naturally exist, for exam the use of ultra violet rays from the sun for the purification of household water.

Even the use of Potash and other flocculants have shown some benefit at least in the physical appearance of water. Availability of Latrines and proper disposal of faces are primary measures which when tackled adequately may have more beneficial effect than any other intervention since most diarrhea causing pathogens are believed to originate from infectious stool coming in contact with humans through the discussed various pathways.

Household water filtration has been shown to have a very high efficacy in the removal of pathogens from water when utilised for that purpose. Studies both in low income countries and wealthy western nations have supported this assertion. But the effectiveness of this intervention in the reduction of significant diarrhea morbidity and mortality is still at best equivocal. But a conclusion can not yet be reached until more studies in deprived communities of Africa and other resource poor settings with little or no access to public water system are carried out.

This author is of the opinion that leading studies done so far on household water filtration in the most advanced countries of the world, including Canada, USA and Australia can not yet be said to be representative of the underserved and hard to reach regions of Africa. Although the authors of previous studies reported significant isolation of pathogenic organisms from the water source, the fact that the households utilised for the study are all supplied by treated Public water source already created a wide disparity from what obtains in other under-privileged settings. Secondly, general level of education and enlightenment including awareness of personal hygiene measures are likely to be high in such parts of the world compared to most parts of rural Africa.

It is hoped that if adequate measures like household water filtration are later shown to be effective in preventing diarrheal diseases, and even when they occur, prevent the occurrence of severe life threatening forms, then we stand to gain money running into

billions of dollars from lost of human resource manpower hour, hospital expenses even without including the QALYS that would have been gained by averting mortalities of young potentially productive children. Cost effectiveness analysis done in Malawi showed a decrease of about 33.6% of the usual economic lose to malaria after the introduction of impregnated mosquito bed nets in that country.(Brinkmann and Brinkmann,1995). Sadly enough, it is generally better to prevent a disease than to rely on treatment as treatment on its own is never 100% guarantee of cure.

One likely source of error will be a very high drop out rate by participants may also introduce errors in the final analysis of the data except information are collected from all enrolled participants including those who withdraw consent and all eventually analysed as part of the whole data analysis. In any case, the sampling process made some accommodation in the sample size calculation in case of participants` early withdrawals from the study.

The index study and its follow-up action plan seem to have benefits to many aspects of the community. Clearly, the outcome of this study will stimulate researchers else where and within the African continent to implement similar studies in consolidate on the degree of effectiveness or otherwise of such interventions. In the event of a consistent positive outcome, its effectiveness in another group of high risk individuals like those living with HIVAIDS would also be tested in similar studies.

To the community under study, it will stimulate hopefully, interest in the observation of measures to prevent diarrhea by making households adopt simple but accessible preventive measures against diarrhea diseases. A plausible impact will also be the expected increase use rate of the ORS during the study and hopefully post intervention by mothers and care givers of children and even adults who suffer from diarrhea diseases. This is in addition to the general degree of awareness that the study is likely to impact on the community.

The Government will also have evidence based information to base public policies on. Simple measures like this will surely save government huge amount of money in the short term but this is not to replace the responsibility of government to provide adequate social facilities for its citizenry. In the long run the government will benefit

from an increased man power availability and a reduced burden on the already over stretched health systems in most of these countries

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Appendix one-Budget Proposal: Reality Project 2008

Activity	**Items**	**Unit Cost**	**Total Cost**
1.1 Meeting with stakeholders(Chiefs, Health Director, Others)	**1.1.1.** Venue(Local Government hall)	Nil	Nil
1.2 Ethical approval from ethical committee and local health authorities	**1.2.1.** Nil	Nil	Nil
1.3 Selection and training of survey core personnel(orientation and introductory meeting)	**1.3.1.**Venue(Hospital Room) **1.3.2.** Per diem	**1.3.1.** Nil **1.3.2.** US$410 x 8	 **1.3.2.** US$80
2.1 Adapt and translate questionnaires and other survey forms	**2.1.1.** Project Core Staff	**2.1.1** US$10	**2.1.1.** US$80
2.2 Pre-test survey forms and revise them accordingly	**2.2.1.**Transportation	**2.2.1**. US$10	**2.2.1** US$80
2.3 Select enumeration areas within communities where surveys will be	**2.3.1**.Transportation **2.3.2.** Per diem	**2.3.1.** US$10x 8 **2.3.2.** US$10x 8	**2.3.1.** US$80 **2.3.2.** US$80

conducted			
3.1 Prepare information and guidelines needed for selection of households in clusters	**3.1.1.** Project Staff	Nil	Nil
3.2 Make copies of the questionnaires	**3.2.1.**1500 Copies	**3.2.1**. US cents 0.33 Cents	**3.2.1.** US$50
3.3 Train survey core personnel	**3.3.1.**Venue **3.3.2.** Writing Materials **3.3.3**. Per diem for Trainees and Trainer	**3.3.1**.Health Centre room **3.3.2.**US$1 X 8 **3.3.3.** US$10 X 9	**3.3.1**.Health Centre room **3.3.2** US$8D **3.3.3.** US$90
3.4 Recruit survey volunteers	**3.4.1.**Transportation Cost	**3.4.1**.US$10 X 60	**3.4.1.** US$600
3.5 Train volunteers	**3.5.1.**Venue **3.5.2.** Meal allowance **3.5.3.** Training materials	**3.5.1**. US$100 **3.5.2.** US$10 x 60x2 days **3.5.3.** US$50	**3.5.1.** US$100 **3.5.2.** US$1200 **3.5.3.** US$50
4.1 Selection of households in Clusters for groups A and B	**4.1.1.** Project Staff	**4.1.1**. US$10 x8x 5 DAYS	**4.1.1.** US$400
4.2 Conduct baseline interviews	**4.2.1.** Project Volunteers **4.2.2.**Supervision by	**4.2.1.**US$10 x60x 2 DAYS **4.2.2.** US$10x8x2	**4.2.1.** US$1200 **4.2.2.** US$600

	Project Staff		
4.3 Monitoring of performance of Survey Personnel	**4.3.1.** Project Staff	**4.3.1.** US$10 x 8x2	**4.3.1.** US$160
4.4 Compilation of Data	**4.4.1.**Laptop Computer	**4.4.1**.US$600	**4.4.1.** US$600
4.5 Data Analysis	**4.5.1.**Coordinator and Project Staff	Nil	Nil
4.6 Interpretation of Results	**4.6.1.** Coordinator and Project Staff	Nil	Nil
4.7 Procurement of water filters and ORS packs from manufacturers	**4.7.1.** Water filters and Transportation **4.7.2.** ORS sachet	**4.7.1.** US$2 USD X 1200 **4.7.2.** US$0.5x 1200	**4.7.1.** US$2400 **4.7.2.** US$600
5.1 Refresher Training for Survey Core Personnel and Volunteers	**5.1.1.** Venue	**5.1.1.** US$100 per day	**5.1.1.** US$100
5.2 Distribution of Water filters to Group A and ORS to Households in Group B with instructions on usage	**5.2.1**.Volunteers	**5.2.1.** US$10 per day per volunteer x 60	**5.2.1.** US$600
5.3 2-weekly follow-up visits routine data collection	**5.3.1**.Volunteers **5.3.2.**Core Project Staff	**5.3.1.**US$10D x 60 x 8 Visits **5.3.2.** 10 USD x 8 x 4 Visits	**5.3.1.** US$4800 **5.3.2.**US$320

5.4 Post intervention survey	**5.4.1.** Volunteers **5.4.2**.Project Staff	**5.4.1.** US$10 x 60 x2 days **5.4.2.**US$10 x 8 x2	**5.4.1.** US$1200 **5.4.2.** US$160
5.5 Monitoring and Evaluation	**5.5.1.** Project Staff	**5.5.1.**US$10 x 1 Evaluation day	**5.5.1.** US$80
5.6 Data Collation	**5.6.1.** Project Staff x 2	**5.6.1.**US$10x 2 x2	**5.6.1.** US$40
6.1 Data Analysis	**6.1.1.** Coordinator	**6.1.1.** Nil	**6.1.1.** Nil
6.2 Authentic Filters for control households	**6.2.1.** 605 authentic water filters	**6.2.1.** US$1.5	**6.2.1.** US$908
6.3 Interpretation of Results and writing of Papers(For publication)	**6.3.1.** Project Staff and Coordinator	**6.3.1.**Materials	**6.3.1**.US$100
6.4 Feed back on Survey results(Community, Local Health Authorities etc)	**6.4.1.**Venue	**6.4.1.** US$100	**6.4.1.** US$100
TOTAL			US$15,186
10 % of Total(Contingency)			US$1,518.6
GRAND TOTAL			**US$16,704.6**

Appendix two-SAS COMMANDS

```
Program for the generation of the 2003 Nigeria DHS variable list

libname in1'/usr/users/olu/sasuser/';
option fmtsearch=(in1);
data one;
set in1.ngkr4bfl;
proc contents;
run;


Program for the generation of diarrhea last two weeks by age group

proc format;
value agemofmt
0-5='0-5'
6-11='6-11'
12-23='12-23'
24-35='24-35'
36-47='36-47'
48-59='48-59'
60-high='above 5y';
libname in1'/usr/users/olu/sasuser/';
option fmtsearch=(in1);
data one;
set in1.ngkr4bfl;
proc freq;
tables HW1*H11;
```

```
format HW1 agemofmt.;
run;
```

Program that showed the age group with the most diarrheal burden

```
Proc format;
value agemofmt
0-5='0-5'
6-35='6-35' 36-59='36-59'
60-high='above 5y';
libname in1'/usr/users/olu/sasuser/';
option fmtsearch=(in1);
data one;
set in1.ngkr4bfl;
proc freq;
tables HW1*H11*;
format HW1 agemofmt.;
run;
```

Program for diarrheal last two weeks by sex controlling for age group

```
proc format;
value agemofmt
0-5='0-5' 6-11='6-11' 12-23='12-23'
24-35='24-35' 36-47='36-47'
48-59='48-59'60-high='above 5y';
libname in1'/usr/users/olu/sasuser/';
option fmtsearch=(in1);
data one;
set in1.ngkr4bfl;
```

```
proc freq;
tables HW1*H11*B4;
format HW1 agemofmt.;
run;
```

Appendix three-Pro forma on Ipaja/Ayobo Local Development Authority

Geographic/Demographic information

1. Total land mass in Km Sq…….
2. Population Size…….
3. Birth rate (No of Births per thousand of the population)……
4. Percentage of Children less than 5 years old in the population…….
5. Population registry e.g. Birth and Death registry: Yes/No.....
6. Divisions within the local Government area e.g. Zones/villages and the total no. ……..
7. Are houses officially numbered? If yes what is the pattern.....
8. Ethnic Composition of the Population in percentage……
9. Religious affiliations of the population e.g. percent Muslims…, Christians….., others.

Socioeconomic information

1. Percentage of houses with radios……., TV sets……Refrigerators……
2. Number of Schools in the area…….; by zone or area…….
3. Primary and Secondary school enrolments for boys……..& Girls……
4. Literacy rates of Men……..& Women…….in the area.
5. Main Occupation in the area…….by majority of the population.

Health information

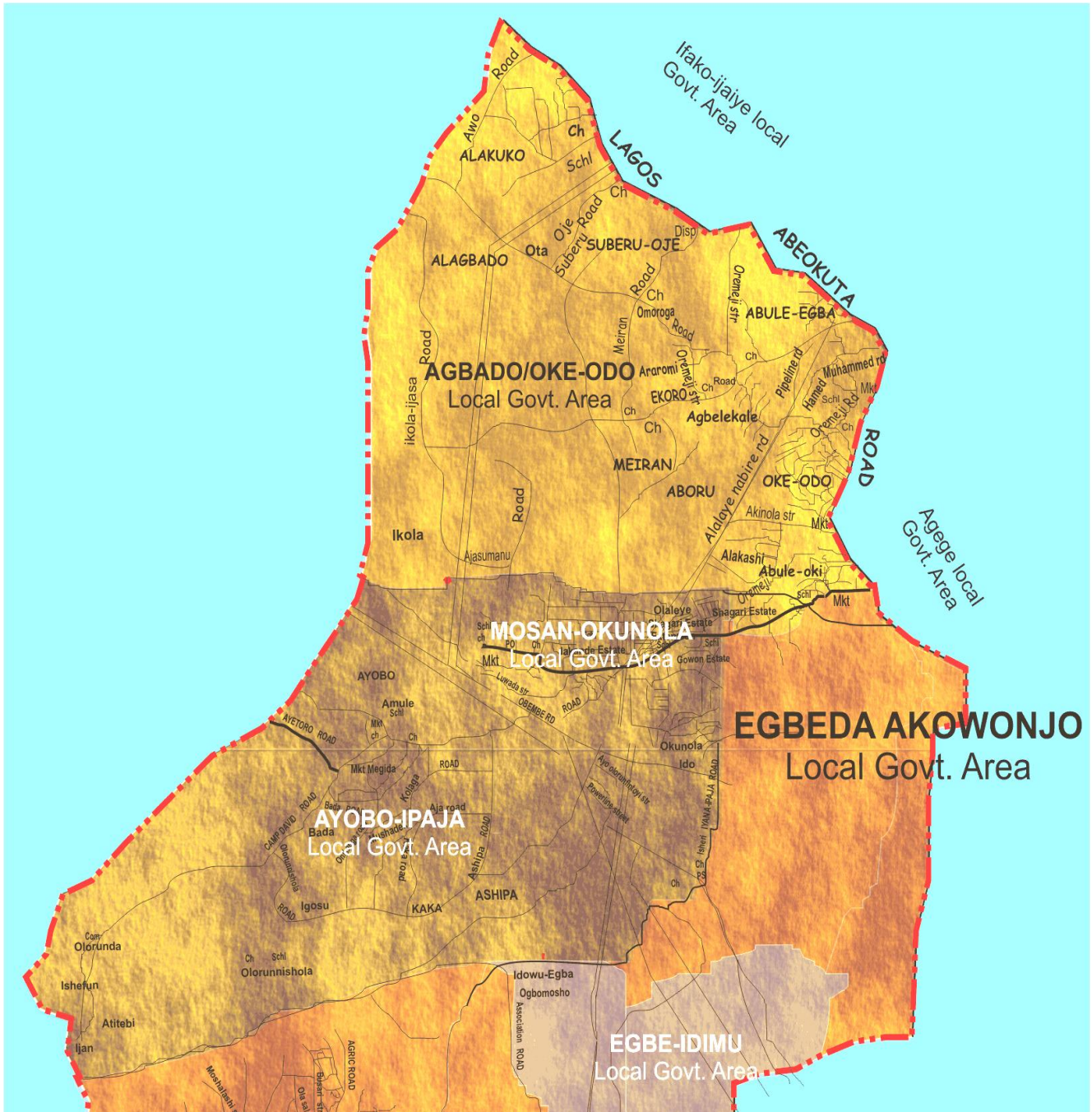
1. What is the under 5 mortality rate in this area? .....
2. Infant mortality rate……..

3. Vaccination coverage rate……
4. What percentage of children less than 5 years old die of diarrhoeal diseases annually……..in this area
5. Antenatal Clinic attendance rate…….
6. Are there TBAs within the LGA? .....How many are they? ……
7. What percentage of pregnancies is delivered in the home? .....
8. What percentage of children is exclusively breastfed? .....
9. Are there traditional/cultural practices that delay initiation of breastfeeding? ..... Please explain briefly……..
10. Percentage of households with Latrines in the area…….

Thank you for your cooperation.

N.B. In conclusion, kindly state the source(s) of the above data and information e.g. Census data, Other Official Government document etc.

The above form was sent to the health officer in charge of Primary Health Care activities who then distributed it to other personnel in the administrative headquarters of the local development authority for their input. The information provided was largely used for the section on the characteristics of the proposed project area.


Ifako-ijaiye local Govt. Area
LAGOS
ABEOKUTA
ROAD
Agege local Govt. Area
ALAKUKO
ALAGBADO
SUBERU-OJE
ABULE-EGBA
AGBADO/OKE-ODO
Local Govt. Area
EKORO
Agbelekale
MEIRAN
ABORU
OKE-ODO
Ikola
Alakashi
Abule-oki
MOSAN-OKUNOLA
Local Govt. Area
AYOBO
Amule
Okunola
Ido
EGBEDA AKOWONJO
Local Govt. Area
AYOBO-IPAJA
Local Govt. Area
Bada
Igosu
KAKA
ASHIPA
Olorunda
Olorunnishola
Ishefun
Atitebi
Ijan
Idowu-Egba
Ogbomosho
EGBE-IDIMU
Local Govt. Area