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Evaluation of availability, access, use and quality of water in Umuenechi Village, Nibo, Anambra State, Nigeria 24 months after the installation of a 200-foot borehole

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An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
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Abstract

Evaluation of availability, access, use and quality of water in Umuenechi Village, Nibo, Anambra State, Nigeria 24 months after the installation of a 200-foot borehole

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Background: Globally, 780 million people currently do not have access to an improved water source. About 43% of the Nigerian population lack access to safe water, thereby placing them at risk of water borne diseases. Sufficient quantities of safe water are needed for the reduction of disease burden, the socio-economic welfare of rural communities, and overall quality of life of the people. Ensuring good water quality and sustainability of rural water supplies in Sub-Saharan Africa has been challenging. Understanding how a community uses and values a new water supply can inform strategies to improve the performance and sustainability of the water system.

Introduction: This study performed a post-intervention assessment of a rural community in Nigeria to examine access, use, quality and willingness to pay for water from a single borehole installed by *Water For Life Nigeria, Inc.* in 2010.

Methods: Both qualitative and quantitative methodologies were used to collect data. Focus group discussions identified themes and key issues surrounding the borehole while key informant interviews gave individual perspectives on this intervention. Water quality testing provided quantitative data on water quality. Survey instrument data measured the community's perception of the availability, accessibility, and quality of the borehole, and household water treatment and storage practices

Results: About 75% of respondents used the borehole as their drinking water source. The average distance (walking time) to the borehole was 31 minutes, and 62.5% of the study population reported that water from the borehole was always available. Water quality testing indicated higher concentrations of *E.coli* (4 CFU/100ml) and total coliform(63 CFU/100ml) contamination in household drinking water than in the borehole (<1CFU/100ml, <1 CFU/100ml). Traditional water sources had the highest concentrations of *E.coli* (500 CFU/100ml) and total coliforms (1660 CFU/100ml).

Discussion: The borehole water does provide clean water to the residents and is an improvement over the community's previous traditional water source. However, deterioration of water quality occurs between the source water and point of consumption and may be attributed to water handling practices. Willingness to pay for water and assigning a steward to manage the borehole are crucial for sustainability. Unfortunately, the majority of survey respondents were not willing to pay due to their perception of water as free and their inability to afford a payment.

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Literature Review

Global Water Crisis

Water supply and sanitation systems have been one of the most important subjects of serious attention in the 21st century (Akpabio 2012).The access to and use of clean water is considered one of the most significant measures to improve public health, spur economic development, and combat poverty (Montgomery, Bartram et al. 2009). In fact, one of the fundamental human rights in our society is access to safe drinking water, and this is linked to gender equality, poverty alleviation and sustainable development (GWTF 2006). Nevertheless, safe drinking water is very limited in supply on a global scale; 780 million people currently do not have access to an improved water source (WHO and UNICEF 2012). ‘Improved’ water source refers to water from protected water sources, such as standpost, borehole, protected spring or well or collected rainwater, that meets the minimum criteria for accessibility (Hutton, Haller et al. 2007).

Regrettably, this situation of limited access to improved water is more alarming in developing countries. People living in extreme conditions of poverty in developing countries within regions of Sub-Saharan Africa, Eastern and Southern Asia are the most affected (Akpabio 2012, WHO and UNICEF 2012). Even if the Millennium Development Goal (MDG) to halve the proportion of people without access to safe drinking water is reached by 2015, there will still be an estimated 790 million people (11% of the world’s population) without access to an improved water supply, and an estimated 1.8 billion people (25% of the world’s population) without access to adequate sanitation (Centers for Disease Control and Prevention 2012). Unfortunately, even as some less developed countries continue to make significant progress towards the MDG, countries in Sub-Saharan Africa are still not on track to meeting the MDG (WHO and UNICEF 2012). In Sub-Saharan Africa, only about 36% of the population are estimated to have access to basic sanitation (WHO and UNICEF 2004)while 37% of the population still rely on unimproved sources of water (Onabolu, Jimoh et al. 2011). In 2002, rural Sub-Saharan Africa ranked as having the lowest water service coverage of any region in the world, primarily because of conflict, political instability, high population growth rates and low priority given to water and sanitation (WHO and UNICEF 2004).

The Water Crisis in Nigeria

Despite the fact that water is regarded as nature's free gift to enable man carry out domestic (cooking, drinking, washing), agricultural and other production activities, many rural communities in Nigeria do not have access to potable water sources (Akinbile, Oladoja et al. 2006). In the context of the water and sanitation sector in Nigeria, most rural communities are quite small, with a population of roughly 5000 people and no access to electricity, pipe water or paved roads (Nwankwoala 2011). Water access in rural communities is very limited. Nonetheless, the WHO recommends 20 liters of water per person per day and access should be within a convenient distance of 200 meters (Rosen and Vincent 1999).

Quite shockingly, in Nigeria, only about half (58%) of its very large population (roughly 158 million) have access to improved drinking water sources (Onabolu, Jimoh et al. 2011, WHO and UNICEF 2012). To complicate matters further, geographical disparities (rural versus urban) contribute to the challenges involved in increasing access to improved drinking water. For instance, 72% of Nigerians in urban areas, compared to 47% of rural dwellers, have access to improved water sources (Onabolu, Jimoh et al. 2011). Another contributing factor to this limited access to water is the fact that demand far outstrips supply (Nwankwoala 2011). With a population close to 165 million and an inadequate water supply system in Nigeria, there is simply not enough clean water for everyone.

Water sources in Nigeria

Water sources in Nigeria include treated and untreated piped water sources, shallow boreholes, unprotected wells, ponds, lakes, rivers, springs and streams. There are three main types of rural water sources that may be developed in a community, specifically, rainwater catchment, surface water and groundwater sources. Rainwater harvesting involves the interception and storage of rainwater for use, and this is most common during the dry season. The surface water sources are created through the impoundment of streams and rivers or direct extraction of water from large rivers, freshwater lakes and oceans and the treatment of the water to remove contaminants (Uma and Egboka 1988). Groundwater sources, piped (uses distribution networks to reach consumers household) or unpiped system (no distribution network), are usually chemically and microbiologically cleaner than surface water (Uma and Egboka 1988).

Since some of these water sources are unprotected and untreated, they are often unsafe for consumption as they may harbor harmful microbiological contaminants that cause diarrheal diseases. Most of the rural dwellers consume unsafe water, thereby negatively impacting their health and wellbeing (Akinbile, Oladoja et al. 2006). Women and children within these communities disproportionately bear the greatest burden since they are primarily the collectors of water outside the household. This population may experience three kinds of negative consequences- health damage incurred from carrying heavy loads of water over a long distance, energy expended during carrying water, and the opportunity cost of time used to collect water (Rosen and Vincent 1999). Therefore, it is very important to increase access to an improved water supply due to the direct benefits (time and energy savings, and improvements in health), as well as the indirect benefits (economy development, household/community empowerment and agricultural growth) (Nwankwoala 2011).

How has this water crisis been addressed?

The need to increase access to sufficient quantities of safe water through the provision of basic infrastructure such as deep wells, boreholes and piped water for the reduction of disease burden and socio-economic welfare of rural communities cannot be overemphasized (Idachaba 2000). For every $1 investment in water supply and sanitation, at least $5 in economic benefit is gained (Hutton, Haller et al. 2007).Thus, governmental, non-governmental (NGO) and bilateral organizations have embarked on several water projects to develop rural communities in Nigeria (Akinbile, Oladoja et al. 2006). Most water supply interventions focus on the provision of an improved water supply, such as the installation of a hand pump with or without household connections, that can be assessed publicly or privately (Fewtrell, Kaufmann et al. 2005). In Nigeria, the provision of a borehole in a centrally-located part of the village has successfully reduced the time spent carrying water by 315 minutes per household per day (Rosen and Vincent 1999). The ideal provision is one borehole for at least 300 persons (Uma and Egboka 1988). Hand pumped boreholes are actually quite popular because of their low cost and simple technology which can be financed, operated and maintained by community members. However, research studies have shown that hand-pumped boreholes are prone to frequent breakdown (Ishaku, Majid et al. 2012).

The use of electrically pumped boreholes (motorized boreholes) is another source of water in rural Nigeria, and it has received growing attention in the 21st century. This may be due to the fact that it is more efficient and requires less manpower to pump water than the hand pump. Nonetheless, such a system is usually more expensive, and may be unreliable in the event of power outages and faulty generators.

The catastrophic rise in broken borehole systems has resulted in households harvesting rainwater as an alternate source of water (Ishaku, Majid et al. 2012). One of the advantages of using rain water is that it is a source of free water that can be used to supplement limited quantities of groundwater and reduce water run-off. Rainwater harvesting is also environmentally-friendly as it reduces erosion and non-point pollution in urban environments (Aladenola and Adeboye 2010). The use of rainwater for domestic activities such as laundry and toilet flushing, can reduce the pressure on public water systems (Aladenola and Adeboye 2010). However, despite the presence of storage tanks in individual households, rainfall systems may be difficult to operate at a sufficient sanitary level (Uma and Egboka 1988). Many households within communities tend to alternate their source of water according to season. For example, a previous study conducted in the rural Nigeria to examine the effect of distance and season on the use of boreholes discovered that in the water-scarce dry season 98% of households used borehole water while in the water-abundant wet season, 64% of households used rainwater as their main source, and borehole use decreased with increased household-to-borehole distance (Blum, Feachem et al. 1987).

Microbiological quality of borehole, surface water and household water in Nigeria

Waterborne pathogens are usually introduced into drinking-water supplies through human and/or animal excreta, and may cause infection in the gastrointestinal tract following ingestion. In order to avoid such infections, the WHO guidelines recommend that drinking water be free of pathogenic microorganisms so that the risk for acquiring waterborne infections is below an accepted limit (Szewzyk, Szewzyk et al. 2000). There is a wide diversity of microbes that can be found in unsafe water. These microbes include a broad range of bacteria, protozoa and viruses. Since these organisms have the potential to cause water borne infections, it is important to conduct microbial quality testing on drinking water. Epidemiological studies have proven that it is not always necessary to detect each specific pathogenic organism in drinking water; it is actually quite sufficient to measure microbiological water quality via the concentration of fecal indicator organisms such as *E.coli* and total coliform bacteria (Clark 1990, Lund 1996). *E.coli,* in particular, is the fecal indicator of choice recommended in the WHO Guidelines for Drinking-water Quality (WHO 2005). On the other hand, total coliforms are not reliable indicators of fecal contamination. However, total coliforms can measure deterioration of water quality in distribution systems which could be evidence of microbial growth and biofilm formation. Nonetheless, the routine monitoring of microbial indicators, such as *E. coli* and total coliforms, can be used to verify microbiological water quality (WHO 2004).

Recontamination of drinking water

The potential for microbial recontamination of drinking water during, collection, transportation and storage of water collected from the borehole has emphasized the need for further treatment of drinking water at point-of-use (Oloruntoba and Sridhar 2007). Studies have shown that there is a substantial decline in water quality between source and point-of-use in terms of fecal and total coliforms (Wright, Gundry et al. 2004, Kanyerere, Levy et al. 2012). Increased contamination levels at point-of-use may have occurred during transportation and storage of water (Mintz, Reiff et al. 1995, Jensen, Ensink et al. 2002). There are multiple points during the collection-to-use sequence where contamination could occur (Trevett, Carter et al. 2004). For example, this increase in the percentage of contaminated samples after water is collected and stored from safe sources could be the result of contamination through hands, unwashed containers and dippers (Wright, Gundry et al. 2004). Fortunately, intervention studies have found that safe storage practices, such as covered vessels, can reduce fecal and total coliform concentrations in stored water by 50% (Wright, Gundry et al. 2004).In addition, point-of-use (POU) water treatment has emerged, and is presently gaining popularity, as a significant water quality improvement intervention (Mintz, Bartram et al. 2001). POU can contribute to the reduction of diarrheal disease transmission by about 40% (Souter 2003, Arnold and Colford Jr 2007).

Sustainability as a new focus

The main objective of any improved rural water supply and sanitation system is to provide potable water on a continuous basis, as this will help address security of supply across both wet and dry seasons (Nwankwoala 2011). In the context of this paper, sustainability implies that water continues to be available for a long period of time, at the same quantity and quality as the day the water point was initially commissioned (Adams 1998). However, many studies conducted in rural Africa continue to show that the percentage of functional rural water projects is between a disappointing range of 35-80% (Mackintosh and Colvin 2003, Sutton 2004, Haysom 2006). In addition, about 30% of water points become non-functional within the first five years of operation (Jimenez and Perez-Foguet 2011).This rate at which water points become non-functional is quite alarming. The monetary cost of these failed water investments sum up to between US$215–360 million and is mainly attributed to poor programming and careless implementation (International Institute for Environment and Development (IIED) 2009).

A diverse range of factors, such as institutional, technical, social and environmental, affects the sustainability of a rural water supply project. Often times, it is quite difficult to measure sustainability; nevertheless, it is very important to find sustainable solutions that are context-specific (Haysom 2006). Improving the sustainability of rural water supplies is critical because it ensures the ongoing provision of a service that is fundamental to improve health, reduce the burden of carrying water over long distances, and enable users to live a life of quality and dignity.

Factors affecting Water point sustainability

The common occurrence of water supply failures may be attributed to a number of reasons (Carter, Tyrrel et al. 1999);

- the intervention is not desired by the community/households,
- the capital and/or recurrent cost is unaffordable by the community,
- there is no sense of ownership, leading to neglect of maintenance and repairs,
- the promised benefits at the start of the project fail to materialize,
- community education programs do not produce immediate results, and
- Community members with technical training could be lost or may move away.

A “lack of maintenance culture” is also another factor that has led to failures of rural water supply projects over the long term. In fact, previous research has identified insufficient or non-existent maintenance as the major inhibiting factor to the sustainability of hand pumps (Olatunji 2003).Thus, a strict maintenance program is necessary to address preventable water supply interruptions and repairs (Akpan and Heinonen-Tanski 2010).

Solutions to sustainability

In order to ensure the sustainability of water supply sources, all four of these essential components need to be linked- motivation, maintenance, cost recovery and continuing support. The failure of any one component could lead to the failure of the entire enterprise (Carter, Tyrrel et al. 1999).

Recent research in the water sector has been devoted to finding solutions to the challenges of sustainability. Presently, several interventions aimed at improving sustainability are taking place at the village level and are described below.

1.) Appropriate technology that is cost-effective, low maintenance, user friendly and readily available can improve sustainability. The type and quality of technology determines the length of time a given water point will function. This is because, in most cases, water point break down is attributed to missing or broken parts (Hoko and Hertle 2006)**.**

2.) The creation of water systems that are managed by a village committee of some sort may be even more important than technology and hardware. Communities need to have a sense of ownership over the system in order to ensure its ongoing operation and maintenance (Harvey and Reed 2006). The participation of the beneficiary community positively contributes to project productivity. In fact, sustainability cannot be attained without participation, even if spare parts and repair technicians are available (Haysom 2006). In essence, participation should span across the entire intervention process, and could be in the form of the community's expression of their specific water needs, choice of a central site for water points location, and choice of water technology (Harvey and Reed 2006). Other forms of community participation include (Nwankwoala 2011)-

- setting up a responsible committee/board for managing the project,
- complete responsibility for operation and maintenance of the water systems,
- determining stewards to receive training and tools for preventive and corrective maintenance (Training and adequate capacity building can eliminate up to 90% of the problems associated with the traditional maintenance approach (Akpan and Heinonen-Tanski 2010), and

- Making financial contributions (about 5-10% of the total cost of facilities) to the project.

Participation is an empowerment process, stimulating village- level mechanisms for unified action and decision-making (Kumar and Kumar 2002). Through participation, the community's sense of ownership over the water supply increases; and this, in turn, ensures sustainability. It is very important for a community to have a sense of ownership because research studies has shown that top-down service delivery by governments and NGOs frequently leaves a legacy of dependency of the villages on external assistance; consequently leading to the villagers' inability to make attempts at repairs in the event of a break-down (Haysom 2006).

Engaging women: a necessary precursor for sustainability

Women should be heavily involved in the sustainability plan as they have been shown to have a major influence on the decision-making process and facilitation maintenance of rural water projects (Addai 2005). Moreover, the World Bank recommends that there should be focus on women as users, planners, operators and managers of the water system (Nwankwoala 2011).

Willingness to Pay

A significant underlying reason for poor levels of sustainability is the prevalence of unacceptable, unaffordable or impracticable financing strategies (Carter, Tyrrel et al. 1999). As a result, it is imperative that realistic and sustainable financing mechanisms are developed to guarantee the provision of quality service. Unfortunately, the financing of newly constructed water supply systems by the community members is not simple. Implementing organizations should be aware of the difficulties experienced by community members, and should not simply hand water systems over to the communities without calculating and communicating long-term Operation & Maintenance (O&M) costs to water users (Harvey 2007). Determining the comprehensive cost of service provision is important because water users can then be informed of the true cost of sustainable water provision (Komives and Stalker Prokopy 2000, Montgomery, Bartram et al. 2009). Ideally, the amount of money users pay for a water supply system should cover costs for the future system upgrade, rehabilitation, expansion, operation and maintenance (Harvey 2007). However, such a full cost recovery financial mechanism is generally shunned because it will be a great financial burden on users. Thus, the recommendation is for communities to contribute between 5 to 15% of initial capital costs. This amount is clearly not going to cover hidden costs for activities such as mobilization, administration, management and transportation, but it will instill a sense of ownership in community members (Deverill, Bibby et al. 2002).

The three most common financing mechanisms for collecting revenue to be used in operation and maintenance activities are reactive financing, pay-as-you-fetch, and monthly tariffs (Harvey 2007). Reactive financing implies that when a water supply system fails or breaks down, the community members assemble together to pay for the repair. Monthly tariffs are the most popular financing system whereby each household in the community is expected to contribute a given amount each month. For pay-as-you-fetch systems, a caretaker needs to be present at the facility at all times to collect water tariffs per container (except when it is locked). Water supply systems that consume energy such as electricity and diesel would require higher tariff payments to cover the energy costs.

Even though community members need to contribute a small percentage of the cost of water supply systems, members are still hesitant to contribute. One of the reasons is a lack of transparency during the handling of money to be used for future investments in the water system. Another reason for the hesitation is the general unwillingness to pay for water among the users. It is very difficult to convince people to pay for water, especially when there is a history of receiving free service. For example, politicians usually promise some kind of service to communities, thus, reinforcing the culture of dependency and the expectation of receiving water services for free (Komives and Stalker Prokopy 2000)**.**

Willingness to pay for water has been a huge determinant of the sustainability of water projects in developing countries. Water authorities, whether they are public or private suppliers, have realized that community members will not pay a higher price for water. This unwillingness stems from the inherent belief that cost of water should be free or charged at a nominal fee. Usually, subsided services cannot be provided due to limited resources in these communities. It is thus recommended that pilot surveys be administered to households in order to assess willingness to pay for improved services since these can yield valuable information for water supply planning (Whittington, Lauria et al. 1991, Rogerson 1996). In fact, there is great danger in not involving community members, through inquiries about the services they want and their willingness to pay before designing rural water supply projects (Briscoe, De Castro et al. 1990). Most studies recommend that users should pay for the water, even if it is a small amount per day or per month (Van Beers 2001).

Recommendations to increase willingness to pay

Despite the general unwillingness of users to pay for water in some settings, there are ways to motivate them to pay for water. According to Harvey, the most effective mechanism that can be used to sustain willingness to pay is having an overseeing institution to monitor systems, give advice on financial matters and regulate transparency (Harvey 2007). Another measure for promoting willingness to pay for water is creating a mindset among users that they must pay for water right from the outset of the project. Finally, if users use water to generate income, they have an incentive to ensure that the system is running and are more likely to make financial contributions to enable operation and maintenance activities (Harvey 2007).

Introduction

About 43% of the population in Nigeria still lack access to safe water; and this situation is worse in the rural communities (Gbadegesin and Olorunfemi 2007). Access to safe water supply is necessary as it has great influence on the health, economic productivity and quality of life of the people (Ishaku, Majid et al. 2011). Most of the households in rural communities rely on free sources of water such as rivers, perennial, streams, water ponds, and unprotected wells. These sources may pose a risk of waterborne diseases such as typhoid fever, cholera, dysentery and hepatitis (Ishaku, Majid et al. 2011).

Fortunately, hydro-philanthropy, in the form of monetary donations by non-government organizations is committed to find solutions to the problems caused by water poverty (Sternlieb and Laituri 2010). Hydro-philanthropy communities are stakeholders and advocates who are responsible for contributing resources towards improving the social, environmental, cultural and economic consequences resulting from water poverty. In 2008, USAID and the Millennium Challenge Corporation, under the Water for the Poor Act, gave a total of US $489.6 million and US $429.0 million, respectively, to safe drinking water, sanitation and hygiene project (Sternlieb and Laituri 2010). In addition, the Millennium Water Alliance, which is a consortium of humanitarian, faith-based, non-profit organizations, invested a total of US $14,109,294 to assist poor communities in low-income countries to gain access to safe water and sanitation in 2008 (Sternlieb and Laituri 2010). Organizations under the Millennium Water Alliance include Africare, CARE, Catholic Relief Services, Food for the Hungry, Life water International, Living Water International, Water for People, Water.org and World Vision.

Despite these smart investments, water poverty still remains in Africa. Poor programming and careless implementation has resulted in approximately 50,000 broken water points in Africa

(International Institute for Environment and Development (IIED) 2009). In fact, Africa, Asia and Latin America have become wastelands for broken water and sanitation infrastructure (Breslin 2010). Such water point failures result from the sector's focus on the number of beneficiary communities they affect, rather than involving communities through the implementation and planning process to ensure sustainability of the project. More so, communities do not financially contribute to the project, and thus do not have a sense of ownership. Consequently, the project is not well-maintained after the intervening agency leaves, resulting in break-down over time. In order for this deplorable cycle of water-point breakdown to be brought to an end, philanthropists should invest their money only when an NGO can show that donation will be used as leverage with counterpart funds from communities and local government. Donors should insist that clear tariffs have been developed, and that communities can in fact pay these – through up-front payments – so that the project has a better chance of success. Finally, NGOs should not continue to propose "sweat equity" as an alternative to cash payments (Breslin 2010).

If philanthropists want to see impactful results, sustainability metrics need to change from numbers of beneficiaries to actual measurements of sustainability. In particular, core sustainability indicators should include (Breslin 2010)-

- The *quality* of water meets host country government standards over time; with a focus on microbiological parameters (*E. coli* and total coliforms)
- The *quantity* of water available to households meets host country government standards over time.
- The water system is inoperable for *no more than 1 day per month.*
- The *number of users* per water point meet host country government standards.

- A realistic financial plan for ongoing operation, maintenance, repair, and replacement

Water For Life Nigeria

Water For Life Nigeria (WFLN) is a newly established non-profit organization, whose fundamental goal is to increase the overall availability, accessibility and quality of water in rural Nigeria. The organization also enlightens beneficiary communities on the importance of using improved water sources, while at the same time, educating them on how to practice household water treatment and safe storage. In response to water poverty in rural Nigeria, WFLN launched its first project in August of 2010, by installing a borehole (200-feet deep) with a power-operated pump, at St. Joseph Catholic church (Figure 1), situated in Umuenechi village, Anambra State, Nigeria. The church's congregation is made up of roughly 500 members who use the borehole.

Purpose of research

An impact evaluation was conducted between June and August of 2012 in order to ensure that this installed borehole continues to meet the water needs of this beneficiary community. The goal of this evaluation study was to assess the degree to which the provision of this borehole provides safe and sustainable water to meet the water needs of the community.

Specifically, this project was conducted, in part, to evaluate the operation and use of the borehole to meet the water needs of the village residents. In addition, the quality of the water provided by the borehole was determined, and then compared to other water sources in the village, as well as to stored household water. The population using the borehole was also characterized as a way to qualify the residents using the borehole. Finally, it is hoped that this project will eventually ensure sustainability of the borehole through the identification of financing options to maintain the borehole. A stewardship plan with the community will also be developed.

Specific objectives and hypotheses

Objective (1): To evaluate the operation and use of this recent water intervention and determine whether it meets the water needs of the residents of Umuenechi village.

Hypothesis 1: The borehole provides sufficient quantities of clean water that is always available and accessible to the residents of Umuenechi village

Objective (2): To compare the quality of water provided by the borehole to the quality of other local water sources and stored household water.

Hypothesis 2a: The borehole water is of higher quality (measured by concentration of fecal indicator bacteria -total coliforms and *E. coli*) than other traditional water sources in the village.

Hypothesis 2b: The water quality at the borehole is better than the quality of water stored in the households.

Objective (3): To characterize the population using the borehole as their water source.

Hypotheses 3: The borehole is used by all residents of the village who live within easy walking distance.

Objective (4): To identify financing options to ensure sustainable operation of the borehole.

Hypotheses 4: Socio-economic status of the residents influences their willingness to pay for water, which in turn influences sustainability of the project.

Objective (5): Develop a stewardship plan with the community to ensure the sustainability of the borehole.

Hypothesis 5: A successful stewardship plan will require both financing options to fund/maintain the project and assigning a steward to be responsible for the borehole.

Nigeria in Profile

Nigeria is a developing country within Sub-Saharan Africa with a population of approximately 162.47 million people (World Bank, 2012). The life expectancy at birth is 52 years (World Bank, 2012). The national literacy rate for women is 54% while that for men is 77%; on a state-level, Anambra state has a literacy of 88% for women and 99% for men (National Population Commission 2009). Presently, the country has an under age 5 mortality rate of 189 per 1000 live births and 13.5% are due to diarrheal diseases (USAID, 2010). Only 58% of the population in Nigeria has access to an improved water source (World Bank, 2012), whereas in the state of Anambra, 67% of households have an improved source of drinking water. Nigeria has 37 water corporation boards and 12 river basin authorities with several water agencies using obsolete water equipment This has been largely due to poor investments by government and private sector organizations in the water sector in the last ten years in Nigeria compared to other sectors, such as oil and gas, energy, and housing (Adoga 2006) .

The Nigerian climate is tropical in nature, with a rainfall pattern strongly influenced by the Southwest monsoon. Rainfall averages roughly 500mm/year in the north between April and September, and then increases to about 3000mm/year in the South between March and October (Nwankwoala 2011). The country possesses two major river systems- Niger and Benue. Due to the North’s aridity, rivers in that region are intermittent, with waters present only during the rainy season. Conversely, rivers in the South flow year round and are often important sources of water for people living in this region.

Nigeria’s rural water supply and sanitation system

Despite ongoing discussions about improving the rural water supply and sanitation system in Nigeria, there has been limited progress in this sector. The first effort to address the rural water supply and sanitation began with the International Drinking Water Supply and Sanitation Decade (IDWSSD) from 1981 to 1990 (Nwankwoala 2011). Following the IDWSSD, the World Summit for Children came along in 1990, then the National Program of Action (NPA) for the Survival, Protection and Development of the Nigerian Child emerged and carried out water supply development projects through external support agencies (Nwankwoala 2011). Such agencies include National Borehole Program, UNICEF Assisted State Water and Sanitation Project, Directorate of Food, Roads and Rural Infrastructure, World Bank Assisted Agricultural Development Projects, Japanese International Cooperation Agency (JICA), Petroleum Trust Fund (PTF) Rural Water Supply and Sanitation Program, Water Aid's Rural Water Supply and Sanitation Program, and the National Rural Water Supply and Sanitation Program.

The National Rural Water Supply and Sanitation (RWSS) started in 2001, and is within the context of the overall water and sanitation sector in Nigeria. Figure 2 illustrates a conceptual framework of the National Rural Water Supply and Sanitation System in Nigeria.

The RWSS Program strives to deliver safe water supplies and improved sanitation and hygiene services, with a special focus on communities, health centers, schools and public/private institutions in rural Nigeria. Nonetheless, rural water and sanitation in Nigeria continues to suffer from "poor co-ordination, poor maintenance culture, poor technical/institutional structure, multiple programs, lack of planning, over bearing bureaucratic control by various supervising ministries, lack of professional inputs on projects, lack of community participation, inadequate funding, lack of clear policy direction as well as lack of adequate quality monitoring and evaluation" (Nwankwoala 2011).

Project Site and Study Population

The main project site was in a rural setting, more specifically, Umuenechi village (Nibo town, Awka South Local Government Area (LGA), Anambra State, Nigeria, Figure 3). The state of Anambra (Figure 4) is located in South Eastern Nigeria with a population density of about 1500-2000 persons per square kilometer (about 7,821, 850 residents) (Nigeria travel info tourism and attraction 2011). Most of the population in Anambra State is rural, although over the last two decades the rural-urban migration has stretched the meager urban services to a breaking point. This pattern of human migration, has posed serious problems for the state's resources, fragile infrastructure, environmental sanitation, erosion control and social services (Ministry of Information Culture and Tourism Awka and 2011). Nibo town is located in Awka South LGA (population of 189,049), which is one of 21 LGAs in Anambra State (Ministry of Information Culture and Tourism Awka and 2011). The target study population is mainly Umuenechi villagers in the town of Nibo, and neighboring communities that benefit from this water intervention. The predominant language spoken in this area is Ibo(Nigeria travel info tourism and attraction 2011). The community members of Umuenechi village are mainly poor people with low standards of living. Before the intervention, this community relied on water from a near-by stream (Nwangwo) to meet their domestic needs.

Research Methods

This evaluation project utilized a sequential, exploratory, mixed methods approach incorporating both qualitative (focus group discussions (FGDs) and key informant interviews (KIIs) and quantitative (water quality testing and survey instrument) methodology for data collection. Both approaches provided holistic insight into issues surrounding the recent borehole intervention. FGDs identified themes and key issues involving this water intervention. Data from KIIs gave individual/insider perspective on this intervention. Water quality testing provided quantitative data on water quality; likewise data from the survey instrument measured the community's assessment of the availability, accessibility and quality of the borehole. Although the amount of data from each method is relatively small, the combination of data from these different methods provided a well-rounded assessment of the intervention in order to achieve the above-mentioned study objectives.

Focus Group Discussions (FGDs)

FGDs were conducted prior to the survey. FGD was advantageous to identify themes and key issues involving this water intervention. We had a total of four focus group discussions (youth female group, adult female group, adult male group and a mixed youth group). The focus group discussions served as the main qualitative data collection instrument and helped inform the survey instrument. Specifically, a question-specific focus group guide was used to understand: a) how well the borehole was meeting the needs of the community; b) what other new resources were needed to properly meet water and sanitation needs; and c) community ideas for sustainability of the project and whether the residents were willing to pay for this resource.

Each FGD had between 7-15 people. All research subjects gave their consent before participating in the discussion (see appendix B). The principal investigator, who was an Emory MPH student, facilitated all four sessions. In addition, all FGD sessions were video- recorded after receiving the consent of study participants.

Key Informant Interviews (KIIs)

KIIs elicited more detailed responses and helped provide an individual context for understanding how this water intervention was meeting or not meeting the needs of the community. KIIs also explored issues identified during the FGDs but with more focus on the individual attitudes about the water intervention. Eight in-depth interviews were conducted with the parish priest, community leaders and residents. KIIs were selected based on willingness and social status in the community.

Water Quality Analyses

The initial plan was to collect water samples twice a week from the water source, and weekly from ten household storage containers. Unfortunately, it was not possible to achieve this goal to technical issues with the incubator of the Del Agua water testing kit. Eventually, the principal investigator solicited assistance from the National Agency for Food and Drug Control (NAFDAC, Agulu, Nigeria) for use of their laboratory facility to conduct the microbiological water quality testing. A household water sampling protocol was used as a guide to collect samples from individual homes. Every household sampled used a cup as the equipment to take water from the container. When collecting water from the other water sources (borehole and stream water), a water quality data collection form was used (see appendix C). The borehole taps were disinfected, opened fully, and left running for at least one minute to ensure any deposits in the pipes were washed out before collecting samples. After collecting the samples were kept cold in a cooler and transported to the lab for immediate testing. All samples were tested for contamination by total coliforms and *E.coli* bacteria (standard indicators of fecal contamination).

Bacterial analyses were performed using the M-ColiBlue24 media (Hach, USA) and the membrane filtration method. When a sample was believed to be highly contaminated (as in the case of the stream water), 10ml of the sample was diluted in 100 ml sterile water before passing through a 16 by 47 mm filter paper using a sterile membrane-filtration unit. Otherwise, 100 ml of sample water was filtered directly for samples with lower level contaminations. After filtration, the filter paper was placed on top of an absorbent pad with M-ColiBlue24 contained in a mini petri-dish. The filters were then incubated at a controlled temperature of 44 degrees Celsius. After about 16 to 18 hours, colonies were counted, with blue colonies indicating *E.coli* and red colonies indicating total coliforms. The concentrations of bacteria were recorded as colony-forming units per 100 mℓ of water (CFU/100 mℓ). The colony counts for the 10-mℓ samples were multiplied by 10 to maintain consistency of units for concentrations. All bacterial analyses were performed in duplicate with the reported bacterial concentrations representing the average per water sample.

The degree of bacterial contamination was used to evaluate the differences between water sources, to assess the water-quality impact of home storage on water quality and to evaluate the effectiveness of home water treatment. Unfortunately, due to a small sample size, we could not perform any inferential statistics.

Survey Instrument (Appendix A)

The survey instrument served as the quantitative data collection tool. The instrument consisted of 37 questions on population demographics, perceptions about water quality and water availability, accessibility of the borehole to resident's homes, water treatment and storage practices, and willingness to pay for the water as a factor for sustainability. Aside from the open-ended nature of the 17 demographic questions, all the other 20 questions were close-ended or partially close-ended in nature. A total of 41 surveys were administered. The surveys were initially pilot-tested with the parish priest, one female and one male participant as a way to validate the instrument.

The project investigator recruited participants through convenience sampling. The village head and the parish priest of St. Joseph's church played key roles in recruiting study participants. A date, time and venue were set aside for the survey to be administered. As the time drew near, the town crier announced through-out the village about the opportunity to be a participant in this survey. The parish priest of St. Joseph's church, where the borehole was installed, also announced the opportunity to be a study participant in the survey to the church community. Participation was purely voluntary, and no participant was coerced to enroll in the study. At the beginning of the survey, the project investigator introduced the research to the participants, and asked if participant would give their written consent to be a research subject (see appendix A). The survey was paper-based, and written in English. The main project investigator and two research assistants were present on the day the survey was administered to translate to the local dialect- *Ibo*, in the event any study participant had issues understanding the English text of the survey.

The survey included questions related to the following specific domains.

<u>Water Availability, Accessibility, Quality and Storage Provided by the Project</u>

Questions related to the availability of water, proximity of water source to homes, mode of water transport and storage, perceived water quality, and type of household water treatment (see questions 18-32 of appendix A for sample questions). In particular, the indicator used to measure availability was the temporal physical presence of water at the water point (reliability), while that used to measure accessibility was the distance and time needed to walk from the household to the water point. The indicator for water quality were based on taste, smell, color and treatment practices while that for water storage was type of water storage container and cover.

Willingness to Pay- Implications for Sustainability

The survey also served as the primary source to gather information on the current socio-economic situation of the local residents. The survey asked demographic questions to determine the household’s asset index (questions 10-17 of instrument in appendix A) in order to determine the range of socioeconomic diversity present in Umuenechi. The socio-economic status (SES) was calculated from an 18-item asset list. Each asset was given a score, based on intuitive judgment on the asset’s value (see appendix D). For example, the possession of agricultural land was given a score of 4 while that of a water dispenser was given a score of 1. Total score per respondent was computed by summing the responses to all 18 items, with higher SES scores indicating more wealth. The Cronbach’s alpha reliability for this scale was 0.7 suggesting internal consistency of scale items. Based on the assumption that SES is uniformly distributed, cut-off points to differentiate households into broad socio-economic categories were arbitrarily defined. Specifically, households were classified into quintiles (5 groups), whereby quintile 1 is considered the poorest group (scores range from 1-10), quintile 2 (score of 11-20), quintile 3(score of 21-30), quintile 4(score of 31-40) and quintile 5, the least poor group (score of 41-50). The survey also asked direct questions on willingness to pay for water (questions 33-35 of instrument in appendix A) as one predictor for the borehole’s sustainability.

Data Analysis

The study yielded textual data from the robust notes taken during the FGDs and KIIs. All qualitative data were analyzed based on thematic analysis by coding according to topic areas relating directly to the research questions- availability, accessibility, sanitation and sustainability (deductive coding) or raised by participants (inductive coding). The coded data was used to draw similarities and comparisons between sub-groups of the study population. The analysis also identified contextual issues, influences, and if there were any gaps in meeting their water needs.

Quantitative data from water quality testing and survey instrument were entered in a Microsoft Excel file and then imported into SAS version 9.3 (SAS Institute Inc., 2011) where it was cleaned and analyzed. Due to the small sample size, inferential statistical analysis could not be performed. Thus, our data analysis was limited to only descriptive statistics. Univariate frequencies of selected variables, such as concentration of indicator organisms in the different water sources, types of water storage, quality of borehole water, frequency of water availability, distance to borehole, motivation to improve drinking water, most important problem to be addressed with borehole, and willingness to pay, were calculated. In addition, cross-tabulation tables of type of water treatment by concentration of indicator organisms, level of education by type of water treatment, socio-economic status by type of water treatment, microbiological water quality and perceived water quality from the survey, and finally, microbiological water quality.

Results

Demographic Characteristics of Study Population

The demographic characteristics of the study population are presented in Tables 1, 2 and 3. Table1 describes the distribution of gender, household position, occupation, education, and marital status within the study population. A total of 19 males (46.3%) and 22 (53.7%) females were enrolled in the study. Approximately 33.3% (n=13) of the respondents held household positions as sons, while 25.6% of respondents were wives and 25.6% were daughters. Most of the respondents described their occupation as students (51.2%, n=21). A high proportion of the participants also had attained a university or higher degree (40.0%, n=16). In addition, most participants were single and had never been married (64.1%, n=25).

As seen in Table 2, the mean age of respondents was 32 years (Std. Deviation= 13 years).Study participants lived an average length of 17 years in Umuenechi (Std. Deviation=15 years). The households in this study population ranged from a size of 1 to a size of 6, with a household size of 5 being the mode.

Table 3 shows the assets of the study population. An asset index was used to measure wealth in the study population. The majority of households had two bedrooms (26.8%) and a separate kitchen (82.9%). The main construction material for the walls (97.6%) and floors (82.9%) was cement while that of the roof was asbestos/zinc (90.2%). The majority of participants had electricity (94.7%), tape recorder (94.4%), telephone (85.7%), television (97.3%), refrigerator (88.9%), motorcycle (52.9%), kerosene stove (100.0%) and possessed agricultural land (75.0%). When the asset index of each respondent was calculated, 2.4% of participants fell under quintile 1 (poorest) group, 9.6% fell into the quintile 2 group, 48.8% fell into quintile 3 group, 39% fell into quintile 4 group, and 0% fell into quintile 5 (least poor) group (Figure 5).

All survey respondents were attendees of St. Joseph Church. However, as elucidated from FGDs and KIIs, borehole users also included non-members of St. Joseph Catholic Church, who were part of the Umuenechi community. In the words of the priest from St. Joseph, “The borehole is open to anyone, irrespective of village, religion or political affiliation.”

Water Availability and Accessibility

In order to determine the proximity of households to the borehole at St. Joseph church, participants were asked to report their walking time (measured as proxy for distance) between the borehole and their home. The longest distance reported was 120 minutes one way. The shortest distance reported was 2 minutes. The mean distance was 30.6 minutes with a standard deviation of 31.0 minutes (Table 4). As can be deduced from the data, the proximity of the borehole to households was subjective. Some key informants were satisfied with the distance of the borehole to their homes, while others felt that the distance was far. For instance, one respondent confirmed that the borehole was very accessible, with only a walking time of five minutes. In contrast, others reported a walking time of 60 minutes between the borehole and their homes.

The borehole at Umuenechi village had an electric pump. Water availability was fairly constant, except on days with prolonged power outages. Nonetheless, when the power failed, a small generator was available to pump water into the borehole tank. However, this small generator required copious amounts of fuel to function, which was not financially sustainable for the church. During the rainy season and in the event of power interruptions, some participants reported collecting rain water (Figure 6). In order to quantify the community’s perception of the frequency of water availability, participants were asked to indicate the frequency of water availability from a 3-point Likert scale. 62.5% (n=25) of respondents reported that water from the borehole was always available, while 37.5 % (n=15) reported that water was sometimes available. There were no reports of complete water unavailability.

Community Water Use

In addition to drinking the water, participants from FGDs and KIIs explained that they used water for domestic activities such as cooking food, bathing, washing, and cleaning houses. 75% of households reported using the borehole water for consumption. However, other households preferred to drink packaged water and use the water from the borehole for domestic purposes. Furthermore, as reported by participants in the KIIs and FGDs, the water has also been used by business owners to run restaurants and automobile workshops.

The types of water sources commonly used by this community for drinking were investigated by asking participants to indicate if they got their drinking water from the borehole, stream, private, public or shared wells. A large percentage of participants (75%) indicated that St. Joseph was one of their water sources (Table 5). Participants also reported that they obtained water from other sources such as public taps (89.5%), private wells (30.8%), shared wells (33.3%), stream (44.4%), and spring (66.7%). Approximately 67% of respondents collected water from an improved water source.

Comparison of water quality from different water sources (stream, household and borehole).

The microbiological water quality from the stream (n=2), borehole (n=2) and household (n=10) were compared. The stream samples had a mean *E.coli* concentration of 500 CFU/100ml while no *E.coli* was detected in the borehole sample (Figure 7). The mean total coliform concentration for stream water was 1660 CFU/100ml while that of the borehole water was <1 CFU/100ml. Interestingly, despite the murky look of the stream water (Figure 8), some research subjects during the interviews still considered the stream water to be better than the borehole water. When probed to know the reason for this response, the respondent narrated that the stream water has been his ancestral family's source of water and so he has a personal tie to it; the taste of the water was also mentioned by this same respondent as better than the borehole water.

Perceived Water Quality, Household Water Treatment and Safe Storage Practices

In order to ascertain the perception of the water quality from the borehole, participants were asked to indicate the degree of safety that they associated with the borehole. The majority of participants reported that the water was safe (Figure 9). Specifically, 65.9% of participants reported that the water was very safe, while 26.8% reported the water was quite safe. Only two respondents (4.9%) reported that the water was not really safe. Reported reasons for the perception of water as unsafe by the two respondents who considered the water unsafe included that "it may contain bacteria," and that "someone said it was unsafe to drink."

The results from FGDs and KII complemented these findings, as the research subjects reported that the borehole water had pristine physical qualities. The following positive adjectives were used to describe the water quality of the borehole-"clean," "odorless," "tasteless," and "colorless." Most research subjects said the water was safe for consumption; although, few others reported that they preferred drinking the readily available sachet water because its distribution in the market has been certified by the National Agency for Food and Drug Control (NAFDAC).

Questions on the household practices related to mode of transportation, treatment and safe storage methods were asked. Participants indicated that they mostly transported water by foot (48.8%) or by wheelbarrow (48.8%) (Figure 10). The most common storage container reported for storing water was the barrel/drum (41.5%); other participants also reported storing water in jerry cans with or without faucet (36.6%) (Figure 11). When asked if they treated their water, the majority of participants (82.1 %, n=32) reported they treat their drinking water. Of those that treat their water, the majority reported that the main water treatment activity they practiced was to boil their water (75%, n=24) (Table 6). Respondents were also asked to explain the reasons that motivated them to choose their specific drinking water treatment method. The majority of respondents indicated that the most convincing reason for choosing the water treatment method was based on its ability to kill germs (n=16, 50%) (Table 7). Other reasons widely reported included that the drinking water treatment method was perceived as safe (n=13, 40.6%) and easy (n=8, 25%).

The reasons for choosing drinking water treatment method were stratified by the preferred water treatment method in order to understand how the reasons influenced the choice of specific water treatment methods. For those whose motivation for adopting a drinking water treatment method was to kill germs, 87.5% of them chose to boil their water. In addition, for those who were motivated by safety concerns, 84.6% of them chose to boil their water (Table 8).

Furthermore, in order to understand the perception of cost of the different drinking water treatment methods, a cross-tabulation of the cost-levels and the participant's chosen drinking water treatment method was examined (Table 9). Most of those that reported that they boiled their water perceived the cost to be very inexpensive (58.3%).

The level of education of participants could also influence the decision to treat or not treat drinking water. A higher number of people who treated their water had a university or higher education (n=14) (Figure 12). For those that treated their water, the study participant's education level and their primary water treatment method were examined. Over 92% (n=13) of those who had a university or higher degree chose to boil water as their primary drinking water treatment method (Figure 13).

The influence of SES on type of primary water treatment method was also examined. The majority of those that boiled their water were in the 3rd and 4th SES quintiles (Figure 14). The majority of respondents who did not treat their water before drinking reported that the reason was because they had never been sick (n=4, 57.1%) while others reported that they perceived the water to be safe (n=3, 42.9%)

Microbiological Household Water Quality Testing

A total of ten household water samples were collected. All households sampled collected their water from the borehole. Household water treatment and storage practices of the study population sampled are summarized in Table 10. Among the ten households sampled during water quality testing, the most common type of container used to store drinking water in this community was a bucket (40%, n=4), as in Figure 15. Approximately half of the storage containers had a narrow mouth (50%, n=5). The majority of the storage containers were covered with a solid material (60%, n=6). However, household water treatment activities were rarely practiced by these households, with only 20% (n=2) reporting that they actually treated their water before drinking. All samples collected for testing were odor-free; however, two samples had a visible turbidity.

E.coli and Total Coliform Concentrations in Samples from Household Water Storage Containers

E.coli and total coliforms were detected in 60% of the ten household water samples tested (Table 11). The concentration of *E.coli* ranged from <1 CFU/100ml to 6 CFU/100ml while that of total coliforms ranged from <1 CFU/100ml to 152 CFU/100ml.

50% of household samples had *E.coli* and total coliform concentrations of <1 CFU/100ml. 20% of samples had low (1-10 CFU/100ml) and medium (11-100 CFU/100ml) concentrations of total coliforms (Figure 16)

In addition to source water quality, household water quality is dependent on storage characteristics and water treatment practices. 20% of household samples were from buckets that contained very high levels of total coliforms (101-1000 CFU/100ml). Similarly, water samples from buckets had the largest percentage of samples with detectable *E.coli* (1-10 CFU/100ml) (Figure 17).

Additionally, the concentrations of indicator organisms in water samples were also stratified by the nature of the mouth of the storage containers. Results were as expected, with wide-mouthed containers having a higher percentage of samples with total coliform concentrations > 100 CFU/100ml (Figure 18).

Likewise, *E.coli* and total coliform concentrations were compared between containers with a solid cover and with a cloth cover or no cover (Figure 19). As expected, the mean total coliform concentration in containers without a solid cover was higher (52 CFU/100ml) than containers with a solid cover (3 CFU/100ml), while the mean *E.coli* concentration was the same in containers with a solid cover and containers without a solid cover (3 CFU/100ml). However, 10% of samples from the two groups had total coliform concentrations between 101-1000 CFU/100ml, and *E.coli* between 1 and 10 CFU/100ml.

When *E.coli* and total coliform concentrations were stratified by reported household water treatment, 20% of untreated household samples had very high concentrations of total coliform (101-1000 CFU/100ml), in comparison to 10% of treated household samples with low levels of total coliforms (1-10 CFU/100ml) (Figure 20).

Sustainability

<u>Financing the borehole</u>

<u>Willingness to Pay for Water</u>

Currently, the water at the borehole is provided for free, so none of the participants reported paying for the water they collected. In order to ascertain if the study population would be willing to pay for water, research subjects were asked to report their willingness to pay for water. 40 participants responded, with majority of respondents reporting that they would be unwilling to pay for water (n=38, 95%). The remaining 2 respondents that were willing to pay for water said they would be willing to pay 5 naira only ($0.03). For those unwilling to pay for water, the most widely reported reason for their unwillingness to pay was their belief that water should be free (n=24, 66.7%); the other was lack of finances (n=12, 33.3%).

Similar responses came from research subjects who participated in the FGDs and KIIs as only two individuals were willing to pay for water. Reasons for this unwillingness stems from the weak financial power of the community. In the words of one interviewee-"Water should be free, and we are poor." As a result of this poverty, the community shies away from making any financial contribution towards the borehole's operation and maintenance.

<u>Business Plan</u>

During KIIs and FGDs, the community presented several business plan proposals for financing the operation and maintenance (O&M) activities of the borehole. One of them was the commercialization of the water from the borehole, whereby proceeds from such sales would be used to run the borehole more efficiently.

Another suggestion was to launch a business that trades in religious devotional items, as these products are in demand in this community, and use the proceeds as the financial resource to fund O&M activities.

Stewardship of the borehole

Understanding the power dynamics in the community was a necessary prerequisite to identifying the right steward for the borehole. The church, currently, is the major overseer of the project, in terms of regulation and financial support. The church's organizational structure is divided in to the following groups- Catholic Women Organization (C.W.O), Catholic Men Organization (C.M.O), Catholic Youth Organization of Nigeria (C.Y.O.N), Mary League Girls Association. Zonally, it is divided into St. Dominic's Zone, S.S Peter and Paul Zone, St. Hilary's Zone and Emmanuel Zone. There are also small groups within the church and they include- Sacred Heart Group, Legion of Mary Group, St. Anthony's Group, and Charismatic Group.

During KIIS interviews with the priest (religious leader) of the church, he admitted that taking responsibility for the borehole has been quite burdensome. However, the parish benefits from the borehole since that is the water the parish house uses. Thus, the benefit of getting water from the borehole motivates him to ensure that water continues to be available.

When the question of shifting responsibility of the borehole to the community arose, neither the community or priest felt it was a wise move. In other words, both the church and the community feel that the church should continue as the caretaker of the borehole. However, when further probed about the burdensome implications for the church to continue to serve as an overseer, especially given the other responsibilities the church faces, the community members agreed that they could take over but only from a reactionary standpoint. That is, the community members were only willing to address maintenance and repair issues as they arise, and not before they arise.

Community Recommendations

During focus group discussions, distance and power disruptions were mentioned as recurring problems associated with the borehole. In addition, during the observation of the site, an overgrowth of weeds surrounded the water station points (Figure 21). The survey instrument asked the respondents about the most pressing issue concerning the borehole that needed to be addressed: distance, power disruptions, or overgrowth of the weeds, and the majority cited the power disruptions as the most critical problem (Figure 22).

When also asked what is the best location for a new water tap among the list of options described during the focus group discussions, the majority of respondents reported the *Number 1pump* as the best location for the new tap (63.4%, n=26) (Figure 23).

Discussion

The purpose of this evaluation study was to assess the degree to which the donation of this borehole provides safe and sustainable water to meet the needs of the community, in terms of access, availability, quantity, quality and sustainability. Utilizing mixed research methods, including survey instrument, focus group discussions, key informant interviews and water quality testing, the operation, use and water quality of the borehole was assessed. In addition, the study population was characterized in terms of their household water quality, water treatment and storage practices, and financial resources. The study also aimed to identify a suitable financing mechanism and a responsible steward to ensure the sustainability of the borehole.

Study Population Characteristics

The demographic and socioeconomic information on the water users within the community was collected by surveys administered to 41 participants enrolled in the study. This study population was quite small, and may have been better educated and possessed more assets than the national average. Data from the Nigerian Demographic and Health Survey in 2008 showed that 56% of households got their drinking water from an improved water supply source; on a state-specific level, 67% of households in Anambra state have access to an improved water source (National Population Commission 2009). Since roughly 67.4% of households within Umuenechi reported getting their drinking water from an improved source, this study population is relatively comparable to the state of Anambra in terms of access to an improved drinking water source. However, access to an improved water source is not a proxy for water that is safe to drink without treatment.

The percentage of households with electricity in the study population (87.8%) was much higher when compared to the Nigerian National average (50%) but similar to the state of Anambra average (84%)(National Population Commission 2009). In addition, the literacy level of the study population was approximately 100% (given everyone in the study above 15 years of age could read and write), and was higher than the national level at 61.3% (UNESCO 2010). The average number of years of school attendance for Nigerians is 9 years (Factbook 2010), whereas 40% of this study population had a university degree or higher.

The Umuenechi community reported obtaining their drinking water from a range of different water sources, including taps at St. Joseph Catholic Church, other public taps, private wells, shared wells, streams, springs and rainwater. The use of multiple sources of drinking water is usually common in poor populations (Howard, Teuton et al. 2002). So, it is no surprise that the study population reported a variety of water sources for obtaining their drinking water. The use of multiple sources of drinking water may be due to the fact that this is a socially acceptable norm in the community of interest , or it may be as a result of an erratic water supply system (Madanat and Humplick 1993). The list of the different water sources included in our survey questionnaire was not a complete representation of all the different water sources possible in this community. In fact, as mentioned in focus group discussions, rainwater was another important water source used by the study population. This observation of rain as an important water source is quite in agreement with previous observations that have been made in this region of the country, where people depend on rain water during the rainy season (Whittington, Okorafor et al. 1990).

Borehole

Amongst the different drinking water sources reported by the study participants, 75% of those that responded indicated that they obtain their drinking water from the borehole at St. Joseph Catholic Church, Umuenechi. As projected by Persson, such a marked preference for a particular drinking water source is usually consistent with the need to maximize utility (Persson 2002). Utility maximization, in this case, could be in the form of time and energy savings from getting water from an improved source (Nwankwoala 2011).The borehole at Umuenechi also meets the definition of an improved water source, which includes sources such as household connections, public standpipe, borehole, protected well, and rainwater collection. Improved water sources are considered safer than unimproved, because the water source is technically protected. As reported during KIIs and FGDs, the borehole water was also used for bathing, cooking, and clothes washing, in addition to drinking. The borehole water has also contributed to the socio-economic development of the community as evident from the participants that reported using the water to run local businesses like restaurants and commercial vehicles.

Borehole ease of access

The amount of time cost is an important determinant of drinking water source. In this study, the average distance reported by study participants to the drinking water source (as measured by walking time) was approximately 31 minutes; although the minimum distance reported was 2 minutes. As such, the population's access to the borehole was relative, and was determined by the proximity of individual households to the borehole. Residents living close to the borehole were more likely to always get their drinking water from this borehole, whereas in the case of those living a full two hours from the borehole, such residents may not always get their water from this borehole since they are more concerned with the high time cost involved rather than the type of water source. Thus, further interventions should consider spatial-temporal factors in the beneficiary community when implementing water supply programs.

Borehole water availability

In terms of availability, the borehole water was always available as reported by 62.5% of the survey respondents. Participants from FGDs and KIIs also reported that water availability was very frequent. Nonetheless, some other respondents reported that the borehole water was only sometimes available. Problems with water availability, as elicited from participants in FGDs and KIIs, stem from power outage issues that interfere with pumping water.

Borehole water quality

Most of the study participants perceived the borehole to be at least quite safe (92.7% total). Such perception of safety is usually based on sensory organoleptic measures, such as taste, odor, color and turbidity (de França Doria 2010). However, it would be quite myopic of an assessment project to only determine the water quality of the borehole from the community's perceptions. Consequently, microbiological quality of the borehole water was also assessed to ascertain if the source water is truly contaminated. Since *E. coli* bacteria are indicators of contamination by human or animal feces, *E.coli* was our primary indicator of contamination (Kanyerere, Levy et al. 2012). The borehole water sufficiently met the WHO recommended quality for drinking water, as it had no detectable *E.coli* (<1CFU/100ml *E.coli* concentration) in it. The concentration of total coliforms in the borehole water was also <1 CFU/100ml. Total coliforms colonies were used only as a secondary indicator of contamination. Overall, the borehole water had very good microbiological water quality contamination. Factors contributing to such high quality could be as result of site characteristics such as high depth-to-water (200-feet deep) at which the borehole was sunk and the fact that the borehole's location is far from sources of contamination such as latrines and animal corrals.

Household water quality

Testing household water quality is important as it ascertains the quality of water actually being consumed. Even though the borehole source water met WHO guidelines, post-source deterioration of water quality can still occur as a result of contamination through hands, unwashed containers and dippers (Wright, Gundry et al. 2004).

Similar to previous studies that have assessed household water quality, this study investigated the impact of several parameters, such as mode of water collection, transportation and storage, type of drinking water treatment, and material used to cover the water storage container, on water quality (Quick, Venczel et al. 1999, Trevett, Carter et al. 2004). Results from this investigation did confirm that, for the majority of samples, water quality deteriorated between the points of borehole water supply and consumption (household samples). Because of the small sample size, it was difficult to determine if the different storage characteristics and water treatment had an impact on the quality of household water. However, water sampled from wide-mouthed containers, like the bucket, had higher concentrations of *E.coli* and total coliforms. Conversely, narrow mouth containers, like the bottle, had lower concentrations of *E.coli* and total coliform. Such differences in water quality between narrow and wide-mouthed container are consistent with previous studies that have shown containers with narrower mouth designs prevent hand-water contact, and thus have a better water quality (Roberts, Chartier et al. 2001). Covering the container with a solid cover also reduced average coliform concentrations from 52 CFU/100ml to 3 CFU/100ml.

Past studies have shown improved water quality as a result of water treatment activities (Kanyerere, Levy et al. 2012). In this study, 20% of untreated household samples had very high concentrations of total coliform (101-1000 CFU/100ml), in comparison to 10% of treated household samples with low levels of total coliforms (1-10 CFU/100ml). Thus, treated water was microbiologically safer than untreated water. Several studies have shown the efficacy of point-of-use treatment methods such as boiling, solar disinfection, UV disinfection with lamps, chlorination and the combined treatments of chemical coagulation-filtration and chlorination for the reductions of bacteria, viruses and in some cases protozoans (Sobsey 2002, Lantagne, Quick et al. 2006). Household water treatment interventions are even more effective than water source treatment interventions as reported in a recent meta-analysis study whereby pooled estimates from 12 studies reporting rate ratios suggest that household-based interventions are more effective at preventing diarrhea than water source based interventions (Clasen, Schmidt et al. 2007). The specific water treatment method common in this community is boiling; and the community's most reported reason for adopting this method was because of its germ-killing ability and the perception of this method as safe. Studies have confirmed boiling as an efficacious treatment method with a greater than 85% reduction in the geometric mean thermo-tolerant coliform concentration (Clasen, Thao do et al. 2008, Rosa, Miller et al. 2010). Socio-economic factors such as level of education and household wealth have also been reported to influence point-of-use water treatment method (Freeman, Quick et al. 2009). Particularly in one study, educational level was a significant predictor of having detectable chlorine residual in stored household water; likewise, households in the upper four quintiles were more likely to have detectable levels of chlorine in their stored water (Freeman, Quick et al. 2009). Similarly, in this study, a higher number of participants with a university or higher degree boiled their water; in addition, households in the upper 3rd and 4th wealth quintiles boiled their water. Thus, targeted interventions should aim to enlighten the least-educated households, as well as find motivational strategies to increase the practice of household water treatment in this group.

<u>Sustainability</u>

The current provision of water from this borehole at no cost to the community members is not sustainable in the long run. Moreover, responsibilities surrounding the maintenance of the borehole are quite burdensome to its current overseer- the church. The daily electrical energy required to keep the borehole functioning is currently borne by the church. The church also absorbs all repair costs associated with the borehole. Consequently, development of a financially-sustainable plan is paramount to ensuring the continued success of the borehole in providing water to the residents. Financial resources are needed for the ongoing operation and maintenance activities for the borehole. Unfortunately, results from our survey show that 95% of study participants were not willing to pay for water.

This unwillingness to pay for water is quite surprising considering the socio-economic status (as indicated by the fairly wealthy community asset index in Figure 5) and the level of education of respondents (Table 1). Majority of residents fell within the 3rd (48.8%) and 4th (39.0%) quintile levels; yet residents continued to refer to themselves as poor during KIIs and FGDs. Even more so, the fact that most respondents (90% of the study population) had at least finished secondary school does not motivate them to pay for water. This unusual unwillingness to pay for water is as a result of the great difficulty encountered in trying to convince people to pay for water, especially when they have previously received this service at no cost (Komives and Stalker Prokopy 2000). Thus, it is generally advised that before any intervention, pilot surveys should be administered to assess willingness to pay for the improved water service (Briscoe, De Castro et al. 1990). More so, it is important to create a mindset among users that they must pay for water right from the outset of the project (Harvey 2007).

Several research studies have been conducted on strategies to increase willingness to pay for water among community members. In fact, one study conducted in Kitwe and Lusaka, Zambia showed that awareness education improved willingness to pay (Ntengwe 2004). This same educational approach of enlightening residents on the importance of paying for water may also work in this study community. In addition, a proposal for an affordable tariff structure could also increase willingness to pay (Ntengwe 2004). Communities are usually advised to contribute between 5 to 15% of initial costs (Deverill, Bibby et al. 2002). The Umuenechi community may be motivated to make such financial contribution if they use the borehole water to generate income, as they will have an incentive to ensure that the system is functioning (Ntengwe 2004).

Assigning a reliable steward for the borehole is also another path to ensuring sustainability. In the Umuenechi community, as derived during KIIs and FGDs, men, women, girls and boys fetch water from the borehole. Commercial drivers in this community are men, and they actually use the water to clean their vehicles. Some men also use the borehole water to run auto shops. Site observations during the study also confirmed that boys and girls equally fetch water. Women also use the water to run their restaurants and for domestic activities like cooking, washing and cleaning at home. The borehole serves everyone irrespective of gender. Consequently, all parties have a stake in ensuring the sustainability of the water supply. However, stewardship should be assigned to a female leader in the community, preferably, the leader of the Catholic Women's Organization. Past research has demonstrated the importance of women as good managers of water resources (Carter, Tyrrel et al. 1999).

Strengths

The mixed methods approach applied to this study was very comprehensive in nature, thus enabling a robust evaluation of the borehole in terms of its ability to provide safe water that is available and accessible to the community members. In particular, FGDs and KIIs provided insider perspectives on the community's specific water needs and attitudes towards improving the borehole's successful operation and maintenance. FGDs and KIIs also provided perspective about contentious issues such as the power dynamics in the community. An understanding of the community's leadership structure was especially useful in identifying a reliable steward to manage the logistics associated with maintaining the borehole's sustainability.

One other strength of the study is the fact that Umuenechi community is a novel community in the field of WASH-related research studies; there has never been WASH-related research conducted in this particular community prior to this study. As such, findings from this new community contribute to the body of scientific knowledge in this research area. The study was also successful in characterizing the population and providing information on the household water treatment and storage practices in this community.

Limitations

Just as limitations are inherent to most research studies, this evaluation of the borehole at Umuenechi was no exception. Unfortunately, despite the thoroughness and validity of this assessment, there were still several methodological limitations and constraints.

One of the most critical limiting factors throughout the evaluation of the borehole was the short time frame of only eight weeks. Given the multi-faceted approach of the study involving FGDs, KII, water quality testing and conducting surveys, it would have been beneficial and pragmatic to have a longer time frame. Regardless of the aspiration to maximize allotted time, the limited timeframe had dire consequences on the data collection in several ways. For one, the time constraint affected the study's sample size. The initial projection was to conduct six to eight FGDs; however, only four could be conducted. Likewise, the plan to conduct water quality testing twice a week from the water source, and weekly from ten household storage containers for five weeks was limited due to time constraints. Another factor that affected the sample size was the delay encountered in getting an IRB approval. The bureaucracy involved in this process, unfortunately, delayed the approval process; thus, interviews with study participants had to be delayed as well. In addition, technical issues with the Delagua incubator unable to stabilize at the controlled temperature of 44 degree Celsius affected water quality testing. Troubleshooting this technical problem and seeking other alternatives for conducting water quality tests further encroached on the study's limited time frame.

All the above-mentioned limitations and challenges resulted in this study's small sample size and its resulting low statistical power, thereby restricting the extent to which inferences could be drawn from the data.

Additionally, the limited time frame inhibited the ability to pilot test the quantitative survey instrument. Pilot testing the survey instrument would have provided preliminary feedback on whether the instrument had a good content and face validity and ensuring that items were measuring all domains that needed to be measured. In the event that the questionnaire was not identifying important issues to be investigated, it would have been developed further.

Furthermore, pilot-testing could have revealed the need for re-wording some of the questions to improve comprehension of what the questions imply, and hence result in more accurate answers.

The sampling technique used in recruiting participants for this study was convenience sampling. Unfortunately, this sampling technique limits the generalizability of this study since such a convenient selection of participants may not be representative of the whole village, and other comparable rural communities. Furthermore, this is an assessment of a single borehole in a single community. Thus, the context-specific findings from this evaluation cannot really be generalized to other rural communities.

Social desirability bias may have also potentially affected the quality of data collected as respondents may have answered survey and interview questions in a way they perceived as favorable.

Lastly, the cross-sectional nature of this study, limits our ability to make any causal inferences between sustainability and specific factors such as the community's financial resources. For instance, convincing associations between willingness to pay and the borehole's sustainability could not be determined. Likewise, we could not make any inferences about the relationship between water quality, and household water treatment, and safe storage practices. Unfortunately, cross-sectional surveys, only provide snapshots of the situation, and thus, do not provide information about causal links. Studying access, use and quality of the borehole water over time would have provided more credibility to this project's findings.

Despite the above-mentioned limitations, the interpretation of results from our data still contribute broadly to the understanding of the impact of this borehole in meeting the water needs of the Umuenechi community.

Lessons Learned

I learned many valuable lessons throughout this impact evaluation study that may be applied to different projects in other environments beyond the scope of this project. I was able to refine my skill sets in data collection, and analysis, while managing a project from conception to culmination. More specifically, I acquired professionalism, project management, communication and interpersonal skills sets. In addition to my professional development and skill acquisition, there were other lessons I learned during the evaluation of the borehole. They are listed below.

Flexibility and Resilience

My ability to adapt myself to the unexpected technical difficulties that ensued from the Delagua incubator malfunction was important. Instead of giving up in the face of this problem, I sought out alternative solutions by negotiating laboratory space with the National Agency for Food and Drug Administration and Control (NAFDAC).

Identifying and Utilizing Key Community Contacts

It is very important to have a contact within the community of interest. This contact will most likely be able to provide some information about the community, as well as recommend persons for key informant interviews. My good relationship with the priest of the church positively affected my study. He assisted us with identifying other important key informants and a research assistant to be part of my study.

Knowledge of Inner-Workings of the Community

In order to save time and increase efficiency during this evaluation project, it is important to be knowledgeable about the organizational structure of the community. This knowledge will enable one to know what key persons and sub-groups to connect with for FGDs and KII.

Effective Time-Management

This study employed a multi-faceted approach for evaluating the success and sustainability of borehole. Thus, data were collected through multiple methodological approaches such as survey questionnaires, key informant interviews and focus group discussions. In order to effectively and efficiently collect and analyze data, time-management was critical, because the time frame was limited.

Recruiting for Focus Group Discussion is Difficult

Recruiting for focus group participants was one of the most challenging phases of the data collection process. To counter-act this, we informed people via word of mouth and announcements. In order to compensate participants for their time, we gave incentives in the form of refreshments.

There is an association between willingness to pay and water point sustainability

Several studies have shown that preventing water-point breakdown and ensuring sustainability requires adequate financial resources to cover operation and maintenance activities. Thus, it is important to increase this community's willingness to pay for water as it will provide the financial resources needed to ensure the continued functioning of the water-point.

Maintenance training and building local capacity is crucial to sustainable water points

Participation of the beneficiary community contributes to project productivity. Consequently, it is essential to empower community members through building their capacity to engage in planning, implementation and maintenance of the borehole.

Recommendations

For Water For Life Nigeria

Engage beneficiary communities and build a sense of ownership

The community's participation is very crucial for water point sustainability. Thus, it is imperative that WFLN involves the community throughout the planning, implementation and follow-up phase of the project. The roles and responsibilities expected from the community need to be taught to them, so that they have a better understanding of the expectations regarding the water point. Moreover, by engaging communities, they become more empowered and well-informed, and are able to hold NGOs and the government accountable.

Determine a financially sustainable scheme before any project implementation

The unwillingness of the community members to pay for water from the borehole, partly, can be ascribed to the fact that they were not contributing financially from Day One. Thus, they do not have a sense of commitment to the project. In the future, it would be highly beneficial for WFLN to incorporate a plan for financing the project, while at the same time recognizing that the community needs to also contribute financially to the project.

Set aside budget for routine operation and maintenance activities

Operation and maintenance activities depend on financial resources. Consequently, the project's budget should include expenses for O & M activities when developing the budget plan.

Implement a robust monitoring and evaluation program

WFLN should allocate funds in the project budget to conduct routine monitoring and evaluation (M&E). By taking the time to develop and implement a robust evaluation of the water point's functionality and quality, one can better understand the factors that most influence water point sustainability in this context, especially when it comes to cost-determination of operation and maintenance.

Strategically and centrally locate future interventions to optimize access for all community members

Access to the borehole was relatively subjective, and was determined by the proximity of the borehole to households. The range in walking time between the closest household and the farthest household from the borehole was very large (118 minutes). This creates an inequality gap and unfair access for those living farther away. It is thus advised that future interventions be strategically and centrally located to benefit all community members and to eliminate any biased access. For this particular intervention, those who were displeased with the location of the borehole recommended other strategic locations where a new borehole could be installed, namely, No. 1 pump, Obunzekwe square and St. Theresa Catholic church.

For Umuenechi community

<u>Perform water treatment</u>

Households should make concerted efforts to ensure that their drinking water is treated correctly. This treated water should also be available consistently and protected from recontamination. Refraining from drinking untreated water will help reduce the risk of waterborne diseases.

<u>Community Engagement</u>

Community members should be fully engaged in all stages of program implementation and management. Stewards should ensure to fulfill their job description as caretakers of the project. Water committee groups should also ensure that they meet regularly, and document the records from their meetings in a transparent manner. In addition, revenue collectors within the community should ensure that they carry out their job honestly and in a timely fashion.

For Future research

<u>Broaden the Scope of the Research by including a larger sample size and a longer time frame</u>

The sample size for the water quality analysis was only ten household samples. This small sample size limited our ability to draw any conclusions about how household water treatment, transportation and storage practices affected water quality. It would be beneficial to collect data on more household water sample. With a longer duration of study, it would be feasible to survey more participants.

<u>Qualitative and quantitative analysis inclusive of non-church attendees</u>

In order to collect comprehensive information about the community’s use of water and willingness to pay for water, it would be beneficial to survey non-members of St. Joseph’s church to get a more representative picture of household water quality, as well as other perspectives on the financing plan for water.

Water Quality Testing

The reported use of rainwater as a supplemental source of water in Umuenechi implies that this is important to consider both when testing water sources and interpreting the results from water stored within the home. In the latter case, seasonal variations in household water quality could be influenced by the collection of rainwater as a source during the rainy season between March and October. In addition, in the future, water usage studies should identify and collect samples from all the water sources commonly used by this population, as this will better inform surveillance projects by increasing the understanding of what contributes to poor water quality.

Conclusions

This study provides a comprehensive overview of the access, use and quality of water from the borehole at St. Joseph church, Umuenechi village, Anambra state, Nigeria. The quality of borehole water was compared to the community's previous source of water and to household water. Based on results obtained, the following conclusions can be made-

- Water from the borehole was available at most times. However, power fluctuations threatened the consistency of water availability. Purchase of a bigger generator should be considered to provide power to pump water when the main source of power fails.
- The community's access to borehole water was relative and was determined by household proximity to the borehole. It is therefore important to centrally locate water supplies to ensure equal access by all members of the community.
- The results indicated that the borehole provided clean water to the residents and was an improvement from the community's previous water source. However, deterioration of water quality occurred between the source water and point of consumption.
- This decline in water quality may be attributed to factors such as lack of household water treatment and safe storage practices. Thus, community members should be educated on the importance of household water treatment and safe storage practices. Members should also be trained on how to perform household water treatment and properly store their water.
- In addition, water point breakdowns due to lack of maintenance activities and inadequate finances threaten the sustainability of this borehole. However, building greater technical capacity within communities, establishing reliable financial schemes, and conducting

routine maintenance activities can mitigate the risk of future break-downs of the water supply.

- Despite the relatively high SES for a rural Nigerian village, community members were not willing to pay for the maintenance of the borehole because of their perception that water should be free and that they could not afford payment. Increased willingness to pay and assigning a steward or water committee to manage the borehole are critical for the sustainability of the borehole. Thus, education about the need for funding to ensure the sustainability of the water supply is recommended to promote greater willingness to pay for the borehole's maintenance.

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Tables

Table 1: Demographic characteristics of respondents from the survey instrument

Demographic Measure	N (%)
Gender	
Male	19 (46.3)
Female	22 (53.7)
Household Position	
Husband	5 (12.8)
Wife	10 (25.6)
Daughter	10 (25.6)
Son	13 (33.3)
Brother-in-law	1 (2.6)
Occupation	
Student	21 (51.2)
Public Servant	15(36.6)
Business Owners	4(9.8)
Retired	1(2.4)
Highest Education	
No Education	0(0)
Some Primary School	0(0)
Finished Primary School	0(0)
Some Secondary School	3(7.5)
Finished Secondary School	15(37.5)
Academy/Diploma	5(12.5)
University or Higher	16(40.0)
Other	1(2.5)
Marital Status	
Married	13(33.3)
Single	25(64.1)
Divorced	0(0)
Widowed	1(2.6)

Table 2: Demographic Characteristics of Study population

		Age (in years)	Duration of residence in area (in years)	# of people in household
N	Valid	40	40	33
	Missing	1	1	8
Mean		31.9	17.4	4.6
Median		27.0	17.0	5.0
Range		15-65	1-65	0-6

Table 3: Assets of the Study population (For each asset item, N=41)

Asset Index			
Item Description	**n (%)**	**Item Description**	**n(%)**
# of Bedrooms		Gas stove	7(17.1)
1	5(12.2)	Kerosene stove	37(90.2)
2	11(26.8)	Electric stove	11(26.8)
3	9(22.0)		
4	6(14.6)	**Construction of Household**	
≥5	10(24.3)	**Wall**	
		Bamboo/Tepas	1(2.4)
Isolated Kitchen	34 (82.9)	Brick/Cement	40(97.6)
Agricultural Land	30(73.2)	**Floor**	
		Mud/Sand	2(4.9)
Electricity	36(87.8)	Marble/Ceramic	1(2.4)
Radio/Tape recorder	34(82.9)	Brick	2(4.9)
Telephone	30(73.17)	Cement	34(82.9)
Television	36(87.8)	Tile	2(4.9)
Refrigerator	32(78.0)		
Water dispenser	8(19.5)	**Roof**	
Bicycle	5(12.2)	Concrete	3(7.3)
Motorcycle	18(43.9)	Asbestos/Zinc	37(90.2)
Car	15(36.6)	Wood	1(2.4)

Table 4: Distance between borehole and household (N=35)

Distance to Borehole (N=35)	**Time (in minutes)**
Mean	30.6
Std. Deviation	31.0
Median	20
Range	2-120

Table 5: Types of drinking water sources

Drinking Water Sources	N*	n(%)+
St. Joseph borehole	24	18(75.0)
Public Tap	19	17(89.5)
Protected private well	13	4(30.8)
Shared well	9	3(33.3)
Stream or River	9	4(44.4)
Spring	9	6(66.7)

*represents the total number of respondents for each specific drinking water source, +represents the proportion of N that answered yes.

Table 6: Main treatment method for drinking water (N=32, for each water treatment)

Main Water Treatment	%
Boil the water	75.0
Add bleach/kaporite	0.0
Use Filter(sand, ceramic, stone)	6.3
Use Cloth filter	6.3
Put in the light or under the sun	0.0
Allow turbidity to settle out	3.1
Safely stored	9.4
Alum	0.0

Table 7: Reason for chosen drinking water treatment method (N=32, for each treatment reason)

Reason	%	Reason	%
Kill the germ	50.0	Cheap	9.4
Safe	40.6	Watched on TV	9.4
To be healthy	25.0	Habit/Tradition	9.4
Easy	25.0	To cook the water	9.4
Recommended by health care provider	25.0	Obligation/Household task	6.3
Make water cleaner	18.8	No need to buy water	6.3
Make water clearer	15.6	Listen from radio	6.3
Trust/Believe	9.4	Neighbors use that	3.1

Table 8: Reason for choice of water treatment by drinking water treatment method

Reason for choice of treatment method	N	Boil water (%)	Use filter (%)	Use Cloth filter (%)	Put it in the light or under the sun (%)	Let turbidity settle out (%)
Easy	8	62.5	12.5	12.5	0.0	12.5
Safe	13	84.6	7.7	0.0	0.0	7.7
Trust/Believe	3	33.3	33.3	0.0	0.0	0.0
Kill the germ	16	87.5	6.2	0.0	0.0	0.0
To be healthy	8	62.5	12.5	12.5	0.0	0.0
Cheap	3	66.7	33.3	0.0	0.0	0.0
Recommended by health care provider	8	87.5	12.5	0.0	0.0	0.0
Listen from radio	2	50.0	50.0	0.0	0.0	0.0
Watched on TV	3	66.7	33.3	0.0	0.0	0.0
Neighbor use that	1	0.0	100.0	0.0	0.0	0.0
Habit/Tradition	3	0.0	33.3	33.3	0.0	0.0
Make water clearer	5	60.0	20.0	20.0	0.0	0.0
Make water cleaner	6	83.3	16.7	0.0	0.0	0.0
No need to buy water	2	50.0	50.0	0.0	0.0	0.0
To cook the water	3	66.7	33.3	0.0	0.0	0.0
Obligation/household task	2	50.0	50.0	0.0	0.0	0.0

Table 9: Primary drinking water treatment method by Cost level

Main water treatment	Cost level				
	N	Very Expensive %	Somewhat Expensive %	Somewhat Inexpensive %	Very Inexpensive %
Boil the Water	24	8.33	12.5	20.83	58.33
Use Filter (Sand, ceramic, stone)	2	50	0	0	50
Use Cloth filter	2	0	0	0	100
Let turbidity settle out	1	0	100	0	0
Safe storage	3	0	33.33	0	66.67

Table 10: Characteristics of Household Water Treatment and Storage Practices

Household water treatment and storage practices	**N=10**	**n**	**%**
Type of water container	no water container	0	0
	Bucket	4	40
	Jerry can with or without faucet	3	30
	Barrel/drum	1	10
	Clay-pot	0	0
	Saucepan	0	0
	Tea pot	0	0
	Jug	0	0
	Kettle or cooking pot	0	0
	Bottles	2	20
Container mouth	Wide mouthed	5	50
	Narrow mouthed	5	50
Equipment for removal of drinking water	Cup	10	100
	Pitcher	0	0
	Bowl	0	0
	Bucket	0	0
	Faucet	0	0
	Pour water directly from container	0	0
Water properties	Odor-free	10	100
	Visible turbidity	2	20
Drinking water treated	Yes	2	20
	No	8	80

Table 11: *E.coli* and total coliform concentration for household water samples.

Household #	Mean+ Total coliform concentration (CFU/100ml)	Mean+ *E.coli* concentration (CFU/100ml)	Type of Storage container	Type of Container's mouth	Type of cover solid	Water treatment
1	2	4	Bucket	Wide	Yes	Yes
2	13	1	Jerry can with or without faucet	Narrow	Yes	No
3	77	4	Jerry can with or without faucet	Narrow	No	Yes
4	0	0	Bucket	Narrow	No	No
5	152	5	Bucket	Wide	Yes	No
6	129	6	Bucket	Wide	No	No
7	0	0	Barrel/drum	Wide	No	No
8	0	0	Bottles	Wide	Yes	No
9	0	0	Jerry can with or without faucet	Narrow	Yes	No
10	6	6	Bottles	Narrow	Yes	No

+ All bacterial analyses were performed in duplicate with the reported bacterial concentrations representing the average per water sample.

Figures

Figure 1: St. Joseph Catholic Church

Figure 2: Conceptual Framework of the National Rural Water Supply and Sanitation System in Nigeria. Retrieved from (Nwankwoala 2011). Related article can be downloaded from http://www.ajol.info/index.php/ajest/article/view/74239. Image is Figure 1 within this article.

Image redacted due to copyright restriction.

Figure 3: Nibo town, Anambra State in a map of Nigeria
Source: http://www.cometonigeria.com/search-by-region/south-east/anambra-state

Image redacted due to copyright restriction.

Figure 4: Map of Anambra State showing Awka South LGA.
Source- http://nigeriamasterweb.com/blog/index.php/2012/10/08/nigeria-flood-disaster-in-anambra-state

Image redacted due to copyright restriction.

Figure 5: Percentage of participants by quintile levels

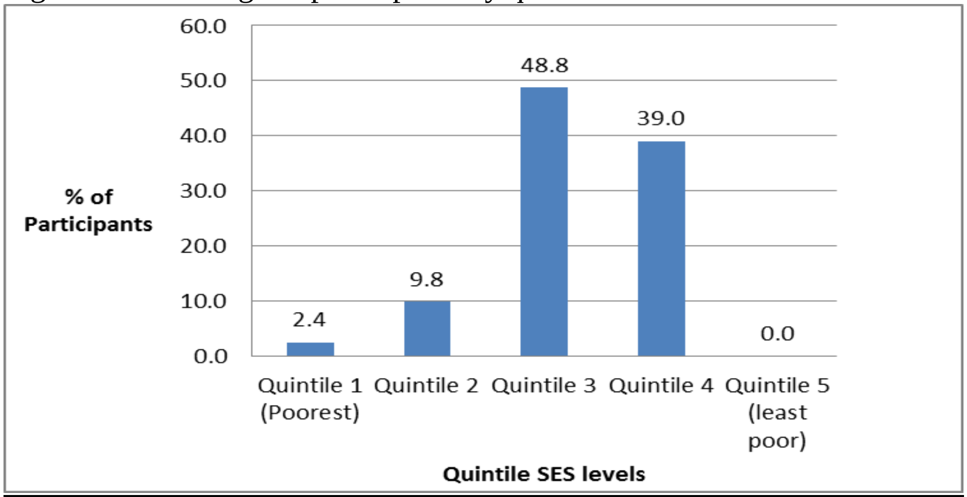


Figure 6: An example of a rain water catchment used in the community

Figure 7: Mean concentration of indicator organisms by water source

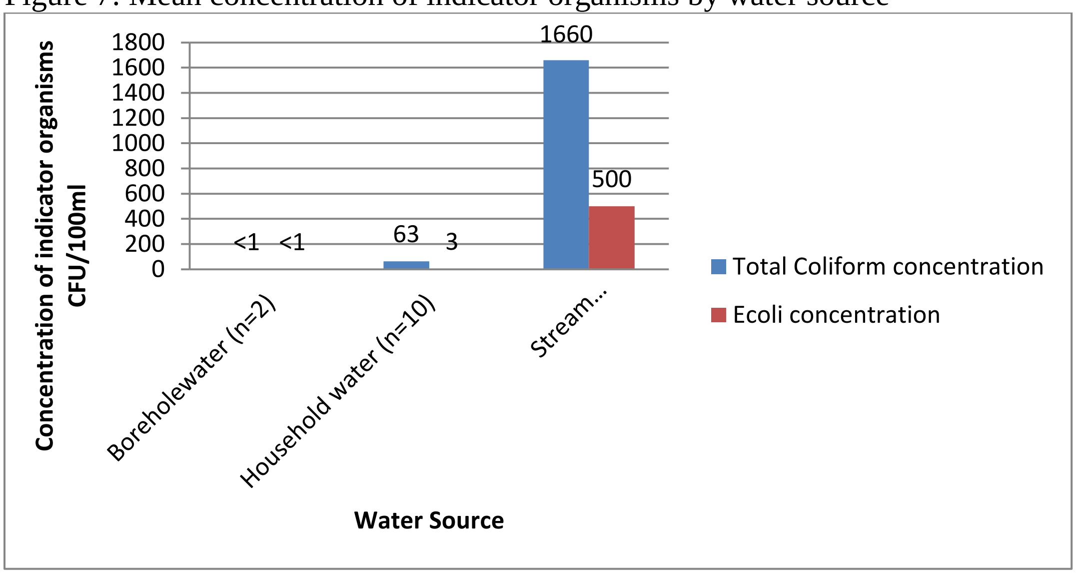


Figure 8: Stream Nwangwo

Figure 9: Perception of borehole water quality (N=41)

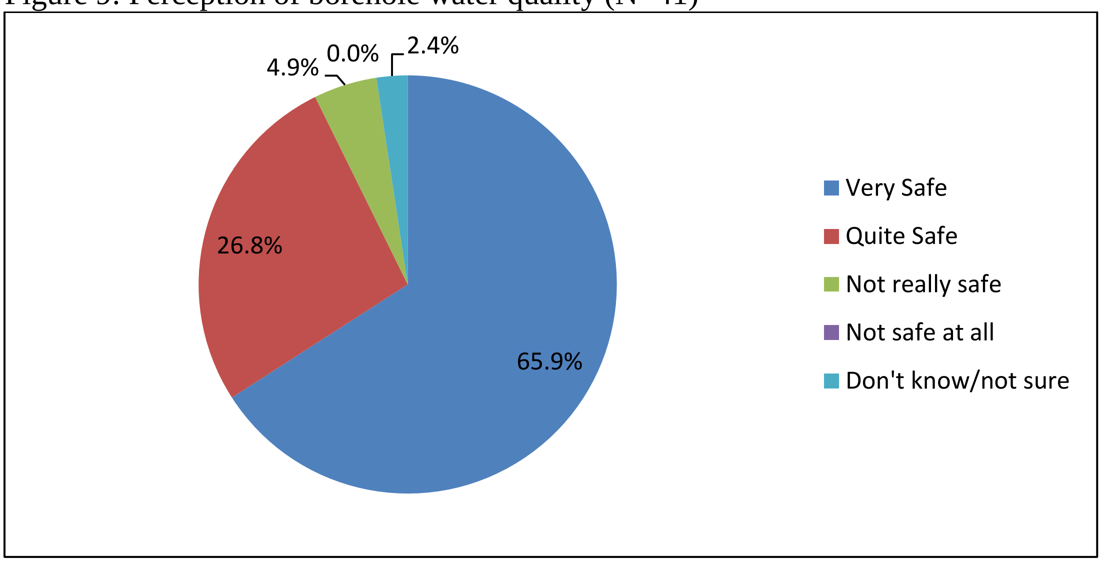


Figure 10: Method of water transportation (N=41)

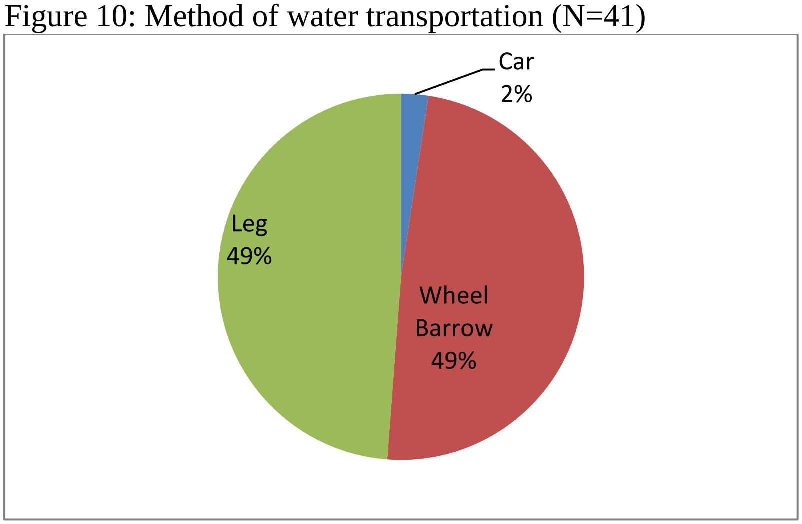


Figure 11: Mode of water storage (N=41)

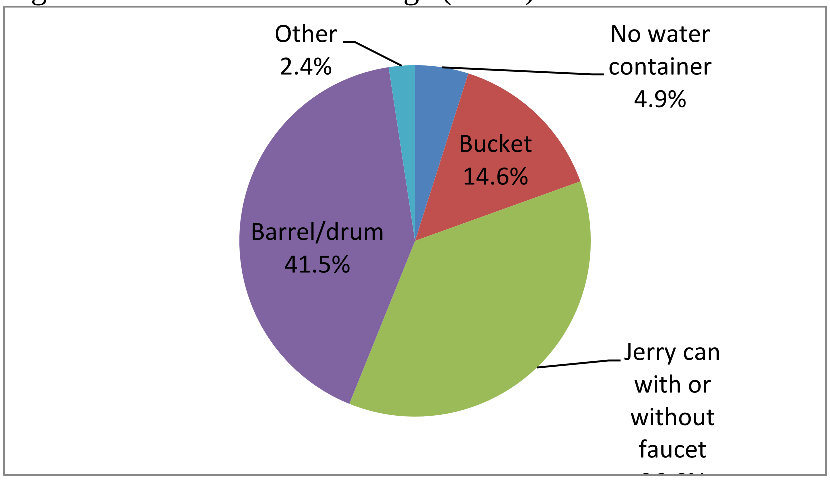


Figure 12: Reported drinking water treatment by Highest Education (N=38)

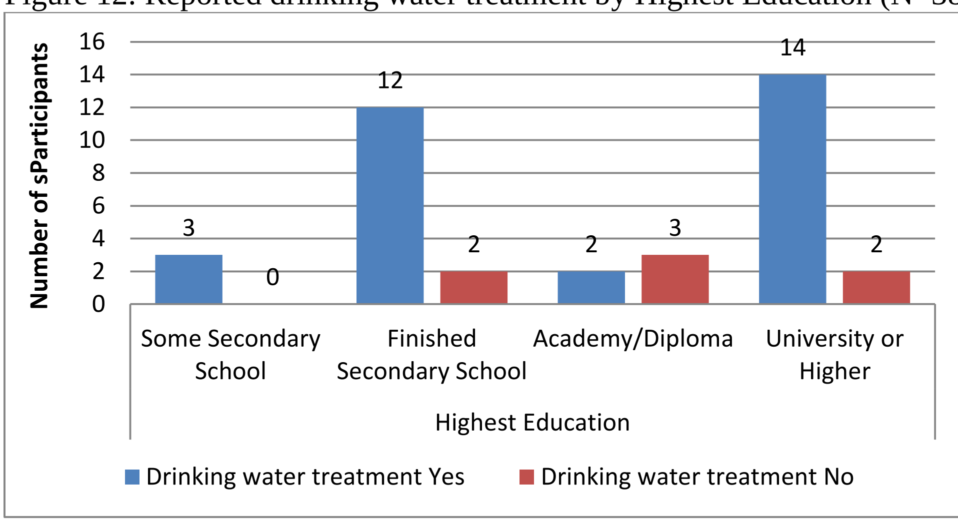


Figure 13: Level of education and Primary water treatment method (N=29)

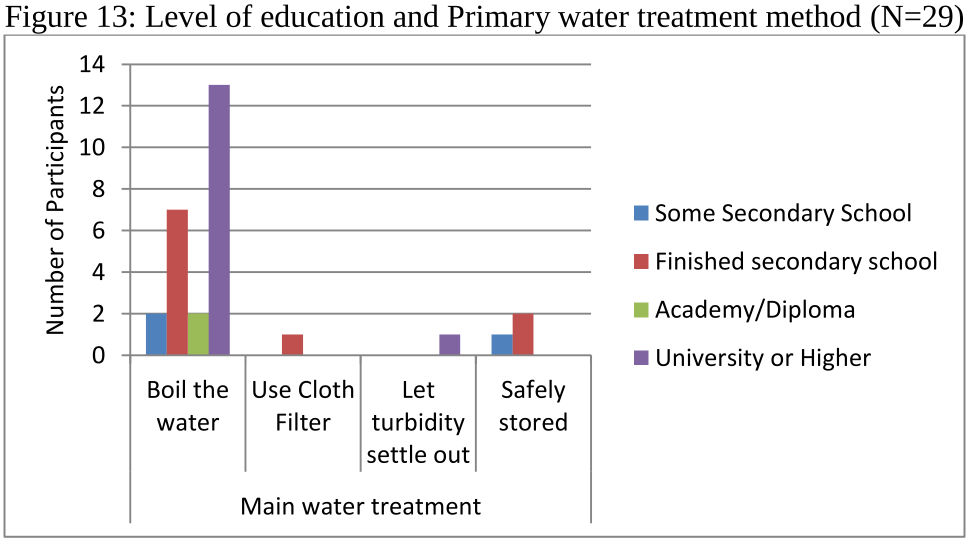


Figure 14: SES and Primary water treatment method (N=32)

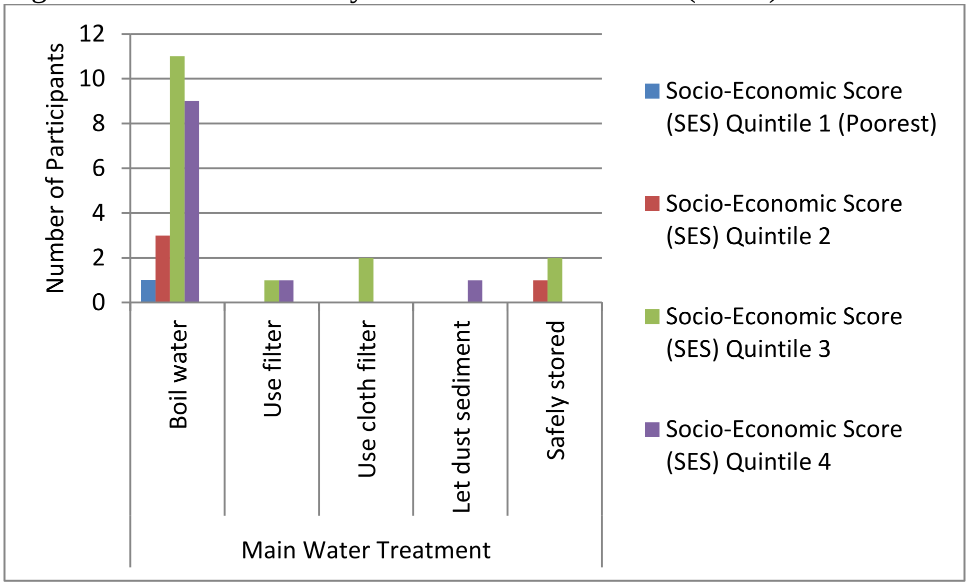


Figure 15: Example of household storage container

Figure 16: Classification of water quality samples according to the magnitude of contamination (n=10)

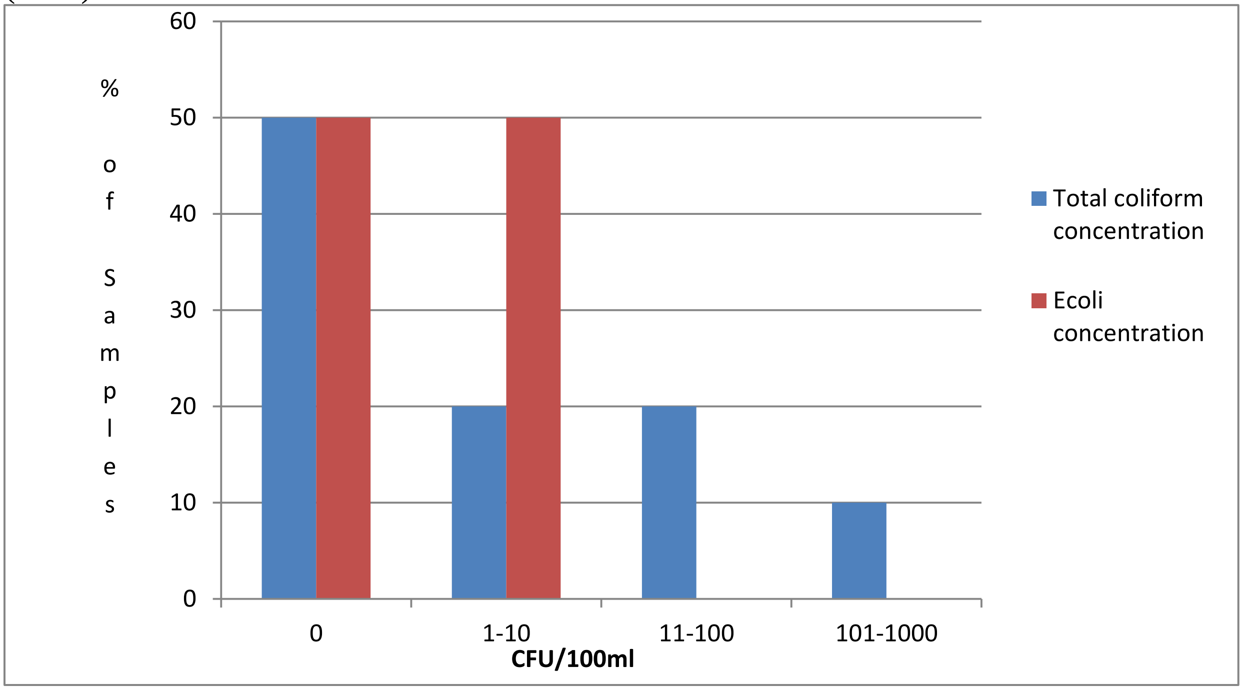


Figure 17: Classification of household water quality by type of storage container (n=10)

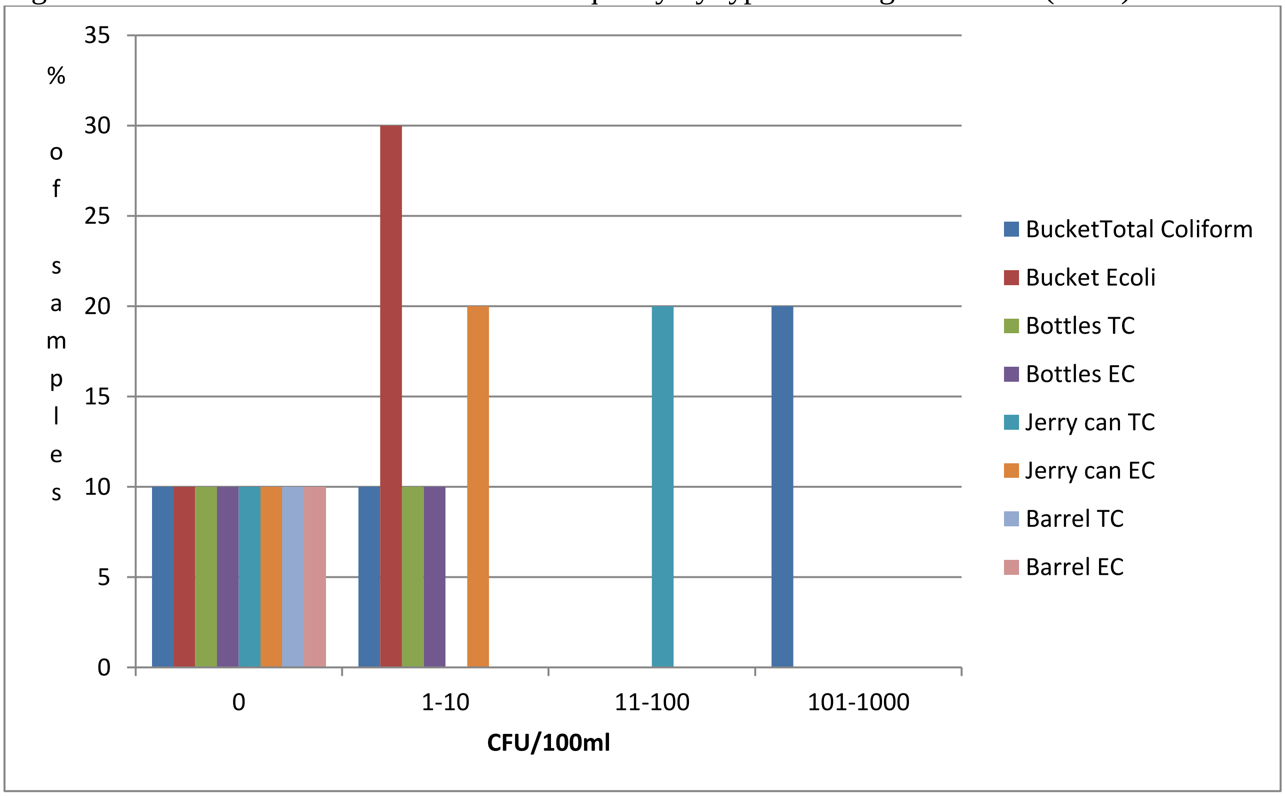


Figure 18: Classification of water quality samples by magnitude of contamination and storage container mouth (n=10).

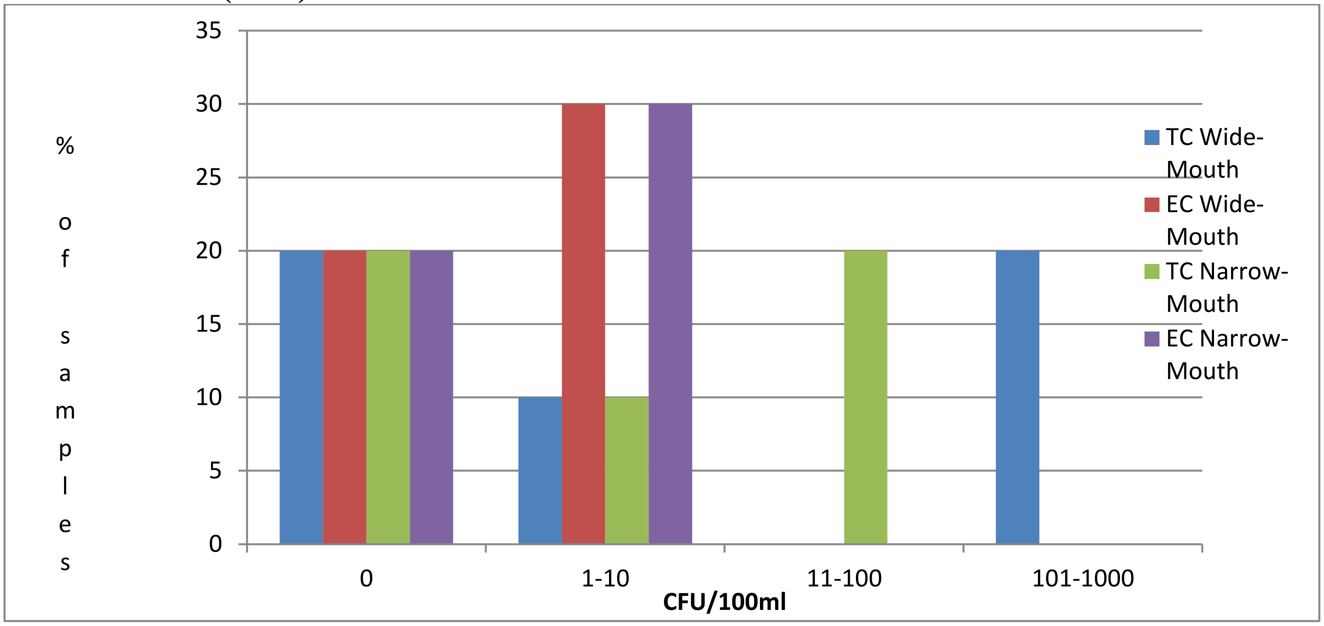


Figure 19: Classification of water quality samples according to the magnitude of contamination in different types of storage containers (n=10).

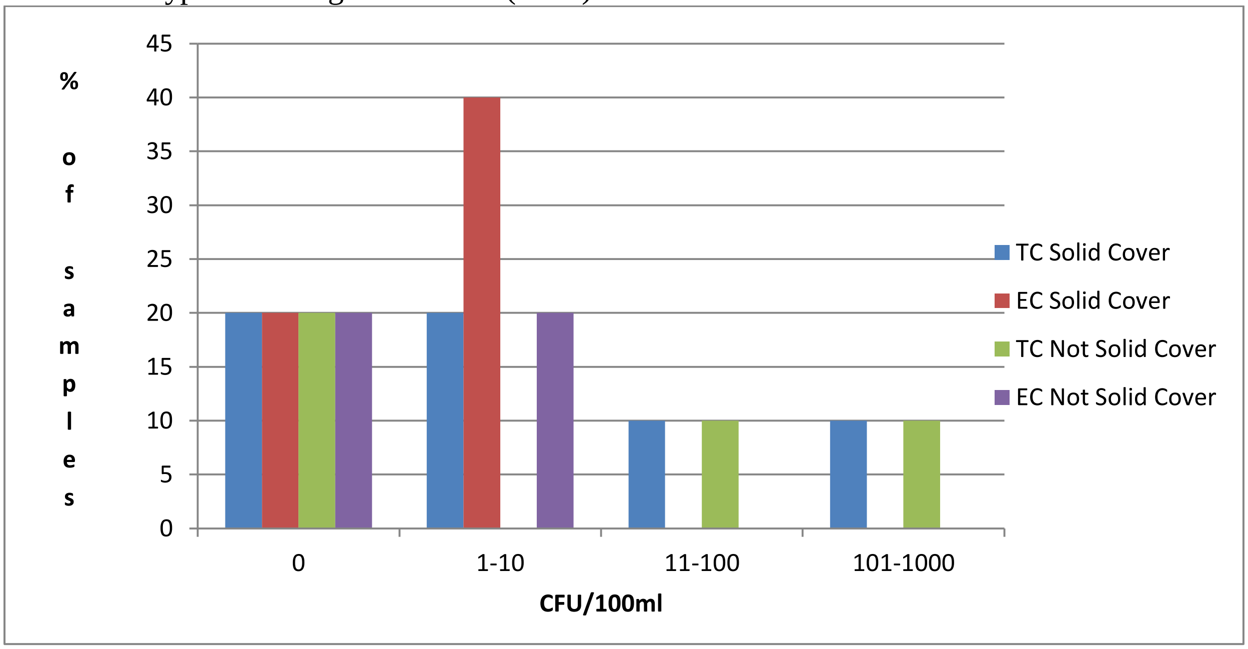


Figure 20: Percentage of samples by indicator concentration levels according to reported drinking water treatment (n=10)

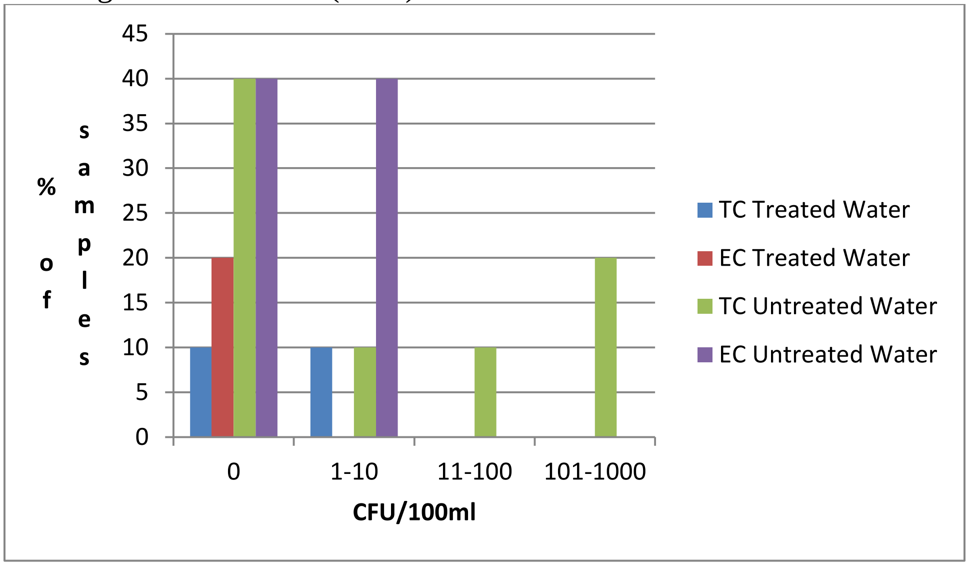


Figure 21: Taps surrounded by an overgrowth of weeds

Figure 22: Most important issue to be addressed (n=41)

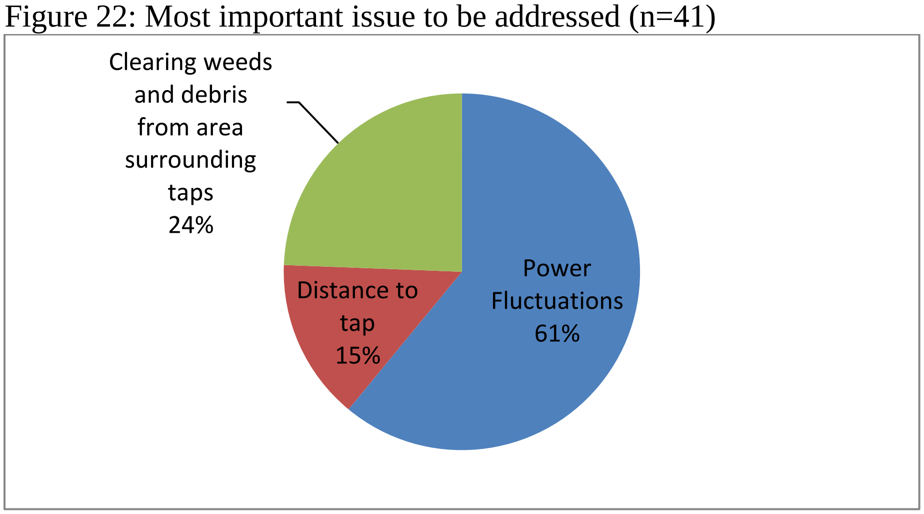
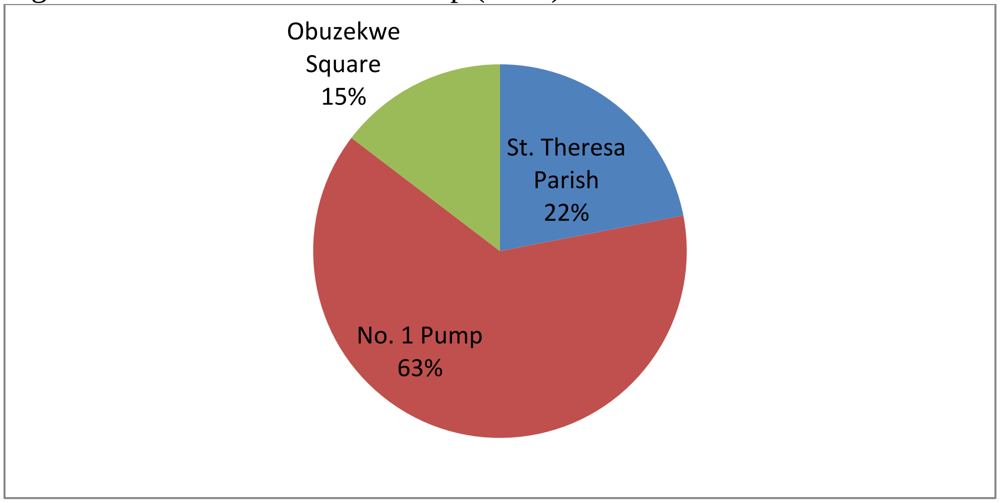


Figure 23: Best location for new tap (n=41)



Appendix A

Title: Evaluation of availability, access, use and quality of water in Umuenechi Village, Nibo, Anambra State, Nigeria 24 months after the installation of a 200-foot borehole

Principal Investigator: Nwabunie Nwana, Master in Public Health Candidate 2013, Department of Global Environmental Health, Rollins School of Public Health, Emory University, Atlanta, Georgia.

Introduction

You are being asked to be in a research study. This form is designed to tell you everything you need to think about before you decide to consent (agree) to be in the study or not to be in the study. **It is entirely your choice. If you decide to take part, you can change your mind later on and withdraw from the research study. You can skip any questions that you do not wish to answer.**

Before making your decision:

- Please carefully read this form or have it read to you
- Please ask questions about anything that is not clear

You can take a copy of this consent form, to keep. Feel free to take your time thinking about whether you would like to participate. By signing this form you will not give up any legal rights.

Study Overview

The purpose of this study is to evaluate a recently implemented borehole project in Eastern Nigeria. In the quest to increase the overall availability, accessibility and quality of water in Nigeria, *Water For Life Nigeria*, a grassroots independent organization, successfully launched this project on August 24th, 2010. Monitoring and evaluation needs to be conducted in order to ensure that this project continues to meet the needs of this community. This monitoring and evaluation program will provide valuable information on ways to further improve program quality, create sustainability and inform future intervention projects.

Procedures

Water Quality Analyses

Water samples will be collected weekly from your household storage containers. The water samples will be tested for *E. coli* and fecal coliform bacteria (standard indicators of fecal contamination).

The Quantitative Survey Instrument

The survey instrument will be used as the quantitative data collection tool and will be administered once to you. Questions related to the domains below will be represented in the survey.

Assess Water Availability, Accessibility and Quality Provided by the Project
I will ask questions related to the availability of water, distance from home to water source, type of household water treatment and mode of water storage in order to analyze if the project's objectives to provide available, accessible and clean water to this population are being met.

Assessing Willingness to Pay- Implications for Sustainability
I will also ask you demographic questions based to determine the community's assets index based on the type of house they live in and property they own in order to determine the range of socioeconomic diversity present in Umuenechi.

Risks and Discomforts
I do not anticipate any risks from participating in this research.

New Information
It is possible that the researchers will learn something new during the study about the risks of being in it. If this happens, they will tell you about it. Then you can decide if you want to continue to be in this study or not. You may be asked to sign a new consent form that includes the new information if you decide to stay in the study.

Benefits

This study is not designed to benefit you directly. However, the targeted community will receive a more improved, reliable and sustainable water supply to meet their domestic and commercial needs, as well as decrease their susceptibility to water-borne and water-related diseases.

You will also not be offered payment for being in this study.

Confidentiality

Certain offices and people other than the researchers may look at study records. Emory employees overseeing proper study conduct may look at your study records. These offices include the Office for Human Research Protections, the funder(s), the Emory Institutional Review Board, and the Emory Office of Research Compliance. Study funders may also look at your study records. Emory will keep any research records we create private to the extent we are required to do so by law. A study number rather than your name will be used on study records wherever possible. Your name and other facts that might point to you will not appear when we present this study or publish its results.

Voluntary Participation and Withdrawal from the Study
You have the right to leave a study at any time without penalty. You may refuse to answer any questions that you do not wish to answer. All information you have provided will be properly discarded at your request if you choose to withdraw.

The researchers also have the right to stop your participation in this study without your consent if:

- They believe it is in your best interest;
- You were to object to any future changes that may be made in the study plan;
- or for any other reason.

Contact Information
Contact Nwabunie Nwana at 319-230-5920:

- if you have any questions about this study or your part in it, or
- if you have questions, concerns or complaints about the research

Contact the Emory Institutional Review Board at 404-712-0720 or irb@emory.edu:

- if you have questions about your rights as a research participant.
- if you have questions, concerns or complaints about the research.
- You may also let the IRB know about your experience as a research participant through our Research Participant Survey at http://www.surveymonkey.com/s/6ZDMW75.

Consent
Please, print your name and sign below if you agree to be in this study. By signing this consent form, you will not give up any of your legal rights. We will give you a copy of the signed consent, to keep.

____
Name of Subject

____ __________________
Signature of Subject Date Time

____ __________________
Signature of Person Conducting Informed Consent Discussion Date Time

____ __________________
Signature of Legally Authorized Representative Date Time

____
Authority of Legally Authorized Representative or Relationship to Subject

________________________________ __________________
Signature of Assent for 17 year old Subject Date Time

Interviewer Name ____________________
Date ________________________________
Reviewed by:______________________________
Study ID Number _____________________
Data entry 1: Who _______ When _________

DEMOGRAPHIC INFORMATION

I would like to start this interview by asking some general questions

1. May I know your name please? (Last Name, First Name)
____

2. May I know your position in this household? Circle one

   1. Husband
   2. Wife
   3. Daughter
   4. Son
   5. Sister
   6. Aunt
   7. Others _________________

3. How old are you?
   Age: _____________________

4. Occupation: _________________

5. What is the highest education level you have <u>completed</u>? **PROBE:** Graduated? (CIRCLE ONLY ONE ANSWER)

   1 = No Education 2 = Some Primary School 3 = Finished Primary School
   4 = Some Secondary school 5 = Finished Secondary School
   6 = Academy/Diploma 7 = University or higher
   8 = Other_________________

6. For how long have you lived here? ______

7. How many people live in this house, including yourself?

Please give the name and age of every person who lives in this household. **Complete the following table.**

Name	**DOB (age if DOB not available)**	**Sex 1 = M 2 = F**	**Relationship with the respondent ***	**Diarrhea Past 7 days?**
		1 2		
		1 2		
		1 2		
		1 2		
		1 2		

*****1=her child, 2=sibling, 3=nephew/niece, 4=cousin, 5= brother/sister in-law, 6=no relationship; 7= other

8. May I know your marital <u>status</u>? (SHOW THE ID CARD, CIRCLE ONE ANSWER)
   1 = Married 2 = Single
   3 = Divorced 4 = Widowed

9. What Church Do you Attend? Circle one
   1= St. Joseph Catholic Church, Umuenechi 2= Other

ASSET INDEX

If you don't mind, now I would like to ask you some questions about your household

10. How many <u>bed rooms</u> do you have in your house?
____

11. Is there a special room used as kitchen <u>only</u> in your house?
    1. Yes
    2. No

12. What is the <u>main</u> material of the <u>wall</u> in your house? (CIRCLE ONE ANSWER)
    1. Wood planks
    2. Bamboo/Tepas
    3. Brick/ Cement
    4. Tripleks
    5. Other____

13. What is the <u>main</u> material of the <u>floor</u> in your house? (CIRCLE ONE ANSWER)
    1. Mud, Sand
    2. Wood or plank
    3. Marble or ceramic
    4. Brick

5. Bamboo
6. Cement
7. Tile
8. Other ________________________________

14. What is the main material of the roof in your house? (CIRCLE ONE ANSWER)
    1. Tile
    2. Concrete
    3. Asbestos/Zinc
    4. Wood
    5. Leaves
    6. Other________________________________

15. Do you at this moment own these things below: **(Fill in this table by asking each listed item)**

Item	**1 = Yes 2 = No**		**Number**
Electricity	**1**	**2**	
Radio or tape recorder	**1**	**2**	
Telephone	**1**	**2**	
Television	**1**	**2**	
Refrigerator	**1**	**2**	
Water dispenser	**1**	**2**	
Bicycle	**1**	**2**	
Motorcycle or motorboat	**1**	**2**	
Car	**1**	**2**	
Gas stove	**1**	**2**	
Kerosene stove	**1**	**2**	
Electric stove	**1**	**2**	
Total			

16. Do you or any member of your household own agricultural land?
    1. Yes
    2. No

17. Do you or any member of your household work in this owned agricultural land?
    1. Yes
    2. No

WATER SOURCE, AVAILABILITY, ACCESSIBILITY, STORAGE AND TREATMENT

Now I will ask you about the water that you are currently using.

18. Where do you get the water that you drink? I will read you a list of possible answers. Please tell me which of the following apply to you. [MARK ALL THE SOURCES THEY USE)

18a. Tap at St. Joseph Catholic Church (WFLN tap)	Yes	No	DK
18b. Public taps	Yes	No	DK
18c. Private well	Yes	No	DK
18d. Shared well	Yes	No	DK
18e. Stream or river	Yes	No	DK
18f. Spring	Yes	No	DK

18g. Other: ______________________________________ [SPECIFY]

19. If not St. Joseph Catholic Church (WFLN water), Why are you not getting water from this source? Circle all that apply
   a. Too Far
   b. Water is not always available
   c. Not safe

20. What is the distance between your home and the tap at St. Joseph Catholic Church?
   In minutes: ______________________________________

21. How often is water available at this water source? Circle one
   Always Sometimes Never

22. How do you transport the water?
   a. Car
   b. Wheel Barrow
   c. Leg

23. How do you store water?
   a. No water container
   b. Bucket
   c. Jerry can with or without faucet
   d. Barrel/drum
   e. Clay-pot
   f. Saucepan
   g. Tea pot
   h. Jug
   i. Kettle or cooking pot
   j. Bottles
   k. Other (Specify) ____________________________

24. According to you, how is the current condition/quality of water source at St. Joseph Catholic Church? (ALLOWED TO HAVE MULTIPLE ANSWERS) PROBE: Is there anything else? How is it? So? And?
    1. Sweet taste/good taste
    2. Clean
    3. Smell good
    4. Salty
    5. Dirty
    6. Clear/no color
    7. Murky/brackish
    8. No smell
    9. Smells bad
    10. Bad taste/bitter
    11. Fresh/cool
    12. Other________________________________

25. According to you, how safe is it to drink the water from this source (above)? (READ THE ANSWERS FROM 1 TO 4 AND CHOOSE ONLY ONE ANSWER)
    1. Very safe
    2. Quite safe
    3. Not really safe→ Go to 26
    4. Not safe at all→ Go to 26
    5. Don't know/not sure

26. In your opinion, why is this water source not really safe or not safe at all? (**DO NOT READ THE ANSWERS and CIRCLE ALL ANSWERS THAT APPLY**)
    a. Contain dirt/has black or murky look
    b. Contain chemical materials
    c. Contain bacteria or dangerous germ
    d. Has a taste
    e. Not clear/not transparent
    f. Someone said that the water is not safe to drink
    g. Has Color/stained
    h. Smell bad
    i. Near toilet/drainage/dumpster
    j. Contaminated by factory or similar
    k. Other (Specify) ____________________________

27. Do you do anything to improve the water from your source before you drink it?
    1. Yes
    2. No → Go to 32

28. What do you do to improve your drinking water? (**DO NOT READ THE ANSWERS and CIRCLE ALL THAT APPLY**)
    a. Boil the water
    b. Add bleach/kaporite

c. Use Filter (sand, ceramic, stone)
d. Use Cloth filter
e. Put it in the light or under the sun
f. Let dust sediment
g. Safely stored
h. Alum
i. Others (Specify) ________________________

29. What is the <u>main activity</u> you do before drink the water? (**DO NOT READ THE ANSWERS and CIRCLE ONLY ONE ANSWER**)
a. Boil the water
b. Add bleach/kaporite
c. Use Filter (sand, ceramic, stone)
d. Use Cloth filter
e. Put it in the light or under the sun
f. Let dust sediment
g. Safely stored
h. Alum
i. Others (Specify) ________________________

30. Why do you choose to do this to improve your drinking water? **(CIRCLE ALL ANSWERS THAT APPLY)**
a. Easy
b. Safe
c. Trust/believe
d. Kill the germ/bacteria
e. To be healthy/not to get sick
f. Cheap
g. Recommended by health provider
h. Listen from the radio
i. Look at the television
j. Neighbour use that
k. Habit/tradition
l. Make water clearer
m. Make water cleaner/sterile
n. No need to buy water
o. To cook the water
p. Obligation/ household task
q. Other ____

31. How expensive or cheap is this cost for you? **(CHOOSE ONLY ONE)**
a. Very Expensive
b. Somewhat expensive
c. Somewhat Cheap
d. Very Cheap

32. Why do you drink untreated water from your source?

a. Never been sick because of that
b. Safe
c. Cheap
d. Recommended by health provider
e. My neighbour does the same
f. Habit Sterile
g. Practical
h. Fresher
i. Other ____

33. Are you paying for this water source?

Yes No

34. Would you be willing to pay for this water source?

Yes→Go to 36 No

35. If No, Why?

a. Water should be free
b. No money

36. How much are you willing to pay? ______________________________________

37. What is the most important issue to be addressed with this borehole?

a. Power Fluctuations
b. Distance to tap
c. Clearing weeds and debris from area surrounding taps

38. Which of these three locations is most important for a new tap to be installed?

a. St. Theresa Parish
b. No. 1 Pump
c. Obunzekwe Square

Appendix B

Purpose of Key Informant Interviews (KIIs)

The current assessment is a research study led by Miss Nwana, a graduate student from the Rollins School of Public Health and mentored by Dr. Christine Moe. KII will be advantageous to identify a deeper personal context in understanding how this water intervention was meeting or not meeting the needs of the community.

What will be done

This interview will take approximately half-hour. Specifically, I would use a question-specific focus group guide to really understand: a) if the recent intervention is meeting the needs of the community; b) what other new resources are needed to properly meet these needs; c) if the villagers are willing to pay for this resource

Benefits and Risks

You will be contributing to knowledge about what improvements can be made to this water intervention.

No risks or discomforts are anticipated from taking part in this interview, but if you feel uncomfortable, you may leave at any time.

Confidentiality

Your responses will be completely confidential. No identifying information is associated with your participating in this interview. A unique number will be assigned to your response choices, thus there is no way any personal or identifiable information can be tied to your answers.

Voluntary

Participating in interview is completely voluntary. You may feel free to leave discussions if you are uncomfortable in any way.

Contact Information

If you have any questions or concerns, please contact researcher, Nwabunie Nwana, at nnwana@emory.edu.

Purpose of Focus Group Discussion (FGDs)

The current assessment is a research study led by Miss Nwana, a graduate student from the Rollins School of Public Health and mentored by Dr. Christine Moe. FGDs will be advantageous to identify themes and key issues involving this water intervention. We hope to have two focus groups (users and non-users group composed of six to eight participants each).

What will be done

This focus group session will take approximately half-hour. Specifically, I would use a question-specific focus group guide to really understand: a) if the recent intervention is meeting the needs of the community; b) what other new resources are needed to properly meet these needs; c) if the villagers are willing to pay for this resource

Benefits and Risks
You will be contributing to knowledge about what improvements can be made to this water intervention.

No risks or discomforts are anticipated from taking part in this focus group session, but if you feel uncomfortable, you may leave at any time.

Confidentiality
Your responses will be completely confidential. No identifying information is associated with your participating in this focus group. A unique number will be assigned to your response choices, thus there is no way any personal or identifiable information can be tied to your answers.

Voluntary
Participating in focus group discussions is completely voluntary. You may feel free to leave discussions if you are uncomfortable in any way.

Contact Information
If you have any questions or concerns, please contact researcher, Nwabunie Nwana, at nnwana@emory.edu.

FOCUS GROUP DISCUSSION and KEY INFORMANT INTERVIEW GUIDE

1. What is your role in the Church?
2. How many members make your congregation?
3. What is the organizational structure of the church?
4. Which gender mainly assumes leadership roles during church events?
5. Which villages in Nibo attend this church?
6. How has this borehole benefitted your community?
7. Who manages the borehole?
8. Would you be willing to pay for the borehole?
9. How else can money be generated to maintain the borehole?

Appendix C

WATER TESTING

Household Number____________________
Interviewer Name ____________________
Date ________________________________
Reviewed by:______________________________
Study ID Number _____________________
Data entry 1: Who _______ When _________

If it's ok with you, I'd like to collect a small amount of water in your house to be tested

1. Could you show me the container you primarily used to store the drinking water? **(LOOK AT THE CONTAINER, CIRCLE ONE)**
   a. No water container
   b. Bucket
   c. Jerry can with or without faucet
   d. Barrel/drum
   e. Clay-pot
   f. Saucepan
   g. Tea pot
   h. Jug
   i. Kettle or cooking pot
   j. Bottles
   k. Other (Specify) ____________________________

2. Does the storage have a narrow or wide mouthed container? **(LOOK AT THE CONTAINER, AND CIRCLE THE ANSWER)**
   a. Wide mouthed (a child's hand can go through the mouth)
   b. Narrow mouthed (a child's hand cannot go through the mouth)

3. Is the storage used covered with solid material?
   a. Yes
   b. No

4. Can you show me the equipment that you used to take water from the container? **(LOOK AND CIRCLE ONE)**
   a. Cup
   b. Pitcher
   c. Bowl
   d. Bucket
   e. Faucet
   f. Pour water directly from container
   g. Other (Specify)_____________

5. May I get a sample of the source water you use to drink? (Have the sample of source water for *E. coli* analysis been collected and labeled with date, enumerator, source, and household ID number)

6. May I get a sample of your drinking water? (Have a sample of stored household drinking water for *E. coli* analysis been collected and labeled with date, enumerator, "STORED" label, and household ID number)
   a. Yes
   b. No

7. Please collect a sample of drinking water to be analyzed and tested for chlorine.
   a. Contain chlorine
   b. Not contain chlorine

8. Was this sample of water (the one tested for chlorine) taken from a wide or narrow mouthed container?
   a. Wide
   b. Narrow

9. Was the container covered with solid material (not textile, etc.)?
   a. Yes
   b. No

10. Was the drinking water being treated?
    a. Yes → 11
    b. No

11. If yes, how and how long was the water being treated?
    (Read the answers, circle all responses. More than one answer is allowed)
    1. Boiled ___________ hours
    2. Chlorinated ___________ hours
    3. Filtered ___________ hours

12. Did her hands touch water when it is served?
    a. Yes
    b. No

WEEKLY Home VISIT LOG

Date: _____/____/____

____

Code	Head of Household (name)	Fecal Contamination	Total Coliform

Water Quality Data Collection Form

		Water Quality Data Collection Form										
Date Collected							If household sample, date of collection from pump					
Time Collected							Type of Storage		Open	Closed		
Volume Collected							Other household details					
Collected by												
Collection Site												
Sample Type												
Na Thiosulfate	Y	N										
Date Tested												
Time Tested												
Tested by												
Volume Tested	Vol:	0.1ml	1ml	10ml	100ml							
	Plate Label											
	Colonies Red											
	Colonies Blue											
Protocol Deviations												
Observations												
Sample Odor												
Visible Turbidity												

Appendix D

Asset items with corresponding Index score

Asset Index+			
Item Description	**Score**	**Item Description**	**Score**
# of Bedrooms		Car	4
1	1		
2	2	Gas stove	2
3	3	Kerosene stove	1
4	4	Electric stove	3
5	5		
6	6	**Construction of Household**	
7	7	**Wall**	
8	8	Bamboo/Tepas	1
9	9	Brick/Cement	2
Isolated Kitchen	1	**Floor**	
		Mud/Sand	1
Agricultural Land	4	Marble/Ceramic	5
		Brick	2
Electricity	1	Cement	3
Radio/Tape recorder	1	Tile	4
Telephone	2		
Television	3	**Roof**	
Refrigerator	3	Concrete	2
Water dispenser	1	Asbestos/Zinc	2
Bicycle	2	Wood	1
Motorcycle	4		

+ Total score possible for each respondent is equal to 50.

Appendix E

IRB Determination Letter

21 June 2012
Nwabunie Nwana
Emory University
Rollins School of Public Health
1518 Clifton Road NE
Atlanta, GA 30322

RE: Determination: No IRB Review Required
eIRB 58490 - Title: ***Evaluation of availability, access, use and quality of water in Umuenechi Village, Nibo, Anambra State, Nigeria 24 months after the installation of a 200-foot borehole***
PI: Nwabunie Nwana

Dear Nwabunie Nwana:

Thank you for requesting a determination from our office about the above-referenced project. Based on our review of the materials you provided, we have determined that it does not require IRB review because it does not meet the definition(s) of "research" involving human subjects or the definition of "clinical investigation" as set forth in Emory policies and procedures and federal rules, if applicable. Specifically, in this project, you will be evaluating the implementation of the updated WASH project in Umuenechi Village, Nibo, Anambra State,Nigeria.

Please note that this determination does not mean that you cannot publish the results. If you have questions about this issue, please contact me.

This determination could be affected by substantive changes in the study design, subject populations, or identifiability of data. If the project changes in any substantive way, please contact our office for clarification.

Thank you for consulting the IRB.

Sincerely,
Julia Duckworth, MS
Research Protocol Analyst