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Water, Sanitation, and Hygiene Practices and Socioeconomic Factors that Contribute to Diarrhea in School-Aged Children in the Moyamba District in Sierra Leone

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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

Title: Water, Sanitation, and Hygiene Practices and Socioeconomic Factors that Contribute to Diarrhea in School-Aged Children in the Moyamba District in Sierra Leone

Background: Diarrhea remains the second leading cause of death among children under five and kills more children than AIDS, malaria, and measles combined (CDC, 2015). It is estimated that nearly 90% of diarrhea-associated deaths are attributable to unsafe water and inadequate sanitation and hygiene (CDC, 2015). As of 2017, WASH was the number two risk factor driving death and disability rates in Sierra Leone (Institute for Health Metrics and Evaluation, 2019). The purpose of this thesis is to understand whether WASH practices and socioeconomic factors contribute to diarrheal disease in school-aged children in five villages in the Moyamba District of Sierra Leone.

Methods: Data was collected via paper copy household surveys administered from May to July in 2019 in five villages in the Moyamba District of Sierra Leone. Data was cleaned in Excel, imported into SAS, and analyzed using descriptive statistics, Chi-square, and logistic regression analyses.

Results: There were 21 cases of diarrhea (13.8%) reported by 152 participants. As for WASH practices, 71.1% of all participants used unprotected water sources, 61.8% used unimproved sanitation facilities, and 52.6% reported using soap and water for handwashing materials as opposed to just water. For socioeconomic factors, 65.8% of participants reported no head of household education; 51.3% of the participants had daily household income less than 10,000 leones; over 50% had a PPI score greater than 43 (highest score = 81); 52.6% had mud flooring in their households; and over half of all participants reported discarding of child feces into a bush. Logistic regression showed type of toilet had largest impact on diarrhea with an odds ratio of 1.30 (99% CI: 0.139, 12.1780) when controlling for water source, handwashing materials, household flooring material, disposal location of child feces, and head of household education.

Conclusion: The findings from this thesis contribute to the existing public health knowledge regarding the importance of safe WASH practices and the impact they have on diarrhea. Furthermore, these findings provide evidence that no single intervention will affect diarrhea as profoundly as an intervention that considers water, sanitation, and hygiene in addition to socioeconomic status.

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To my family and Rijalda, thank you for your endless support. Thank you for always listening and checking in, encouraging me to do my best, and believing in me when I had moments of doubt. Remy, thank you for all the FaceTime calls and for always brightening my day. Mom, you have always been my biggest supporter and by my side through all my endeavors. Thank you.

I am grateful for my applied practical experience with Children of the Nations during the summer of 2019. They are an incredible organization and are doing important work to address disparities in several countries. The faces, memories, and conversations from my time in Sierra Leone have been the backbone of this thesis.

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Chapter 1 – Introduction

Introduction and Rationale

Extensive research, public health interventions, and training have gone into combating the global burden of diarrhea. However, diarrhea remains the second leading cause of death among children under five and kills more children than AIDS, malaria, and measles combined (CDC, 2015). Diarrhea can be treated using oral rehydration therapy and/or antibiotics, yet many countries lack the ability to seek care for treatment or, arguably more important, the resources for prevention.

Diarrheal disease creates a plethora of broad public health implications. Aside from it being among the leading causes of death, there is also a significant portion of the global population who suffer from diarrheal disease without the result being death. In 2015, it was estimated that diarrhea was the leading cause of disability adjusted life years (DALYs) worldwide due to the disproportionate impact the disease has on children (Troeger et al., 2017). Although, the burden of diarrheal disease has declined, the rate at which this happens depends largely on access to health care, WASH infrastructure and behaviors, and socioeconomic factors, leaving developing countries lagging behind the rest of the world in reductions of diarrheal disease.

It is estimated that nearly 90% of diarrhea-associated deaths are attributable to unsafe water and inadequate sanitation and hygiene (CDC, 2015). Various studies focused on water, sanitation, and hygiene (WASH) interventions have proven to be successful at reducing diarrhea and are also cost effective with a $1 investment yielding a return of $5-$46 in developing regions and $5-$12 in least developed regions, depending on the intervention (Hutton, Haller, & Bartram, 2007). Wolf et al. performed a systematic review on the assessment of the impact of unsafe WASH on childhood diarrheal disease and found that several WASH interventions were associated with lower risk of diarrheal morbidity, including "evidence for greater reductions when high sanitation coverage is reached and [in] interventions promoting handwashing with soap versus no intervention" (Wolf et al., 2018, p. 508).

Historically, public health practitioners have encouraged populations to use WASH infrastructure and maintain healthy practices based on the idea that it will reduce disease and morbidity. However, it is important to consider socioeconomic factors and geographic areas (i.e. rural vs urban) when tailoring interventions and messages to promote safe WASH practices. In Nigeria, a study was conducted using Demographic and Health Survey (DHS) information to see how improving WASH practices and housing quality can help prevent diarrhea (Yaya et al., 2018). The study found that diarrhea rates were significantly higher in rural vs urban areas and that lacking access to an improved toilet source or water facilities was associated with 14% and 16% higher odds, respectively, of having diarrheal disease (Yaya et al., 2018). The researchers also found statistically significant relationships between children under five diarrheal disease and parental education, position within the wealth index, and household wall and flooring material (Yaya et al., 2018).

Many rural areas lack resources to build and maintain infrastructure and often also lack education regarding healthy and safe WASH practices or the ability to maintain these practices due to poverty and socioeconomic factors. In order to sustain interventions that potentially reduce diarrhea, socioeconomic factors must be considered and motivators behind using WASH infrastructure must be identified for compliance to be upheld.

Sub-Saharan Africa, particularly countries in West Africa, suffer disproportionately from high rates of diarrhea and little to no maintained WASH infrastructure or behavior change. A study looked at diarrheal childhood morbidity and mortality in Africa from 2000 to 2015 and found that the highest diarrhea case-fatality rates occurred mostly in West Africa with Nigeria, Mali, Benin, and Sierra Leone included among the highest (Reiner et al., 2018).

Problem Statement

In Sierra Leone, health outcomes are some of the worst in the world, with children under five diarrhea prevalence reaching up to 23% in some districts and an average life expectancy of 52 years old (Statistics Sierra Leone, 2014). Infrastructure, specifically WASH related, is scarce and resources are limited. Estimates show that 56.4% of the national population use unimproved sanitation sources and 28.7% use unimproved drinking water sources (United Nations, 2020). In 2017, it was found that over 97% of water at the household level was contaminated which suggests that improved sources may still need to be treated (United Nations, 2020).

As of 2017, WASH was the number two risk factor driving death and disability rates in Sierra Leone, falling only behind malnutrition. Moreover, diarrheal diseases ranked fourth as the cause of premature death across all age groups (Institute for Health Metrics and Evaluation, 2019). This data is evidence that addressing both WASH and diarrheal disease in Sierra Leone should be a priority and if done properly, there could be a potential reduction in morbidity and mortality.

During the summer of 2019, Children of the Nations (COTN) conducted an assessment of WASH practices and socioeconomic status in five villages in Sierra Leone. COTN is a Christian non-profit organization located in the Moyamba District of Sierra Leone, and four other countries, dedicated to raising children out of poverty and hopelessness so they can transform their nations (Children of the Nations, 2020). They focus on caring for the whole child including physical, mental, emotional, and spiritual health with programs that are meant to be sustainable for the long term (Children of the Nations, 2020). COTN was interested in this research in order to better understand the villages that they serve and identify WASH practices and socioeconomic factors that might contribute to poor health across the region.

The current diarrheal prevalence and WASH practices are unknown in the villages served by COTN. It is assumed that extreme poverty is present but socioeconomic factors that may be contributing to diarrheal disease are not known. Bridging the knowledge gap between diarrheal prevalence, WASH practices and existing infrastructure, and statistics on socioeconomic factors is necessary to understand the burden of diarrheal disease in the area and eventually target interventions that prioritize WASH practices/infrastructure and socioeconomic factors. Potentially, this could provide greater opportunities for children to live longer, healthier lives and truly transform their nations, as is the mission of COTN.

Purpose of Study

The goal of this thesis is to expand on the data that was collected by COTN to understand whether WASH practices and socioeconomic factors contribute to diarrheal disease in school-aged children in five villages in the Moyamba District of Sierra Leone. This objective will be achieved through five specific aims, which address the goal by examining household survey data related to WASH practices and socioeconomic factors.

Specific Aims

1) Compare demographics, WASH practices, diarrhea rates, and socioeconomic factors in the five villages using bivariate descriptive statistics.

2) Identify whether individual WASH practices are risk factors for diarrhea using Chi-square analyses.

3) Identify whether multiple WASH practices in tandem are risk factors for diarrhea using multiple logistic regression.

4) Identify socioeconomic factors that are risk factors for diarrhea using multiple logistic regression.

5) Compare how WASH practices impact diarrhea when controlling for socioeconomic factors using multiple logistic regression.

Research Question: Do water, sanitation, and hygiene practices (either individually or in tandem) and socioeconomic factors contribute to diarrheal disease in school-aged children in five villages in the Moyamba District of Sierra Leone?

Null Hypothesis: Water, sanitation, and hygiene practices (either individually or in tandem) and socioeconomic factors do not contribute to diarrheal disease in school-aged children in five villages in the Moyamba District of Sierra Leone.

Significance Statement

The results of the thesis will be given to COTN to show how WASH practices and socioeconomic factors in the villages could be risk factors for diarrheal disease in school-aged children. Additionally, the results could guide the development of interventions targeting specific WASH practices that potentially reduce rates of diarrhea. If successful, these interventions could be scaled up to the district level in areas practicing similar WASH habits with high rates of diarrheal disease.

<u>Definition of Terms</u>

Diarrhea: Diarrhea is defined as the passage of three or more loose or liquid stools per day (WHO, 2017).

School-aged children: For the purposes of this thesis, school-aged children include any child less than 18 years of age who attends school. The range for this study was 3-17 years old.

Improved water source: WHO defines an improved water source as one that, "by nature of its construction, adequately protects the water from outside contamination, in particular from fecal matter" (JMP, 2012). Examples of improved water sources include piped household water, public standpipe, borehole, protected dug well, protected spring, and rainwater collection (JMP, 2012).

Unimproved water source: An unimproved water sources is not protected from outside contamination and is therefore susceptible to fecal matter and other pathogens. Examples of unimproved water sources include unprotected well, unprotected spring, surface water, tanker truck water, and bottled water (JMP, 2012).

Improved sanitation: WHO defines improved sanitation as any sanitation facility "that hygienically separates human excreta from human contact" (JMP, 2012). Examples of improved sanitation include sewer connections, septic system connections, pour-flush latrines, ventilated improved pit latrines and pit latrines with a slab or covered pit (JMP, 2012).

Unimproved sanitation: Unimproved sanitation is defined as sanitation facilities that lack the ability to hygienically separate human excreta from human contact (JMP, 2012). Examples of unimproved sanitation include pit latrines without slabs or platforms, hanging latrines, bucket latrines, or open defecation in fields or forests (JMP, 2012).

Chapter 2 – Literature Review

Introduction

In order to understand whether water, sanitation, and hygiene (WASH) practices and socioeconomic factors contribute to diarrheal disease in school-aged children in this study, it is necessary to understand the existing literature on this topic. The burden of diarrhea, its diverse etiologies, and transmission routes for pathogens are well studied areas, as are the health impacts it causes, which disproportionately affect children. WASH is a major known contributor to diarrheal disease, as are various socioeconomic factors. Sierra Leone has implemented national policies to help strengthen their WASH sector and mitigate negative health effects. The known relationship between diarrhea, WASH, and socioeconomic factors is outlined below in order to better understand the scope of the problem, both globally and in Sierra Leone.

Diarrhea: Definition and Etiology

Definition

It is necessary to define diarrhea before explaining its etiology and the morbidity and mortality it causes. According to the World Health Organization (WHO), diarrhea is defined as the passage of three or more loose or liquid stools per day, or more frequent passage of stool than is normal for the individual (WHO, 2017). This definition is standard for all age groups, and it may be accompanied by other manifestations such as vomiting, fever, and abdominal cramps. Diarrhea is classified clinically as either acute watery diarrhea, acute bloody diarrhea (also known as dysentery), or persistent diarrhea which lasts 14 days or longer (WHO, 2017).

Etiology

Diarrheal diseases have many known causes, with some being much more common than others. Disease severity is determined by the type of pathogen, host susceptibility, and environment. Rotavirus, *Cryptosporidium*, *Shigella*, and Enterotoxigenic *E. Coli* (ETEC) are four pathogens responsible for most illnesses that result in diarrheal disease, with rotavirus being the most common cause of diarrhea in children (Kotloff, 2017). Rotavirus is a viral pathogen, *Cryptosporidium* is a protozoa, and *Shigella* and *E. coli* are bacterial agents; however, many parasites also cause diarrheal disease.

Viruses such as rotavirus replicate in the small bowel of the human host and cause cell destruction and villous shortening which causes the cells of the intestine to secrete water and electrolytes (WHO, 1992). Similarly, protozoans adhere to the epithelium in the small bowel and cause villous shortening (WHO, 1992). Bacteria invade the body in different ways depending on the specific species. Some bacteria adhere to the mucosa in the small intestine, others cause intestinal secretion by producing toxins that alter cell function, and others invade and destroy mucosal epithelial cells mostly in the colon which causes bloody diarrhea (WHO, 1992). Parasites also have diverse strategies for success in the human host, depending on the species. Most parasites produce eggs and grow in the small or large intestine; however, some can also spread in the bloodstream and reach the liver, lungs, or brain (Kucik, Martin, & Sortor, 2004).

The most common types of viruses causing diarrheal disease in children are rotaviruses, calicivirus, enteric adenovirus, and astrovirus (Kotloff, 2017). The Global Enteric Multicentre Study (GEMS) was a three year, case-control study focused on diarrhea among children under five years old living in Sub-Saharan Africa and South Asia (Kotloff, 2017). The leading pathogen at every study site was rotavirus during the first year of life, and the incidence of rotavirus among infants was more than twice as high as any other pathogen (Kotloff, 2017). Fortunately, there is a vaccine for rotavirus that is distributed globally.

The most common types of bacteria causing diarrheal disease in children are *Shigella*, *Salmonella*, *Campylobacter, Yersinia*, *E. coli*, *Vibrio*, and *Clostridium difficile* (Kotloff, 2017). GEMS found that incidence of *Shigella* increased with age, becoming the second most common pathogen among children aged 12 to 23 months and the leading pathogen among children aged 24 to 59 months (Kotloff, 2017). Shigella is commonly associated with dysentery but can also be the cause of watery diarrhea. Enterotoxigenic *E. coli* (ETEC) is the leading cause of travelers' diarrhea worldwide and is also a major cause of diarrhea among children in lower-income countries (CDC, 2014).

The most common types of protozoa causing diarrheal disease in children are *Cryptosporidium, E. histolytica*, and *Cyclospora* (Kotloff, 2017). GEMS found that *Cryptosporidium* ranked second after rotavirus among infants at all sites and had a significantly higher risk of death for children aged 12 to 23 months during the ensuing 2 to 3 months post infection (Kotloff, 2017). It is estimated that nearly 10% of the world's population is infected with *E. histolytica*, but nearly 90% of cases are asymptomatic (Reed, 2005) and is likely second only to malaria as a protozoan cause of death (Petri and Singh, 1999).

The most common parasites known to cause diarrheal disease are *E. vermicularis*, *Giardia lambia*, *A. duodenale*, and *N. americanus* (Kucik, Martin, & Sortor, 2004). Giardia is likely the most common parasitic infection of humans worldwide and does well in populations with poor sanitation and close contact. *E. vermicularis* is a nematode with the largest geographic range of any helminth and is known to infect about 210 million people worldwide, with more than 30% of children worldwide infected (Goldmann & Wilson, 1997). *A. duodenale*, and *N.*

americanus are two species of hookworms found exclusively in humans and were controlled in the United States with the widespread use of modern plumbing and footwear (Kucik, Martin, & Sortor, 2004).

It is important to understand the causes of diarrheal disease worldwide and which etiologic agents are of greatest concern, but it is arguably more important to understand how those agents are transmitted throughout the environment. It is by understanding transmission routes that disease patterns can be interrupted, and the burden of disease can be diminished.

Transmission Routes for Diarrheal Pathogens

Most pathogens responsible for diarrheal diseases are transmitted fecal-orally. Unsafe drinking water, poor sanitation, and insufficient hygiene cause over 90% of diarrheal deaths (Water1st International, 2019). As shown in Figure 1, feces can be transmitted through fluids, fields, flies, fingers, and food pathways to infect a new host. Notably, feces in the diagram refers

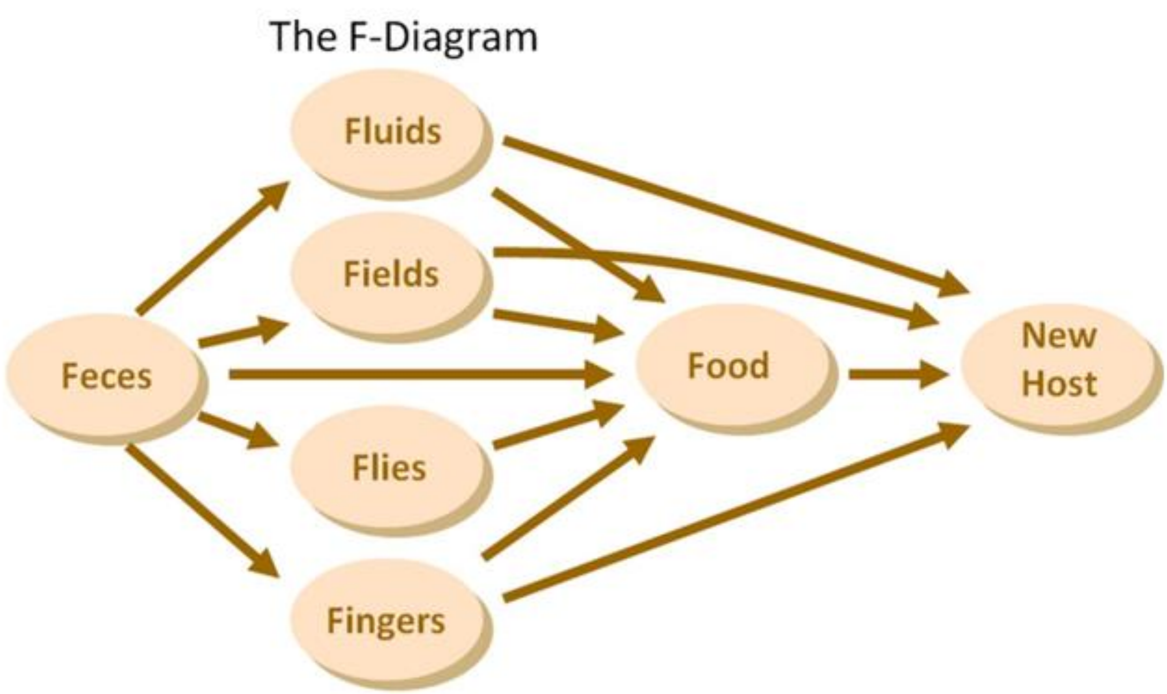

Figure 1. F-Diagram highlighting pathways for pathogen transmission.

to humans and animals, as both are of concern as the main sources of diarrheal pathogens. Various water, sanitation, and hygiene interventions target different pathways in order to interrupt transmission routes. Sanitation interventions prevent the spread of feces through fluids, fields, and fly pathways. Water interventions prevent contaminated fluids from infecting a new host, while hygiene interventions prevent all pathways from contaminating food.

As stated previously, rotavirus, *Cryptosporidium*, *Shigella*, and Enterotoxigenic *E. coli* are four causes associated with the most diarrheal disease; therefore, it is important to distinguish transmission routes of these pathogens, especially as they relate to diarrhea. Rotavirus is known to be transmitted fecal-orally but can also be transmitted in developing countries via the fecal contamination of water. It is also suspected that rotavirus is commonly transmitted from child to child through contamination of the caretaker's hands by infected fomites or surfaces (Dennehy, 2000). *Cryptosporidium* transmission routes include waterborne, food-borne, and occasionally person-to-person (Huang, Chappell, & Okhuysen, 2004). *Shigella* is transmitted through person-to-person contact or indirectly through contaminated food, water, or fomites. Since as few as 10 organisms can cause infection, *Shigella* is highly infectious and easily transmitted (CDC, 2019). Houseflies have also been known to transmit *Shigella*. Finally, enterotoxigenic *E. coli* (ETEC) is transmitted through food and water contaminated with human or animal feces (CDC, 2014). Since ETEC is most commonly seen in young children, this suggests that a protective immune response occurs as children get older (Qadri et al., 2005).

Poverty and malnutrition are also contributing factors that lead to the transmission of diarrhea. Poverty prevents households and communities from having access to safe water, appropriate sanitation or soap for handwashing. Malnutrition weakens the immune system in children and leaves them more vulnerable to diseases. Sustainable interventions and behavior changes are difficult to maintain which has left diarrheal disease as a major contributor to morbidity and mortality worldwide.

Diarrhea Globally

Morbidity and Mortality

The burden of diarrhea extends across the globe, however, low-income countries with poor infrastructure and health care access suffer disproportionately from this disease. Diarrhea was the leading cause of mortality worldwide in 2015, and nearly 90% of diarrheal deaths occur in south Asia and sub-Saharan Africa (Troeger et al., 2017). Furthermore, diarrhea was the fifth leading cause of death among children under five years of age in 2016, and its global impact is highlighted in Figure 2 (Naghavi et al., 2017). Diarrhea is responsible for killing nearly 1.6 million people of all ages every year and causes significant morbidity in those who survive (Naghavi et al., 2017). Diarrhea is a leading cause of disability adjusted life years (DALYs) due to its disproportionate impact on young children (Troeger et al., 2017). Although diarrheal deaths have been decreasing over the last 25 years, some countries are still suffering more than others and continued efforts to improve safe WASH need to be prioritized.

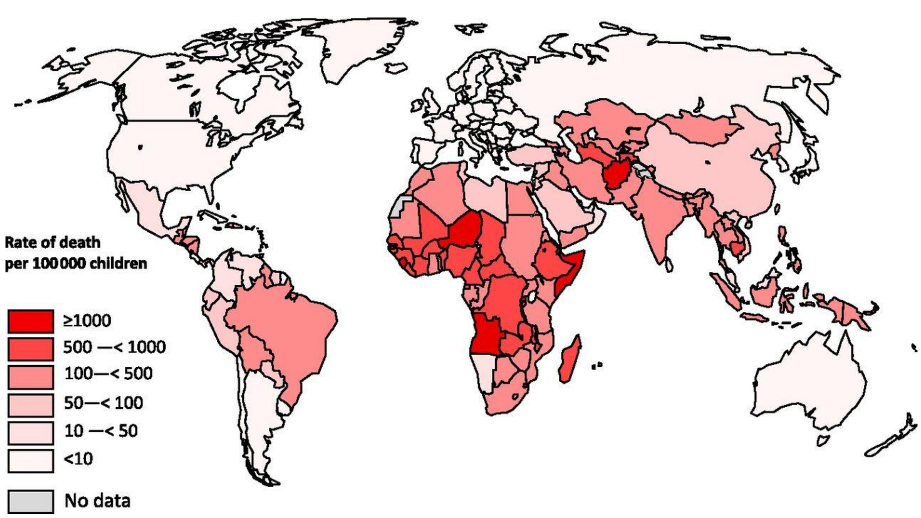

Figure 2. Rates of child mortality due to diarrhea per 100,000 people in 2010.

Health and Economic Impact

While deaths due to diarrhea are decreasing in children, the number of diarrheal episodes in children is not following the same trend. Studies have shown that repeated bouts of diarrhea in children under five result in stunting due to growth faltering (Guerrant et al., 2013). Furthermore, stunting in children leads to a decrease in cognitive development and increased risk of mortality from other infectious diseases such as pneumonia, measles, and malaria (Black, Allen, & Bhutta, 2008).

It is estimated that within a single year, diarrhea cases and deaths in children under five were responsible for 40 million DALYs (Wierzba & Muhib, 2018). An increase in DALYs leads to decreased economic opportunity as children miss school, adults miss work, and health outcomes lead to health care bills. Health system and household costs for diarrhea can be a major burden in low-income settings.

A study in Malawi found that rural inpatient costs for diarrheal treatment was roughly $19 including lost income, while the average person lives on $1.25 per day (Hendrix et al., 2017). A study in Kenya, Gambia, and Mali asked participants why the household did not seek care for their child who had diarrhea and 36.5%, 22.5%, and 23.3%, respectively, said treatment costs were a barrier (Rheingans et al., 2012). Of the participants that did seek care in Kenya, Gambia, and Mali, it was reported that 34.3%, 44.1%, and 65.6%, respectively, had to use their savings in order to cover the cost of treatment (Rheingans et al., 2012). While many treatments do exist for diarrhea including oral rehydration therapies, antibiotics, and zinc, the cost and income lost to seek care can prevent households from properly caring for children who are ill.

<u>Childhood Diarrhea in Sierra Leone</u>

Morbidity and Mortality

Due to poor WASH infrastructure, low access to health care, and high rates of poverty, Sierra Leone suffers from high diarrheal rates in children. In 2013, Sierra Leone reported that 18% of deaths among children under five were caused by diarrhea (Carvajal-Velez et al., 2016). Another study found that in 2015, Sierra Leone had one of the highest diarrhea-related case fatality rates in Africa at 16 per 10,000 children (Reiner et al., 2018). For comparison, the median country-level diarrhea-related case fatality rate for all countries in the study was 5 cases per 10,000 children (Reiner et al., 2018). According to the CDC, diarrheal disease rank fourth as top causes of death in Sierra Leone behind malaria, lower respiratory infections, and neonatal disorders (CDC, 2019). Many of the diarrheal deaths are preventable with access to treatment and improved infrastructure.

The Demographic and Health Survey (DHS) conducted in 2013 in Sierra Leone found that 11% of children under five had diarrhea within two weeks of the survey, and 2.4% had blood in their stool (Statistics Sierra Leone, 2014). Furthermore, the Moyamba District had a diarrhea rate of 14.8% in children under five within two weeks of the survey being administered (Statistics Sierra Leone, 2014). The data also showed that younger children between 6-35 months were more prone to diarrhea with rates as high as 14.8% compared to the overall 11%, but this could potentially be explained by children at this age being introduced to complementary foods in addition to breast feeding (Statistics Sierra Leone, 2014).

Prevention, Control, and Treatment of Diarrhea

According to WHO, key measures to prevent diarrhea include access to safe drinking water, use of improved sanitation, hand washing with soap, exclusive breastfeeding during the first six months of life, adequate personal and food hygiene, health education about disease transmission, and rotavirus vaccination (WHO, 2017).

In Sierra Leone, the country has taken a comprehensive approach targeting the control of diarrheal disease. Oral rehydration solution (ORS) and zinc have been added to the Essential Medicines List, volunteers and community-based distributors are trained to maintain ORS supply chains, and communities are educated about proper treatment of diarrhea with ORS (Wilson, Morris, & Gilbert, 2012).

As is the case in many countries, Sierra Leone treats diarrheal disease in children through oral rehydration therapy and antibiotics. In 2013, DHS found that 65% of children with diarrhea were taken to a health care facility to receive treatment. Of those that sought medical care, 90% of children received oral rehydration therapy, 85% received ORS, and 48% were given antibiotics (Statistics Sierra Leone, 2014). Treatment options are available but as stated previously, cost and access to health facilities can be barriers. The spread of diarrhea continues in Sierra Leone, and many low-income countries, because of various risk factors such as water, sanitation, and hygiene and socioeconomic factors.

Water, Sanitation and Hygiene (WASH) Globally

Sustainable Development Goal #6

The Sustainable Development Goals (SDGs) are a set of 17 goals, each with several targets and indicators, adopted by 193 countries in 2015 to end extreme poverty, reduce inequality, and protect the planet by 2030 (United Nations, 2020). Goal #6 of the SDGs is clean water and sanitation which aims to ensure availability and sustainable management of water and sanitation for all (United Nations, 2020). There has been great progress with this goal, yet billions of people still lack safe water, sanitation and handwashing facilities. In 2017, at least 785 million people worldwide lacked a basic drinking water service, over 2 billion people lacked access to improved sanitation, and roughly 3 billion people lacked handwashing facilities at home (United Nations, 2020). Notably, nearly 700 million of the 2 billion people who lack access to improved sanitation practice open defecation (United Nations, 2020). Achieving SDG #6 by 2030 would require doubling the current annual rate of progress which implies that most countries are unlikely to reach the targets within this time period.

WASH Impacts on Health

WASH interventions have been used to target several health outcomes throughout the world by governments, non-profit organizations, and local communities alike. Without access to handwashing and sanitation facilities, improved access to drinking water sources does not provide a sustainable benefit. Thus, the three factors go hand in hand and provide beneficial socio-economic impacts, especially for women and girls. Education, violence against women and girls, and maternal and newborn health are three key areas that are heavily impacted by WASH, aside from diarrhea.

Adequate WASH can improve education through various ways such as children spending less time fetching water for their families and girls attending school even when they are menstruating. Children are often given the duty of fetching water for their household which leads to missed classes, especially if they must make multiple trips per day to collect water (Hemson, 2007). One study performed in 25 countries in sub-Saharan Africa estimated that, collectively, children spent nearly 4 million hours each day collecting water, undeniably affecting their ability to attend school (Mills & Cumming, 2016). In addition, there is strong qualitative evidence of challenges associated with menstrual hygiene management among schoolgirls and absenteeism

(Mills & Cumming, 2016). Women and girls require access to clean water, soap, and a toilet, both at home or in school, in order to manage menstrual hygiene properly and with dignity, which means when this access is denied, young girls will likely not attend school.

Improved WASH infrastructure and behavior change has had a profound impact on violence against women and girls (Mills & Cumming, 2016). Women who must walk long distances to fetch water or have to go out late at night to defecate due to cultural norms are at increased risk for violence and sexual abuse. Furthermore, case studies have shown that poor access to WASH services has led to vulnerability, rape and sexual assaults, and fear of assault, all of which prevent women and children from using sanitation facilities at night (Mills & Cumming, 2016). One study in Kenya found that women who did not have a sanitation facility had 38% greater of odds of experiencing non-partner violence within the last 12 months compared to women that reported using a sanitation facility (Winter & Barchi, 2016).

Poor handwashing and unprotected water sources in healthcare facilities put maternal and newborn health in danger and contribute to high rates of maternal mortality and neonatal deaths (WHO, 2019). Birth attendant hygiene has direct effects on maternal infection making it critical for health facilities to have clean water and soap for handwashing (Mills & Cumming, 2016). Poor sanitation has indirect effects on maternal health including increased risk of pre-eclampsia and anemia caused by urinary tract infections arising from delayed urination or reduced water or food intake due to lack of sanitation facilities (Mills & Cumming, 2016). WASH has a significant impact on various health outcomes but, arguably, is the most important preventative factor for diarrheal disease.

WASH as a Risk Factor for Diarrhea

It is estimated that 88% of cases of diarrhea worldwide are attributable to unsafe water, inadequate sanitation, or insufficient hygiene (Pruss-Ustun & WHO, 2008). Many pathogens that cause diarrhea are transmitted fecal-orally through flies, fields, fingers, fomites, fluids, and food as was shown in Figure 1. Unsafe WASH promotes the transmission of these pathogens and leads to at least 1.4 million preventable child deaths per year (Pruss-Ustun & WHO, 2008).

Weather events such as heavy rainfall and flooding likely increase risk of diarrhea in areas that have poor sanitation facilities. Open defecation allows for feces to travel during these weather events and impact households nearby even if they are using improved sanitation facilities. Furthermore, this contaminates water sources and puts entire communities at risk even if only a few households openly defecate.

Improved water, sanitation, and hygiene infrastructure has been shown to reduce the transmission of pathogens and put fewer individuals at risk for diarrheal disease. However, unless the infrastructure is well maintained and communities are educated on proper use and are motivated to use it, the effects will not be sustained. Therefore, it is necessary to take all of these factors into consideration when implementing WASH interventions aimed at reducing diarrhea.

Disposal of Child Feces from Non-Potty-Trained Children as a Risk Factor for Diarrhea

Sanitation interventions often overlook where children’s stool is disposed of for those who are not potty-trained which makes the household susceptible to diseases if it is being disposed of unsafely. Common places for the disposal of children’s stool include latrines, throwing it outside in a bush, burying it, or throwing it in a nearby water source. The only safe disposal is to throw it in a latrine or sanitation facility. A study in India found that 79% of children’s stools were disposed of unsafely, and they found a significant statistical association between children's stool disposal and childhood diarrhea (Bawankule et al., 2017). In Indonesia, researchers used a cross-sectional data set from a recent national household survey to examine associations between diarrhea and WASH characteristics and found that the unsafe disposal of child feces was associated with increased odds of childhood diarrhea (OR: 1.46; 95% CI: 1.18-1.82, p= 0.001) (Cronin et al., 2016). In 2013, the DHS in Sierra Leone found that 75% of children's stools were disposed of safely, however, this was much more common in urban areas than rural and varied by wealth status (Statistics Sierra Leone, 2014). These studies highlight the need to consider safe disposal of child feces when implementing programs targeting WASH or diarrhea.

WASH in Sierra Leone

National Policies

In rural households in Sierra Leone, over 50% use unprotected sources for drinking water and over 60% use unimproved sanitation facilities (Statistics Sierra Leone, 2014). This is a major issue and is being addressed by national policies in Sierra Leone with the help of WHO. The Ministry of Health in Sierra Leone and WHO are developing a new Public Health Ordinance which will replace the country's 1960 Public Health Act and align this ordinance with the requirements of the International Health Regulations (WHO, 2017). WHO supported the effort to strengthen water quality monitoring by providing portable testing kits in Freetown and various districts and also providing training of Ministry staff on the use of the kits (WHO, 2017).

Diarrhea and WASH in Sierra Leone

In 2013, a qualitative study was conducted to gather information on local understandings of diarrhea causes and prevention through in-depth interviews and focus groups in rural Sierra

Leone (McMahon et al., 2013). In villages further than three miles from health facilities, not one participant believed that unwashed hands of the child or mother contributed to diarrheal disease or that a child playing with its own feces was an issue; however, many believed that exposure to contaminated drinking water was a cause of diarrhea (McMahon et al., 2013). Other common causes of diarrhea that participants discussed were exposure to contaminated breast milk, bad spirits, and eating too much of a certain food (McMahon et al., 2013). It is necessary to for communities to understand what does and does not cause diarrhea in order to lessen the burden and prevent disease.

Socioeconomic Risk Factors for Diarrhea

Socioeconomic risk factors are often controlled for or associated with diarrhea in the literature (Melese et al., 2019; Okour, Al-Ghazawi, & Gharaibeh, 2012; McMahon et al., 2013). Specifically, head of household education, household income, and household flooring material are common risk factors that have been identified in diarrheal studies and were utilized in this project as well (McMahon et al., 2013; Kalakheti, Panthee, & Jain, 2016; Cattaneo et al., 2009). Presumably, caretakers with higher education have knowledge regarding proper hygiene use and therefore, children in these households may have lower rates of diarrhea (McMahon et al., 2013). Households with higher incomes may have the financial means to buy soap for handwashing or to build a latrine or protected dug well, and children in these households may have lower diarrheal rates (Okour, Al-Ghazawi, & Gharaibeh, 2012). Household flooring material and/or roofing material has been associated with childhood diarrhea in households that have mud floors (Melese et al., 2019). Additionally, poverty probability index (PPI) bases poverty status estimates on quality of life indicators rather than just income and provides the proportion of participants living below a specific poverty line. The Children of the Nations organization that sponsored this study was interested in using PPI as a risk factor in this study in addition to income to identify any differences between the two.

Poverty Probability Index (or Progress out of Poverty Index)

The Poverty Probability Index (PPI) is a poverty measurement tool that asks 10 questions about a household's characteristics and asset ownership and computes a predetermined score to understand the likelihood that the household is living below the poverty line (Innovations for Poverty Action, 2020). The questions include how many members the household has, if all members ages 6 to 13 are in school, main occupation of the female head, how many rooms the house has, main flooring material, main construction material of the outside walls, type of toilet used, main source of lighting, main fuel for cooking, and number of radios in the household. Each question has response choices that represent various points so the total score can be calculated by the researcher at the end. In Sierra Leone, a PPI score of 55-59 represents about 45% below the poverty line (Innovations for Poverty Action, 2011). PPI can be used as a wealth index, similar to how income or wealth quantiles are used in studies with diarrhea as the outcome.

A study in Kenya distributed biological sand filters to remove turbidity and fecal coliforms in water and included PPI as a risk factor for successfully operating the filters. They found that non-operational filters were found in households with an average PPI of 29.7, while operational filters were found in households with an average PPI of 41 (Lackey, Semmendinger, & MacCarthy, 2019). This suggests that households with lower PPI may not have the resources or means to maintain safe WASH practices.

Household Flooring Material

Household flooring material has been studied as a socioeconomic risk factor for diarrhea. In developing countries, the flooring material is often made of mud or dirt in poorer households and cement or wood in wealthier households. A study in Ethiopia found that household flooring material consisting of mud instead of cement [OR: 3.22; 95% CI: (1.16, 8.91)] was significantly associated with the occurrence of diarrheal disease in children under five (Melese et al., 2019). This could be related to a clean home environment which is critical for reducing the transmission of pathogens that cause diarrhea (Melese et al., 2019). According to a study done by the World Bank in Mexico, a complete substitution of dirt floors by cement floors in households led to a 49% reduction in diarrhea (Cattaneo et al., 2009). Furthermore, a study in Saudi Arabia found a diarrhea prevalence rate of 15.3% in children with homes that had mud floors compared to a rate of 7.5% in children with homes that had cement floors; this difference was statistically significant (Al-Mazrou et al., 1995). These studies provide evidence that flooring material should be taken into consideration when studying diarrheal disease in children.

Income

Income can be defined in many ways and can be categorized into yearly, monthly, or daily income. Income can be broken up into quantiles or quintiles depending on tax brackets, or it can be dichotomized based on the sample median as was the case for this thesis. A study in Jordan identified various risk factors contributing to diarrhea in children under five and found that family income was significantly related to the occurrence of diarrhea in an area where the average family income was below the poverty line in Jordan (Okour, Al-Ghazawi, & Gharaibeh, 2012). Another study in Nepal found that the occurrence of diarrhea among children was lower when the income of the parents was more than one US dollar per day ($p=0.01$) (Kalakheti, Panthee, & Jain, 2016). It is necessary to consider income as a risk factor in various health outcomes, including diarrhea, because of its association in previous studies.

Head of Household Education

Head of household education, or primary caregiver or mother's education, is often included as a risk factor in studies relating to diarrhea and WASH. It may be categorized as no school, primary, junior secondary school, and secondary and higher. It may also be categorized simply based on the number of years. For this thesis, it was dichotomized at the median number of years which was zero.

In Ethiopia, a study was conducted to understand risk factors associated with childhood diarrhea, and the researchers found that having a mother or caretaker with no formal education increased odds of diarrhea significantly [OR: 3.97; 95% CI: (1.60, 8.81)] (McMahon et al., 2013). This may be due to educated mother's having a positive influence on hygienic practices, child feeding, and weaning (McMahon et al., 2013).

Research Gaps and Importance

Due to the number of pathogens, various transmission routes, and risk factors involved in diarrhea, it can be complex to study and understand the causative agents at play. WASH interventions are designed to control the spread of diarrheal disease, but the sustainability of the programs can be difficult to maintain. In the rural area of the Upper Banta Chiefdom in the Moyamba District in Sierra Leone, there are no existing studies or interventions at play to understand household WASH practices, socioeconomic risk factors and the morbidity of childhood diarrhea.

This thesis was designed to understand whether WASH practices and socioeconomic factors contribute to diarrheal disease in school-aged children in five villages in the Moyamba District of Sierra Leone. It is necessary to understand possible transmission routes and household characteristics in order to address the burden of diarrhea and develop a strategy to control it.

Chapter 3 – Methodology

Introduction

The purpose of this thesis was to understand whether WASH practices and socioeconomic factors contribute to diarrheal disease in school-aged children in five villages in the Moyamba District of Sierra Leone. Data was collected via paper copy household surveys filled out by the research team. Household surveys were administered from May to July in 2019 in the Moyamba District of Sierra Leone in five villages – Mogborie, Mokpangumba, Ngolala, Ngolala Junction, and Senehun. All five villages are located in a rural area of the Upper Banta Chiefdom within the Moyamba District. The approximate number of households within each village are as follows: 42 households in Mogborie, 73 households in Mokpangumba, 79 households in Ngolala, 127 households in Ngolala Junction, and 17 households in Senehun.

The study team consisted of one United States researcher and five locals from Sierra Leone who helped to mark houses within the villages. Four of the locals were trained on the survey instrument; however, due to various factors, only three of the four locals that were trained assisted with the administration of the survey in the villages. The methodology used for this thesis is outlined in the following sections.

Study Setting and Population

The study region was in the Upper Banta Chiefdom of the Moyamba District in Sierra Leone. There are 16 districts and 190 chiefdoms in Sierra Leone, and within the Moyamba District, there are a total of 14 chiefdoms, as is noted in the figure below. There is one main river in the Chiefdom, called the Jong or Taia River, which separates Mokpangumba from the rest of the villages surveyed. Children of the Nations, the organization that collected the data, is located in Ngolala Junction and serves the surrounding villages.

The sampling process began by marking houses in each of the five villages. This process consisted of one United States researcher and five local Sierra Leoneans walking through each of the villages and numbering houses with chalk. The locals had grown up in the villages and knew the layout which ensured that every house was marked.

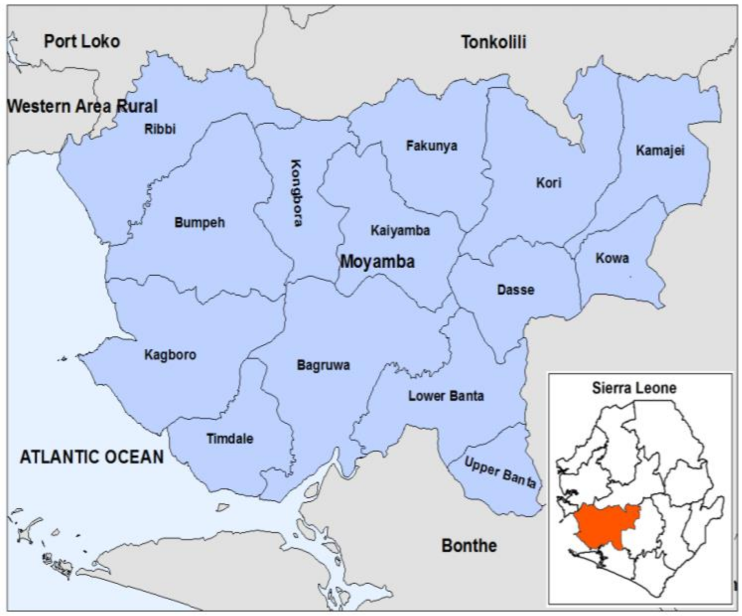

Figure 3. Map showing study region in the Upper Banta Chiefdom of the Moyamba District in Sierra Leone.

After all houses were marked, sample sizes for each village were calculated using 10% precision, 50% prevalence of households having access to an improved sanitation facility and/or protected water source, and a 95% confidence interval which produces a Z score of 1.96. The sample size was then adjusted since the population in each village was less than 25,000. For example, there were 73 households marked in Mokpangumba, so the sample size was calculated using the formula $\frac{1.96^2\ (0.50)(0.50)}{0.10^2}$ which equals 96.04. This was adjusted for a small sample size by taking $\frac{96.04}{[1+\left(\frac{96.04}{73}\right)]}$ which equals 41.5 and was rounded up to 42. Households were picked in each village using a random number generator.

The participants in the study were heads of households, both male and female, or someone residing in the household above the age of 18. The inclusion criteria consisted of any household with at least one school-aged child in it actively attending school. This was defined loosely as children ages 4-17; however, some children were 3 and were enrolled in school and therefore, that household was included. Households that did not have any children in them, or children who were not yet school-aged or attending school, were excluded from the study.

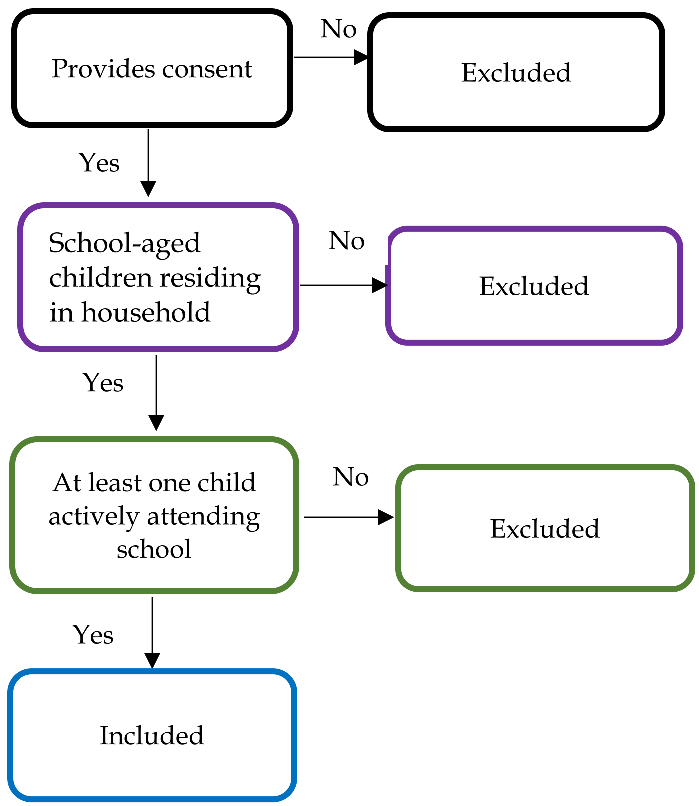

Figure 4. Inclusion and exclusion criteria.

Research and Instrument Design

This study utilized a cross-sectional research design, and the same protocol was used in all five villages. The survey was administered by the research team to all randomly selected households that were eligible and gave consent, asking questions related to wealth, socioeconomic factors, health, education, and WASH practices. Emory IRB was not required for this thesis, as ethical considerations involving human subjects' research was obtained by Children of the Nations. As stated previously, the original research question asked whether household's had access to a sanitation facility and/or protected water source. The purpose of this thesis was to use the secondary data to better understand diarrhea and its potential contributing factors.

The United States researcher, with the help of the Sierra Leone Country Liaison and Country Director from Children of the Nations, developed the survey instrument in English. The survey was translated orally into Krio and Mende, depending on the household, by the local researchers. The United States researcher read the questions aloud in English, and they were then translated by one of the local researchers at the household to ensure that the survey was administered the same way every time. The survey instrument was divided into four main sections including demographics and household characteristics, WASH practices, religion, and general health questions. The full survey can be found in Appendix A.

The demographics and household characteristics section asked questions about the head and female head of household, number of household members, education, household wall and floor materials, number of rooms, main source of lighting and fuel used, and number of radios in the house. The WASH practices section asked question about what kind of toilet and drinking water source are used (how far it is, how many people use it, barriers to using it), diarrhea, materials used for washing hands, reasoning for washing hands, key times for washing hands, primary water collector for the household, and where the household learned about WASH. The religion section asked questions about primary religion in the home, owning a bible, and attending church. The general health questions section asked questions about immunizations, common sicknesses, common medications taken, clinics/hospitals visited by the household, food staples, meals per day, mosquito nets, and income.

In addition to the survey, observations were made by the study team to ensure accuracy of answers for certain questions. Number of rooms, type of lighting and cooking fuel, mosquito nets, wall and floor materials, and type of toilet were observed by the researchers in every household. If there was a discrepancy between what was reported and observed, the researcher noted this and circled the response option corresponding to what was observed.

Procedures

Before the survey was administered in the field, four local staff were trained on the instrument by the United States researcher. The training included background about the survey, process for non-response households, specific questions on the survey and question types, and things to observe in or near the household. The full training materials discussed with the team can be found in Appendix B. After reading through the survey as a group in English, each local staff took a turn translating the questions into Krio and Mende. This ensured that all local staff knew how to ask the questions in both languages, and if they did not know or did not word the question correctly, the other local staff members could assist or explain any inaccuracies.

After training local staff, the survey instrument was piloted with a few of the staff at Children of the Nations who took care of the children residing in the children's homes on site. This population was chosen due to their accessibility and applicability for the survey given that they cared for children who attended school. Each of the local researchers piloted the survey with one of the staff. After this process, it was decided that one of the local researchers was not fit for this project. This process also brought to light confusion with some of the questions by the respondents. Because of this, some questions were modified by changing the instructions for the administrator to read the response options aloud or to circle all that apply or to not read the responses. The survey was then ready for administration in the surrounding villages by three local staff and the Unites States researcher.

After generating random household numbers in each village, the researchers screened each household for school-aged children actively attending school and asked for consent before administering the survey. Surveys were administered via paper copies as the organization determined that tablets or a laptop would not be culturally appropriate for the area. The surveys were then transferred to word documents which were stored on one of the researcher's laptops and on a USB drive. These word documents were verified for accuracy twice to ensure there were no discrepancies between paper copies and word documents. Furthermore, de-identified data from the surveys was transferred to an excel sheet which was also stored on one of the researcher's laptops and a USB drive. The process of transferring data began in Sierra Leone and was verified upon returning to the United States. Data was cleaned in Excel (Microsoft Office 365 ProPlus, 2002), and questions that had multiple responses were comma delineated for easier analysis. The original paper copies of the surveys were left with Children of the Nations in Sierra Leone.

Data Analysis

The excel file containing all survey data was imported into SAS software, 9.4 (SAS Institute Inc., Cary NC). Data from all five villages was merged into one file. There were two questions in the survey where participants selected "not sure" or "don't know." One question asked participants about the immunization history of their children, and the other question asked participants about the family head income per day. For those who answered "not sure" to immunization history, this was coded as an answer choice. For those who answered "don't know" to family head income per day, this was coded as missing.

Descriptive statistics were performed for each variable and the summary of frequencies and percentages can be found in Table 1 in Chapter 4. After descriptive statistics were performed, a few variables were recoded. Head of household education, income, and PPI score were all dichotomized based on the median value for each. Type of toilet was categorized as improved or unimproved, as was type of water source, based on the guidelines set forth by the World Health Organization (WHO). The new variables created from these modifications were used in the remaining analyses.

WHO lists piped household water connection, public standpipe, borehole, protected dug well, protected spring, and rainwater as improved water sources (JMP, 2012). Unimproved water sources include unprotected dug well, unprotected spring, surface water (river, dam, lake, pond, stream, canal, irrigation channel), vendor-provided water, bottled water, and tanker truck water (JMP, 2012). For sanitation, WHO lists sanitation facilities with sewer connections, septic system connections, pour-flush latrines, ventilated improved pit latrines, and pit latrines with a slab or covered pit as improved sanitation (JMP, 2012). Unimproved sanitation facilities include pit latrines without slabs or platforms or open pit, hanging latrines, bucket latrines, open defecation in fields, forests, bushes, bodies of water or other open spaces, or disposal of human feces with other forms of solid waste (JMP, 2012).

Bivariate Chi-square tests of association were performed for various WASH practices with diarrhea as the outcome of interest. More specifically, type of toilet, main water source, and handwashing materials were investigated with diarrhea as the outcome. A p-value less than 0.05 was considered a statistically significant relationship. Then logistic regression analyses were also performed to understand the relationship and effect size changes between the various WASH practices and socioeconomic factors with diarrhea.

For Specific Aim 1, demographics, WASH practices, cases of diarrhea, and the various socioeconomic factors discussed above were analyzed across the five villages using bivariate descriptive statistics.

For Specific Aim 2, a Chi-square test of association was used to determine whether individual WASH practices (type of toilet, water source, handwashing materials) were different for households with children who experienced diarrhea versus those that did not. The null hypothesis stated that individual WASH practices were not different for households with children who experienced diarrhea versus those that did not.

For Specific Aim 3, logistic regression was used to determine whether multiple WASH practices in tandem are risk factors for diarrhea. The various WASH factors were put into the model individually and together to establish whether they were confounding each other. The null hypothesis stated that there was no relationship between WASH practices and diarrhea.

For Specific Aim 4, logistic regression was used to determine whether socioeconomic factors are risk factors for diarrhea. These socioeconomic factors included head of household education, floor material, PPI score, disposal location for child feces, and income. The null hypothesis stated there was no relationship between socioeconomic factors and diarrhea.

For Specific Aim 5, logistic regression was used to determine how WASH practices impact diarrhea when controlling for socioeconomic factors. The null hypothesis stated there was no relationship between WASH practices and diarrhea when controlling for socioeconomic factors.

Ethical Considerations

This project was determined to not be research with human subjects because it is an analysis of secondary data and all data were de-identified prior to analysis. The survey was conducted in May through July of 2019 by trained field staff employed by Children of the Nations.

Chapter 4 – Results

Descriptive Analysis

Demographics

A total of 152 participants from five villages in the Upper Banta Chiefdom of the Moyamba District were enrolled in the study. Of the 152 participants, 22 were enrolled in Mogborie, 42 were enrolled in Mokpangumba, 23 were enrolled in Ngolala, 55 were enrolled in Ngolala Junction, and 10 were enrolled in Senehun. The majority of heads of households were male (71.7%) and aged 22-42 (46.1%), followed by ages 43-62 (36.8%) and 63-96 (17.1%). Most households had 10 or more members in them (32.2%) followed by households with seven, eight, or nine members (29.0%). Additional demographic characteristics are reported in Table 1 below.

Water, Sanitation, and Hygiene (WASH) Factors

Univariate WASH factors of interest were type of water source, type of toilet, and handwashing materials. Unprotected water sources were most common with 71.1% of all participants using unprotected dug wells or surface water such as a lake, river, or stream. Notably, the majority of each village reported using unprotected water sources except for Senehun, where 90% of participants reported using a protected water source such as a borehole. Whereas, 100% of the 42 participants in Mokpangumba reported using unprotected water sources such as a lake, river, or stream.

For type of toilet, 61.8% of all participants in the study reported using an unimproved sanitation facility such as openly defecating in a bush or using a pit latrine without a slab. This trend was seen in Mogborie, Mokpangumba, and Ngolala where 86.4%, 83.3% and 78.3%, respectively, reported using an unimproved sanitation facility. However, the opposite was true for Ngolala Junction and Senehun with 63.6% and 80%, respectively, reporting use of improved sanitation facilities.

Finally, more participants overall reported using soap and water (52.6%) for handwashing materials as opposed to just water. This did not hold true for Mogborie, Mokpangumba, and Ngolala where more than half of the participants reported using water only for handwashing. Additional results for univariate WASH factors can be found in Table 1.

Socioeconomic Factors

Socioeconomic factors of interest included head of household education, head of household income, poverty probability index (PPI) score, household flooring material, and disposal location of child feces for children who are not potty trained. Overall, 65.8% reported no head of household education. This trend of no education among heads of households held true across all villages as shown in Table 1.

Head of household income was dichotomized at the median value for all participants which was 10,000 leones per day. Over half of the participants had daily household income less than 10,000 leones. However, in Ngolala Junction, 65.5% of participants had daily household income greater than or equal to 10,000 leones.

As a reminder, PPI was scored based on responses to 10 specific questions in the survey. Each response for each question has a standard point value assigned to it. PPI score was dichotomized at the median value for all participants which was 43, with a minimum value of 21 and maximum value of 81. Overall, just over 50% had a PPI score equal to or greater than 43. This trend was true for Ngolala Junction and Senehun; however, Mogborie, Mokpangumba and Ngolala all had nearly 60% of participants with PPI scores less than 43.

Table 1. Descriptive statistics for bivariate relationships between villages and demographics, WASH factors, socioeconomic factors, and the outcome of interest (diarrhea).

Villages	**Mogborie (N=22)**	**Mokpangumba (N=42)**	**Ngolala (N=23)**	**Ngolala Junction (N=55)**	**Senehun (N=10)**	**N = 152**
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Demographics						
Age of Head of Household						
22-42	8 (36.4)	20 (47.6)	7 (30.4)	31 (56.4)	4 (40.0)	70 (46.1)
43-62	9 (40.9)	16 (38.1)	7 (30.4)	19 (34.5)	5 (50.0)	56 (36.8)
63-96	5 (22.7)	6 (14.3)	9 (39.1)	5 (9.1)	1 (10.0)	26 (17.1)
Sex of Head of Household						
Male	17 (77.3)	34 (81.0)	13 (56.5)	40 (72.3)	5 (50.0)	109 (71.7)
Female	5 (22.7)	8 (19.0)	10 (43.5)	15 (27.3)	5 (50.0)	43 (28.3)
Number of Household Members						
One, two, or three	1 (4.5)	6 (14.3)	2 (8.7)	2 (3.6)	1 (10.0)	12 (7.9)
Four	3 (13.6)	3 (7.1)	0 (0)	4 (7.3)	0 (0)	10 (6.6)
Five	3 (13.6)	5 (11.9)	5 (21.7)	6 (10.9)	0 (0)	19 (12.5)
Six	3 (13.6)	6 (14.3)	2 (8.7)	4 (7.3)	3 (30.0)	18 (11.8)
Seven, eight, or nine	7 (31.8)	13 (31.0)	4 (17.4)	17 (30.9)	3 (30.0)	44 (29.0)
Ten or more	5 (22.7)	9 (21.4)	10 (43.5)	22 (40.0)	3 (30.0)	49 (32.2)
WASH Factors						
Type of Water Source						
Protected	2 (9.1)	0 (0)	8 (34.8)	25 (45.5)	9 (90.0)	44 (28.9)
Unprotected	20 (90.9)	42 (100)	15 (65.2)	30 (54.5)	1 (10.0)	108 (71.1)
Type of Toilet						
Improved	3 (13.6)	7 (16.7)	5 (21.7)	35 (63.6)	8 (80.0)	58 (38.2)
Unimproved	19 (86.4)	35 (83.3)	18 (78.3)	20 (36.4)	2 (20.0)	94 (61.8)
Handwashing Materials						
Soap and Water	8 (36.4)	16 (38.1)	11 (47.8)	38 (69.1)	7 (70.0)	80 (52.6)
Water Only	14 (63.6)	26 (61.9)	12 (52.2)	17 (30.9)	3 (30.0)	72 (47.4)
Socioeconomic Factors						
Head of Household Education						
0 years	11 (50.0)	33 (78.6)	19 (82.6)	31 (56.4)	6 (60.0)	100 (65.8)
> 0 years	11 (50.0)	9 (21.4)	4 (17.4)	24 (43.6)	4 (40.0)	52 (34.2)
Head of Household Income						
< 10,000 leones per day	12 (54.5)	29 (69.0)	13 (56.5)	19 (34.5)	5 (50.0)	78 (51.3)
≥ 10,000 leones per day	10 (45.5)	13 (31.0)	10 (43.5)	36 (65.5)	5 (50.0)	74 (48.7)
PPI						
< 43	13 (59.1)	26 (61.9)	13 (56.5)	17 (30.9)	4 (40.0)	73 (48.0)
≥ 43	9 (40.9)	16 (38.1)	10 (43.5)	38 (69.1)	6 (60.0)	79 (52.0)
Household Flooring Material						
Mud	14 (63.6)	32 (76.2)	13 (56.5)	14 (25.5)	7 (70.0)	80 (52.6)
Cement	8 (36.4)	10 (23.8)	10 (43.5)	41 (74.5)	3 (30.0)	72 (47.4)
Disposal Location of Child Feces						
Taken to the Latrine	4 (18.2)	8 (19.0)	8 (34.8)	35 (63.6)	4 (40.0)	59 (38.8)
Buried Outside	1 (4.5)	0 (0)	0 (0)	2 (3.6)	0 (0)	3 (2.0)
Thrown in Bush	16 (72.7)	33 (78.6)	15 (65.2)	18 (32.7)	3 (30.0)	85 (55.9)
Other	1 (4.5)	1 (2.4)	0 (0)	0 (0)	3 (30.0)	5 (3.3)
Health Outcome of Interest						
Diarrhea Cases[1]						
Yes	5 (22.7)	4 (9.5)	2 (8.7)	9 (16.4)	1 (10.0)	21 (13.8)
No	17 (77.3)	38 (90.5)	21 (91.3)	46 (83.6)	9 (90.0)	131 (86.2)

[1] Diarrhea was reported in response to the question, "Have any of your children had diarrhea within the last two weeks (3 or more loose stools in a day)?"

Household flooring material in the five villages consisted of either mud or cement. Overall, 52.6% had mud floors in their households. The majority of all villages had households with mud floors, except for Ngolala Junction where 74.5% of households surveyed had cement floors.

Various locations of discarded stool for children who are not potty-trained included stool being taken to the latrine, buried outside, thrown in a bush, or other. Over half of all participants (55.9%) reported throwing the discarded stool into a bush. Additionally, nearly 40% of participants reported disposing of the child feces in the latrine.

Diarrhea

Diarrhea was the primary health outcome of interest for this study and was recorded as yes or no in response to the survey question, "Have any of your children had diarrhea within the last two weeks (3 or more loose stools in a day)?" There were 21 cases of diarrhea (13.8%) reported by 152 participants, with nine of those cases reported in Ngolala Junction. Additionally, five cases were reported in Mogborie, and four cases were reported in Mokpangumba. In Ngolala, two cases of diarrhea were reported followed by just one case in Senehun. Table 1 includes all data for diarrhea.

<u>Chi-square Analysis</u>

Individual WASH factors and the outcome of interest, diarrhea, were analyzed using the Chi-square goodness of fit test. The results of this analysis can be found in Table 2 below. The Chi-square value for type of toilet as the independent variable with diarrhea was 1.36 (p=0.244) with 15 of the 21 cases of diarrhea coming from those who use unimproved sanitation facilities. The Chi-square value for type of water source as the independent variable with diarrhea was 1.16 (p=0.281) with 17 of the 21 cases of diarrhea coming from those who use unprotected water sources. The Chi-square value for handwashing as the independent variable with diarrhea was 2.07 (p=0.151) with 13 of the 21 cases of diarrhea coming from those who used water only to wash their hands. Despite the recognized trend of increased diarrhea with poor WASH practices, none of the Chi-square analyses reached statistical significance.

Table 2. Chi-square relationships between individual WASH variables and diarrhea cases.

	Type of Toilet		
Diarrhea	**Unimproved**	**Improved**	**Total**
No	76	55	131
Yes	15	6	21
Total	91	61	152
	$\chi2$ = 1.36, p-value = 0.244		
	Type of Water Source		
Diarrhea	**Protected**	**Unprotected**	**Total**
No	40	91	131
Yes	4	17	21
Total	44	108	152
	$\chi2$ = 1.16, p-value = 0.281		
	Handwashing Materials		
Diarrhea	**Soap and Water**	**Water Only**	**Total**
No	72	59	131
Yes	8	13	21
Total	80	72	152
	$\chi2$ = 2.07, p-value = 0.151		

Logistic Regression with WASH Factors

Each WASH factor (variables for water, sanitation, and hygiene from Table 1) was placed into the logistic regression model in order to understand the odds of a child having diarrhea based on individual WASH practices. The other WASH practices were then added into the model, one at a time, and then all together in order to determine if they were confounding each other. For example, type of toilet was placed into the model individually, and then type of water source and handwashing materials were also placed into the model with type of toilet to identify potential confounding relationships. The results are shown in Table 3 below.

For type of water source, the odds of a child having diarrhea are 0.535 as high for a household using a protected water source as for a household using an unprotected water source (99% CI: 0.118, 2.429). Controlling for type of toilet and handwashing materials, the odds of a child having diarrhea are 0.672 as high for a household using a protected water source as for a household using an unprotected water source (99% CI: 0.127, 3.557).

For type of toilet, the odds of a child having diarrhea are 1.809 as high for a household using an unimproved sanitation facility as for a household using an improved sanitation facility (99% CI: 0.481, 6.808). Controlling for type of water source and handwashing materials, the odds of a child having diarrhea are 1.264 as high for a household using an unimproved sanitation facility as for a household using an improved sanitation facility (99% CI: 0.272, 5.869).

For handwashing materials, the odds of a child having diarrhea are 0.504 as high for a household using soap and water to wash hands as for a household using water only to wash hands (99% CI: 0.146, 1.747). Controlling for type of water source and toilet, the odds of a child having diarrhea are 0.582 as high for a household using soap and water to wash hands as for a household using only water to wash hands (99% CI: 0.154, 2.199).

Logistic Regression with Socioeconomic Factors

Each socioeconomic factor was placed into the logistic regression model in order to understand the odds of a child having diarrhea based on individual socioeconomic factors. As a reminder, the socioeconomic factors included head of household education, income, PPI, disposal location of child feces, and household flooring material. The results are shown below in Table 4. For disposal location of child feces, the odds of a child having diarrhea are 0.528 as high for a household discarding stool in a latrine for children who are not potty trained as for a household throwing discarded stool in a bush (99% CI: 0.140, 1.997). For household flooring material, the odds of a child having diarrhea are 1.012 as high for a household with cement floors as for a household with mud floors (99% CI: 0.301, 3.401). The results are shown in Table 4.

Table 3. Odds ratios for relationships between WASH variables and diarrhea when controlling for various WASH confounders.

Diarrhea vs. WASH Variables			
Independent Variable	**Potential Confounder**	**Odds Ratio (99% Confidence Interval)**	**% Change from Crude**
Water source	-	0.535 (0.118, 2.429)	-
Water source	Toilet	0.659 (0.124, 3.488)	+23.1
Water source	Handwashing materials	0.609 (0.130, 2.847)	+13.8
Water source	Toilet and handwashing materials	0.672 (0.127, 3.557)	+25.6
Toilet	-	1.809 (0.481, 6.808)	-
Toilet	Water source	1.536 (0.357, 6.613)	-15.1
Toilet	Handwashing materials	1.468 (0.354, 6.078)	-18.9
Toilet	Water source and handwashing materials	1.264 (0.272, 5.869)	-30.1
Handwashing materials	-	0.504 (0.146, 1.747)	-
Handwashing materials	Toilet	0.576 (0.152, 2.180)	+14.2
Handwashing materials	Water source	0.546 (0.154, 1.932)	+8.3
Handwashing materials	Water source and toilet	0.582 (0.154, 2.199)	+15.5

Table 4. Odds ratios for relationship between various socioeconomic factors and diarrhea.

Diarrhea vs. Socioeconomic Factors	
Independent Variable	**Odds Ratio (99% Confidence Interval)**
PPI	0.654 (0.193, 2.219)
Head of Household Income	0.952 (0.283, 3.198)
Disposal Location of Child Feces	0.528 (0.140, 1.997)
Household Flooring Material	1.012 (0.301, 3.401)
Head of Household Education	0.519 (0.153, 1.766)

Logistic Regression with WASH Factors, Controlling for Socioeconomic Factors

Water

Type of water source was the first independent WASH variable of interest in the logistic regression model with diarrhea as the outcome of interest. Various socioeconomic factors were then added to the model in order to identify potential confounders. A confounder was identified when the adjusted odds ratio changed by 10% or more when compared to the crude odds ratio. This was true for all WASH variables.

When disposal location of child feces for children who are not potty trained was controlled for with water source as the independent variable, the odds ratio was 0.687 (99% CI: 0.139, 3.398) which was an increase of 28.4% from the crude value. No other socioeconomic factors were found to be confounders. Refer to Table 5 for the logistic regression models highlighting these relationships.

Sanitation

With sanitation as the independent variable and diarrhea as the outcome of interest, three socioeconomic factors were identified as confounders. When controlling for household flooring material, the odds ratio was 2.113 (99% CI: 0.486, 9.192) which was a 16.8% increase from the crude value. When controlling for location of discarded stool for children who are not potty trained, the odds ratio was 1.313 (99% CI: 0.164, 10.539) which was a 27.4% decrease from the crude value. Finally, when controlling for head of household education, the odds ratio was 2.108 (99% CI: 0.539, 8.240) which was a 16.5% increase from the crude value. Refer to Table 5 for the logistic regression models highlighting these relationships.

Hygiene

With handwashing materials as the independent variable and diarrhea as the outcome of interest, location of discarded stool for children who are not potty-trained was the only confounder identified. When controlling for this variable, the odds ratio was 0.64 (99% CI: 0.171, 2.394) which was a 30% increase from the crude value. Other values can be found in Table 5 below.

<u>Full Logistic Regression Models, Controlling for WASH and Socioeconomic Factors</u>

Water

The purpose of running the full logistic model for each WASH variable while controlling for other WASH variables and socioeconomic factors that were previously identified as confounders is to show the impact of the variables on diarrhea as reported by the odds ratio. Three confounders were identified in previous analyses with water as the independent variable. The confounders were type of toilet, handwashing materials, and disposal location of child feces. When controlling for these with type of water source, the final odds ratio was 0.707 (99% CI: 0.134, 3.727). This finding, along with the models for sanitation and hygiene, can be found in Table 6 below.

Sanitation

Five confounders were identified in previous analyses with type of toilet as the independent variable. The confounders were water source, handwashing materials, household flooring material, location of discarded stool, and head of household education. When controlling for all of these with sanitation, the final odds ratio was 1.30 (99% CI: 0.139, 12.178).

Hygiene

Three confounders were identified in previous analyses with handwashing materials as the independent variable. The confounders were water source, type of toilet, and location of discarded stool. When controlling for all of these with handwashing materials, the final odds ratio was 0.812 (99% CI: 0.219, 3.009).

Table 5. Odds ratios for relationships between WASH variables and diarrhea when controlling for various socioeconomic factors.

Diarrhea vs. WASH Variables, Controlling for Socioeconomic Factors			
Independent Variable	**Potential Confounder**	**Odds Ratio (99% Confidence Interval)**	**% Change from Crude**
Water source	-	0.535 (0.118, 2.429)	-
Toilet	-	1.809 (0.481, 6.808)	-
Handwashing materials	-	0.504 (0.146, 1.747)	-
Water source	PPI	0.582 (0.124, 2.736)	+8.8
Toilet	PPI	1.636 (0.365, 7.325)	-9.6
Handwashing materials	PPI	0.539 (0.150, 1.940)	+6.9
Water source	Head of Household Income	0.515 (0.107, 2.479)	-3.7
Toilet	Head of Household Income	1.867 (0.473, 7.370)	+3.2
Handwashing materials	Head of Household Income	0.494 (0.138, 1.761)	-2.0
Water source	Household Flooring Material	0.516 (0.110, 2.427)	-3.6
Toilet	Household Flooring Material	2.113 (0.486, 9.192)	+16.8
Handwashing materials	Household Flooring Material	0.47 (0.128, 1.731)	-6.7
Water source	Location of Discarded Stool	0.687 (0.139 3.398)	+28.4
Toilet	Location of Discarded Stool	1.313 (0.164, 10.539)	-27.4
Handwashing materials	Location of Discarded Stool	0.64 (0.171, 2.394)	+30.0
Water source	Head of Household Education	0.532 (0.116, 2.434)	-0.56
Toilet	Head of Household Education	2.108 (0.539, 8.240)	+16.5
Handwashing materials	Head of Household Education	0.494 (0.141, 1.727)	-2.0

Table 6. Odds ratios for relationship between individual WASH variables and diarrhea when controlling for all confounders.

Diarrhea vs. WASH Variables, Controlling for All Confounders		
Independent Variable	**Confounders**	**Odds Ratio (99% Confidence Interval)**
Water source	Toilet, handwashing materials, disposal location of child feces	0.707 (0.134, 3.727)
Toilet	Water source, handwashing materials, household flooring material, disposal location of child feces, head of household education	1.30 (0.139, 12.178)
Handwashing materials	Water source, toilet, disposal location of child feces	0.812 (0.219, 3.009)

Chapter 5 – Discussion, Recommendations, and Conclusion

Discussion

The goal of this thesis was to determine whether water, sanitation, and hygiene practices in addition to various socioeconomic factors contribute to diarrheal disease in school-aged children in the five villages surveyed in the Moyamba District of Sierra Leone. Quantitative methods were used to administer a survey to 152 households throughout the five villages and perform statistical analyses in SAS to generate results.

Household demographics of the study sample were consistent with what was expected as most heads of households were younger men, and most households had more than seven people living in them. Socioeconomic factors were similar throughout all villages, suggesting that most households share the same risk factors. The majority of heads of households had no education (>65%) as was seen across all villages. The lack of education in that generation may be due to the civil war that struck in Sierra Leone from 1991-2002 leaving a lasting impact on the surviving population. Most heads of households make less than 10,000 leones per day which equates roughly to $1.12 USD. This trend held true in every village except Ngolala Junction where 65.5% of respondents made more than 10,000 leones per day. Ngolala Junction was the largest village surveyed, and it is the village responsible for most of the trade in the region which could potentially allow individuals to make more income than in other areas. Household flooring material consisted of either mud or cement and was split evenly throughout the villages. The majority of child feces was disposed of in a bush which coincides with the lack of sanitation facilities in the villages to dispose of the feces properly.

WASH factors were surprising as some results did not show the expected 50% prevalence of households using safe WASH practices. In fact, less than 30% of households were using a protected water source, and only 38% were using an improved sanitation facility. These results varied by village where one village had 100% of respondents report using unprotected water sources, and yet another village had 90% of respondents report using a protected water source. This variation was seen also with sanitation facilities as one village had over 60% of respondents report using an improved sanitation facility. Over 52% of households reported using soap and water to wash hands which was expected.

Many respondents stated that they used to have a pit latrine, but it filled up and they had not built another one. Some also stated that they were using boreholes with pumps, but the pumps were broken, or the water became contaminated and they had to revert to using the stream or an unprotected well. The unexpected lack of safe WASH practices and access to protected and improved facilities across the villages suggest that multifaceted interventions may be needed to address these issues, and the interventions must be sustainable and maintained by local community members.

The prevalence of diarrhea in school-aged children was 13.8%. This was very similar to what DHS found in 2013 in Sierra Leone where 14.8% of respondents reported diarrhea in children under five in the Moyamba District (Statistics Sierra Leone, 2014). Some villages reported diarrheal rates as high as 22.7% and 16.4% which suggests that the prevalence could be higher than what was reported overall.

While no statistically significant Chi-square values were found, the analysis showed that most diarrhea cases occurred in households using unsafe WASH practices. For example, 15 out of 21 diarrhea cases were in households using unimproved sanitation facilities, and 17 out of 21 diarrhea cases were using unprotected water sources. Additionally, 13 out of 21 diarrhea cases came from those using water only to wash their hands with no soap. This information suggests that these practices may be contributing to the spread of diarrhea, as 88% of diarrhea cases worldwide are attributable to unsafe water, sanitation, and hygiene (Pruss-Ustun & WHO, 2008).

Logistic regression analyses produced odds ratios that were expected based on WASH practices and socioeconomic factors that were known to contribute to the spread of diarrhea or be protective and prevent its transmission. Those who used an unimproved sanitation facility were at greater odds for diarrhea, and those who used a protected water source and washed their hands with soap and water both had decreased odds for diarrhea. Similar results were found in a study in Indonesia looking at risk factors for childhood diarrhea where researchers reported a statistically significant relationship between sanitation and diarrhea and also handwashing with soap and diarrhea rates (Conin et al., 2016). The odds ratios changed as WASH factors were added to the model, suggesting a confounding relationship between type of toilet, type of water source, and handwashing materials.

The socioeconomic factors that showed a protective effect were PPI score, safe disposal location of child feces, and head of household education. A study in Ethiopia found that households that used unsafe disposal methods for child feces, such as throwing it in an open field or nearby water source, were three times more likely to have a child that experienced diarrhea (Melese et al., 2019). This highlights the intersectionality of WASH as it is possible to use an improved sanitation facility but throw child feces into a nearby stream that others use to drink and further contribute to the spread of pathogens. Both head of household income and household flooring material showed no effect as both odds ratios were near one.

The use of a protected water source showed a protective relationship with diarrhea. When controlling for type of toilet, handwashing materials, and disposal location of child feces, use of a protected water source decreased odds of a child experiencing diarrhea by 30% [OR: 0.707; 99% CI: (0.134, 3.727)]. The use of an unimproved sanitation facility showed increased odds for diarrhea. When controlling for water source, handwashing materials, household flooring material, disposal location of child feces, and head of household education, use of an unimproved sanitation facility increased odds of a child experiencing diarrhea by 30% [OR: 1.30; 99% CI: (0.139, 12.178)]. The use of water and soap for handwashing materials showed a protective relationship with diarrhea. When controlling for water source, type of toilet, and disposal of child feces, use of soap and water for handwashing decreased odds of a child experiencing diarrhea by nearly 20% [OR: 0.812; 99% CI: (0.219, 3.009)]. Notably, disposal of child feces was a confounder in all three WASH models which speaks to the importance of safe disposals and the impact it has on not just sanitation, but also water and hygiene. PPI score and head of household income were not confounders for any of the WASH factors and therefore, they may not be of significance in the villages that were surveyed.

Based on the analyses performed, it is evident that water, sanitation, and hygiene practices, in addition to various socioeconomic factors (household flooring material, head of household education, and disposal of child feces), contribute to diarrheal disease in school-aged children in the five villages surveyed in the Moyamba District of Sierra Leone.

Limitations

There were a number of limitations with this thesis which may have impacted the results. Diarrhea experienced by school-aged children within the last two weeks was reported by the head of household or a respondent over 18 years of age living in the household. Recall bias could be an issue as it is difficult to keep track of and remember events that happened specifically in the last 14 days. Furthermore, parents and guardians are more likely to keep track of bathroom habits for children under five than they are for all school-aged children in the house. This could lead to under-reporting as they likely do not accompany potty-trained children to the bathroom or know if they have experienced diarrhea.

Sample size was a limitation for this study as it was a secondary data analysis. The original purpose of the survey addressed whether a household had access to a protected water source and/or improved sanitation facility. The prevalence of this access was assumed to be 50% which made for a sample size of 152. For this thesis, however, the interest was in the health outcome diarrhea which has a prevalence of nearly 15%. Therefore, the original sample size was not sufficient to observe statistically significant outcomes for this secondary analysis.

Type of water source and toilet were observed at each household in addition to what the respondent reported. However, this was not the case for handwashing materials as the researchers decided not to ask to see soap in each household. This could create response bias as most respondents know it is better to wash hands with soap and water rather than just water. Therefore, the percentage of the population reporting soap and water use could be higher than what is actually true.

Recommendations

It is evident that unsafe water, sanitation, and hygiene practices are contributing to the diarrheal rates in school-aged children in this area. However, in order to know exactly where to target interventions or promote behavior change, more research needs to be done. Protected water sources are being used in some capacity in every village, but there was no water quality testing done to know if the water is safe or contaminated. It is necessary to know which pathogens may be contaminating water sources so that specific pathways can be targeted to disrupt transmission. In the meantime, education on filtering or chlorinating water should be given in communities in order to ensure safe practices.

Sanitation is a major issue in this area. Over 60% of respondents use unimproved sanitation facilities with the majority of them openly defecating in nearby fields or bushes. Heavy rainfall can spread feces throughout the entire village and quickly contaminate water sources. Children playing outside can come into contact with feces and be exposed to pathogens, even if their own household has a latrine. Widespread sanitation coverage should be prioritized but will require extensive education and resources. A urine-diverting dry toilet may work well in these communities as urine and feces are separated and can be turned into compost and used for agricultural purposes. This would eliminate feces going into the ground and potentially contaminating the groundwater, and it would also eliminate the burden of having to empty the pit latrine or build multiple latrines. Until interventions can begin, open defecation areas should be marked so that feces is not spread throughout the villages.

All interventions that take place should only occur with the input of the communities. Education campaigns should focus on the health benefits and further research should be done to understand motivations behind improved WASH in the area by locals. When asked on the survey what the single most important thing the village needs to improve health is, over 60% of respondents said clean water. This suggests that respondents understand that clean water is needed and is currently not safe.

Conclusion

In conclusion, this project utilized quantitative methods to determine whether water, sanitation, and hygiene practices in addition to various socioeconomic factors contribute to diarrheal disease in school-aged children in the five villages surveyed in the Moyamba District of Sierra Leone. Despite results being statistically insignificant, the data showed type of water source, type of toilet, handwashing materials, head of household education, household flooring material, and disposal location of child feces as potential risk factors for diarrhea in school-aged children. The findings from this thesis contribute to the existing public health knowledge regarding the importance of safe WASH practices, and the impact they have on diarrhea. Furthermore, these findings provide evidence that no single intervention will affect diarrhea as profoundly as an intervention that considers water, sanitation, and hygiene in addition to socioeconomic status.

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Appendix A – Full Survey

PPI and Water, Sanitation, and Hygiene Practices Survey in Banta, Sierra Leone, 2019

Conducted by Emory University for Children of the Nations

Respondent's Identification
Village name ____
Household number [__] [__] [__]
Household has at least one child in it who attends school: VPP ☐ Village ☐ Community ☐

Interviewer: Read to the respondent before the interview begins.

"My name is (YOUR NAME). I am conducting research on behalf of Children of the Nations. The purpose of this survey is to understand the water, sanitation, and hygiene practices in the communities of the chiefdom of Upper Banta in Sierra Leone.

This interview will last less than one hour. Your participation is important to obtain this information, but it is not required. If you agree to participate, you do not have to answer every question if you do not wish to, and you can stop at any time. Your information will remain completely confidential. Your participation is voluntary, please tell me if you do not wish to participate."

Today's Date _____/_____/_____
(day/month/year)

Interviewer Guidelines:

1. If respondent agrees to participate, continue with the interview.
2. Read all questions and only read the responses out loud when told to do so. Otherwise, you will just read the question and wait for the respondent to give an answer.
3. Directions for the interviewer will always be underlined and are NOT to be read out loud.
4. The interviewer should read instructions out loud that are bolded, italicized and in quotations.
5. Do not read unknown or none out loud when reading answer choices. Only circle those options if they are said aloud by the respondent.
6. Circle the letter that corresponds to the respondent's answer. If the respondent gives an answer that is not listed, circle the number corresponding to 'other' and write their answer in the space provided.
7. Only circle one answer per question unless directed to circle all that apply.
8. No questions should be skipped or left blank.

Time Begun __ __:__ __ (24 hour time)

Household Head

Name	Age	Number of years completed in school
What was the activity of the household head in their main occupation in the past 12 months?		

Household Members

Name	Age	How many years of schooling completed?	Tick if this is a VPP Child

Number of household members =

Other school age children in family that are not currently living in your household: (If more than one)

Name	Age	What is the relationship with the person currently taking care of the child?

Other comments or observations about the state of the children in the household:

"The first section of the survey asks general questions about your household and the people in it."		
1. How many members does the household have? Do not read responses out loud.	A. Ten or more	0
	B. Seven, eight, or nine	9
	C. Six	13
	D. Five	16
	E. Four	21
	F. One, two, or three	28
2. Are all household members ages 6 to 13 in school now? Do not read responses out loud.	A. No	0
	B. Yes, or no one aged 6 to 13	5
3. What was the activity of the female head/spouse in her main occupation in the past 12 months? Do not read responses out loud.	A. No female head/spouse	0
	B. Agriculture, forestry, mining, or quarrying	3
	C. Other, or does not work	9
4. How many rooms does the household occupy (exclude bathrooms, toilets, kitchen, pantry, hall, and storage)? Do not read responses out loud. Compare their answer to your observation. If different, circle the letter you observe.	A. One	0
	B. Two	4
	C. Three or more	7
5. What is the main flooring material? Do not read responses out loud. Compare their answer to your observation. If different, circle the letter you observe.	A. Earth/mud, stone/brick, or other	0
	B. Wood, or cement/concrete	3
6. What is the main construction material of the outside walls? Do not read responses out loud. Compare their answer to your observation. If different, circle the letter you observe.	A. Stone/burnt bricks, or other	0
	B. Mud/mud bricks, or wood	11
	C. Cement/sand crete, or corrugated iron sheets	14
7. What type of toilet is used by the household? Do not read responses out loud. Compare their answer to your observation. If different, circle the letter you observe.	A. Bush/river, none, or other	0
	B. Bucket, common pit, or VIP	1
	C. Private pit, common flush, or flush toilet	7
8. What is the main source of lighting for the dwelling? Do not read responses out loud. Compare their answer to your observation. If different, circle the letter you observe.	A. Generator, kerosene, gas lamp, candles/torch light, or other	0

	B. Electricity (mains)	6
9. What is the main fuel used by the household for cooking? Do not read responses out loud. Compare their answer to your observation. If different, circle the letter you observe.	A. Wood, or other	0
	B. Charcoal	4
	C. Gas, kerosene, or electricity	6
10. How many radios, radio cassettes, record players, or 3-in-1 radio cassettes do members of the household own? Do not read responses out loud.	A. None	0
	B. One	4
	C. Two or more	14
11. Do any of the children in the household have parents elsewhere or have any lost both parents?		
Please explain with details of where the parents are now or how they died:		
PPI Score		
"The next section of the survey asks questions about water, sanitation, and hygiene in your household."		
12. What kind of toilet do the members of your household use most often? Do not read responses out loud. Compare their answer to your observation. If different, circle the letter you observe.	A. Pit latrine with slab	
	B. Pit latrine without slab	
	C. Designated open area	
	D. Bucket	
	E. Bush/field	
	F. Other (specify):	
13. Approximately, how far away in minutes is your primary latrine facility from your home? [__] [__] If latrine is very close, estimate [0] [1] minute; otherwise, write the number of minutes they tell you. If there is not a latrine, write however many minutes it takes to get to where they go to the bathroom.		
14. Estimate the number of people using your household or shared latrine (if using one): [__] [__] If there is not a latrine, write [0] [0] people.		
15. What do you perceive, if any, to be barriers to children using toilets or latrines? ***"You can say yes or no after each option. Please choose all that apply."*** Read responses out loud. Circle all letters corresponding to the answers given.	A. Distance to latrine	
	B. Cleanliness or safety of latrine	
	C. Child is not potty trained	
	D. No privacy at latrine	
	E. No latrine available	
	F. Other (specify):	
	G. No barriers	
16. How is or was stool from children who are not potty-trained discarded? Do not read responses out loud.	A. Taken to latrine	
	B. Buried outside	
	C. Thrown in bush	
	D. Thrown in rubbish pit	

	E. Other (specify):	
17. Have any of your children had diarrhea within the last two weeks? (3 or more loose stools in one day) Do not read responses out loud.	A. Yes	
	B. No	
	C. Unknown	
18. What materials do your children use to wash their hands? Read responses out loud.	A. Water only	
	B. Soap and Water	
	C. Other (specify):	
	D. None	
19. What do you perceive, if any, to be barriers to your children washing their hands? ***"You can say yes or no after each option. Please choose all that apply."*** Read responses out loud. Circle all letters corresponding to the answers given.	A. Distance to water source	
	B. Soap frequently runs out	
	C. Water frequently runs out	
	D. Other (specify):	
	E. No barriers	
20. What is the main reason for your children washing their hands? Read responses out loud.	A. To remove dirt	
	B. Because they are told to	
	C. To prevent disease	
	D. Other (specify):	
	E. Unknown	
21. Before and after which activities do children wash their hands during the day? ***"You can say yes or no after each activity. Please choose all that apply."*** Read responses out loud. Circle all letters corresponding to the answers given.	A. After going to the toilet	
	B. Before eating each meal	
	C. After playing outside	
	D. Before cooking each meal	
	E. Other (specify):	
	F. Never	
	G. Unknown	
22. What is the main source of drinking water that your family uses? Do not read responses out loud.	A. Borehole	
	B. Rainwater	
	C. Natural spring	
	D. Lake, river or stream	
	E. Protected dug well	
	F. Unprotected dug well	
	G. Other (specify):	
23. Does the water source provide enough water every day of the year? Do not read responses out loud.	A. Yes	
	B. No	
24. How is your drinking water stored? Do not read responses out loud.	A. Jerri can / 5 gallon	
	B. Clay/mud bowl or pot	
	C. Metal bucket	

	D. Plastic bucket without lid	
	E. Plastic bucket with lid	
	F. Other (specify):	
25. How often is the water storage container cleaned? ***"Please choose all that apply."*** <u>Read responses out loud. Circle all letters corresponding to the answers given.</u>	A. When getting new water	
	B. When it is dirty	
	C. Once a day	
	D. Once a week	
	E. Other (specify):	
	F. Never	
26. Do you use any methods to filter or chlorinate your water? <u>Do not read responses out loud.</u>	A. Yes	
	If yes, which method?	
	B. No	
27. How long, in minutes, is spent waiting in line at your main water source? <u>If they say water source does not usually have a line, estimate [0] [0] minute; otherwise, write the number of minutes they tell you.</u>	[__] [__] [__]	
28. How long, in minutes, does it take to travel round trip to collect drinking water? <u>Make sure to emphasize round trip. This is the total time it takes to get drinking water, going to get it and coming back.</u>	[__] [__] [__]	
29. How long, in minutes, does it take to collect your water for the day, including wait time and travel to source? <u>This should be the total time each day that is spent travelling and collecting water.</u>	[__] [__] [__]	
30. Who usually collects the water for your household (including drinking, cooking, and hygiene)? <u>Do not read responses out loud.</u>	A. Adult man	
	B. Adult woman	
	C. Female child (under 15 years)	
	D. Male child (under 15 years)	
	E. Other (Specify):	
	F. Unknown	
31. Where did/do you learn about water treatment and storage, sanitation and hygiene? ***"You can say yes or no after each option. Please choose all that apply."*** <u>Read responses out loud. Circle all letters corresponding to the answers given.</u>	A. Family	
	B. Clinics/Doctors	
	C. Friends	
	D. School	
	E. Radio	
	F. Other (specify):	
	G. Never learned about this before	
32. What do you think is the most important thing this village needs to improve the health of its people? <u>Write in answer. Only write down one answer which should include what they think is the most important.</u>		

"The next section of the survey asks a couple questions about religion."		
33. What is the primary religion in the home? Write in answer.		
34. If primary religion is Christian, is there a bible in the home? Do not read responses out loud.	A. Yes	
	B. No	
	C. Christian is not the primary religion	
35. If primary religion is Christian, does the family attend a local church on Sundays? Do not read responses out loud.	A. Yes	
	B. No	
	C. Christian is not the primary religion	
"The final section of the survey asks general health questions about the household."		
36. Are all children in household up to date on immunizations? Do not read responses out loud.	A. Yes	
	B. No	
	C. Not sure as there is no record	
37. What is the most common sickness amongst the children in the house? Write in answer. Only record one response.		
38. What are the medicines/treatments most commonly used? Write in up to three answers.		
39. How many meals do the children receive per day? Do not read responses out loud.	A. None	
	B. One	
	C. Two	
	D. Three	
40. What are your staple foods? Write in up to four answers.		
41. Does every child in the household sleep under a mosquito net? Read responses out loud.	A. No mosquito nets	
	B. Some children sleep under mosquito nets	
	C. All children sleep under mosquito nets	
42. OBSERVE mosquito nets. TALLY how many you see. Write in observation.		
43. Where do you go if someone in your household is sick? Write in up to two answers.		
44. Where do you get medicine if you are sick? Write in up to two answers.		
	A. Yes	

45. Has anyone in your family completed the WASSCE exam before this time? Do not read responses out loud. If they say yes, make sure someone has actually completed the exam and is not just preparing for it or about to take it.	B. No	
46. How much does the family head earn per day? Write in answer in leones.		
47. What type of home does the household live in? Read responses out loud.	A. Owned home	
	B. Rented home	
	C. Freely given home	
	D. Household members staying in rooms of multiple homes	
48. If home is owned, how many rooms are rented out to members of other households? Write in number of rooms or circle B if home is not owned.	A. [__] [__]	
	B. Home is not owned	

"These are all of the questions I have for you. Thank you for taking the time to talk with us today. We really appreciate your help with this research project."
Time Finished __ __:__ __ (24 hour time)

Appendix B – Training Guidelines for Survey

Background about the survey:
We are conducting this survey in order collect information on poverty, water, sanitation, hygiene, and general health. Children of the Nations will be given the results of the survey and recommendations for how to proceed with those results. It should not be promised to any of the

communities what will be done after the survey has been administered because we do not know that information yet. The majority of the surveys will be collected from households that have at least one child who attends school at COTN. A small amount of surveys from each village will be collected from households that have children who attend school somewhere other than COTN. This is being done in order to compare households with children who come to COTN versus households that have children who attend other schools. We will only be surveying households that have school-aged children in them (4-18). If a household does not have any children in this age range, they do not qualify for our survey.

<u>House numbers:</u>
We have a list of household numbers that we will follow to complete the surveys. If we get to a household on the list and they do not answer the door, we must make 3 attempts to come back on separate days at different times. If after 3 attempts they do not answer the door, we will consider that household to be a non-response. We will then add another household number randomly to the list to replace them.

<u>Training:</u>
Training and practicing the survey before administering it is extremely important. Everyone who plans to administer the survey must understand the interviewer instructions and every question on the survey. It must be administered the exact same way every time in order to obtain accurate results. We will start out as a group and all of us will go to each house. We will do this until everyone feels comfortable going on their own. When we are at each house, I will ask the questions in English and each person will take a turn at a different house translating the survey. It is important that only one person translates at each house, as it can be very overwhelming to have five people talking at one person.
If a person does not understand a question, it should be repeated at a slower pace, but it should not be re-worded. The interviewer will be told when to say the answer choices for the question and when they should just read the question and let the respondent answer without knowing the choices. Most choices should be listed, but if something is said that is not an option, it can be written in next to "other". If there are any questions that come up while administering the survey, please make a note next to the question so we can go back to the household and clarify at a later time if we need to. Also, every page has a space at the top for the village name and the house number. This must be filled in on every page and all three spaces need a number. If we are surveying house number 5, the space should be filled in as [0] [0] [5]. If we are surveying house number 32, the space should be filled in as [0] [3] [2]. If we are surveying house number 147, the space should be filled in as [1] [4] [7].

<u>Questions on the survey:</u>
There are a couple questions on the survey where the answer is a number written in this form [__] [__] [__]. All spots must be filled in, similarly to the house number. If the respondent says 5 minutes, the space should be filled in as [0] [0] [5]. If the respondent says 24 minutes, the space should be filled in as [0] [2] [4]. There are a few questions where the answers will be open-ended, meaning there are no letters to choose from and you must write what the respondent tells

you. It is important to listen to what they have to say, but not every word needs to be written down because there isn't enough room for that.
For example, with #37, they might say the most common sickness is malaria and talk about it for 5 minutes. However, the only thing you need to right down is malaria.
For #11, you will write yes or no next to the question. If the answer is no, then in the box below you will just say both parents are at home. If the answer is yes, you will explain the situation.
For #32, it is important to write down just one or two words for this. Some answers might include more latrines or water sources or jobs. It is important to just write down one thing though, if they name several, ask them what they think the single most important thing is to improve health in the village.
For #33, if the primary religion is not Christian, then you do not need to ask #34 and #35, you can simply circle the letter C for both of those which states that Christian is not the primary religion. It is still important to write in what the primary religion is for #33. If they are Christian, you must ask #34 and #35.
For #47, only select answer D (Household members staying in rooms of multiple homes) if the members don't have a permanent place to stay or call their own.

<u>Things to observe while administering surveys:</u>

- Number of rooms (only bedrooms and shared living room)
- Main flooring material
- Main construction material of the outside walls
- Type of toilet
- Main source of lighting
- Main fuel used
- Mosquito nets

If observations of these things are different from answers given on the survey, circle the letter corresponding to your observation and make a note of what the respondent said next to the question.